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An Improved Distance-Vector Routing Protocol For Reliable Network Transmission in Local Area Networks

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ABSTRACT

Routing protocols govern the prime path for data communication amongst network nodes. These protocols are employed once there is a major growth in organisations were, static routes are uncontrollable. Distance vector routing protocols which is one of the two main routing protocols for communication uses data packets sent over Internet Protocol (IP). This routing protocols are classified into Enhanced Interior Gateway Routing Protocol (EIGRP) and Routing Information Protocol (RIP). They are dynamic Internet Gateway Protocols (IGPs) which route packets within one Autonomous System (AS). However, RIP is considered an effective solution for small homogeneous networks. An organisation who needs to expand its network cannot use the RIP due to its limitations of fifteen hop counts. This problem has been a major concern in corporate organisations which hence the need for an improved distance vector routing protocol. EIGRP although, is a Cisco proprietary protocol based on Diffused Update Algorithm (DUAL) was introduced in this research to serve as an extension to an organisation's network. Packet flowing from RIP network interface if exhausted its maximum hop count, can re-route its packet through EIGRP network interface. With this improvement, organisations have no worries of changing the entire routing protocol.

Introduction

Routing protocols specifies how routers communicate with each other, disseminating information that enables them to select routes between any two nodes on a computer network [1]. Routing algorithms determine the specific choice of route. Each router has a priori knowledge only of networks attached to it directly. A routing protocol shares its routing information first, among immediate neighbours and then throughout the network. This way, routers gain knowledge of the topology of the network [2].

Although there are many types of routing protocols, three major classes are in widespread use on IP networks:

- Interior gateway protocols type 1, link-state routing protocols, such as OSPF and IS-IS.
- Interior gateway protocols type 2, distance-vector routing protocols, such as Routing Information Protocol, RIPv2, IGRP.
- 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.

Routing protocols, according to the OSI routing framework, are layer management protocols for the network layer, regardless of their transport mechanism such as:

- IS-IS which runs on the data link layer (Layer 2)
- Open Shortest Path First (OSPF) is encapsulated in IP, but runs only on the IPv4 subnet, while the IPv6 version runs on the link using only link-local addressing.
- IGRP and EIGRP are directly encapsulated in IP. EIGRP uses its own reliable transmission mechanism, while IGRP assumed an unreliable transport.
- RIP runs over UDP
- BGP runs over TCP

Routers as a small physical device that joins several networks together and a layer 3 device of the OSI model as shown in Figure 1.1. Most of our home network uses either the wired or the wireless Internet Protocol Router (IP Router) which is the most used and common in the OSI Model [3].

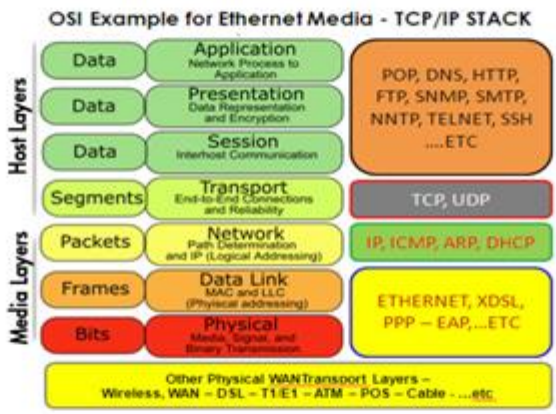

Figure 1. OSI Reference Model [3]

By evaluating and maintaining the configuration information in a stage known as routing table, routers have the ability to filter traffic which are either coming in or going out depending on the Internet Protocol (IP) address of both the sender and the receiver. Most routers give permission to the network administrator to update its routing table manually using a web browser interface. Most of these routers are classified into several types which are wireless routers and broadband routers.

Literature Review

The cornerstones of the internet are the routers. They determine the way data packets take and send them on their next hop in the journey to their destinations. So many people make use of the internet daily having no clear understanding on how it

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works. It is not easy to understand how the internet looks like. Research has been made which focuses on the possibility of moving routing from the routers into the network itself by having a separate routing platform that selects routes on behalf of routers [1]. However, the routers are crucial for networking and will continue to be in the near future. The routers must be configured in some way depending on their place in the network, the vendor and on the policies of the owner (e.g. private person, company, Internet Service Provider (ISP), government). The configuration process is generally not straightforward; it is quite error-prone. Moreover, the configurations are mostly made manually and this can be very time consuming and tedious. As Caldwell et al 2004 put it, “manual configuration is bad”.

