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Routing Protocols Convergence Activity and Protocols Related Traffic Simulation With It's Impact on the Network

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***Abstract*— routing protocols are the heart and soul of internetworking, routers uses routing protocols as their algorithms to decide the best path from a given source to a destination. That being said it is very critical to choose the right routing protocol for the topology as many parameters exists such as throughput, delay and QoS. Network convergence on the other hand is the state of set of routers having the same topological awareness about the network.**
In this paper I will discuss the network convergence activity and time if the given routing protocols (EIGRP, OSPF, and RIP) are being simulated. Also I will discuss the convergence time and how implementing each protocol affects our simulation.

Keywords-component; routing, convergence, EIGRP, OSPF

I. Related Work

"Towards network convergence and traffic engineering optimization" by H. Liu et al Sch. of Comput., Nat. Univ. of Defense Technol., Changsha, China. The objective of this paper was to optimize network convergence based on the related traffic of the network. [1]

"Performance analysis of OSPF and EIGRP routing protocols for greener internetworking" by Y. N. Krishnan et al Dept. of Comput. Sci. Eng., RV Coll. of Eng., 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. [2]

"A Fast Rerouting Approach to Reduce Packet Loss during IP Routing Protocols Convergence" by F. Barreto Univ. of Technol. of Parana, Sao Carlos.

This paper introduced a new fail recovery approach called "Fast Emergency Paths" which helps improving overall network convergence. [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]

II. Network Convergence And Dynamic Routing Protocols

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.

Convergence is a vital expression for a group of routers that engage in dynamic routing; All Interior Gateway Protocols depend on convergence to function correctly. To have converged it is the normal state of an operational autonomous system. The Exterior Gateway Routing Protocol BGP usually never converges because the Internet is too big for any to be relayed fast enough.

- ***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.

A state of convergence happens when all routers exchange all their network related information with each other. 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.

- ***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. [5] Of course, the size of the network also plays an important role, a larger network will converge slower than a small one.

RIP is a routing protocol that converges so slowly that even a network of a few routers can take a couple of minutes to converge. In case of a new route being advertised, triggered updates can speed up RIP's convergence but to flush a route that previously existed takes longer due to the hold down timers in use. OSPF is an example of a fast-converging routing protocol. A network of a few routers can converge in a matter of seconds.

Certain configuration and hardware conditions will prevent a network from ever converging. For instance, a "flapping" interface (an interface that frequently changes its state between "up" and "down") might cause conflicting information to propagate the network so that routers never agree on its current state. Under certain circumstances it might be desired to withhold routing information details from parts of the network via route aggregation, thereby speeding up convergence of the topological information shared by all routers.

a. **EIGRP Routing protocol**

The Enhanced Interior Gateway Routing Protocol (EIGRP) is a hybrid routing protocol that gives a noticeable development on IGRP. EIGRP replaced IGRP in 1993 since Internet Protocol is created to support IPv4 addresses that IGRP could not support. Hybrid routing protocol contains advantages of both Link-state and Distance-Vector routing protocols, it was based on Distance-Vector protocol but contains more features of Link-State protocol. EIGRP saves all routes rather than the best route to ensure the faster convergence. EIGRP keeps neighboring routing tables and it only exchanges information that it neighbor would not contain. EIGRP is commonly used in large networks, and it updates only when a topology changes but not periodically unlike old Distance-Vector protocols such as RIP.

Metric is used to determine whether the chosen route is optimized. EIGRP metric is based on its bandwidth, delay, reliability, load and MTU. A default expression for EIGRP metric is $Metric = BandWidth + Delay * 256$. There are four basic components to operate EIGRP, which are

1. Neighbor Discovery/Recovery
2. Reliable Transport Protocol
3. DUAL Finite State Machine
4. Protocol Dependent Module

b. **Open Shortest Path First (OSPF)**

OSPF is mentioned in RFC 2328 which is an interior Gateway Protocol used to distribute routing information within an AS (Autonomous System). Among all the three chosen samples, OSPF is the most widely used routing protocol in large scale enterprise networks. OSPF core is based on link-state technology by using SPF algorithm which calculates the shortest path.

