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Performance Optimization of OSPF Protocol in IPv6 Networks

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ABSTRACT: IPv6, the replacement protocol for IPv4 provides the ultimate solution for the problem of running out of IPv4 address. OSPF is popularly used link-state routing protocol in IP networks for real time applications. OSPF implements different type of timers to reduce the overhead of protocol. These timers ensure that the OSPF network takes several seconds to recover from the failure. In this paper we evaluate the performance analysis of OSPF protocol based on metrics such as convergence time and CPU power utilization using GNS3 software. The purpose is to understand the convergence time for link failures, and to determine the techniques to reduce convergence time and CPU power utilization.

KEYWORDS: IPv6, OSPF, Convergence, CPU

I. INTRODUCTION

Now a days, Internet is essential in globe with the advancements like broadcast services, faster communication, IPTV etc. Routers are the backbone components to the internet, which guarantee the communication between Internet users. It is possible to exchange routing information between routers with the help of different Routing protocols [1]. A routing table is a memory of a router that keeps track of routes to reach the particular network. The ultimate concentration of research work is to find the performance analysis of routing protocols [9]. The performance characteristics of various routing protocols are based on the convergence time and the CPU power utilization. The convergence time is the time needed by the network to converge back when change in network occurs [2].

CPU power will be utilized by the router to exchange the routing information and to forward the packets to the neighbouring routers. The optimum CPU power utilization is essential in greener internetworking [3].

The purpose of this paper is to calculate the OSPF convergence time when one of the links in the architecture of ISP network goes down. We have created a simple ISP topology to investigate the convergence behaviour and CPU power utilization while routing taking place. All experiments were performed 10 times and each time 100 ping packets were sent. Also we describe methods to improve convergence time and CPU power utilization.

II. RELATED WORK

This section gives the details about IPv6, OSPF, and GNS3 which is a network simulator which is used to perform all simulation works in current project.

A. *INTERNET PROTOCOL VERSION 6(IPv6):*

IPv6 [4] is the most recent version of Internet Protocol which is being used in internet. The communication protocol is the one that provides identification for computers and routers in the network connectivity. IPv6 has number of improvements over IPv4 with increased addressing space, by providing 128 bits of addressing space providing 2^{128} IP addresses; a practically limitless address space for new internet enabled devices. IPv4 contains no security mechanism [5], this issue is resolved in IPv6 with increased security with the help of integrated Internet Protocol security (IPSec). The flow control bits which are used in IPv6 add support for Quality of Service (QoS) which guarantees the reliable transmission of packets. IPv6 uses a fixed length header of 40 octets, utilizes a separate header after main protocol header which enables the protocol to be extended for future developments.

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B. ***OPEN SHORTEST PATH FIRST(OSPF):***

OSPF [6] is a dynamic routing protocol which had been developed in 1998 which is an LSA type routing protocol. OSPF is a classless routing protocol which supports Variable Length Subnet Mask (VLSM) for division of protocol. An OSPF network can be divided into subnets called areas. An area is a logical connection of routers, links that have same area identification. A router within an area maintains a database for the particular area to which it is belonging. The router will not have detailed information about topology of network outside of its area, thereby reducing the database size.

When there is a change in network topology, the router will communicate with the neighboring routers to determine the state of all networks which are adjacent. Hello protocol is used in order to detect the failure and then the router will generates new Link State Advertisements. When a router receives new LSA, then this will be sent to all of router interfaces, except one from which it has received LSA. Based on this mechanism the routers will calculate routing table for packet forwarding.

C. ***GRAPHICAL NETWORK SIMULATOR:***

GNS3 is a Graphical Network Simulator which allows simulation of various complex networks, to run a CISCO IOS in a virtual environment on computer. It is a Graphical front end to a product Dynagen, which is a core program that allows IOS emulation. With GNS3 it is exactly seen an actual IOS will have access to any command supported by Internetwork Operating System. GNS3 provides around 1000 packets per second throughput in virtual environment for testing packet transmission. The routers do not take place of a real router, but it is a tool for learning and testing in lab environment.

III. PERFORMANCE PARAMETERS

The performance evaluation of OSPF protocol is based on the time needed to re-converge when the change of network occurs and CPU power utilization for the link updates, hello packet transmission and to transmit LSAs to the neighbouring routers. The fast convergence is needed in the real time packet transmission on the Internet; CPU power utilization is also a notable parameter in routers.

