SIMULATION AND TESTING OF ROUTING PROTOCOLS

ENSC - 894
Communication Networks
Prof. Ljiljana Trajkovic

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Simon Fraser University
Student ID: 301258052
vgupta@sfu.ca

Syed Hamza M Rufai
Student ID: 301254373
srufai@sfu.ca

Abstract

Routing Protocols govern the best route/path to transfer data between various nodes in a network while it is transmitted from a sender to the receiver. This paper shows the simulation of a network through which different formats of data is transmitted using multiple protocols like: Routing Internet Protocol (RIP), Interior Gateway Routing Protocol (IGRP), Intermediate System to Intermediate system (IS-IS) Open-Shortest Path Protocol (OSPF) & Enhanced Interior Gateway Routing Protocol (EIGRP). Simulation scenarios are designed, for each of these protocols. The simulation platform used for this paper is Riverbed Modeler 18.0 through which the system behaviour is tested and the performance of the protocols are analysed for to real time application

The simulation model for a real time practical network is designed using Riverbed modeler18.0 The connectivity between the end nodes are dependent on the wireless media.

Keywords: Routing Protocols, Internet protocols, Riverbed modeler18.0

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List of Acronyms

IEEE	Institute for Electrical and Electronics Engineers
DRP	Dynamic Routing Protocol
IGP	Internal Gateway Protocol
EGP	Exterior Gateway Protocol
BGP	Border Gateway Protocol
RIP	Routing Information Protocol
IS-IS	Intermediate State – Intermediate State
OSPF	Open Shortest Path First
IGRP	Interior Gateway Routing Protocol
EIGRP	Enhanced Interior Gateway Routing Protocol
AS	Autonomous System
IP	Internet Protocol
PPP	Point to Point Protocol

1. Introduction

The **Internet Protocol** (IP) is the primary governing protocol for communications i.e. transfer of data packets from the sender to the receiver in the network layer. It facilitates as a link connecting various parts of the internet. It is generally used in conjunction with Transfer Control Protocol (TCP) and is also referred as TCP/IP. The TCP/IP is a part of the Internet Protocol suite and is an open system as it has the ability to communicate across multiple interconnected networks.

The delivery of packets from its source to destination is achieved by using a unique addressing system. The IP address which resides in the packet header specifies the host and destination address. The data is encapsulated in the packet and labelled appropriately. The 2 major functions of IP is to provide a connectionless delivery of datagrams, on best effort basis and to fragment and reassemble datagrams to be compatible with varied data links having different MTU sizes. Most dominant protocol of IP is the IP Version 4 standard that is 4 bytes (32 bits) in length. Due to the exhaustion of IP V4 addresses its successor, the Version 6 i.e. IP V6 is gaining popularity. IP V6 is 16 bytes (128 bits) long and has a larger pool of IP addresses to be used. The IP Network can be divided into smaller networks called sub-networks or subnets using subnet masks. This is done for better manageability and to get more number of IP addresses within an organization.

