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Investigating the Impact of Simulation Time on Convergence Activity & Duration of EIGRP, OSPF Routing Protocols under Link Failure and Link Recovery in WAN Using OPNET Modeler

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ABSTRACT
Routing Protocols become one of the important decisions in the design of the network. An important aspect of routing protocol is how quickly it converges when there is a change in the topology table. Convergence is when the routing tables of all routers have complete and accurate information about the network. Convergence time is the time it takes routers to share information, calculate best path and update their routing tables. Routing protocols that converge within the minimum amount of time are considered to be efficient. In this paper an attempt has been made to investigate the impact of simulation time on convergence duration and convergence activity of EIGRP and OSPF routing protocols for WAN in the context of link failure and recovery using OPNET simulator. From the experimental results we found that convergence activity and convergence duration is maximum for OSPF and minimum for EIGRP.
Keywords :- OSPF, EIGRP, OPNET**.**

I. INTRODUCTION

A routing protocol is the language a router speaks with other routers in order to share information about the reachability and status of network.[1] It includes a procedure to select the best path based on the reachability information it has and records this information in a route table. Regarding to select the best path, a routing metric will be applied and it is computed by a routing algorithm.

In the context of routing protocol performance, each of them has different architecture, adaptability, route processing delays, convergence capabilities and many more.

Among different routing protocols, EIGRP and OSPF have been considered as the pre-eminent routing protocols. These protocols use different algorithm to route the packets and this may vary the route processing delay. As a consequence, the impact of different algorithm can affect the overall network performance.

Convergence is the state of a group of routers that have the same topological knowledge about the network in which they exist. For a group of routers to have converged, they should have collected all available topological knowledge from each other via the implemented routing protocol, the information they collect must not negate any other router's topological knowledge in the group, and it must reflect the current status of the network. In other words: In a converged network all routers "agree" on what the network topology should look like.

1) ***Convergence process***

When a routing protocol process is activated, every router in the group will attempt to send and receive packet related to the network. The extent of this exchange, the way it is exchanged, and the type of packets exchanged is widely dependable on the routing protocol being used. Any change in the network that affects routing tables will affect the convergence temporarily until this change is communicated successfully to all other routers in the network.

2) ***Convergence time***

Convergence time is a measure of how fast a group of routers reach the state of convergence. It is one of the main design goals and an important performance indicator for routing protocols to implement a mechanism that allows all routers running this protocol to quickly and reliably converge. [2] Of course, the size of the network also plays an important role; a larger network will converge slower than a small one.

II. LITERATURE REVIEW

"Performance analysis of OSPF and EIGRP routing protocols for greener internetworking" by Y. N. Krishnan et al Department of Computer Science. Engineering, RV College. of Engineering, Bangalore. This paper discussed routing protocols performance based on the quantitative metrics such as Convergence Time, Jitter, and End-to-End delay, also they proved that EIGRP is more CPU intensive than OSPF and hence uses a lot of system power. [3].

"Dynamic Routing Protocol Implementation Decision between EIGRP, OSPF and RIP Based on Technical Background Using OPNET Modeler" by S. G Thorenoor et al Wipro Technol., Bangalore, India. This paper discussed decisions to be made when the choice is between protocols that involve distance vector or link state or the combination of both. They compare each from memory and CPU utilization point of views. [4].

"Routing Protocols Convergence Activity and Protocols Related Traffic Simulation with Its Impact on the Network" by Mustafa Abdulkadhim Computer Networks Department, College of Information engineering, Nahrain University. The traffic generated by the given routing protocols were simulated and noticed from the analysis of the simulation that EIGRP has the minimum impact on the network followed by OSPF and at the end RIP has the highest traffic impact on the network [5].

III. ROUTING PROTOCOLS

Routing Protocols can fall into two groups: static routing and dynamic routing. Static routing is simply the process of manually entering routes into a device's routing table via a configuration file that is loaded when the routing device starts up. In static routing, all the changes in the logical network layout need to be manually done by the system administrator. However, dynamic routing allows routers to select the best path when there is a real time logical network layout change. EIGRP and OSPF belong to dynamic routing protocols.

