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Network Performance Analysis of Dynamic Routing Protocols for Real Time Application

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Abstract: *Routing protocol is taking a vital role in the modern internet era. A routing protocol determines how the routers communicate with each other to forward the packets by taking the optimal path to travel from a source node to a destination node in the network layer. Algorithms that are used for route selection and data structure are the main parts for the network layer. But in this paper we have explored four eminent dynamic routing protocols namely, Routing Information Protocol (RIP), Open Shortest Path First (OSPF) & Enhanced Interior Gateway Routing Protocol (EIGRP) and Interior Gateway Routing Protocol (IGRP) protocols. Evaluation of these routing protocols is performed based on the quantitative metrics such as Delay, FTP, E-mail, HTTP, VoIP and Video Conferencing through the simulated network models. The simulation results are analyzed, with a comparison between these protocols on the effectiveness and performance in network implemented. Results show that EIGRP will be best for delay, E-mail and FTP but for real time applications OSPF and RIP give better results.*

Keyword: *Network OPNET, Routing Protocols, FTP, HTTP, Video conference, Voice*

I. Introduction

Communication in the Internet has become a fundamental part of life. Transmission Control Protocol TCP / IP are the engine for Internet and interconnection networks worldwide. The main objective of the TCP / IP was to achieve interconnection, which led to the provision of universal communication through natural heterogeneous networks [2]. Routing links together small networks to form huge internetworks that span vast regions. This cumbersome task makes the network layer the most complex in the OSI reference model. The network layer provides the transfer of packets across the network. At the network layer, the Internet can be seen as a collection of sub networks or Autonomous Systems (AS-Autonomous Systems sites) that are connected together via the main backbone. The Internet connection is performed using IP protocol (Internet Protocol).

Routing protocols determine the mechanism by which routers obtain information on the state of the network topology respectively. Routing protocols are based on routing algorithms, which rely on various metrics to find the best path to transmit data across networks. Metrics include cost, bandwidth, packet delay, and hop count. Routing protocols utilize a routing table to store the results of these metrics. Based on whether the routing is within an Autonomous System (AS) or between ASs, there are two types of routing protocols: Interior Gateway Protocols (IGP) and Exterior Gateway Protocol (EGP). RIP, OSPF, EIGRP, IS-IS and IGRP are commonly used IGPs. A typical EGP is the Border Gateway Protocol (BGP).

II. Dynamic Routing Protocol Concept

Dynamic routing protocols play an important role in today's networks. They are used to facilitate the exchange of routing information between routers. They dynamically share information between routers, automatically update routing table when topology changes, and determine the best path to a destination. Compared to static routing, dynamic routing protocols have better scalability and adaptability and require less administrative overhead. Dynamic routing protocols allow routers to dynamically advertise and learn routes, determine available routes and identify the most efficient routes to a destination. Dynamic routing protocols have the capability to maintain the network operation in case of a failure or when network configuration or topology change [11].

Basically "Distance vector" and "link state" are used to describe routing protocols used by routers to forward packets. There are two groups of routing protocols, based on whether the routing protocol selects the best routing path based on a distance metric (the distance) and an interface (the vector) or selects the best routing path by calculating the state of each link in a path and finding the path with the lowest total metric to the destination. Distance vector protocols evaluate the best path based on distance, which can be measured in terms of hops or a combination of metrics calculated to represent a distance value. The IP Distance vector routing protocols in use today are RIP and IGRP. In link state routing, every node constructs a map of the connectivity to the network in the form of a graph showing connectivity of the nodes to each other. Each node then independently calculates the next best logical path to every possible destination in the network [5]. The collection of best paths forms the node's routing table. Link state protocols have the routers announce their closest neighbors to every router in the network. Only a part of the table pertaining to its neighbors is distributed. EIGRP, OSPF, and Intermediate System-Intermediate System (IS-IS) are link state routing protocol.