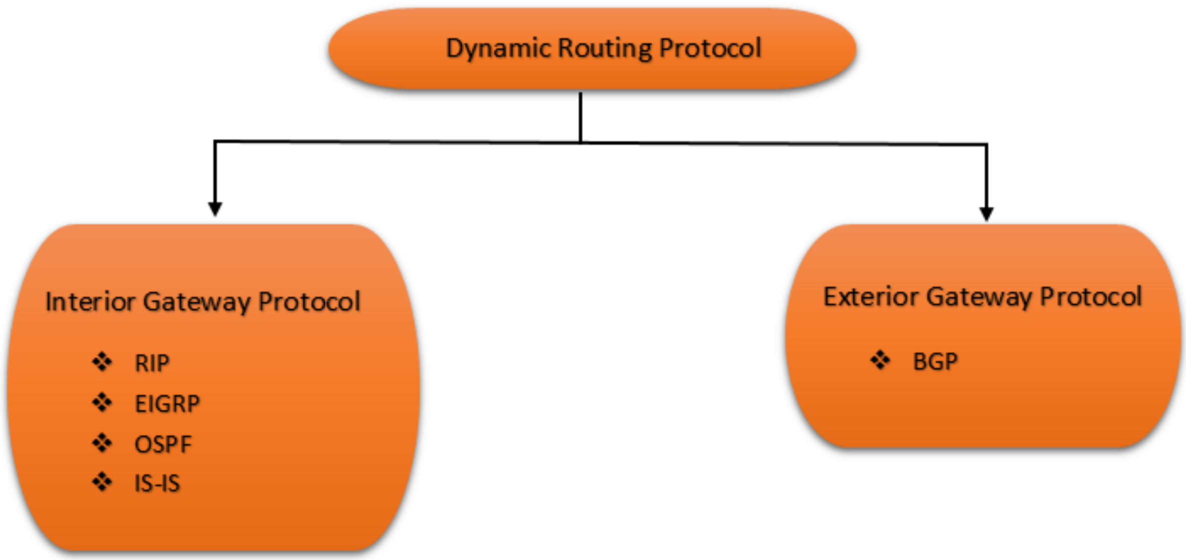


Fig 1: Dynamic Routing Protocol Chart

Routing Protocol: The Communication between intermediate routers are specified using a routing protocol, in which the information is propagated so that it is possible to select routes between two nodes in a network. The route selection is determined by the routing algorithms. Each router has the information of only the networks attached to it directly. A routing protocol allots this information first among close neighbours, and then all across the network. Through this pattern, routers gain the understanding of the network topology.

Although there are multiple types of routing protocols, three major classes are widely used on IP networks:

- Interior gateway protocols type 1, OSPF and IS-IS which are the link-state routing protocols.
- Interior gateway protocols type 2, IGRP, RIP and other such distance-vector routing protocols.
- Exterior gateway protocols are routing protocols used on the Internet for exchanging routing information between Autonomous Systems, such as Border Gateway Protocol (BGP), Path Vector Routing Protocol.

The term "Exterior gateway protocol" has two implications. It could imply a category of protocols that are used between autonomous systems to exchange routing information. Alternatively, it could also mean a specific RFC-described protocol. Numerous routing protocols are described in texts about RFC. In some interpretations of the Open System Interconnection (OSI) networking model, the routing protocols are distinguished in a sublayer of the Layer 3 viz. Network Layer. The unique characteristics of routing protocols comprise of the way in which they avert routing loops, the manner in which they opt the most preferred routes, using knowledge about hop costs, the time period they require to reach convergence of routing, their scalability, and other varied factors.

Routing Information Protocol (RIP): It is kind of a family of IP Routing protocols, and is an Interior Gateway Protocol (IGP) designed to give away routing information within an Autonomous System (AS). RIP is a type of protocol which limits the number of hops allowed in a path from the source to a destination. Only maximum 15 hops are allowed in RIP. However this limit define the size of networks that it can support. Hop count when greater than 15 is overlooked as an infinite distance, in other words the route is considered to be far away.

In usual prevailing networking environments, RIP is the least preferred choice for routing as its convergence time is poor in comparison with other routing protocols (EIGRP,OSPF and IS-IS) and a hop limit severely limits the size of network. However, it is easy to design, because RIP does not stand in need of any framework on a router unlike other protocols.

Open Shortest Path First (OSPF) Routing Protocol: The OSPF protocol is part of a family of IP Routing protocols, and is used to distribute IP routing information through the entire single Autonomous System (AS) in an IP network

The OSPF protocol makes use of link-state routing protocol, wherein the routers exchange information of the topology with their nearest neighbours. The topology information is supplied throughout the AS, so that each and every router within the AS has a complete description of the topology of the AS. This description is then used to calculate end-to-end paths through the AS. This is usually done with the help of Shortest Path First (SPF) or Dijkstra algorithm. Accordingly, in a link-state routing protocol, the next hop address to which data is delivered is resolved by choosing the optimum end-to-end route to the possible destination

The superiority of using a link state routing protocol like OSPF is that the complete knowledge of topology allows routers to calculate routes that satisfy particular norm. This can aid the traffic engineering purposes, where direction can be embarrassed to meet particular quality of service precondition. The major drawback of a link state routing protocol is that it does not scale well like more routers are added to the routing domain.

In a way OSPF routing protocol works as

- The protocol recollect routes when network topology changes, while using the Dijkstra's algorithm, and decrease the routing protocol traffic that it generates.

- It provides a multi-level hierarchy (two-level for OSPF) called "area routing," so that description about the topology within an area of the AS is hidden from routers outside this area. This enables a routing protection and reduces the traffic level of routing protocol.

Enhanced Interior Gateway Routing Protocol (EIGRP) : Until march 2013 EIGRP was a Cisco-proprietary routing protocol that is used on a computer network to help automate routing decisions and configuration.

EIGRP is also noted as a hybrid routing protocol as it has possesses the properties of both distance-vector and link-state protocols. EIGRP does not make use of a port number to identify traffic as it does not operate using the Transmission Control Protocol (TCP) or the User Datagram Protocol (UDP) instead it runs on Cisco's Reliable Transport Protocol (RTP) so as to deliver EIGRP router updates to all neighbors completely.