In addition, most routing protocols can be classified into two classes: distance vector and link state. Distance vector routing protocol is based on Bellman – Ford algorithm and Ford – Fulkerson algorithm to calculate paths. A distance vector routing protocol uses a distance calculation and a vector direction of next hop router as reported by neighboring routers to choose the best path. It requires that a router informs its neighbors of topology changes periodically.

Link state routing protocols build a complete topology of the entire network are and then calculating the best path from this topology of all the interconnected networks. It requires more processing power and memory because it has a complete picture of the network.

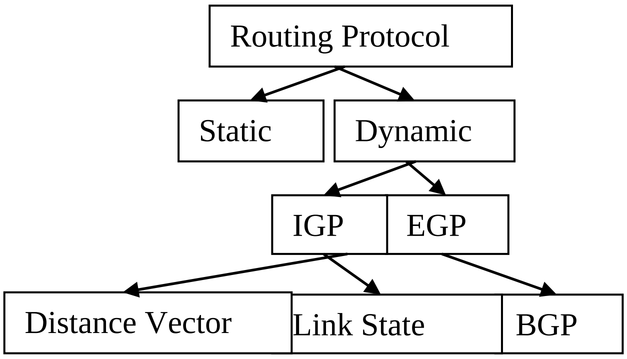

Figure 1: Routing protocol classification

A. *Enhanced Interior Gateway Routing Protocol*

Enhanced Interior Gateway Routing Protocol (EIGRP) is a routing protocol which is based on Interior Gateway Routing Protocol (IGRP). It has the property of both distance as well as link-state routing protocol due to which it is also known as a hybrid routing protocol.

EIGRP supports classless inter domain routing (CIDR). EIGRP allows a router to share information it knows about the network with neighboring routers within the same logical area known as an autonomous system. Contrary to other well known routing protocols, such as routing information protocol, EIGRP only shares information that a neighboring router would not have, rather than sending all of its information. EIGRP is optimized to help to reduce the workload of the router and the amount of data that needs to be transmitted between routers.

The Enhanced Interior Gateway Routing Protocol (EIGRP), referred to as an advanced Distance Vector protocol, offers radical improvements over IGRP. Traditional DV protocols such as RIP and IGRP exchange periodic routing updates with all their neighbors, saving the best distance (or metric) and the vector (or next hop) for each destination. EIGRP differs in that it saves not only the best (least-cost) route but all routes, allowing convergence to be much quicker. Further, EIGRP updates are sent only upon a network topology change; updates are not periodic.

A router running EIGRP stores copies of all its neighbor's routing tables so that it can quickly adapt to alternate routes. If no appropriate route exists i.e. if it can't find a route to a destination in one of these tables, EIGRP queries its neighbors to discover an alternate route. These queries propagate until an alternate route is found. When a routing table entry changes in one of the routers, it notifies its neighbors of the change only (some earlier protocols require sending the entire table). 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/dead. Unlike some earlier routing protocols that would send an entire table to neighboring routers when one routing table entry changed, EIGRP notifies the neighbors of only the specific change in the table.

The fast convergence feature in EIGRP is due to the Diffusing Update Algorithm (DUAL). The diffusing update algorithm is a routing protocol used by EIGRP to calculate and create routing tables to determine whether a path is looped or loop-free and it determine the most efficient (least cost) route to a destination. It also allows a router running EIGRP to find alternate paths without waiting on updates from other routers.

B. *Open Shortest Path First*

Open Shortest Path First (OSPF) is a link-state routing protocol for IP networks and is based on the Shortest Path First (SPF) algorithm. OSPF is perhaps the most widely used interior gateway protocol (IGP) in large enterprise networks. OSPF is used to determine the best route for delivering the packets within an IP networks. OSPF routes Internet Protocol (IP) packets within a single routing domain (autonomous system). It gathers link state information from available routers and constructs a topology map of the network. The topology determines the routing table presented to the Internet Layer which makes routing decisions based solely on the destination IP address found in IP packets.

OSPF detects changes in the topology, such as link failures and converges on a new loop-free routing structure within seconds. It computes the shortest path tree for each route using a method based on Dijkstra algorithm, a shortest path first algorithm. OSPF sends link-state advertisements (LSAs) to all other routers within the same area. Information on attached interfaces, metrics used, and other variables are included in OSPF LSAs. Link-state advertisement (LSA) is a packet that contains all relevant information regarding a router's links and the state of those links.

