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Evaluation of Equal Cost Multipath "ECMP" Design and Implementation

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Abstract

High quality is the matter of concern among any telecommunication fields, and a group of parameters is set to represent the how grade is the Quality of services of the network, during the last decade the mobile telecommunication become a network that not only carry voice calls it become one of the networks that supports high data rates and support high consumption applications, the routing in any network is based on a hardware and software, each has its benefit.

In this project a study and analysis to algorithms used to prevent the network congestion will be done in order to test and set the parameters of the network to improve the performance of educational network by achieving fast routing by split traffic between paths by designing and simulating multipath network on Matlab to illustrate the "OSPF" network while Appling an Equal Cost Multipath "ECMP".

Keywords: "OSPF", "ECMP", "RSVP", "Multipath", "QoS", "Voice Call"

INTRODUCTION

The impotency of "IP networks" has continually improved during the last decade. More than the size of the Internet including the "backbone", "access networks" and "number of linked devices" has greater than before but also the requirements for network performance from "end-users" and "network efficiency" from "Internet service providers" "ISPs" and "mobile service providers" have increased. Traffic engineering efforts to optimize both network efficiency and the performance to the present network circumstances.[1] One traffic engineering method is "Equal Cost Multipath" "ECMP" that enables the usage of "multiple equal cost paths" from the source node to the destination node in the network. The advantage is that the traffic can be fragmented more evenly to the whole network avoiding congestion and increasing bandwidth. "ECMP"[2] is also a protection method, because during link failure, traffic flow can be transferred quickly to another "equal cost path" without severe loss of traffic.

"Dijkstra's algorithm" is one effort to find the "shortest-path" from one node to all other nodes in the network. It assuming that the link lengths are always "non-negative". Every node is assigned a label with two components "*x", and "y"*. A label could either be impermanent or permanent. The algorithm stops when all labels are permanent. As will soon become apparent, after completion .the labels give info on the shortest distances "OSPF" as well as "shortest path" from a specific node to all another nodes. Also a node is mentioned to being in the "open-state" if its related label is impermanent; it is to be in the closed state if the label is permanent.[3]

The "Open Shortest Path First OSPF" is an "Interior Gateway Protocol". It is a "routing-protocol" established for "Internet Protocol IP" networks by the "Interior Gateway Protocol IGP" "working group of the Internet Engineering Task Force IETF"[4]. The team work was formed in "1988" to design an "IGP" depend on the "Shortest Path First SPF algorithm" for use in the Internet. "OSPF" was created since "1980s", the "Routing Information Protocol" "RIP" was increasingly unable of serving "large heterogeneous networks".

PROBLEM STATEMENT

One of the problems today that face networks is traffic congestion and its effects on the real time data transmission.

Network Congestion occurs due to the increasing of demand on bandwidth compared to decreased actual bandwidth.

Aim and Objectives

The objectives of this project consist of general objectives and specific objectives.

General objectives

- To improve the performance of educational network by achieving fast routing by split traffic between paths.
- To avoid the congestion traffic and increase the network throughput.
- Study and analysis of network traffic congestion.

METHODOLOGY

A study and analysis of routing techniques and the way that to avoid the traffic congestion in "OSPF" algorithm, in this study data will be collected through related works. Then a study and analysis to the network structure will be done in order to simulate the network. After that a simulation program will be written using "MATLAB' to evaluate the performance of network after using Equal Cost Multipath.

The simulation will cover "OSPF" based network structure with a "Equal Cost Multipath ECMP" Algorithm, the simulation results will be obtained including delay, data rate, and throughput of the network.

REQUIRED TOOLS

The simulation of equal cost algorithm in the network must be done through a simulation program, a simulation program that was used in this project is "Matlab2016a" and it was a good environment for the simulation due to its capability to simulate such networks with all of the functionality block structure, and the helpful libraries and special and general functions that improves the designing and help in programming.

Moreover Matlab provides two main types of simulations 1st based on "M-File" scripts and the 2nd based on blocks which called Simulink, in this simulation m-file scripting was used to generate the code of the simulation.

