Evaluation of Routing Protocols based on Performance

[1,]Ms. Pallavi R, [2,]TanviAggarwal, [3,]Ullas Gupta
[1,2,3,]*Sir M Visvesvaraya Institute of Technology, Bangalore – 562157*

ABSTRACT

In a network, various routing protocols are used to forward packets. Each router maintains a routing table which stores the information of its neighbors. The extent of information stored about the network depends on the routing it follows. This information is regularly sent on the network to find the efficient path between the source and destination. Thus every protocolconsumes a part of the network resources forthis transmission. This paper tries to find themost efficient protocol that is best suited for anetwork based on its performance parameterslike latency, throughput, convergence time andother factors.

Keywords: *High Performance, Routing, RIP, OSPF, EIGRP, BGP*

I. INTRODUCTION

A *network* is a group of devices connected to each other. When a process in one device is able to exchange information with a process in another device, the two devices are said to be networked. The set of rules that are required for exchanging information over a network are called *communication protocols*. Internet uses the standard internet protocol suite (TCP/IP) to serve billions of users' worldwide.Internet protocol suite TCP/IP provides end to end connectivity and also specifies how data should be formatted, addressed, transmitted, routed and received at the destination.

Efficient transmission of data between any two computer systems depends upon the overall performance of a network. Performance is of utmost importance for any network and is affected by the following four most important factors: **latency, packet loss, retransmission and throughput**. A network which has least latency, less packet loss, low retransmission and maximum throughput is rankedas a high performance network.The performance of a network is the measure of its effectiveness which can be enhanced dramatically by using proper routing techniques.As we know, the *Internet* is one of the 20th century's greatest communications developments. It is considered as a global system of interconnected networks and is thus, considered the best example of a high performance network.Routing finds a key role in such high performance networks.

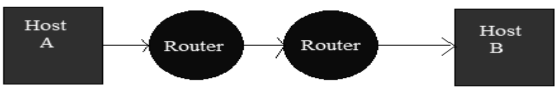

Fig. 1: Routers connecting devices

In this paper we are primarily focusing on routing which is the function of the network layer (OSI model).*Routing* is the process of moving a packet of data from source to destination. This is enabled by *router* which is a device that forwards data packets between computer networks, creating an overlay internetwork, as shown in Fig. 1. It is connected to multiple data lines (homogeneous or heterogeneous) from different networks.

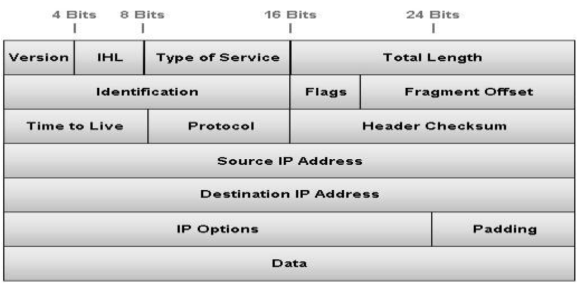

Fig. 2: IP Header Format

As shown in Fig. 2, when a data packet comes in on one of the lines, the router reads the Destination IP Address information in the packet to determine its ultimate destination. Then, using information in its routing table or routing policy, it directs the packet to the next network on its journey. The construction of routing tables is the primary goal of routing protocols.

II. ROUTING

Routing [1] is the process of moving packets across a network from one host to another. It is usually performed by dedicated devices called routers. The routing process usually directs forwarding on the basis of routing tables which is used to determine the forwarding or next hop IP address and the interface to be used. Thus, constructing routing tables, which are held in the router's memory, is very important for efficient routing.

RRAS-ROUTER1 - IP Routing Table

Destination	Network mask	Gateway	Interface	Metric	Protocol
10.57.76.0	255.255.255.0	10.57.76.1	Local Area C...	1	Local
10.57.76.1	255.255.255.255	127.0.0.1	Loopback	1	Local
10.255.255.255	255.255.255.255	10.57.76.1	Local Area C...	1	Local
127.0.0.0	255.0.0.0	127.0.0.1	Loopback	1	Local
127.0.0.1	255.255.255.255	127.0.0.1	Loopback	1	Local
192.168.45.0	255.255.255.0	192.168.45.1	Local Area C...	1	Local
192.168.45.1	255.255.255.255	127.0.0.1	Loopback	1	Local
224.0.0.0	224.0.0.0	192.168.45.1	Local Area C...	1	Local
224.0.0.0	224.0.0.0	10.57.76.1	Local Area C...	1	Local
255.255.255.255	255.255.255.255	192.168.45.1	Local Area C...	1	Local
255.255.255.255	255.255.255.255	10.57.76.1	Local Area C...	1	Local

Fig. 3: Routing table

From Fig. 3, it can be seen that a routing table consists of

Network ID: The network ID or destination corresponding to the route
Network Mask: The mask is used to match a destination IP address to the network ID.
Next Hop: The IP address of the next hop.
Interface: An indication of which network interface is used to forward the IP packet.
Metric: A number used to indicate the cost of the route so the best route among possible multiple routes to the same destination can be selected.