A. ***OSPF CONVERGENCE TIME:***

Convergence is the state in which set of routers that has the same topological information about internetwork in which they operate for message transmission. For a set of routers to be converged, they must have collected all topology information from each other based on the protocol in which they configured the information they gathered is not to be contradicting with any other router's topology information and must reflect the real state of network [7]. Network convergence is nothing but the process of synchronizing network forwarding table after network change occurs because the failure in any of the link. The state of network is said to be converged when none of the forwarding tables are changing for some interval, based on expected maximum time to stabilize after topological change occur. Network convergence is the process of network restoration, since it heals the lost connections during the packet transmission. The process of convergence with all propagation mechanisms is depicted in the following Figure 1.

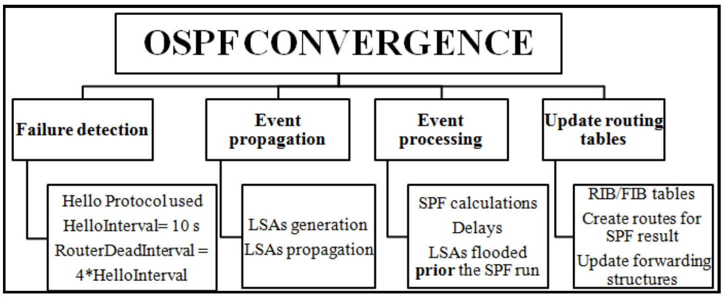

Figure 1. OSPF Convergence Diagram

GNS3 is a Graphical Network Simulator which allows simulation of various complex networks, to run a CISCO IOS in a virtual environment on computer. The convergence time for the OSPF protocol is the sum of the time needed

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to detect the failure of network, the time takes to propagate the event, the time required to perform the SPF calculations on all routers and the time takes to update the forwarding tables for all routers. The OSPF shortest path first throttling feature will help in configuring SPF scheduling in millisecond intervals and hence, it delays the SPF calculations during network instability. SPF will calculate the shortest path whenever there is change in network topology, and it may have included multiple topological changing events. The interval is so chosen dynamically for SPF calculations and is based on the frequency at which topological changes occur. It is a Graphical front end to a product Dynagen, which is a core program that allows IOS emulation. With GNS3 it is exactly seen an actual IOS will have access to any command supported by Internetwork Operating System. GNS3 provides around 1000 packets per second throughput in virtual environment for testing packet transmission. The routers do not take place of a real router, but it is a tool for learning and testing in lab environment.

B. *CPU POWER UTILIZATION:*

The routing protocols utilize the CPU power in the routers for calculating the shortest path for the packet transmission to the other routers [8]. The CPU power is more at the time of the start up for the network initialization for the sending of the hello packets. The hello packets will be transferred for every 10 seconds to convey its aliveness to other routers. The percentage of CPU power utilization is varied for different time intervals depending on the routing protocol present calculations. When a path change has occurred in the network then OSPF will have to use LSA packets again to find the new neighbors and paths to reach the other routers in the topology which use extra CPU power. In OSPF routing process router ID has to be calculated for every router and hence the total delay will be average delay multiplied with the total number of routers. The CPU utilization will be controlled with the technique of changing the timers in the topology is the suitable in the routing process. The variation of the Hold time effect the resource utilization in the routers because in the process of calculating routing tables the time needed for SPF transmission between routers. The Hold time is the time needed to wait for the new SPF to be generated when one of the links goes faulty. By reducing the Hold time the routers is not going to lose any useful information instead, it is not taking extra time to wait for SPF thereby reducing the CPU wait time giving less CPU power utilization.

IV. EXPERIMENTAL ANALYSIS

In this section the experiments were performed on a network topology created using routing software GNS3 to measure and analyse the convergence time and to monitor the CPU power utilization for different time intervals.

A. *TEST SCENARIO:*

The topology is created using GNS3 emulation software based on the OSPF routing protocol environment in IPv6. The routers which were taken in the simulation are the CISCO priority routers in the series c7200 which supports all dynamic routing protocols in real environment. The routers perform all real environment basis experiments like sending and receiving of hello packets, routing table calculation based on the shortest path, and timer modification is also available. The interfaces to connect the routers are the WAN links having the capacity 1.544Mbps to transfer the routing information between them. The OSPF routing protocol based topology is also having the area concept which reduces the overhead on the respective routers. The set up of experiments in topology is showed in the Figure 2.