2.1 Routing Information Protocol (RIP)

Distance vector routing algorithm assumes that each router maintains a table (e.g. a vector) that preserves the best known distance to each destination and the line to be followed to get there [3]. Distance vector routing algorithm is also known by other name such as distributed routing algorithm Bellman-Ford or Ford-Fulkerson algorithm; named researchers have proposed (Bellman, 1957 Ford and Fulkerson, 1962).

RIP is a distance vector dynamic routing protocol that employs the hop count as a routing metric. RIP is implemented on top of the User Datagram Protocol (UDP) as its transport protocol [11]. RIP prevents routing loops by implementing a limit on the number of hops allowed in a path from the source to a destination. The maximum number of permitted hops is 15. Hence a hop count of 16 is considered an infinite distance. RIP depends upon no of hop and selects paths that have the smallest hop counts. However, the path may be the slowest in the network. RIP is simple and efficient in small networks. However, it may be inefficient in larger networks. Every RIP router updates its own routing table by communicating with neighboring routers and transmits full updates in every 30 seconds [5]. RIP may take 30–60 seconds to converge based on the features of distance vector protocols. RIP has lower power consumption and memory than some other routing protocols.

2.2 Open Shortest Path First (OSPF)

OSPF uses a link state routing algorithm and it operates within a single AS. It exhibits faster routing compared to RIP. Each OSPF router stores the local network connection state with Link State Advertisement (LSA) and advertises to the entire AS. Each router receives the LSA generated by all routers within the AS. The LSA collection then forms Link State Database (LSDB). Each LSA is the description of the surrounding network topology of a router. Hence, the LSDB reflects the AS network topology [6]. When a new router is added to the network, it will broadcast hello messages to every neighbor and will receive the feedback hello messages from its neighbors. Eventually, routers establish connections with newly added router and synchronize their routing databases. Every router broadcasts link state update messages when network topology changes. Every router calculates the best paths to all destinations and indicates the closet router for each transmission. OSPF is the most widely used IGP in large enterprise networks.

2.3 Enhanced Interior Gateway Routing Protocol (EIGRP)

EIGRP is a Cisco proprietary routing protocol, which is an improved version of the interior gateway routing protocol (IGRP). EIGRP is being used as a more scalable protocol in both medium and large scale networks.

EIGRP is said to be an extensively used IGRP where route computation is done through Diffusion Update Algorithm (DUAL) [12]. EIGRP metrics are based on reliability, MTU, delay, load, and bandwidth. EIGRP collects data from three tables. The first is the neighbors' table, which stores data about neighboring routers that are directly accessible through interfaces that are connected. The second is the topology table, which contains the aggregation of the routing tables that are gathered from all neighbors that are directly connected. It contains a list of destination networks in the EIGRP routed network and their respective metrics. The third routing table stores the actual routes to all destinations. EIGRP does not rely on periodic updates to converge in the topology, instead building a table that will contain announcements on neighbours about changes in topology. The EIGRP router broadcasts to other neighbors if it cannot locate a router based on its routing database.

2.4 Interior Gateway Routing Protocol (IGRP)

IGRP is a Cisco-proprietary Distance-Vector protocol, designed to be more scalable than RIP. IGRP sends out the full routing table every periodic update every 90 seconds. IGRP metrics are based on bandwidth and delay. IGRP requires including an Autonomous System (AS) number in its configuration. Only routers in the same Autonomous system will send updates between each other. It support up to six parallel paths to the destination for load balancing. It provides loop free environment. It only support IP routing. By default it supports maximum 100 hops.

III. Simulation

In this paper, we used OPNET Simulator, a real time simulator specifically designed for network design and analysis, to compare these protocols, when considering a hypothetical network model. It enables simulation of heterogeneous networks by employing a various protocols [5]. The OPNET IT Guru provides a

GUI to create the virtual network conveniently. OPNET simulator is built on top of discrete event system (DES) and it simulates the system behavior by modeling each event in the system and processing it through user defined processes. It has several distinct methods of creating topologies. Modeler supports almost all network types and technologies [9].

3.1 Design and Analysis in OPNET

When implementing a real model of the system in the OPNET, some steps are to be followed to design on simulator. Figure 1 shows the workflow for OPNET.