EIGRP makes use of The Diffusing Update Algorithm (DUAL) allowing all routers involved in a topology change to synchronize at the same time. EIGRP collects data from three tables, first being the neighbors' table, which save the data about neighboring routers that are directly accessible through interfaces that are connected, second is the topology table, containing the aggregation of the routing tables that are gathered from all neighbors that are straightly connected. It involve a list of destination networks in the EIGRP routed network and their respective metrics and the final routing table stores the actual routes to all destination.

Some of the following features:

- Fast Convergence
- Support VLSM
- Updates conserve network bandwidth
- It support all layers 2 (Data Link Layer) protocol and typologies.
- Use Multicast instead of broadcast
- Support Authentication.

Interior Gateway Routing Protocol (IGRP) : falls into the category of distance-vector routing protocols developed by Cisco, so as to transport routing data with the autonomous system. IGRP came into being in order to overcome limitations exhibited by RIP (maximum hop count of only 15, and a single routing metric), advantage of IGRP is that it support multiple metrics for each route, bandwidth, delay, load, MTU and reliability. Also to compare two routes these metrics are combined together into a individual metric by using a formula which can be modify through the use of per-set constants. The default configuration of the IGRP sets the composite metric is a sum of the segment delays and the minimum bandwidth. The maximum configurable hop of IGRP-routed packets is 255 (default 100), and routing information updates are broadcast every 90 seconds (by default) IGRP uses port number 9 for communication.

IGRP sets the complex metric which is the sum of the of the section delay and the lowest section bandwidth. IGRP maximum hop count is 255(default 100) and updates for routing are simulcast for every 90-second by default where it uses 9-port number for connection.

Intermediate System to Intermediate System (IS-IS) is a kind of a link state routing protocol which belongs to a part of OSI family of protocols like OSPF it also uses Dijkstra's algorithm to select the routes. IS-IS is a classless internal gateway protocol that use router information and resources very efficient. Each IS-IS router individually frame a database of the network's topology, accumulate the flooded network information.

The IS-IS protocol is an Interior Gateway Protocol (IGP) for the Internet, used to assign IP routing information throughout a single Autonomous System (AS) in an IP network. IS-IS share the topology information with their nearest neighbouring routers, that is why it is known as Link-State Routing Protocol. IS-IS carry IP network information, But it does not use IP as its transport protocol. It uses OSI protocols CLNS (Connection less Network service) and CLNP (Connection less Network Protocol) to deliver its updates.

2. **Network Topology**

The below snapshot shows the network topology designed using Riverbed modeller 18.0 to implement and test the different protocols with varied types of data.