In an OSPF network, routers or systems within the same area maintain an identical link-state database that describes the topology of the area. Each router or system in the area generates its link-state database (LSDB) from the link-state advertisements (LSAs) that it receives from all the other routers or systems in the same area and the LSAs that itself generates. Based on the link-state database, each router or system calculates a shortest-path spanning tree, with itself as the root, using the SPF algorithm.

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.

To handle routing efficiently and in a timely manner, OSPF divides an autonomous system into areas. An area is a collection of networks, routers and links all contained within an autonomous system that share the same detailed LSDB information, but not with routers in other areas, for better efficiency[6].

IV. METHODOLOGY

Three methods are available for performance evaluation of protocols in a network which include mathematical or analytical analysis, direct measurement and computer simulation. After taking all the constraints and parameters under consideration mathematical and computer simulation are suitable for our research.

There are various advantages of mathematical analysis like cost, time and the ability of providing best predictive results. The direct measurement as a choice of method could be expensive but an alternative to simulation. In direct measurement the analysis is to be done on an operational network which can lead to disruptive situation and an operation network could be very expensive in terms of configuration complexity. The advantage of direct measurement is fairly accurate results.

There are various simulators like NS-2, NS-3, Qualnet, Telnet, Omnet++, OPNET etc. In order to do simulation work, the simulator was to be chosen suitably. The suitable choice after keeping many considerations was OPNET simulator introduced by the OPNET Technologies inc. OPNET modeler is an object oriented and discrete event system (DES) based network simulator. The discrete event system is a widely used efficient simulation tool and well known for its efficient performance and reliability.

OPNET is configured in four phase which include the design of the network model, appoint the statistics, implement the simulation and the last phase is the result phase in which the simulation results are analyzed. Starting with the first phase in which first a network model is design which is to be created by using simulator, once the designing of the network model is done, the next step is for choosing the statistics that are required for the network model these statistics are global statistics, node statistics and the link statistics. The global statistics include the protocols which are to be simulated on the network as well as the stats which are to be tested during simulation which include jitter, traffic send and receive etc. The node statistics determine the node in the network which is across the network and at last the link statistics helps to configure the network on the particular link which is point-to point.

Following steps are used to design a network into consideration.

i. Create Network Model
ii. Choose Statistics
iii. Run Simulation
iv. Analysis Result

V. SIMULATION ENVIRONMENT

We designed the network model in OPNET Modeler V 17.5. The simulation parameters are given in the following table.

Table I: Simulation Parameters

Parameters	Values
Examined protocols	EIGRP, OSPF
Simulation time(m)	5, 10, 15,20
Simulation area (m x m)	1000x1000
Performance Parameters	Convergence activity Convergence duration

VI. RESULTS AND ANALYSIS

To evaluate the performance of routing protocols, the following metrics are considered.

a) Network Convergence Activity: Records a square wave alternating between the ordinates 0 and 1. It is 0 during a time interval in which no signs of convergence activity are detected in the entire network. It is 1 during a time interval in which signs of convergence are detected somewhere in the network.

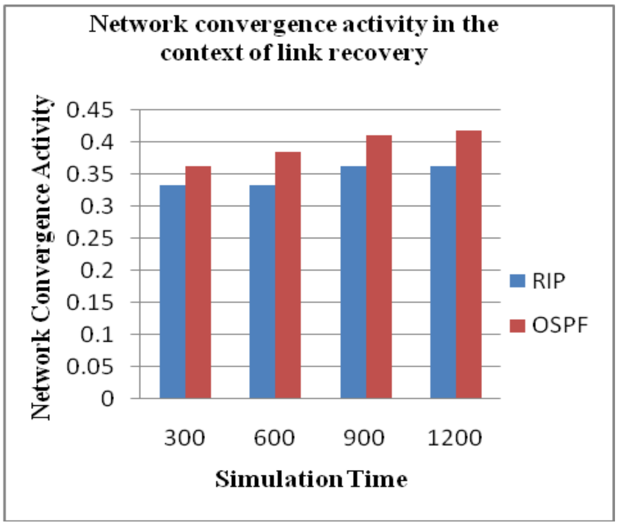

Figure 2: A graph showing variation in network convergence activity with respect to simulation time in the context of link recovery.

b) Network Convergence Duration: Records the duration of convergence cycles for the routing tables across the whole network.