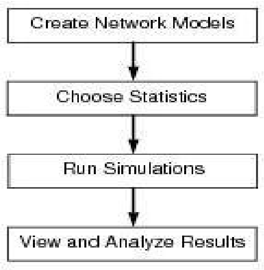


Fig.1: OPNET Analysis

3.2 Simulation Environment

The simulated network shown in Figure 2 consists of six subnets connected to each other with *Point to Point Protocol* (PPP) using Digital Signal 3 (DS3, 44.736 Mb/s). One subnet is acting as server at centre and remaining subnets are connected as shown in Fig 2. Each subnet consists of Ethernet4_slip8_gtwy routers, switches and 10BaseT LANs and nodes are connected with Ethernet 100BaseT cables as shown in Fig. 4. Server subnet is consists of three servers, two workstations and switches as shown in Fig 3. The network topology design in Fig. 1 is configured for RIP, OSPF, IGRP and EIGRP protocols with two scenarios such as Fail and No Fail. In order to analyze the network in terms of different parameters like upload and down load response time, packet end to end delay, throughput, etc., the global, node and link statistics are configured accordingly.

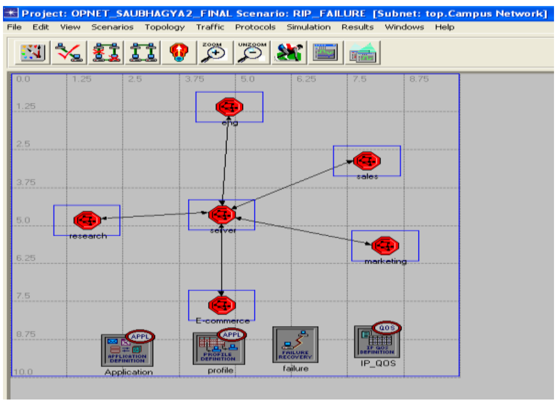


Fig.2: OPNET Simulated Network Topology

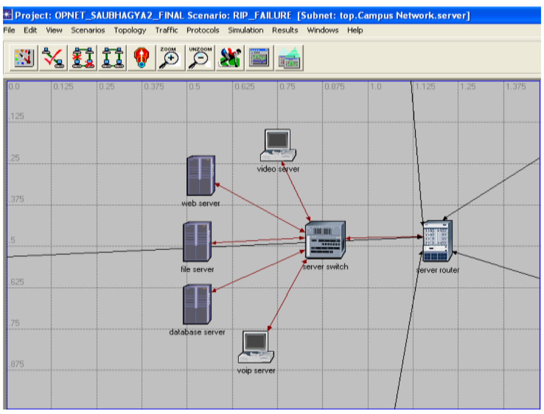


Fig.3: Design of server subnet

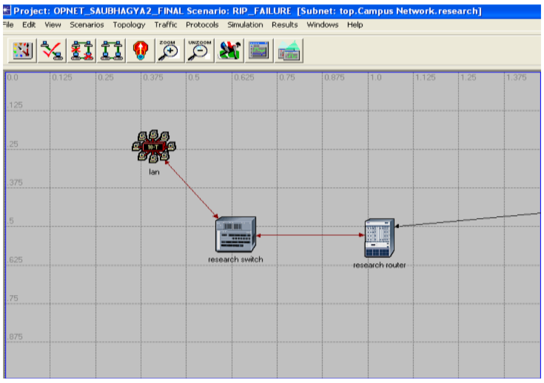


Fig.4: Design of client subnet

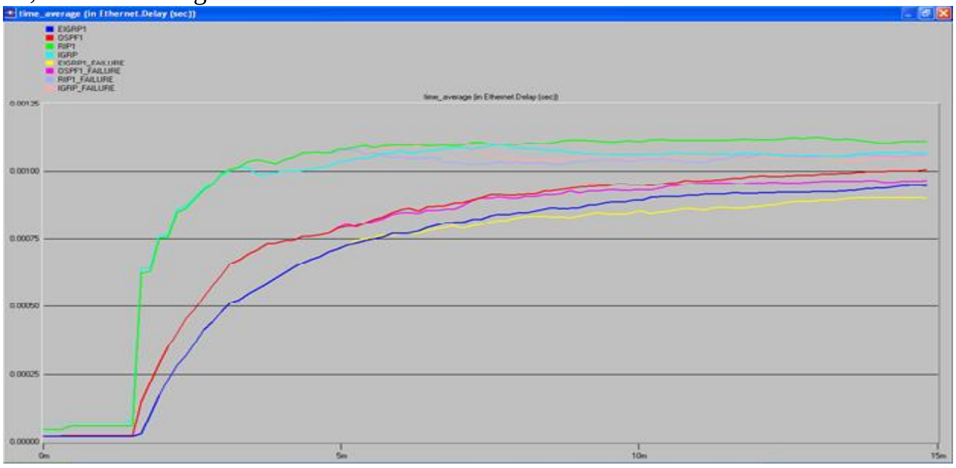
3.3 Design Parameters

(Ftp)Table		**(Http)Table**		**(Video Conferencing)Table**	
Attribute	Value	Attribute	Value	Attribute	Value
Command Mix(Get/Total)	50%	Http Specification	HTTP1.1	Frame interval time information	15 frames/sec
Inter-Request Time (seconds)	Constant(100)	Page Interval Time(sec)	Exponential (2000)	Frame size information	128×240 pixels
File Size(bytes)	Constant(100000)	Page Properties	(…)	Symbolic destination name	Video destination
Symbolic Server Name	FTP Server	Server Selection	(…)	Type of service	Streaming multimedia (4)