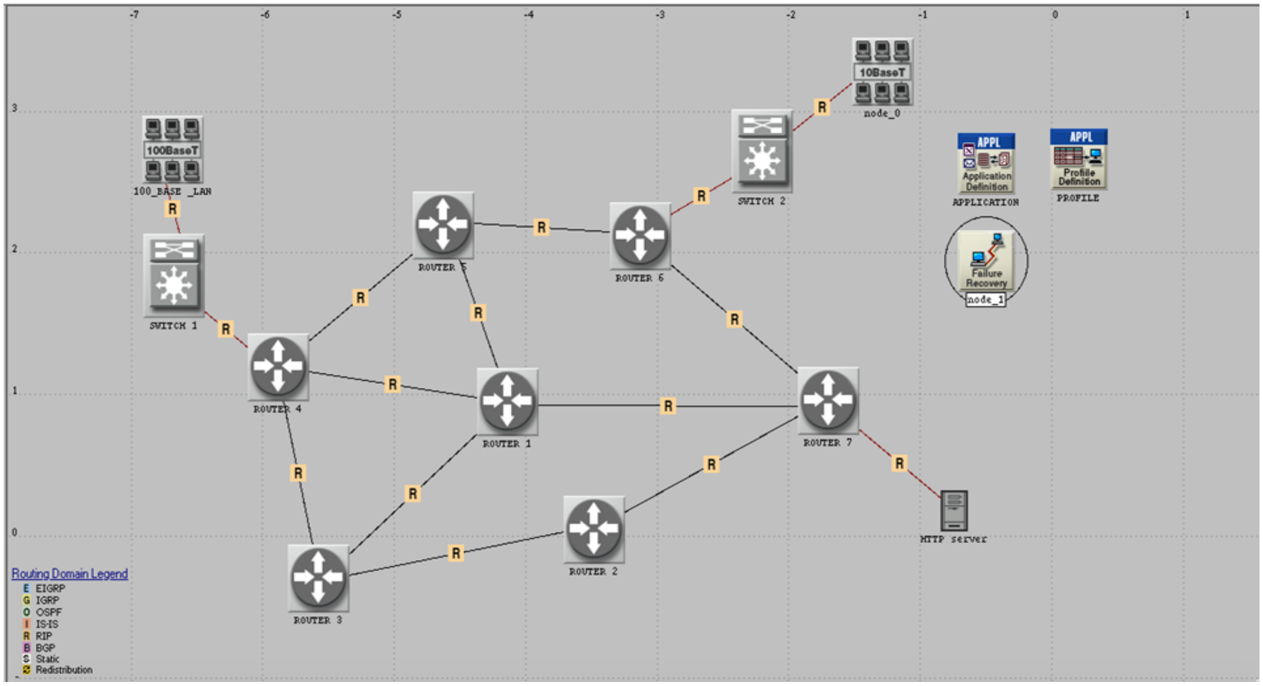


Fig 2: Model Configuration Network Topology

The network scenario consists of 7 Ethernet routers connect in a partial mesh network topology, wherein the boundary routers are connected using PPP_DS 3 links with bandwidth of 44.736Mbps while the internal connection in the mesh is connected PPP_DS1 links having bandwidth of 1.544Mbps.

A connection of two '100BaseT' LAN, stations with the two routers, router 4 and router 6, via two 'ethernet_slp_gtw' switch, switch1 and switch2 is established. The data in the network is provided by http server, connected through router 7. In the network the application configuration and profile configuration is set up particularly for HTTP heavy browsing and Web TV applications. A failure recovery is setup in the link between the router 4 and router 1.

The above network shows RIP protocol being implemented throughout the designed network, the same model network has been used while engaging and testing the other routing protocols, IGRP, EIGRP, OSPF & IS-IS.

3. Configurations

a. Application Configuration:

For the applications, on which the designed network is to be evaluated, are configured in application configure profile. The operation of the network is tested and apprehend the output of the network on the basis of two ‘http heavy browsing’ and ‘web TV’ applications.

For heavy browsing the user is receiving large amounts of packet data from the source, the attributes for this type of data utilization is set as

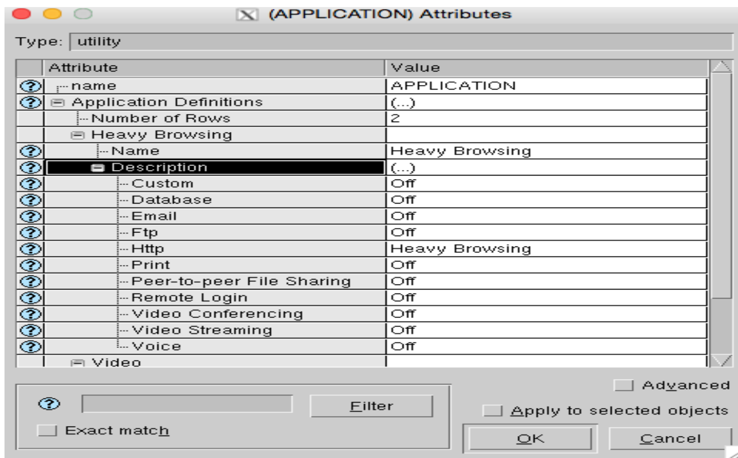


Fig 3: Application Configuration (Heavy Browsing)

In Web TV continuous packets of data are acknowledged, hence to furnish the study of the effect of routing protocols on the web TV application the profile attributes are

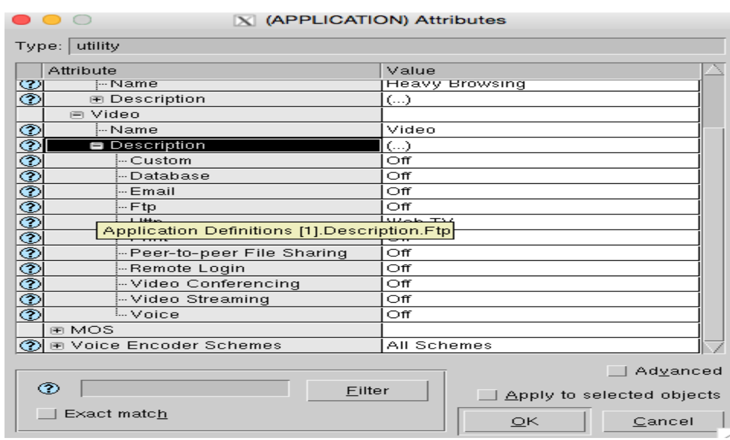


Fig 4: Application Configuration (web TV)

b. Profile Configuration

In profile configuration the corresponding profile of the application which is to be implemented in the network. The attributes of profile configuration for the corresponding applications are framed up as