Routing is the way of determining the path network traffic should take. This process is carried out by routers. When a packet arrives to a router, the router determines the next hop for the packet by matching the contents of the packet with its routing table. The actual transit of packets is called forwarding and is directed by routing [2].The routers communicate with each other using routing protocols. Routing protocols are divided into two categories which are the Interior Gateway Protocols (IGPs) and the exterior gateway protocols (EGPs). IGPs are responsible for routing inside an Autonomous System (AS) and EGPs are responsible for routing between ASs. ASs are a group of both networks and routers within a single administration and are designated by a number. For instance, SUNET (Swedish University Computer Network) has AS number 1653. The difference between IGP and EGP is shown in Figure 2.1.

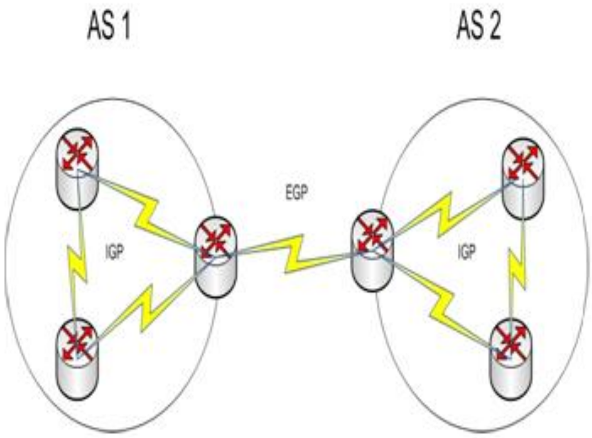

Figure 2. Difference between IGP and EGP [4]

Distance Vector Routing (DVR)

DVR Protocol presents the routes as distance vector and direction vector. The distance is represented as hop count and metrics while the direction is represented as the exit interface. In distance vector routing, Bellman Ford algorithm is used to calculate the path while the nodes takes the position of the links and the vertices. Talking about distance vector routing, in reaching its destination, a certain distance vector is maintained in the entire node used in the network. The distance vector comprises of destination ID, shortest distance and next hop. Here, each of the node passes a distance vector to its neighbour and informs about the shortest paths. Thus, the route coming from the adjacent routers are discovered and advertised from its own side. Each node depends on its neighbouring nodes for collecting the route information. The nodes in the network are responsible for the exchange of distance vector which can take between 10 to 90 seconds to be accomplished. Once a node in a network path receives the lowest cost advertisement from its neighbours, the receiving node adds the entry to its routing table [5].

Characteristics of Distance Vector Routing Protocol

According to [6], they characterised distance vectors as follows:

- Distance Vector (DV) routing protocol as routing table where all the neighbours are connected directly to the table within a regular period of time.
- As soon as the root becomes unavailable, the updated information should be in the routing table.
- DV routing protocols are more efficient and easy in smaller networks, thus, needs little management.
- DV routing are mainly based on hop count vector.
- The distance vector algorithm is iterative.
- A fixed subnet mask length is used.

Advantages of DV Routing

According to [5], DV routing protocols have different advantage and some of them are:

- More efficient in smaller networks.
- The configuration is easy.
- There resource usage is very low.
- DV routing protocol experiences counting problem to infinity.

In contrast, routing loops cannot be prevented by Bellman Ford algorithm [7].

Disadvantages of DV routing protocols

Most of the disadvantages of distance vector routing protocols are:

- Loop creation.
- Slow convergence.
- Problem in scalability.
- Lack of metrics.

Research Architectural Design

The aim and objectives of this research is to proffer solution to the existing routing protocol by designing and implementing an improved distance vector routing protocol for reliable network transmission in LAN. The architectural design shown in Figure 3.1 is composed of the following components: protocol, configuration, changeover router and the Local Area Network (LAN) described as follows:

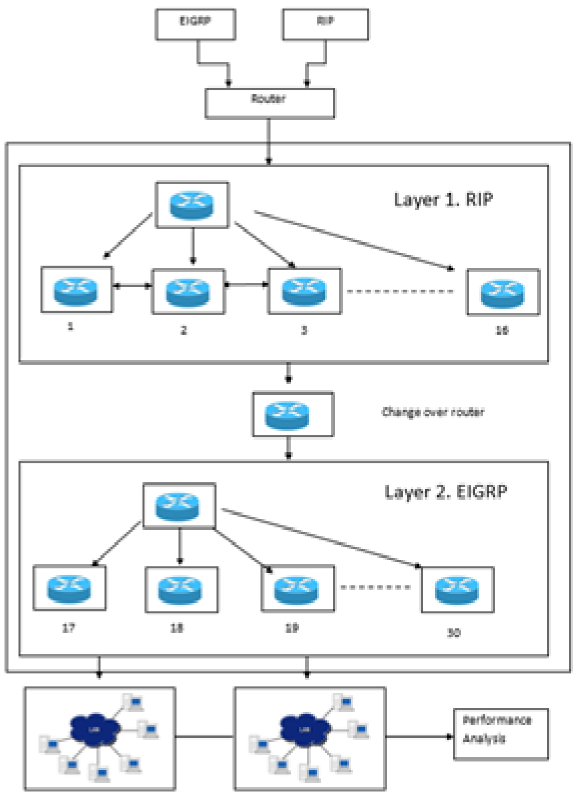

Figure 3. Framework of Architectural Design

Protocol component

The protocol component integrates EIGRP and RIP. These two routing protocols were chosen because of their performances. EIGRP supports Variable Length Subnet Mask (VLSM) / Classless Inter Domain Routing (CIDR), efficient neighbour discovery, support for summaries and discontiguous networks, while RIP uses the hop counts, split horizon and holds down time.

Router configuration

The router configuration component configures the settings for the two routing protocols (EIGRP and RIP).

Change over component

This components is to detect optimal protocol and make a switch over from hop layer 1 to hop layer 2

LAN component

The LAN component represents the network platform on which the protocols configured are tested.

Performance Metrics

The performance analysis component shows the result of the performance experiment of the routing protocols. This metrics will be used to calculate the parameters.

EIGRP Composite Cost Metrics

The Enhanced Interior Gateway Routing Protocol (EIGRP) uses bandwidth, delay, reliability, load, and K values (various constants that can be configured by a user to produce varying routing behaviours) to calculate the composite cost metric for local Routing Information Base (RIB) installation and route selections. The EIGRP composite cost metric is calculated using the following formula:

EIGRP composite cost metric = 256*((K1*Scaled Bw) + (K2*Scaled Bw)/(256 – Load) + (K3*Scaled Delay)*(K5/ (Reliability + K4)) – [8]

RIP Metric

The metric that RIP uses to rate the value of different routes is hop count. The hop count is the number of routers that can be traversed in a route. A directly connected network has a metric of zero; an unreachable network has a metric of 16. This small range of metrics makes RIP an unsuitable routing protocol for large networks.

A router that is running RIP can receive a default network via an update from another router that is running RIP, or the router can source (generate) the default network itself with RIP. In both cases, the default network is advertised through RIP to other RIP neighbours.

RIP sends updates to the interfaces in the specified networks. If the network of an interface network is not specified, it will not be advertised in any RIP update.

Simulator (Cisco Packet Tracer v 5.3)

This is a network Simulation program which allows students to experiment and monitor behaviour of packets and ask questions like “what if”. Being an important part of the comprehensive learning experience of networking academy and in the progress of this research, this simulator provides simulation, assessment, collaboration capabilities, authoring, learning of complex technology concept and visualization [8]. Figure 4.1, shows the LAN setup and the packet tracer simulator platform used in configuring the routing protocols.

Performance analysis

Round trip time

After both routing protocols have been configured on the router, the next step is to check the Round Trip Time (RTT) from source to destination as it is the length of time taken for a signal to be sent from source router to destination router, plus length of time which an acknowledgement is received.