Type of Service	Best Effort(0)	Type of Service	Best Effort(0)	Traffic Mix	All discrete
(Database)Table		**(Email)Table**		**(Voice)Table**	
Transaction Mix(current/total)	100%	Send interval time	Exponential (3000)	Encoder scheme	G.711
Transaction interval Time	Constant(100)	Send group size	Constant(4)	Voice frames per packet	1
Transaction Size	Constant(512)	Receive interval time	Constant(10)	Type of Service	Interactive voice(6)
Symbolic Server Name	Database Server	Receive group size	Constant(4)	Symbolic destination	Voice destination
Type of Service	Best Effort(0)	Symbolic server name	Email server	RSVP Parameters	None

3.4 Simulation Results and Analysis

OPNET Modeller is used extensively to decide which protocols would be best suitable for applications. The metrics used for network performance are network convergence, queuing delay, throughput, QoS and CPU utilization. We consider a random network design so as to have a standard network with different profiles such as student, research, marketing, etc. each of which would require different applications, some of which would be real time while others non-real time. We start with the analysis of non-real time applications where on the topology shown in fig.2. It is necessary that we understand the effect of choice in routing protocols, the QoS that it offers, the effect of number of simultaneous users and applications which would add to the server load and hamper the QoS of real-time applications which work on a low latency QoS. The simulation time is set to fifteen minutes to all routing protocols.

Ethernet Delay: The Ethernet delay, representing the end to end delay of all packets received by all the stations in the network, is shown in Figure 5.