- SPF calculation

Before running the calculation, it is required that all routers in the network to know about all the other routers in the same network and the links among them. The next step is to calculate the shortest path between each single router. For all the routers they exchange link-states which would be stored in the link-state database. Every time a router receives a link-state update, the information stores into the database and this router propagate the updated information to all the other route OSPF is defined in RFC 2328 which is an interior Gateway Protocol used to distribute routing information within an AS (Autonomous System). Among all the three chosen samples, OSPF is the most widely used routing protocol in large enterprise networks. OSPF is based on link-state technology by using SPF algorithm which calculates the shortest path.

c. **Routing Information Protocol (RIP)**

RIP is a standardized vector distance routing protocol and uses a form of distance as hop count metric. It is a distance vector. Through limiting the number of hop counts allowed in paths between sources and destinations, RIP prevents routing loops. Typically, the maximum number of hops allowed for RIP is 15. However, by achieving this routing loop prevention, the size of supporting networks is sacrificed. Since the maximum number of hop counts allowed for RIP is 15, as long as the number goes beyond 15, the route will be considered as unreachable.

When first developed, RIP only transmitted full updates every 30 seconds. In the early distributions, traffic was not important because the routing tables were small enough. As networks become larger, massive traffic burst becomes more likely during the 30 seconds period, even if the routers had been initialized at different times. Because of this random initialization, it is commonly understood that the routing updates would spread out in time, but that is not the case in real practice.

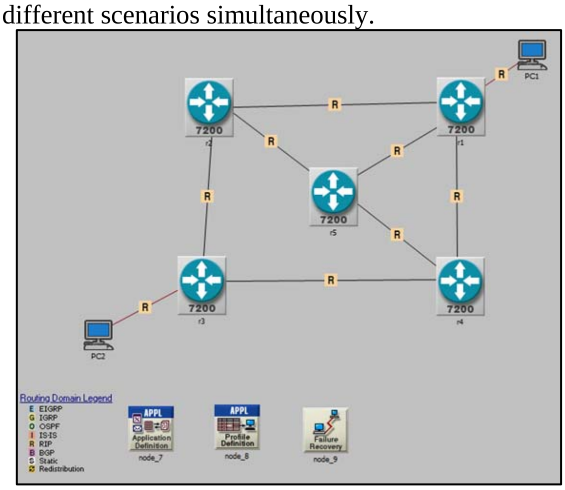
RIP has four basic timers: Update Timer (default 30 seconds): defines how often the router will send out a routing table update.

Invalid Timer (default 180 seconds): indicates how long a route will remain in a routing table before being marked as invalid, if no new updates are heard about this route. The invalid timer will be reset if an update is received for that particular route before the timer expires. A route marked as invalid is not immediately removed from the routing table. Instead, the route is marked with a metric of 16, which means the route is unreachable, and will be placed in a hold-down state.

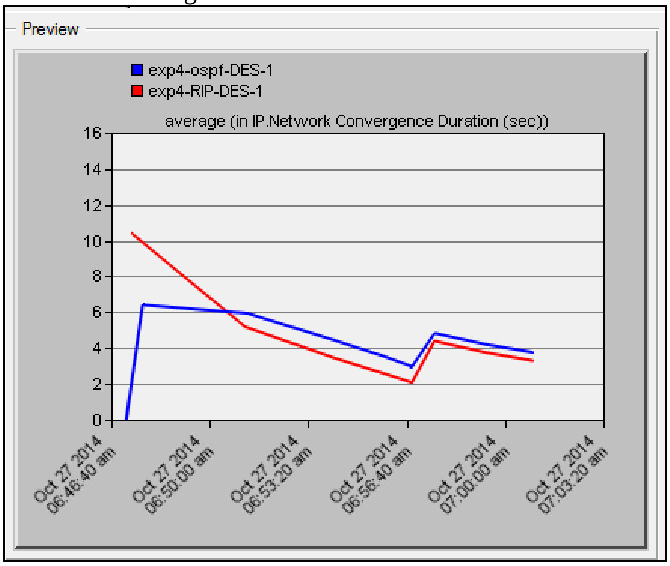
Hold-down Timer (default 180 seconds): specifies how long RIP will keep a route from receiving updates when it is in a hold-down state. In a hold-down state, RIP will not receive any new updates for routes until the hold-down timer expires.

III. The Simulated Network Model:

First RIP and OSPF protocols were modeled to compare their convergence duration and activity and it impact on the network. In the below scenario. The simulation model was created in OPNET Modeler 14.5 the simulation time was set for 1 hour and both protocols were configured in two different scenarios simultaneously.