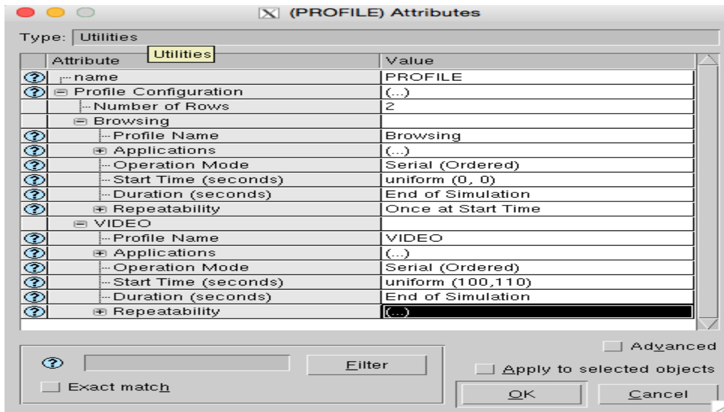


Fig 5: Profile Configuration

4. **Failure Recovery**

The network is modelled in a way that the link node between the router4 and router1 is simulated to fail at five intervals of time and it recovers after every failure. The response of failure recovery is same is examined over all the five routing protocols (RIP, IGRP, EIGRP, OSPF and IS-IS)

Scenario Name	**Routing Protocol**	**Failure Link**	**Fail Time 1**	**Recovery Time 1**	**Fail Time 2**	**Recovery Time 2**	**Fail Time 3**	**Recovery Time 3**
RIP	RIP	Router 4 - 1	240	420	520	580	610	620
OSPF	OSPF	Router 4 - 1	240	420	520	580	610	620
IS-IS	IS-IS	Router 4 - 1	240	420	520	580	610	620
EIGRP	EIGRP	Router 4 - 1	240	420	520	580	610	620
IGRP	IGRP	Router 4 - 1	240	420	520	580	610	620

Scenario Name	Routing Protocol	Failure Link	Fail Time 4	Recovery Time 4	Fail Time 5	Recovery Time 5
RIP	RIP	Router 4 - 1	625	626	726	826
OSPF	OSPF	Router 4 - 1	625	626	726	826
IS-IS	IS-IS	Router 4 - 1	625	626	726	826
EIGRP	EIGRP	Router 4 - 1	625	626	726	826
IGRP	IGRP	Router 4 - 1	625	626	726	826

Fig: Five failure recovery scenarios

The attributes set in Riverbed Modeller 18.0 for failure recovery over the five routing protocols are used in failure recovery are as