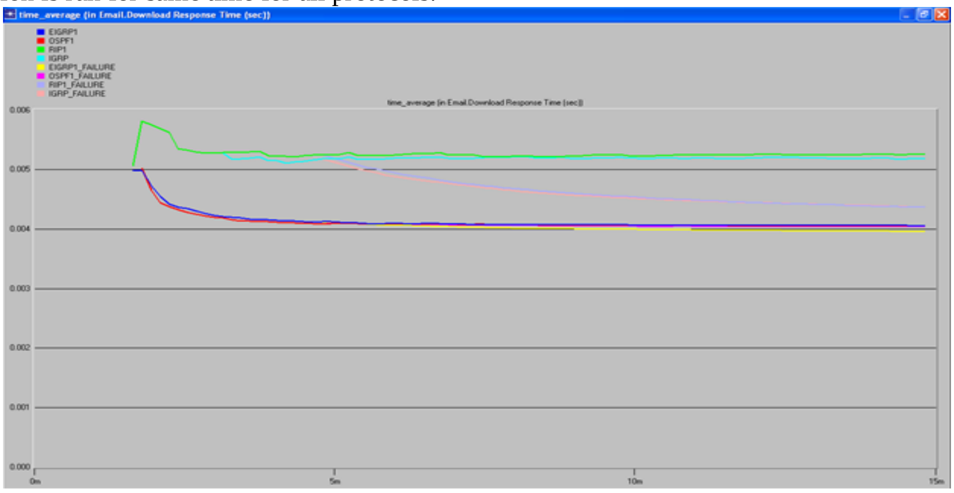


Simulation Time

Fig.5: Ethernet Delay

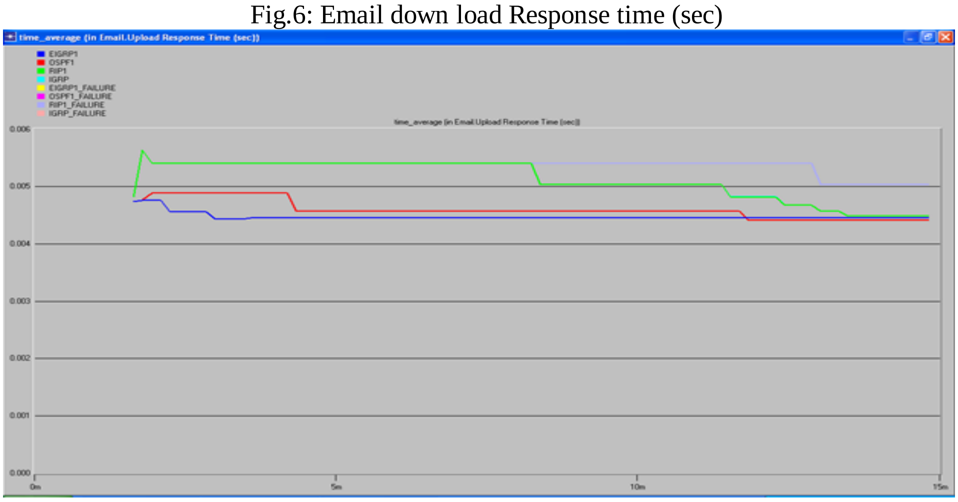
The lowest delay is experienced by EIGRP and the highest delay is experienced by RIP. EIGRP has very low usage of network resources during normal operation only *hello* packets are transmitted. When routing table changes, its convergence time is short and it reduces bandwidth utilization.

Email: The parameters which are considered for Email are Download response time and upload response time. The simulation is run for same time for all protocols.



Simulation Time

Fig.6: Email down load Response time (sec)

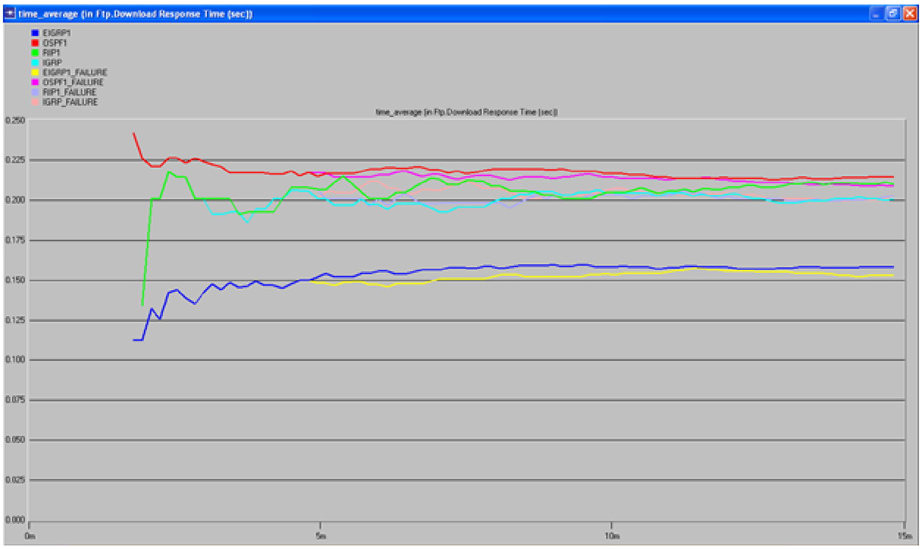


Simulation Time

Fig.7: Email Upload Response time (sec)