III. ROUTING PROTOCOLS

Routing protocols are a set of rules or standards that determine how routers communicate and exchange information on a network, enabling them to select best routes to a remote network. The rest of this section discusses four different routing protocols giving a glimpse of their merits and demerits.

3.1rip - Routing Information Protocol

RIP [2][3] is a distance-vector protocol that uses hop count as it's metric. This signifies the maximum distance that a routing protocols packet can travel in a network. The Routing Information Protocol provides the standard IGP protocol for local area networks, and provides great network stability, guaranteeing that if one network connection goes down the network can quickly adapt to send packets through another connection. RIP implements thesplithorizon, route positioning and hold down mechanisms to prevent incorrect routing information from being propagated.RIP prevents routing loops by implementing a limit on the number of hops allowed in a path from the source to a allowed destination. The maximum number of hops for RIP is 15. This hop limit, however, also limits the size of networks that RIP can support.RIP itself evolved as an Internet routing protocol, and other protocol suites use modified versions of RIP. IP RIP is formally defined in two documents: Request for Comments (RFC) 1058 and 1723. RFC 1058 (1988) describes the first implementation of RIP, while RFC 1723 (1994) updates RFC 1058. RFC 1058 enables RIP messages to carry more information and security features.

Advantages:

- Easy Configuration.
- Minimum overload over the Processor.

Disadvantages:

- The protocol is limited to networks whose longest path involves 15 hops.
- It protocol uses fixed "metrics" to compare alternative routes.
- The protocol depends upon "counting to infinity" to resolve certain unusual situations.

3.2 Ospf - Open Shortest Path First

OSPF [4] is an interior gateway protocol which is used to distribute IP routing information throughout a single Autonomous System (AS) in an IP network.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.

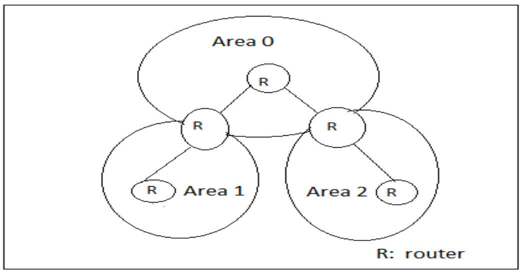

Fig. 4: Hierarchical structure of OSPF protocol

As shown in Fig. 4,OSPF provides a hierarchical structure [5] by sub-dividing large networks into AREAs and limits the multicast LSAs within routers of the same area — Area 0 is called backbone area and all other areas connect directly to it. All OSPF networks must have a backbone area.

Advantages:

- Supports VLSM and route summarization.
- Faster convergence.
- No limitation of network diameter.
- Better handling of multiple equal-cost paths.
- Divides the network into OSPF regions.
- Uses designated router[6] to reduce the number of OSPF messages that are exchanged. The designated router is elected by a hello protocol.

Disadvantages:

- It requires more memory to hold the adjacency, topology and routing tables.
- It requires extra CPU processing.

3.3eigrp- Enhanced Interior Gateway Routing Protocol

EIGRP is a Cisco-proprietary routing protocol. It is a classless routing protocol. It is a hybrid protocol as it incorporates features of a Distance Vector routing protocol and features of a Link State routing protocol. Enhanced Interior Gateway Routing Protocol (EIGRP) is an enhanced version of IGRP used in TCP/IP and OSI internet. EIGRP and IGRP can interoperate because the metric (criteria used for selecting a route) used with one protocol can be translated into the metrics of the other protocol. EIGRP can be used not only for Internet Protocol (IP) networks but also for AppleTalk and Novell NetWare networks.A router running EIGRP stores all its neighbors' routing tables so that it can quickly adapt to alternate routes. 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.