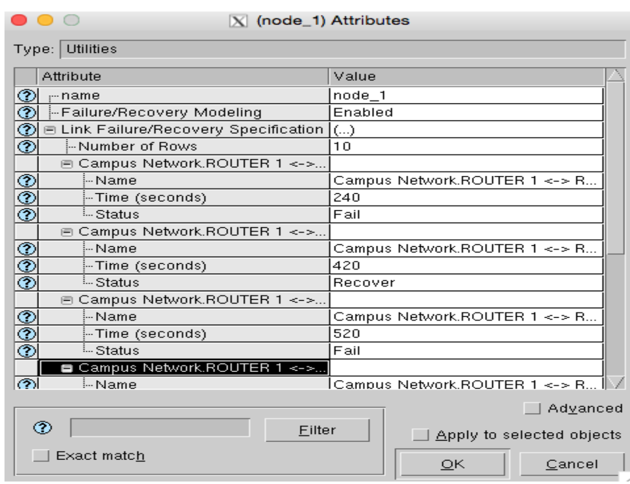


Fig 6: Failure recovery attributes

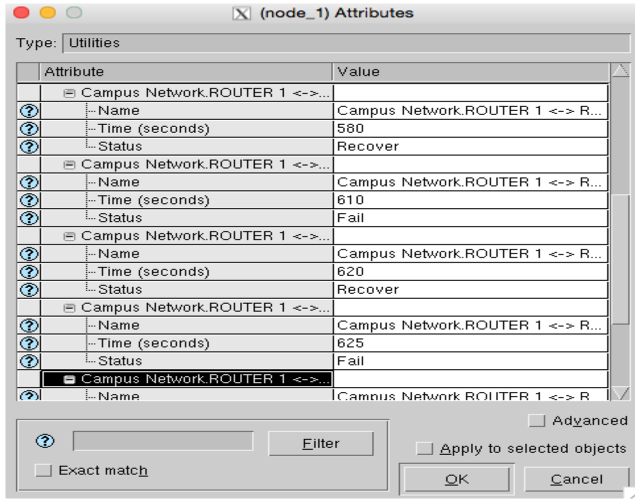


Fig 7: Failure recovery attributes

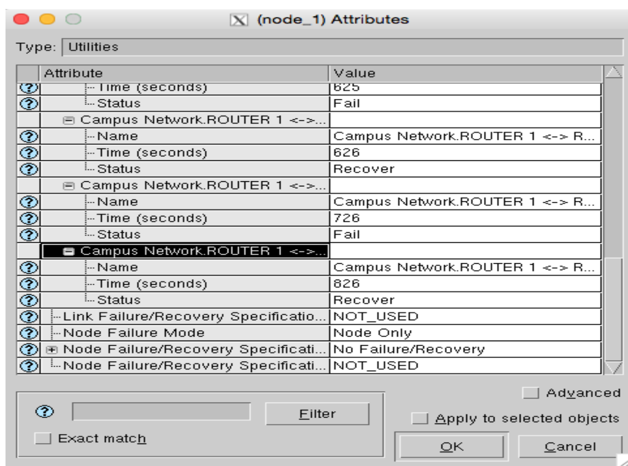
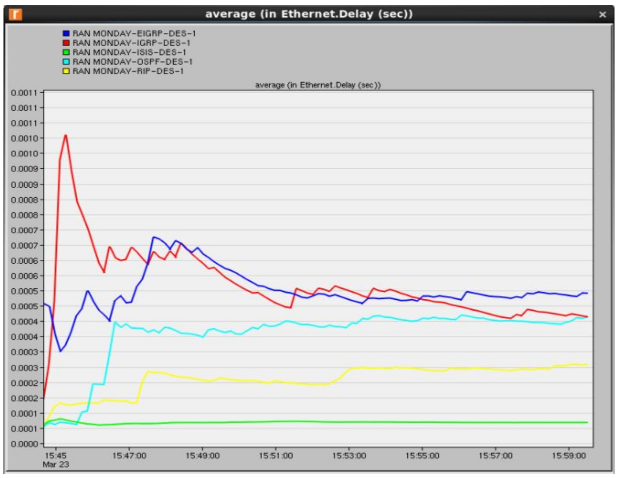


Fig 8: Failure recovery attributes

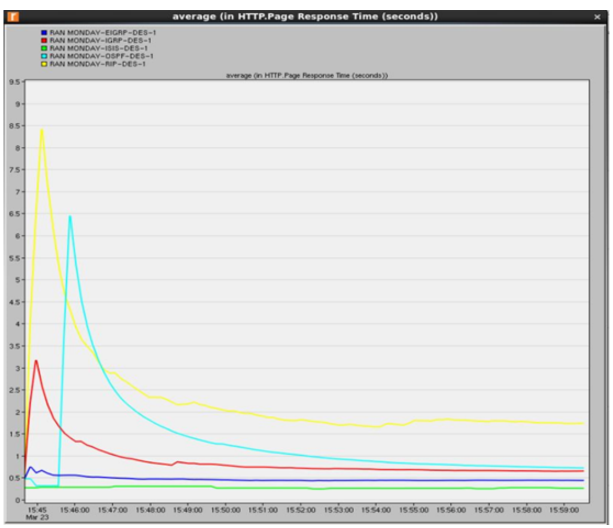
5. **Simulation Results:**

For Riverbed the model network is simulated for 15 minutes which is ample time to interpret operations of the various routing protocols, RIP, IGRP, EIGRP, OSPF, IS-IS over the prototype partial mesh network. The resulting graphs which are collected are in time average.



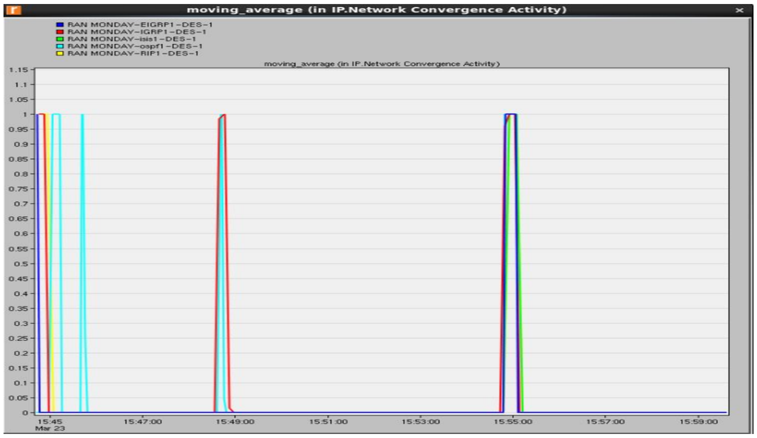
Ethernet Delay: Ethernet delay is the time delay between a data packet being sent from one computer to another and receiving a returning packet in response. As per the simulation, the graph shows that IS-IS has the lowest Ethernet delay followed by RIP, OSPF and IGRP while as EIGRP is highest of them all