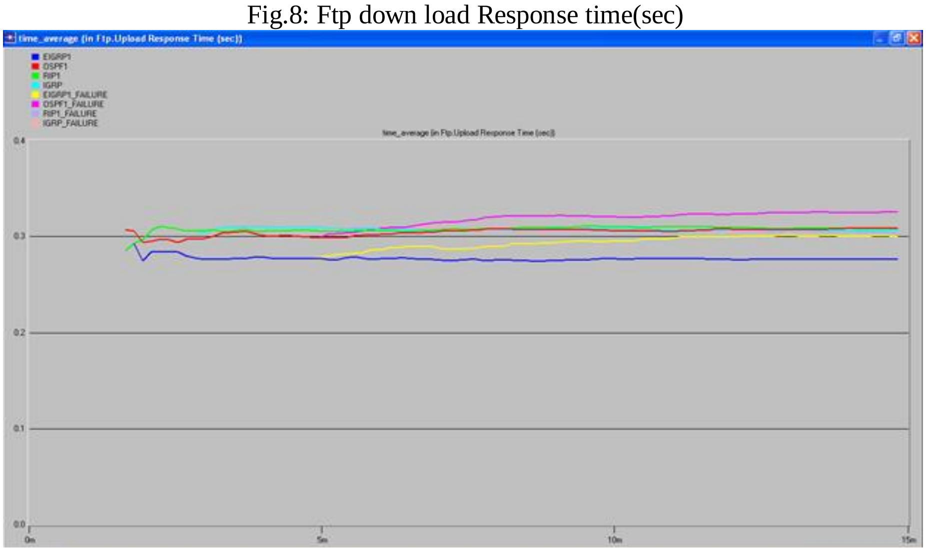
On the basis of simulation result, we observe that EIGRP protocol exhibits the shortest response time and RIP exhibits the highest response time for any simulation network in terms of convergence and latency for any standard simulated network. After failure also EIGRP exhibits shortest response time.

FTP: The parameters which are considered for ftp Download response time and upload response time. By default FTP application model transfers only one file at a time. FTP creates lots of packets which move through the network like a single packet. These packets tend to congest the flow through the network and affect the high priority traffic.



Simulation Time

Fig.8: Ftp down load Response time(sec)

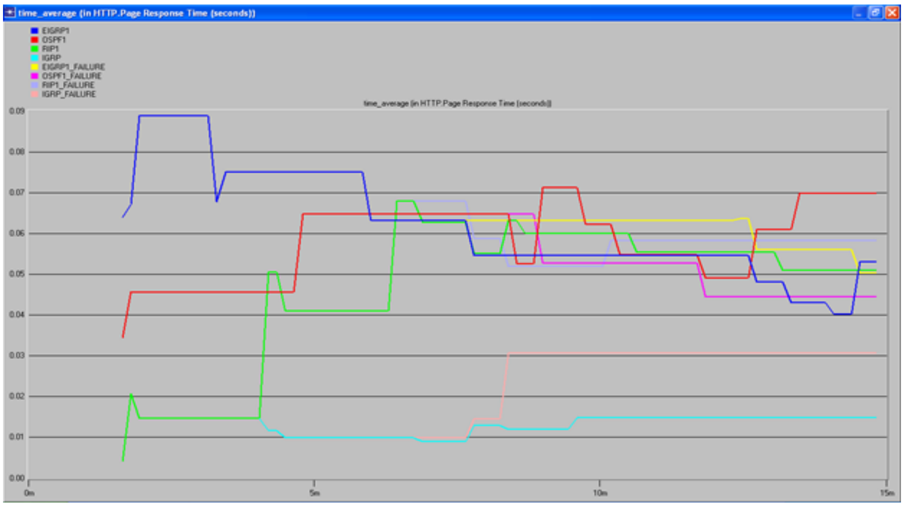


Simulation Time

Fig.9: Ftp down load Response time (sec)

We consider all routing protocols to determine which would provide most results for ftp. After simulation we conclude that EIGRP protocol would work best for ftp under standard network topology.