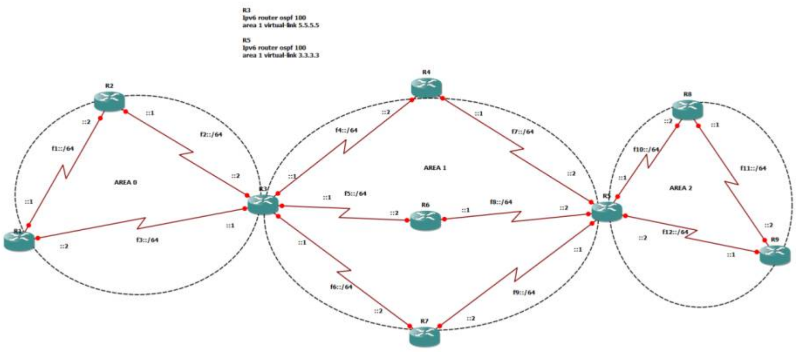

Figure 2. Evaluation Topology with Area concept

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We investigate the convergence behavior of the network when one of the links goes faulty, by sending the 100 ping packets each time and this process is repeated for 10 times. In this experiment we have sent the ping packets from the router1 to router 8, meanwhile we shutdown the link between router 5 and router 8 to measure the convergence time. The CPU power utilization is also monitored for different time intervals. The convergence time and CPU power utilization have been reduced by modifying the OSPF timers.

B. ***RESULTS FOR OSPF timer Hold time =10000msec:***

The topology is created using GNS3 emulation software based on the OSPF routing protocol environment in IPv6. The routers which were taken in the simulation are the CISCO priority routers. The normal traffic will flows from router R1 to R3 directly. To verify this traffic pattern we can use the command 'trace route' in the router configure mode. If we disconnect the interface between the R1 and R3 then the alternate path will be chosen via R2 for the information exchange. To verify the convergence time we use 100 ping packets from R1 to R8 using the ping command. During the pinging process we disconnect the link between R5 and R8, and then the traffic has to choose other path to reach to R8 via R9. The time taken to find alternate path is nothing but convergence time which is tabulated for 10 experiments in Table 1.

The CPU power utilization is to be known in the router for different time intervals for the default OSPF timer values. The percentage of CPU Utilization is more when the initialization process is going on the routers. These values are taken in the screen shot of the processes of routers is shown in the Figure 3 below. When CPU percentage utilization reaches more than 5% then it is represented with the mark in the process.

Number of experiments	Packets received	Packets lost	Convergence time (in seconds)
1	96	4	8
2	96	4	8
3	97	3	6
4	97	3	6
5	97	3	6
6	97	3	6
7	97	3	6
8	97	3	6
9	97	3	6
10	98	2	4
Average	96.9	3.1	6.2

Table 1. OSPF Convergence time for link failure

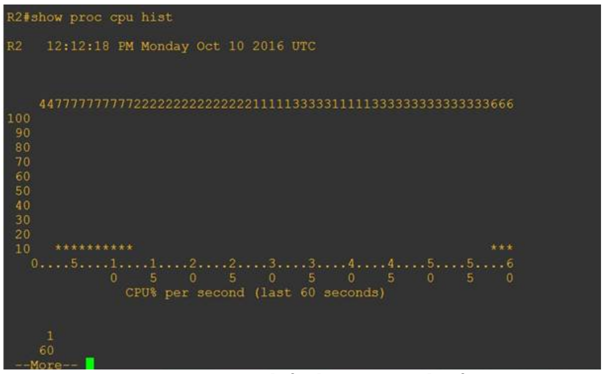

Figure 3. CPU Graph for last 60seconds of router 1

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C. ***RESULTS OF OSPF timer Hold time=1000msec:***

The OSPF timer value is modified and the parameters convergence time and CPU power utilization is calculated by repeating pinging process. To verify the convergence time we use 100 ping packets from R1 to R8 using the ping command. During the pinging process we disconnect the link between R5 and R8, and then the traffic has to choose other path to reach to R8 via R9. The time taken to find alternate path is nothing but convergence time which is tabulated for 10 experiments in the following Table 2. We can observe that after modifying the timer values we can significantly decrease the convergence time to 2 seconds.

The CPU power utilization is also a factor which is improved after modifying the OSPF timer values to another value. The percentage of CPU Utilization is more when the initialization process is going on the routers. These values are taken in the screen shot of the processes of routers is shown in the Figure 4 below. When CPU percentage utilization reaches more than 5% then it is represented with the mark in the process. The percentage of CPU utilization is reduced to maximum 4% by modifying the timer values.