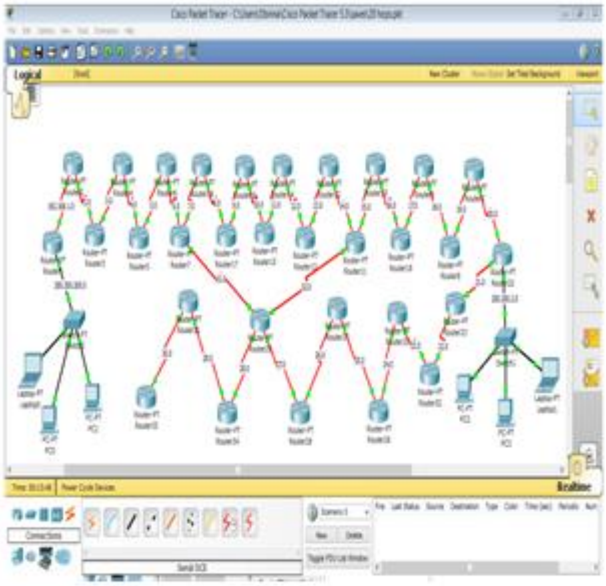

Figure 4. Showing the Configurations of the Routing Protocols in the Simulator

After observing the round trip time of both EIGRP and RIP routing protocol, we realized the minimum, average and maximum RTT after monitoring the flow of Internet Control Message Protocol (ICMP) packets in 30 scenarios In obtaining the total sum of minimum, average and maximum RTT for packet transmission from source to destination, we generate the mathematical expression as shown in the example below:

For RIP;

$$\text{Minimum} = \sum \frac{\textit{total number of minimum value}}{\textit{total number of scenarios obtained}} = \frac{2865}{30} = 95.50\text{ms}$$

$$\text{Average} = \sum \frac{\textit{total number of average value}}{\textit{total number of scenarios obtained}} = \frac{3239}{30} = 107.96\text{ms}$$

$$\text{Maximum} = \sum \frac{\textit{total number of maximum value}}{\textit{total number of scenarios obtained}} = \frac{3513}{30} = 117.10\text{ms}$$

For EIGRP;

$$\text{Minimum} = \sum \frac{\textit{total number of minimum value}}{\textit{total number of scenarios obtained}} = \frac{2841}{30} = 94.70\text{ms}$$

$$\text{Average} = \sum \frac{\textit{total number of average value}}{\textit{total number of scenarios obtained}} = \frac{3236}{30} = 107.86\text{ms}$$

$$\text{Maximum} = \sum \frac{\textit{total number of maximum value}}{\textit{total number of scenarios obtained}} = \frac{3577}{30} = 119.20\text{ms}$$

We were able to represent the minimum, average and the maximum round trip time of EIGRP and RIP in a bar chart as shown in Figure 5.1

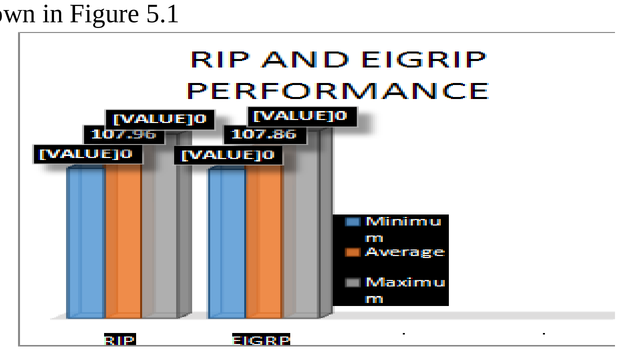

Figure 5. Chart Representation of RIP and EIGRP RTT

The experimental result shows that the average RRT of packets in the network using RIP is a bit lesser than that of EIGRP routing protocol. The scale of difference in RTT is in microseconds, which in-fact does not have significant impact on application performance. This small variation is possible because the hello packets that are sent by the EIGRP are smaller than RIP and this will reduce the overhead in the router and in turn reduce the delay.

EIGRP Metrics

The performance metrics which EIGRP implements for efficient packet delivery from router 1 with a LAN address 200.200.200.0 to router 21 with a LAN address 200.200.2.0 is calculated using the value of k, these values are default values in calculating EIGRP, if one of the value is to be changed, then the entire values have to be changed in the entire router as long as they belong to the same autonomous systems (AS).