Advantages:

EIGRP advantages[7] include:

- Very low usage of network resources during normal operation; only hello packets are transmitted on a stable network.
- Enhanced IGRP uses partial updates. Only changed information is sent only to the routers affected. Because of this, Enhanced IGRP is very efficient in its usage of bandwidth.
- Rapid convergence times for changes in the network EIGRP also supports VLSM, multiple network layer protocols.

Disadvantages:

- There is no area in EIGRP， so it is not good at dealing with big hierarchy network.
- EIGRP is a protocol come up with by Cisco, it is a private protocol, not a open standard.

3.4 Bgp - Border Gateway Protocol

BGP is the routing protocol that is used to span autonomous systems on the Internet. It is used for inter-domain routing. It acts as a mediator for communicating to different domains. It is a robust, sophisticated and scalable protocol that was developed by the Internet Engineering Task Force (IETF).BGP is a relatively simple protocol with a few salient features. It is used to communicate the Ad numbers across the different autonomous systems. BGP is an incremental protocol, where after a complete routing table is exchanged between neighbors, only changes to that information are exchanged. It is a distance vector protocol. It also supports VLSM(variable length subnet masking).

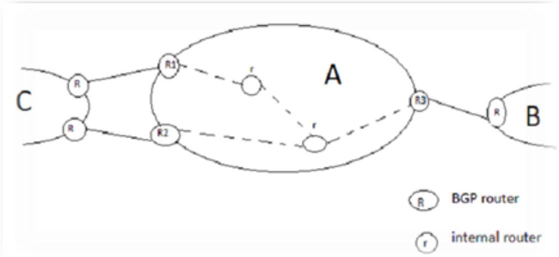

Fig.5: Example topology with 3 ISPs A, B, C

BGP sessions are established between border routers that reside at the edges of an AS and border routers in neighboring ASes. These sessions are used to exchange routes between neighboring ASes. Border routers then distribute routes learned on these sessions to non border (internal) routers as well as other border routers in the same AS using internal-BGP (iBGP). In addition, the routers in an AS usually run an Interior Gateway Protocol (IGP) to learn the internal network topology and compute paths from one router to another. Each router combines the BGP and IGP Information to construct a forwarding table that maps each destination prefix to one or more outgoing links along shortest paths through the network to the chosen border router.

Advantages:

- BGP is an incremental protocol, where after a complete routing table is exchanged between neighbors, only changes to that information are exchanged.
- It also supports VLSM (variable length subnet masking).
- It performs load balancing when there are multiple ISPs on the same router.

Disadvantage:

- Slow convergence due to the counting-to-infinity problem

IV. COMPARISON OF PROTOCOLS

Administrative distance (AD) of a protocol: Every routing protocol has an Administrative Distance (AD) [8], which is a value representing the trustworthiness of the specific routing protocol.

PROTOCOL	RIP	OSPF	EIGRP	BGP
AD	120	110	90	20

Table 1: AD values of routing protocols

A routing protocol with the lesser AD value is considered a better routing protocol in the network.

According to AD values given in the table, OSPF is considered best for networking. The other metrics for comparing the best high performed network is discussed as follows:

LINK UTILIZATION: Better link utilization [9] improves quality of service in a network. The metrics that directly affect link utilization are: required recourses, buffer size packet queues, latency and losses.

THROUGHPUT: Throughput [10] ratio of the total amount of data that reaches a receiver from a sender to the time it takes for the receiver to get the last packet.

QUEUING DELAY: The queuing delay is the time a job waits in a queue until it can be executed. It depends on both the router and the routing protocol. *This factor is responsible for the overall latency of the network.*

Table 2 gives us an overview of the comparative study made on the performance merits described above.

PROTOCOL	LATENCY	UTILIZATION	THROUGHPUT	ALGORITHM	AD
RIP	Worst	Worst	Worst	Bellman-ford Algorithm	Worst
OSPF	Average	Average	Best	SPF algorithm	Best
EIGRP	Best	Best	Average	DUAL algorithm	Average

Table 2: Comparison between different routing protocols

V. CONCLUSION

On analyzing the result of the performance of various routing protocols naming RIP, OSPF and EIGRP over a scenario for throughput, link utilization and queuing delay, we can say that OSPF has best performance overall as it has the maximum throughput amongst all routing protocol and queuing delay of it is second lowest after EIGRP and it also has second highest link utilization after EIGRP. Then EIGRP performs well in terms of throughput, queuing delay and link utilization. So for best effort service that is transmission of data packets OSPFperforms better than other protocols for throughput, queuing delay, utilization.

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