Designing the network starts from gaining some knowledge among the network structure and the basic settings and characteristics.

Moreover the effects of the noise during the transmission and receiving, also step the number of users in the system.

The noise that can disturb the communication is a major part of the network since the noise free system does not exists.

Refining the system performance focusing on the transmission scenario to evaluate such an algorithm like equal cost a good conditions must be taken.

DESIGN CONSIDERATIONS

In this simulation certain considerations must be occupied, the usage of high data rate can end with high "CPU" usage that can end the simulation with Matlab crash, so a limited number of nodes was used with an ideal data rates, in addition the usage of node creation in Matlab based on a graphical functions that represents the nodes as an object and it is used to visualize the network status and to simplify the understanding of system flow. Moreover randomization of all of the parameters in the written code end the simulation with non-fixed results which will effect on the accuracy and the final conclusions, thus some parameters will be used as a fixed values.

SIMULATION PARAMETERS

The following table represent the simulation parameters that used in configuring the simulation environment.

No.	Parameter Name	Value
1	Number of nodes	11
2	IP Address Class	A
3	Reference Bandwidth	100,000
4	Data Size	500 byte
5	Short path detection algorithms	Dijkstra, Belmanford

"OSPF" Flowchart

This flowchart show the steps of Open shortest path algorithm for "Matlab"

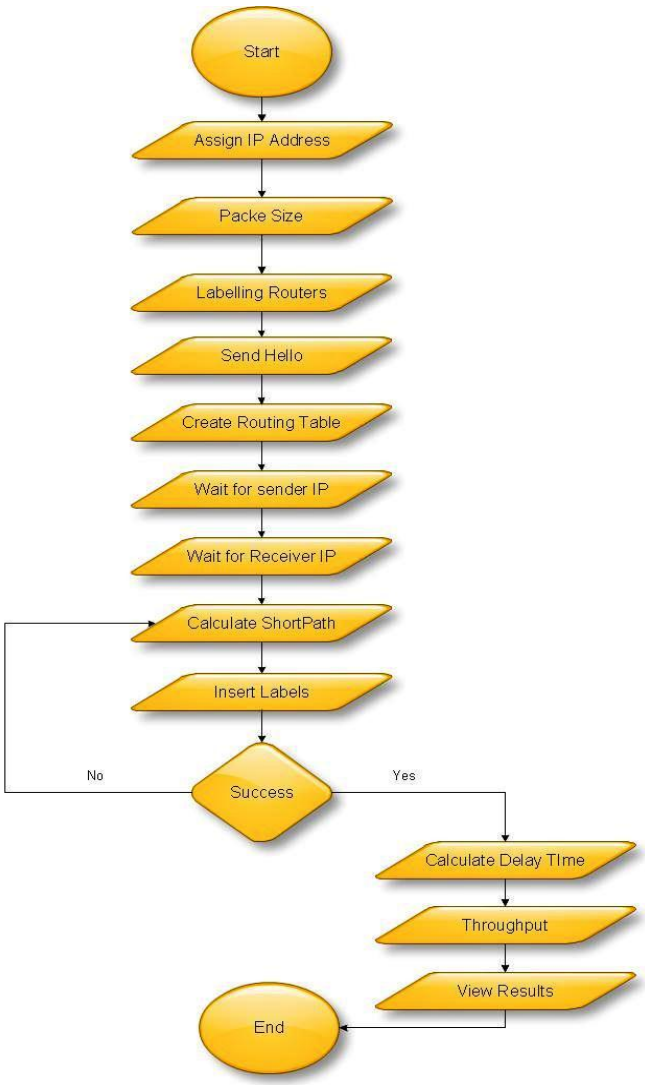

Figure 1: "OSPF" System Flowchart

The simulation starts by creating an "IP address" to each node this "IP Address" identify the "routing IP" between stations and network equipment, then the packet size is set while the label for each node was set.