Using the show IP route command on the router to display the calculated metrics to network 200.200.2.0 as shown in Figure 5.2

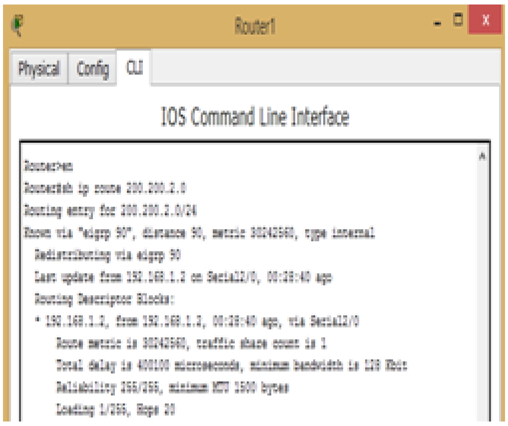

Figure 5.2: EIGRP Route Metrics

We came to realize that the route metrics calculated is 30242560 with a total delay of 400100 microseconds, bandwidth 126kbit. The calculation in the example below shows how EIGRP arrived at 30242560 as its metrics value.

Metric= 256 × $[(k1.Bandwidth + \frac{k2.Bandwidth}{256-Load} + K3.Delay).\frac{k5}{k4+Reliability})]$-- - (Cisco, 2012)

Default value for k are:

K1=1, K2=0, K3=1, K4=0, K5=0

Bandwidth=128 kbit

Delay=400100 microseconds and are calculated in tens of microseconds = 60100/10=40010

$= 256 \times [(\frac{10^7}{minimum\ Bandwidth} + Delay)]$

Where the minimum bandwidth is in Kbps and delay is in μsec.

The metric from Router 1 to Router 21 is calculated as follows:

$=256 \times [(\frac{10000000}{128\ (Kbps)} + 40010\ (\mu sec\ ))] = 30242560.$

RIP Metrics

Using the show IP route to obtain the metric of RIP as shown in Figure 5.3, we see that the metrics is calculated as 15, because in getting to the 192.168.16.0 network, the hello packet sent from 192.168.1.1 network passes through 15 routers known as hops, with an administrative distance of 120 as default.

```
Router#sh ip route 192.168.16.0
Routing entry for 192.168.16.0/24
Known via "rip", distance 120, metric 15
  Redistributing via rip
  Last update from 192.168.1.2 on Serial2/0, 00:00:25 ago
  Routing Descriptor Blocks:
  * 192.168.1.2, from 192.168.1.2, 00:00:25 ago, via Serial2/0
      Route metric is 15, traffic share count is 1
```

Figure 5.3 IP Route From Network 192.168.16.0 to 192.168.16.0

The ping command as shown in Figure 5.4 to verify the length at which RIP can send packets, the results obtained shows that RIP could not exceed more than 15 hops in packet delivery as 15 seems to be its last and maximum hop count by default.

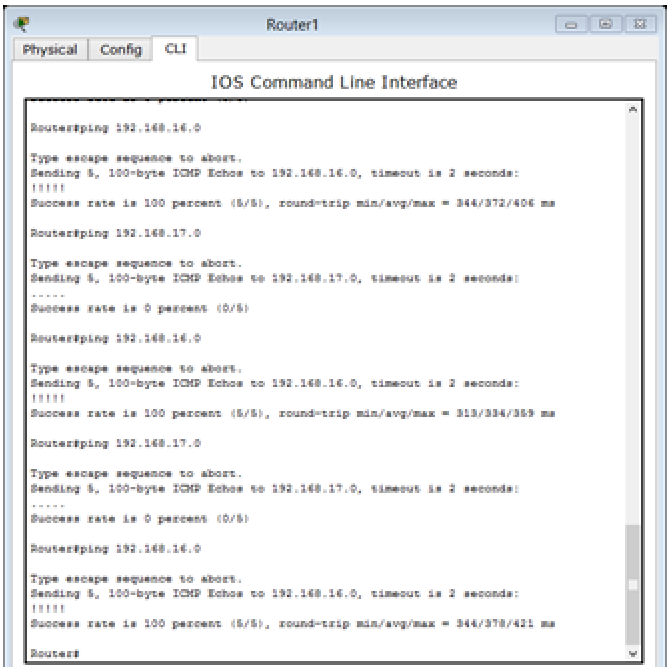

Figure 5.4. Ping Command

Discussion/ Conclusion

The need for routing protocols is to ensure that packets sent are delivered using some set of rules to guide those packets to its destination. According to [9] "Routing protocol is the key for the quality of modern communication network to propagate network topology information to the neighboring routers efficiently". The efficiency and scalability in routing is one of the major challenges in the design and performance of a large scale intra-domain network. This intra-domain routing is basically dynamic routing protocols which distance vector is one of its categories.