HTTP web browsing: The parameters which are considered for Http are page response time.



Simulation Time

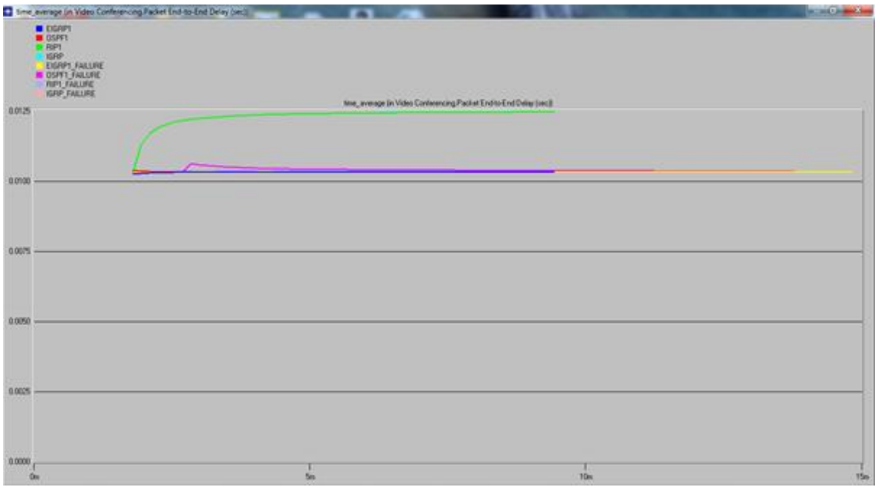
Fig.10: Http page Response time (sec)

The HTTP web browsing takes both heavy as well as light traffic into account due to which scheduling of packets and congestion changes with time. Here the time average of page response time and object response time based on comparative results shown above we can say that IGRP is the best suited protocols for HTTP.

Real time applications

As seen in fig 3 the real time applications such as VoIP and video conferencing application are based on a peer to peer network and hence also can be termed as high bandwidth resource utiliser with improved QoS to meet demands of the user satisfaction. They are peer to peer applications and are more bandwidth dependant for better QoS.

Video Conferencing: The Video Conferencing application models transmission of video traffic between two nodes in the network. Video Conferencing application runs over the UDP transport protocol to avoid connection management and other delays associated with the TCP protocol. The selection of appropriate protocol for real time application is more important in terms of packet delay variation and End-to-End delay. The attribute for video conferencing is shown in design parameters.