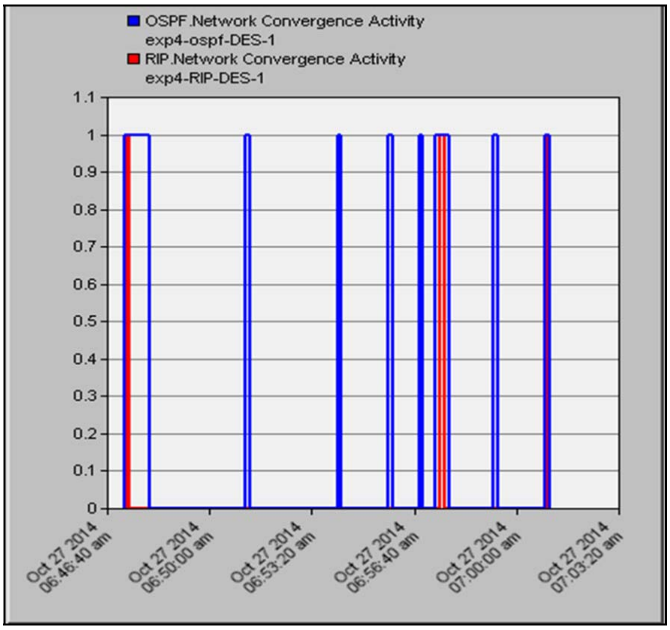


And their convergence duration is shown below



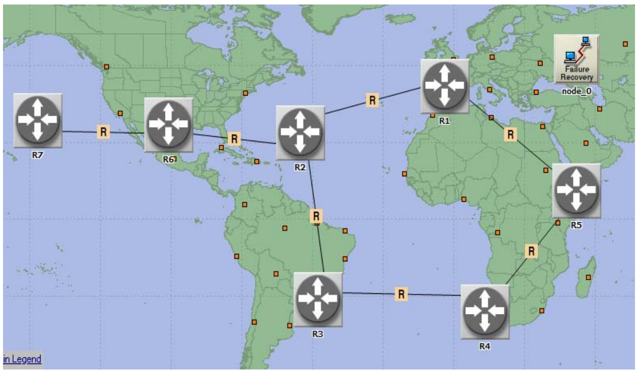
From the above results analysis we can notice that OSPF converges very quickly compared to RIP. Due to the timers rip has and the nature of its operation, it falls behind when it comes to quick response to the network needs.

Second the convergence activity was measured in the network and we should expect OSPF to have high activity compared to RIP as the latter falls behind due to its 30 second timers, as shown below:

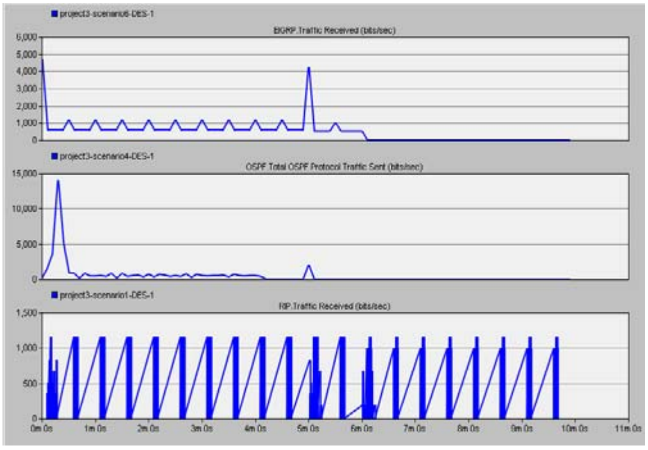


In the above analysis we notice the high activity of OSPF compared to that of OSPF. This falling behind of RIP creates a major issue in case of network failure as the network should wait for RIP to converge in order to recover, and that is translated into a delay.

Then the below model is simulated to model a more complicated scenarios, EIGRP, OSPF and RIP were simulated and their protocol related traffic were analyzed as shown below :



The traffic generated for each routing protocol was captured and analyzed in a three different scenarios as shown below:



As we can see from the traffic analysis, EIGRP started at 4500 bit/Sec and then drops to 1100 Bit/Sec. when an error occurs (from the implemented error model in the scenario) it spikes to 4100 Bit/sec)
The OSPF starts at 14000 Bit/Sec due to the massive hello packets broadcast at the beginning but then drops to a very low traffic even when the error occurs.
Finally RIP protocol's traffic is constant at 1100 Bit/Sec which has the most impact on flooding the network with unnecessary protocol related traffic which translates into network delay.

IV. CONCLUSIONS

As a conclusion we conclude that the convergence time of OSPF as faster than that of RIP and that is due to the internal characteristic of the protocols. Also the convergence activity of OSPF is much more than that of RIP and that makes OSPF a better routing protocol that can react to failure much more quickly.
The traffic generated by the given routing protocols were simulated and we can notice from our 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.
This research can act as a guidance for service providers and network administrators to help them make better discussions when it comes to choosing the right routing protocol for their network.

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