The simulation expect the "IP" and "label" of the source to destination by setting the "sender IP" and the "recipient IP" and then start sending data

Using conditional statements it can be determined that a success transmission and receiving was done, then a calculation to the "delay" and "throughput" is done to evaluate the system while using short path.

Equal Cost Flowchart

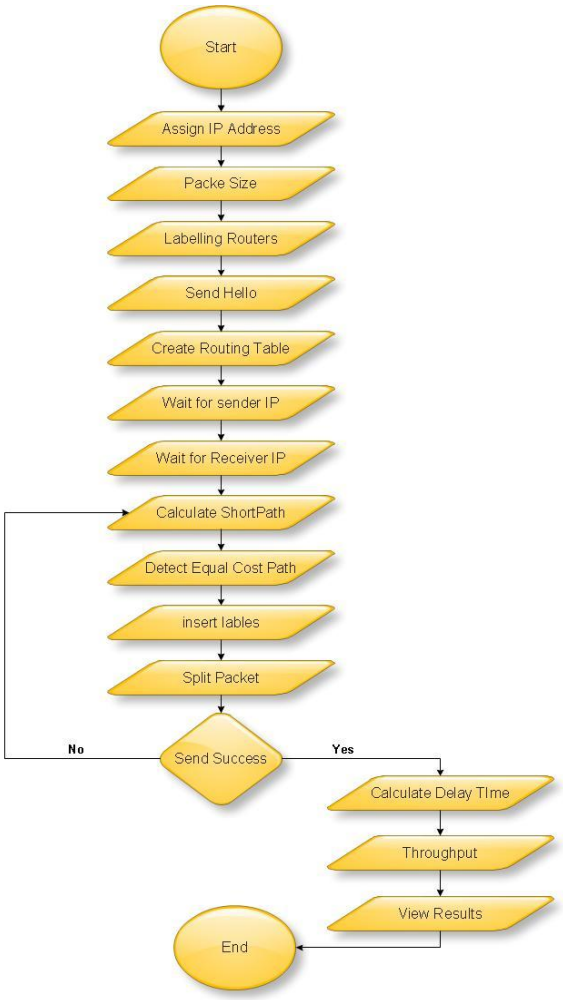

Figure 2: Equal Cost System Flowchart

The simulation starts by creating an "IP address" to each node this "IP Address" identify the "routing IP" between stations and network equipment, then the packet size is set while the a label for each node was set.

The simulation does not expect the "IP" and "label" of the path because the path is determined automatically to the destination. And by Using conditional statements it can be determined that a success transmission and receiving was done, then a calculation to the delay and throughput is done to estimate the system while using short path.

Link Cost Detection

The link cost are calculated through the division of default bandwidth reference over the actual bandwidth available

Link _Cost = $B_R/A_{vailable}$

Where

BR: "Reference bandwidth"

Available: "Available Bandwidth"

Network scenario

The total number of used routers inside "OSPF" network is six routers, and the outside of the "OSPF" are four routers, the "IP address" was set to "static IP" address with different classes.

The "bandwidth" also was set between each link to another as a fixed constant, after setting the link costs three major algorithms were used to simulate the network "Bellman algorithm" and it is used to detect the neighbors and create the dynamic routing table, "dijkstra algorithm" was used to detect short path, and another algorithm to simulate the data flow into the links.

Table 1. Simulation Parameters:

No.	Parameter	Settings
1.	PE1(192.168.0.1)	Router
2.	PE2(192.168.0.3)	Router
3.	P1(192.168.0.2)	Router
4.	P2(192.168.0.4)	Router
5.	P3(192.168.0.5)	Router
6.	P4(192.168.0.6)	Router
7.	CEA1(10.0.0.10)	Router
8.	CEA2(10.0.1.20)	Router
9.	CEB1(20.0.0.10)	Router
10.	CEB2(20.0.1.20)	Router
11.	Data size	512 byte/n

Network performance

Network performance refers to measures of service quality of a network as understood by the customer. There are numerous altered methods to measure the performance of a network, as each network is altered in nature and design. Performance can also be established and simulated instead of measured.