Number of experiments	Packets received	Packets lost	Convergence time (in seconds)
1	98	2	4
2	98	2	4
3	99	1	2
4	99	1	2
5	99	1	2
6	99	1	2
7	99	1	2
8	99	1	2
9	99	1	2
10	99	1	2
Average	98.8	1.2	2.4

Table 2. Convergence time for Hold time = 1000msec

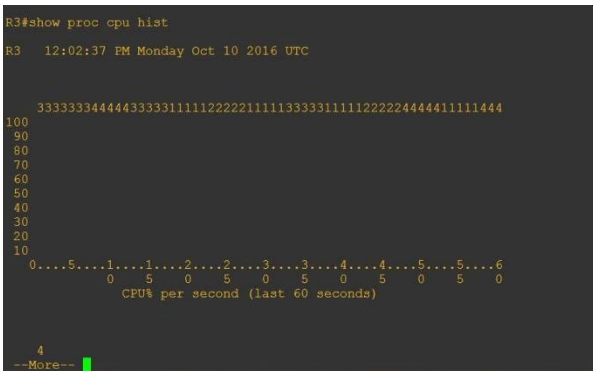

Figure 4. CPU graph for last 60 seconds of router 1

V. SIMULATION AND RESULTS

When compared to the results the convergence time of the network and CPU utilization can be minimized by changing the OSPF timers. The changing of timers will reduce the time required to calculate the shortest path in routing table. From the Figure 5, it is clear that the convergence time of the network is 6.2 seconds when there is no change of OSPF timers. This experiment is repeated for 10 times and the averaged convergence time is considered finally. The graph is also showing that after changing the OSPF timer value, the convergence time is reduced to 2.4 seconds. This value is also calculated after averaging the 10 experiment outcomes. These results are shown in the graph which is in the Figure 5.

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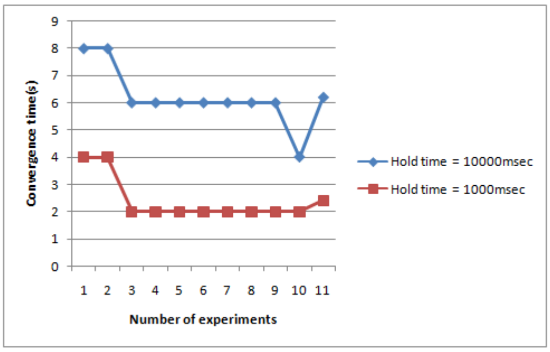

Figure 5. Comparison between Convergence times for different Hold times

The CPU utilization is also plotted in the graph for different time intervals for two cases. The CPU utilization will be maximum when there is no changing the OSPF timers, and the maximum CPU utilization is also 6% from the figure 6. After changing the Hold time value the utilization of CPU by the routing process has been reduced, and the maximum CPU utilization is 4% which can be observed by the following Figure 6.

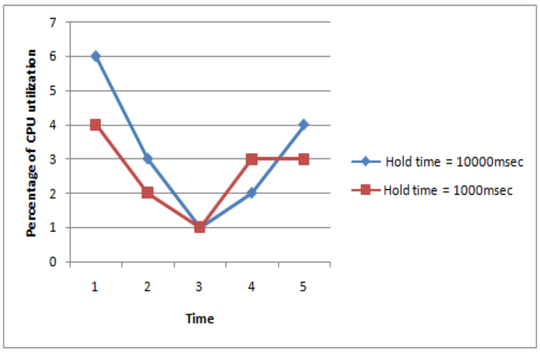

Figure 6. Comparison between CPU utilizations for different Hold times

VI. Conclusion and Future Work

The aim of this paper is to measure and analyse OSPF convergence and percentage of CPU utilization under two different situations in IPv6 networks. We investigated the performance of routing protocol under two cases and we can conclude that OSPF Convergence is 6.2 seconds when there is a broken link, and it is reduced to 2.4 seconds by modifying OSPF timer hold time to 1000msec. The CPU power utilization is also reduced by modifying the OSPF timers from 6% to 4% of its maximum value.

According to the experimental results, the convergence time and CPU utilization are influenced by the values of OSPF timers. Larger values of timers cause slower convergence and more CPU utilization, while smaller timer values ensures fast convergence and less CPU power utilization. It is recommended to keep timers to smaller values to reduce convergence time and CPU utilization in the case of dynamic networks. However setting timers requires lot of on specific networks and also requires network management practice. This paper gives some detail about the future IPv6 networks, and this is a wide research area that has just started exploring.

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