A distance vector routing protocol works by advertising the information regarding the destination of the information together with the way to reach that destination. The implementations for the distance vector routing protocols incorporate the Bellman-Ford algorithm, in order for a router to update routing information of its neighbors within fixed intervals. A neighboring router then updates its distance vector value and subsequently, the updates are propagated to its neighbors. A simple configuration of the distance vector routing protocols makes them popular to be widely used. However, their routing mechanism makes them suitable only for small networks where the performance is not the main priority. In this research RIP and EIGRP which are distance vector routing protocols were studied. It was revealed that a metric hop count is used by RIP while routing. In comparison with other protocols, it is popular mainly due to the ease of use, administration and configuration. Starting with the source router, the maximum hop count of 15 nodes is allowed, otherwise the destination is considered to be unreachable. In addition, it has a large support for Classless Inter-Domain Routing (CIDR) together with the multicast mechanism. This limitation in hop counts of 15 which is the major problem of this research was tackled by introducing EIGRP. EIGRP as a Cisco proprietary distance vector routing protocol based on diffused update algorithm (DUAL) serves as an extension to the network. RIP was known to work on a small network perfectly without any limitations or problems, but as organisation network grows and improves, the network administrator of such organisation might need an extension on the organisations network. With the introduction of the sixteenth router which both EIGRP and RIP are configured on, since at a standard, packets from RIP do not surpass 15 hops. This was able to re-route the packets coming from RIP network interface to EIGRP network interface as shown in Figure 5.5, and a free flow of packets over a large network in Figure 5.6.

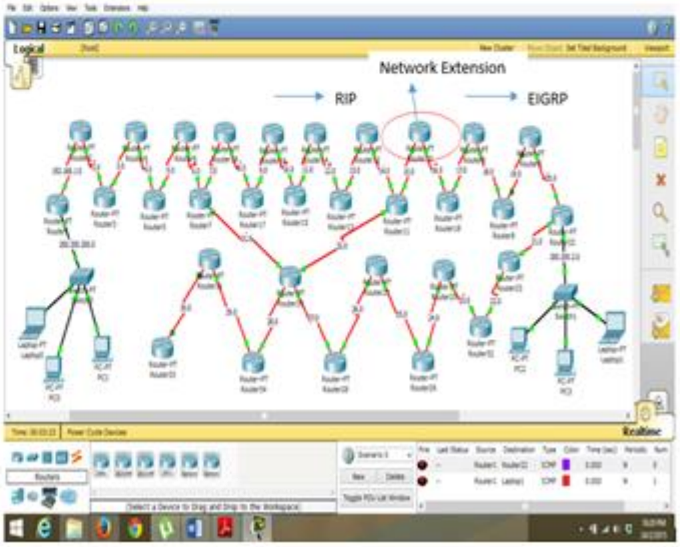

Figure 5.5. Incorporation of both routing protocols on a router

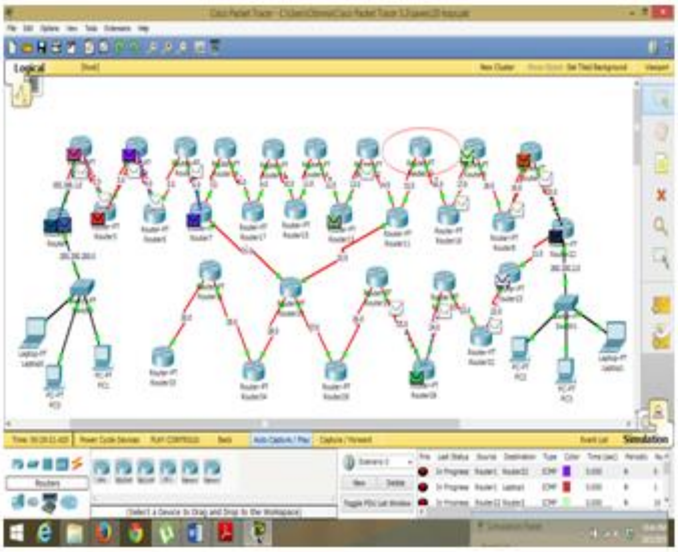

Figure 5.6. Successful flow of packets on the extended network

With this improvement for reliable network transmission, there is no need for an organisation to change the entire router on the network as this will save cost for most growing organisations. This shows that distance vector routing protocol has been improved for reliable network transmission in local area networks.

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