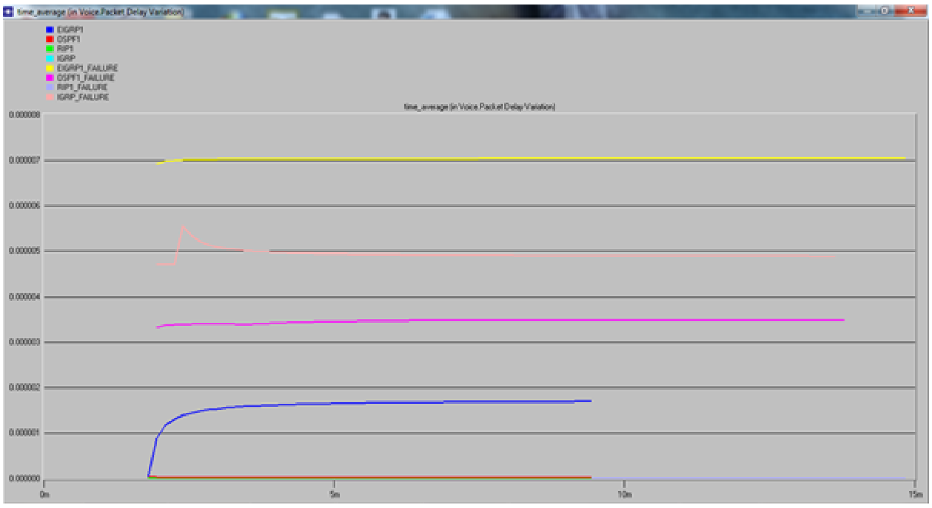


Simulation Time

Fig. 11: Video Conferencing packet End-to-End Delay (sec)

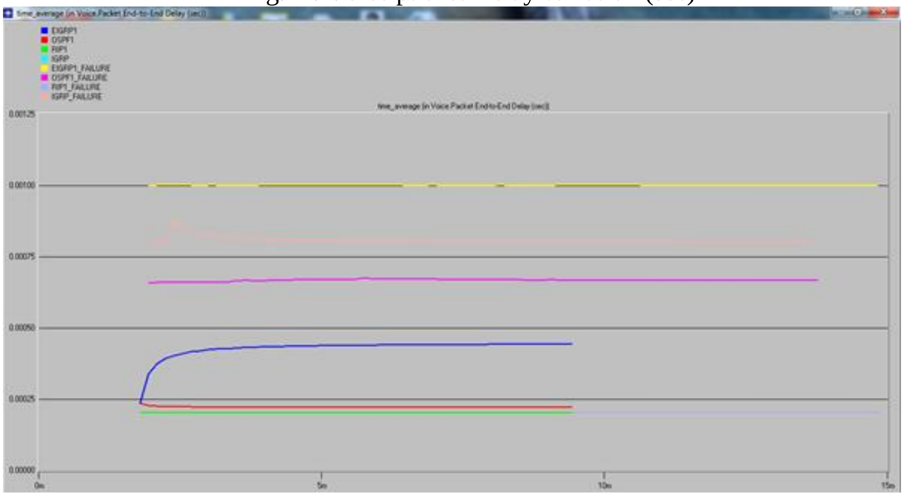
On the basis of simulation result we conclude that real time application for video conferencing and streaming packet End-to-End delay would work best with EIGRP routing protocol.

VoIP: Voice over IP technology integrates data and voice networks and offers flexibility by supplying device interoperability using standards-based protocols. Routing is an essential data networking function that provides an efficient real-time data delivery VoIP requires [10]. Best effort networks leverage IGP technologies to determine path between hosts.The VoIP performance metrics include delay, jitter, and packet loss. The parameters which are considered for VoIP are voice packet delay and End-to-End Delay variation.



Simulation Time

Fig.12: Voice packet Delay variation (sec)



Simulation Time

Fig.13: Voice packet End-to-End Delay (sec)

As we expected, EIGRP carries out low-efficient routing in the network. RIP and OSPF perform with excellence because they computing the fastest possible route. On the basis of the above results we can conclude that based on the voice encoder schemes selected and the most optimal routing algorithm would be RIP and OSPF for real time VoIP application. RIP performs better in terms of voice packet delay because it is a simple routing protocol that relies on distance vector algorithms. OSPF has large protocol overhead when updating the routing table.

IV. Conclusions

In this paper we would like to find which routing protocol would serve best based on applications running in our network topology. Here we classified the application into real time and non-real time where RTP protocols are simulated over IGP protocols. EIGRP is a robust protocol, combines the attributes of distance-vector and link-state protocols attributes, resulting in a hybrid protocol that is easy to configure, efficient and also has a faster Convergence. We can conclude that EIGRP is the best choice for Delay, FTP and E-mail. We can use live requirement of video and voice applications to work with specific QoS to meet requirement of low latency and packet dropping. The best results for video and voice packet delay is OSPF and for video and voice end-to-end delay is EIGRP. As a future work we need to study the effect of newer applications on server load as well effect of nodes on QoS of applications. We can do new applications based on our current network topology using application and profile definition as a guideline.

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