Performance measures

Bandwidth commonly measured in bits/second is the maximum rate that information can be transferred

- ✓ Throughput is the actual rate that information is transferred
- ✓ Latency the delay between the sender and the receiver decoding it, this is mainly a function of the signals travel time, and processing time at any nodes the information traverses
- ✓ Jitter variation in packet delay at the receiver of the information
- ✓ Error rate the number of corrupted bits expressed as a "percentage" or "fraction" of the "total sent".

Bandwidth

The available "channel bandwidth" and reachable "signal-to-noise-ratio" control the maximum thinkable throughput. It is not generally possible to send more data than verbalized by the "Shannon-Hartley Theorem".

Throughput

Throughput is "total successful transmitted bits" per "unit time". Throughput is controlled by "available bandwidth", available "signal-to-noise-ratio" and "hardware limitations".

Latency

The speed of light executes a lowest propagation time on all electromagnetic signals. It is not possible to decrease the "latency" below

$t = s / c_m$

Where s is the distance and "cm" is the speed of light in the medium. This roughly means "1" extra millisecond "RTT" for "100km/62miles" of distance between hosts.

Error rate

The "number of bit errors" is the number of bits the is received of a "data stream" in a communication channel that have been reformed due to "noise", "interference", "distortion" or "bit synchronization errors".

The "bit error rate or bit error ratio BER" is the "number of bit errors" is divided by the total number of transmitted bits during a considered time-interval. "BER" is a unit less performance measure, frequently stated as a percentage.

The "bit error probability" is the expectancy value of the "BER". The "BER" can be measured as an estimation of the "bit error probability". This assessment is precise for a long time interval and a high "number of bit errors".

Designed Network

Simple design was implemented to represent the network and its elements used in the simulation.

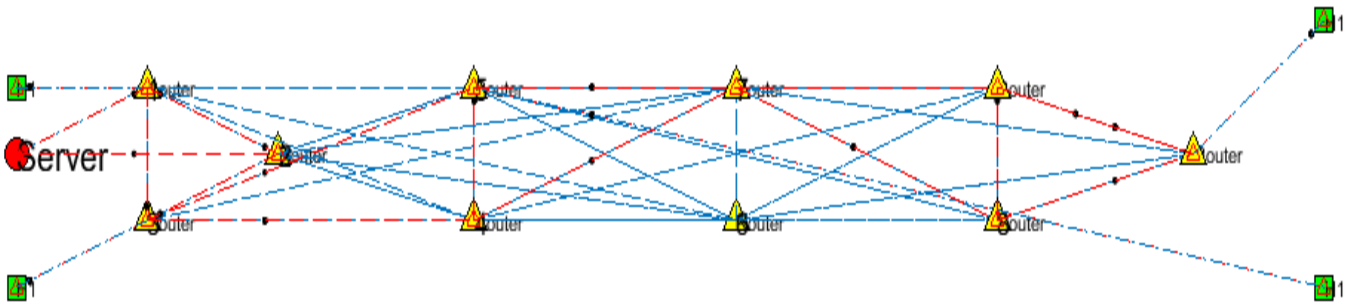

Figure 3: Simulated Network Structure

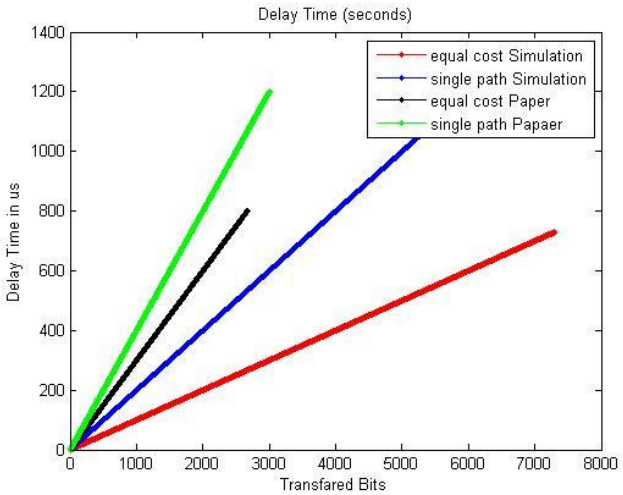

Figure 4: Delay time comparison between equal cost and signal path

SIMULATION RESULTS

Delay time

While running the simulation the following graph of delay time appears The y axis represents delay time in microseconds and the x axis represents the transfer bits over the simulation.