Fig 9: Average Ethernet Delay

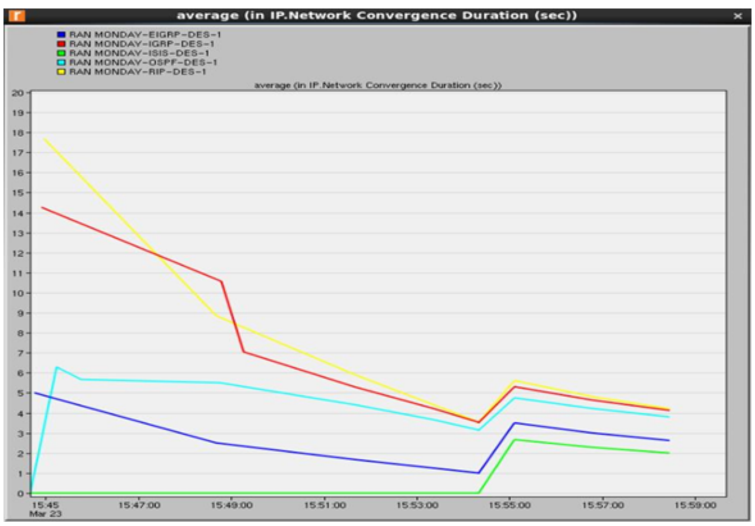


Page Response Time: It is the time difference from the end of an inquiry in a computer system and the time from which the response starts. As per the simulation, the graph shows that IS-IS has the fastest response time followed by RIP and IGRP while as EIGRP is slowest of all

Fig 10: Average HTTP Page Response Time

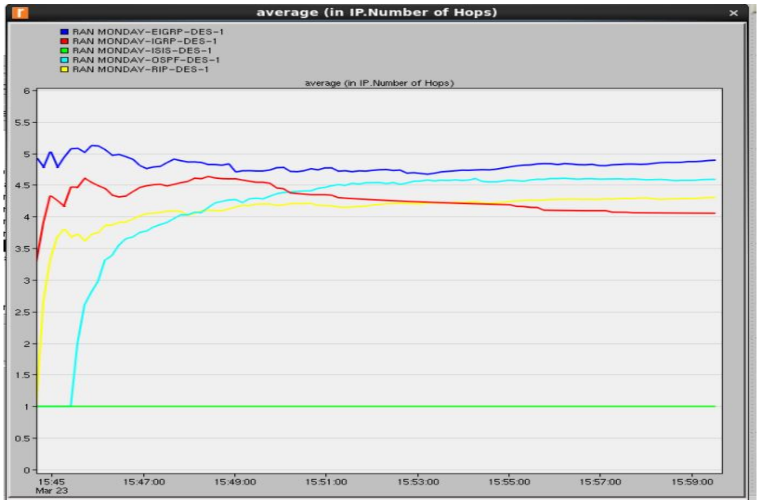


Network Convergence: It is the presence of voice, video and data converged over a single network. As per the simulation, the graph shows that Network Convergence is the shortest for IGRP, and longest for EIGRP



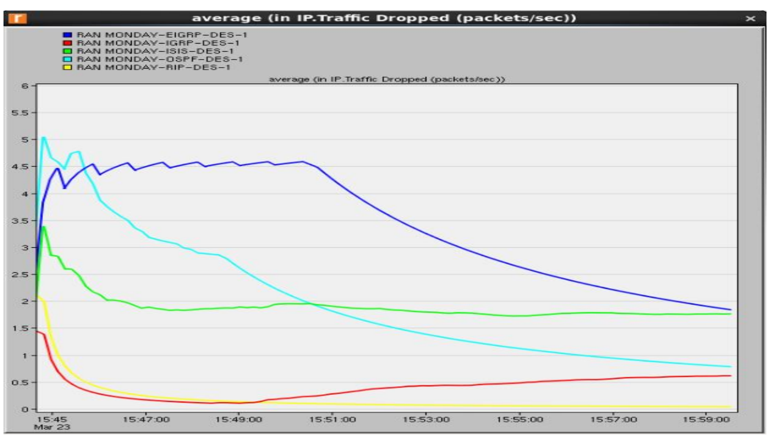
Network Convergence Duration: It is the time taken by the network to converge voice, video and data onto a single channel. As per the simulation, the graph shows that IS-IS is fastest, followed by OSPF, EIGRP and RIP while as IGRP is slowest

Fig 11: Average Network Convergence



Number of Hops: Number of hops, is the number of intermediate devices like routers through which the data travels from the sender to the receiver As per the simulation, the graph shows that Least number of hops in IS-IS and EIGRP has the maximum

Fig 12: Average Number of Hops



Traffic Dropped: Traffic dropped is the number of packets missed/ dropped during transmission over the network.