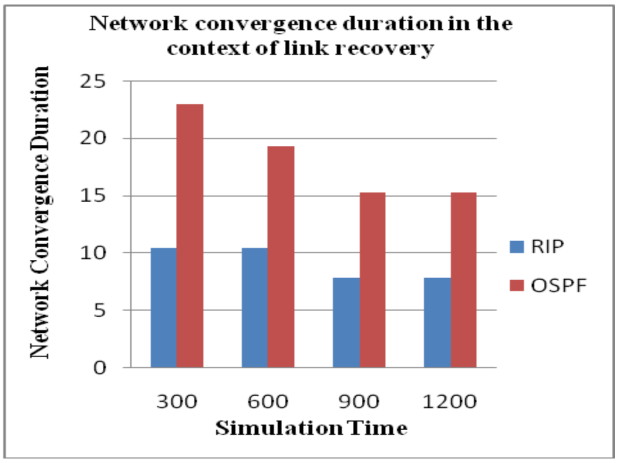

Figure 3: A graph showing variation in network convergence duration with respect to simulation time in the context of link recovery.

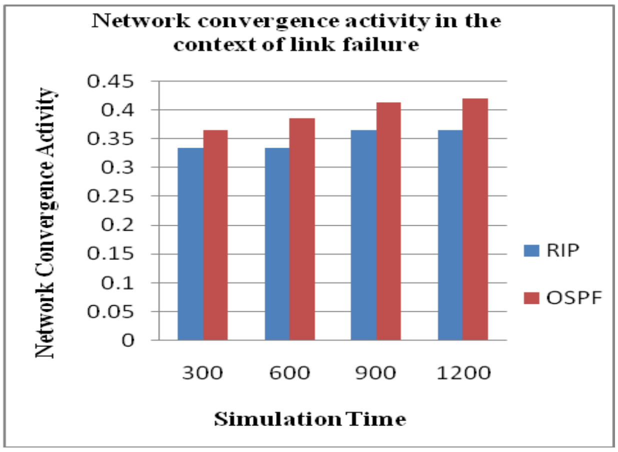

Figure 4: A graph showing variation in network convergence activity with respect to simulation time in the context of link failure.

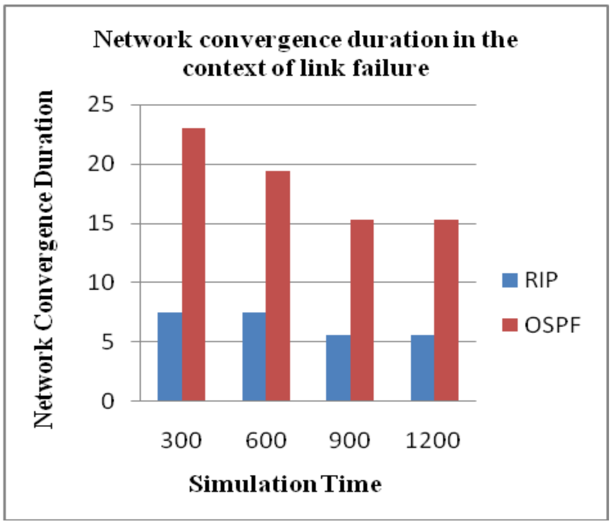

Figure 5: A graph showing the variation in network convergence duration with respect to simulation time in the context of link failure.

VII. CONCLUSIONS

When a link fails, it is important that the dynamic routing protocol recognizes that failure, and converges upon a new topology to allow for the network segment to still be online. This paper tests the scenario of a link failure and recovery and quantifies the convergence duration.

EIGRP scales well and converges quickly with minimal network traffic. To minimize its load on the network, EIGRP propagates only routing table changes instead of the entire routing table when a change occurs.

From the experimental results, we found that network convergence duration is maximum for OSPF and minimum for EIGRP.

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