The above Fig.4 shows an equal cost simulation and theoretical results along with the single path simulation and results.

According to the graph the equal path has a delay time less than the signal path due to the split of the packet into two different paths with an equal cost.

Throughput

While running the simulation the following graph of throughput appears

The y axis represents throughput in "Bit/us" and the x axis represents the time in seconds over the simulation.

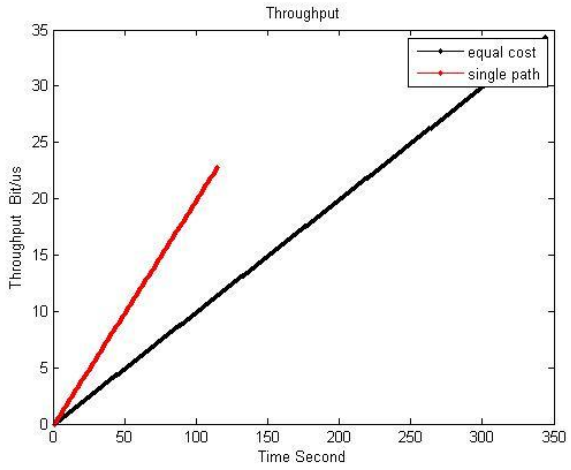

Figure 5: Throughput comparison between equal cost and signal path

The above Fig. shows an equal cost simulation and theoretical results along with the single path simulation and results.

According to the graph the equal path has a throughput higher than the signal path due to the split of the packet into two different paths with an equal cost which upgrades the "throughput".

Data rate

While running the simulation the following graph of throughput appears The y axis represents Data rate and the x axis represents the time in seconds over the simulation.

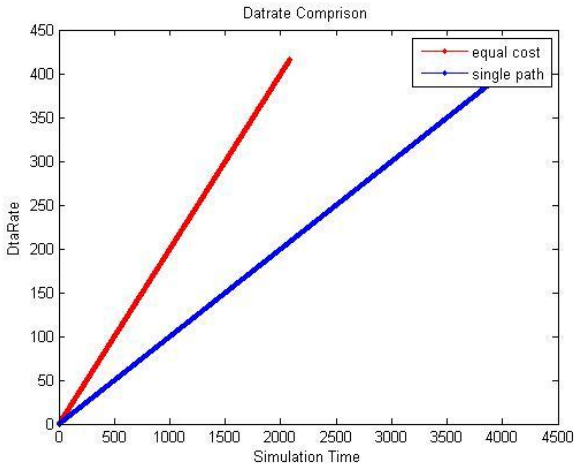

Figure 6. Data rate comparison between equal cost and signal path

The above Fig. shows an equal cost simulation and theoretical results along with the single path simulation and results.

According to the graph the equal path has a data rate identical to the signal path.

CONCLUSION

The project simulation was successfully implemented to solve the problem of traffic congestion and its effects on the real time applications such as real time data transmission. Splitting of packets between links to avoid congestion is one technique used to upgrade performance of the network. The used simulation and algorithm help to improve the performance of educational network by achieving fast routing by split traffic between path in order to avoid the congestion traffic and upgrade the network throughput.

A design a network using Matlab to illustrate the "OSPF" based network structure and applying Equal Cost Multipath "ECMP" in "OSPF" algorithm was done using "Matlab 2016a" version and the obtained results of the network includes delay, data rate, and throughput, and it was found that using equal cost technique has a higher throughput and a minimum delay time compared with the signal path propagation with an identical data rate.

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