As per the simulation, the graph shows that RIP has the lowest and EIGRP has the highest

Fig 13: Average Traffic Dropped

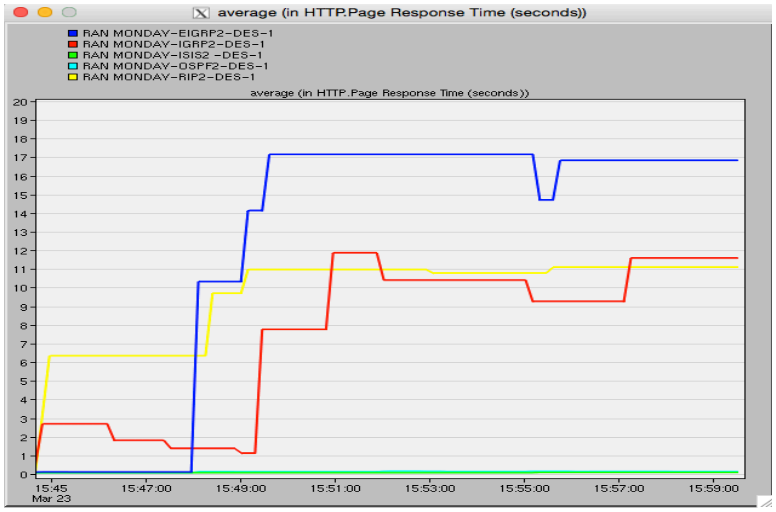


Fig 14: Average Page Response Time (Video)

Video Response Time: It is the time required for buffering video content after the sender sends a request. As per the simulation, the graph shows that IS-IS has the fastest response time followed by RIP and IGRP while as EIGRP is slowest of all

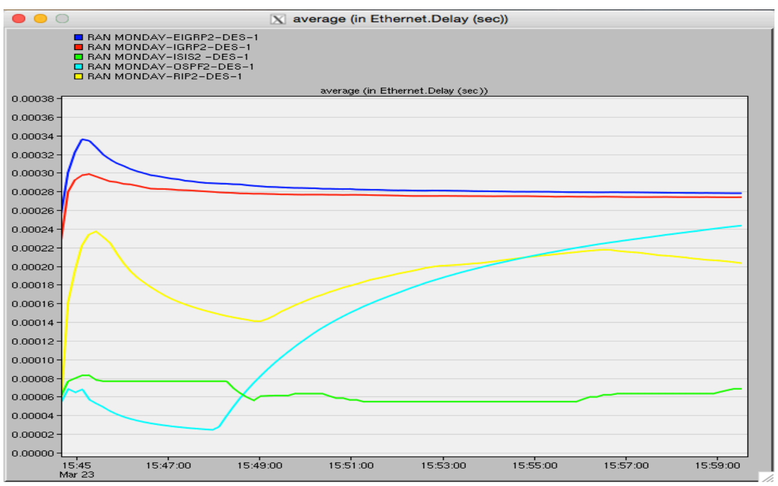


Fig 15: Average Ethernet Delay (Video)

Video Ethernet Delay: Video Ethernet delay is the time delay between a video data packet being sent from one computer to another and receiving a returning packet in response. As per the simulation, the graph shows that IS-IS has the lowest Ethernet delay followed by RIP, OSPF and IGRP while as EIGRP is highest of them all

Consolidated Results

From the above simulation test results for the various routing protocols which has been arrived upon by the designed network topology, shows the consolidated result for the respective protocols

- ISIS: It has the lowest Ethernet delay and least number of hops. The network convergence is fast and has the lowest page response time.
- RIP: It has the least number of hops and low traffic drop. The page response time is relatively high
- OSPF: It has a fast network convergence which makes it conducive to be used in large networks. The drawback of this routing protocol is that it is comparatively complex.
- IGRP: It has a slow network convergence duration but the shortest network convergence activity. The Ethernet delay is the highest.
- EIGRP: It has the highest traffic drop when teste for heavy browsing. It has the longest convergence activity with a high traffic drop. It also has the maximum number of hops for heavy browsing. In case of video streaming it has a high Ethernet delay with slowest page response time.

6. Conclusion and Future Work

In this paper, a comparative study of selected routing protocols such as IS-IS, OSPF, RIP, EIGRP, IGRP is presented. The comparative analysis has been done in the same network topology with different protocols for real time applications like heavy browsing and Web TV i.e. Video Streaming. Performance has been measured on the basis of some parameters that aimed to figure out the effects of routing protocols by studying the various attributes like Network convergence, Ethernet delay etc.. The most suitable routing protocols can be selected basis on the output and test results and it can be further optimized to increase the network operation efficiency. In future, these results can be endorsed by testing same network over the routing protocols for different applications apart from heavy browsing and Web TV

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