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# Reduce BGP Convergence Time

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## ABSTRACT
The Border Gateway Protocol (BGP) is the de-facto routing protocol between various autonomous systems (AS) on the internet. In the event of route failure, a considerable delay in BGP convergence has been shown by empirical measurements. In the event of failure, a considerable delay in the BGP convergence has been shown by empirical measurements. During the convergence time the BGP will repeatedly advertise new routes to some destination and withdraw old ones until it reach a stable state. It has been found that the KEEPALIVE message timer and the HOLD time are tow parameters affecting the convergence speed. This paper aims to find the optimum value for the KEEPALIVE timer and the HOLD time that maximally reduces the convergence time without increasing the traffic. The KEEPALIVE message timer optimal value founded by this paper is 30 second instead of 60 second, and the optimal value for the HOLD time is 90 seconds instead of 180 seconds.

## Keywords
BGP; KEEPALIVE ;HOLD time

## 1. INTRODUCTION
The internet consists of thousands of computer networks from all around the world [1]. Each network is typically known as a domain or an Autonomous System (AS), which is controlled by a common administrative entity. The Border Gateway Protocol (BGP) is the de facto routing protocol between various AS types in the internet [2]. This protocol allows us to receive email, surf the web, and connect to any available internet data within milliseconds. That is why it is considered the glue that binds networks together in the internet.

For any routing protocol like the BGP, an important metric is convergence time, which is the time required to reroute the packet after a failure. The first significant researches were carried out about the BGP convergence time using the internet measurements that showed the BGP convergence time was slow [3]. This slow convergence is because of the fact that, for a single link failure the global internet will be forced to exchange a large number of advertisements while exploring a new path.

There was a demand for changing the value of the KEEPALIVE message timer and the HLOD time to reduce the convergence time. However, the new value should be setting carefully. Even though the existing value for the KEEPALIVE message timer and the HOLD time needed to be smaller than the default value, setting too small value will harm the network stability [4].

Given that the current value for the KEEPALIVE and HOLD time causing a delay to the convergence time, we propose an optimum value for the KEEPALIVE message timer, which improves the convergence process with paying enough attention for the network traffic. We examine a number of networks with different topologies to identify the optimum value for the KEEPALIVE message timer.

The rest of the paper is organized as follows. In Section II, an overview of the BGP is given. The Impact of the KEEPALIVE message timer on the BGP is explained in Section III. The methodology is presented in Section IV. Finally, Section V presents the conclusion and outlines future work.

## 2. BGP OVERVIEW
BGP is a path vector routing protocol, which means that the BGP speaking system exchanges network reachability information between the BGP systems to find the most efficient path for the data in the Internet [5]. To exchange the reachability information, a BGP session must be established between two BGP routers. The session is supported by the TCP connection. Through this connection, the BGP routers exchange four different messages [2]:

- OPEN: opens the session between the two peers.
- UPDATE: either advertises a new feasible route or withdraws an unfeasible route. This message is also known as an advertisement.
- NOTIFICATION: sent to shutdown the session whenever an error condition is detected.
- KEEPALIVE: periodically exchanged to verify that the BGP peer is still available.

When a BGP router comes up to the internet, it establishes connection with its neighbors, which are the other BGP routers that directly communicate with it, then it will download the entire routing table of each neighbor router. When a BGP router detects a routing change, an update messages will be sent, the message could be announcing a new path or a withdrawal for a path that does not exist anymore. The convergence time is the time required to reroute packets after a routing change. It has been found that the current convergence delay could stretch into more than hundreds of seconds and can lead to high packet drop rates [6].

## 3. KEEPALIVE MESSAGE TIMER IMPACT ON THE BGP
According to [2] the KEEPALIVE messages timer is 60 sec and the HOLD time is 180 sec. Instead of using transport protocol based keep alive mechanism to determine if the peers are reachable, KEEPALIVE messages are swapped between peers often as not to cause the hold timer to expire. The relationship between the KEEPALIVE messages timer and the HOLD time is one third, so before the HOLD time expired the KEEPALIVE message would be sent three times [5].

When the value of the KEEPALIVE message timer is reduced, the BGP will be aware faster about any failure, which leads to accelerating the convergence time as shown in figure 1. However, setting the timer to a very small value will increase the traffic. The traffic may delayed the KEEPALIVE messages which will causes rabid convergence and that will harm the network stability. That is why the new value for the KEEPALIVE messages timer and the HOLD time should be selected carefully.

## 4. Methodology

The methodology for finding the KEEPALIVE message timer and the HOLD time optimum value is shown in figure 1 .This will be done by first generating different networks graphs similar to the internet topology, then configuring different scenarios for each graph using the OPNET simulation tool, using different values of the KEEPALIVE message timer and the HOLD time. Results for the convergence time and the traffic are collected and used to train the neuro-fuzzy system in order to provide two modules: one for the convergence time and the other one for the traffic. Then, the Particle Swarm Optimization (PSO) algorithm is applied on the models to get the optimum value for the KEEPALIVE message timer and the HOLD time. A detailed explanation for each step is given next:

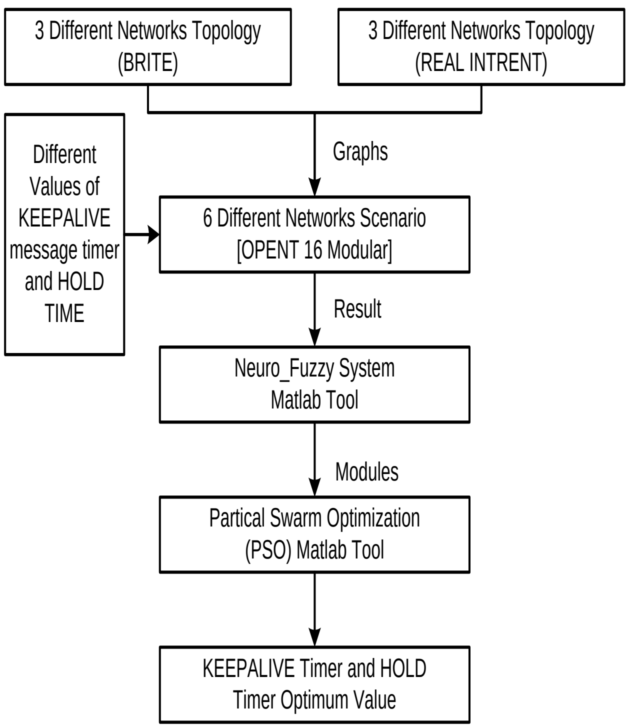


Figure.1: Steps to find the optimum value of KEEPALIVE timer value

### 4.1 Networks graphs

The topology of a group of networks, such as the Internet, has a strong bearing on many performance and management issues. It is essential to have good models of the topological structure of networks for developing and analyzing internetworking technology [7]. Graphs were made using the Boston University Representative Internet Topology gEnerator (BRITE) tool [8], or from the AS graphs extracted from the outing tables at Route Views [9].

There were six graphs with different parameters, as seen in Table 1. The parameters were: Number of node, node degree, and diameter, as the network diameter and node degree are the network topology key parameters. The Average Degree shows how many neighbors(adjacent nodes) a node in the network has on average. The Diameter is the longest path from the shortest paths between any two nodes in the network.

### 4.2 BGP simulater.

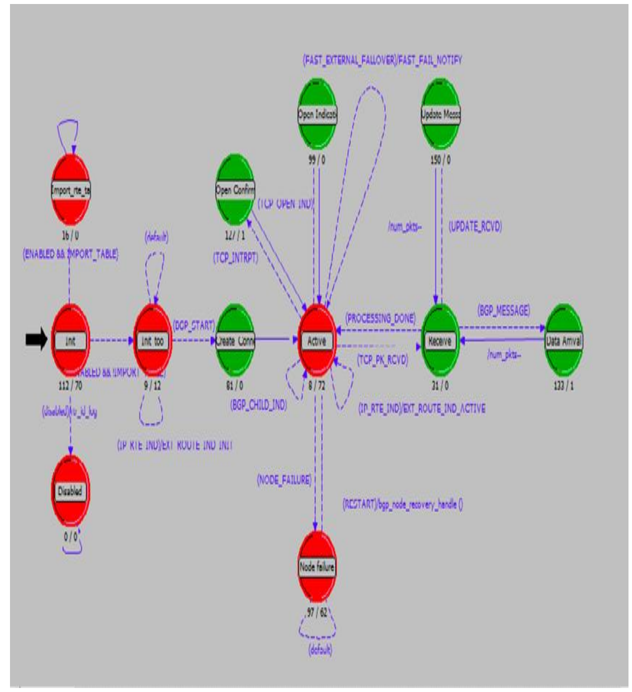

Figure 2: The process model for BGP node within OPNET16 modeller

For each network graph, there was a BGP scenario simulated using OPNET Modeler, which is a powerful simulation tool with a wide variety of capabilities. Then, for each scenario, the values for the KEEPALIVE message timer - the HOLD time were changed for values smaller than the default value (60 – 180 seconds) and larger than 0. The convergence time and the number of the traffic were recorded for every time the timer value was changed in the entire scenarios.

### 4.3 Neuro_Fuzzy System.

Neuro-fuzzy system is the combinations of artificial neural networks and fuzzy logic in the field of artificial intelligence. Neuro-fuzzy combinesthe learning and connectionist structure of neural networks with the human-like reasoning style of fuzzy systems. In fuzzy modeling research, the neuro-fuzzy field is divided into two areas: Mamdani modeling, which is a linguistic fuzzy modeling that is focused on interpretability; and the Takagi-Sugeno-Kang (TSK) model, which focuses on accuracy; the latter is used in the present paper. TSK is a tool for static nonlinear system modeling [10]. To achieve accurate models, there should be good quality historical data. Data-driven models analyze several historically obtained input-output pairs to construct the mapping function. The resulting mapping function depends on the historical data.

There were 4 inputs and output. Input1 is the number of the node in the network; input2 is the average degree; and input3 is the diameter. Also input4 is the different values of KEEPALIVE message timer and the HOLD time between 60 and 0 that applied to each case. The output is the convergence time and the traffic for each case.The results for this step were two models: one for the convergence time and the other for the traffic.

### 4.4 Partical Swarm Optimization (PSO) algorithm

The PSO algorithm simulates the behavior of flocking birds. When a group of birds is searching for only one piece of food in an area, the group does not know where the food is, though they know how far the food is at each iteration. Thus, the best strategy to find it is to follow the nearest bird to the food [11].

The same scenario is used in the PSO algorithm to solve the optimization problems. In the algorithm, each single solution, or as it is known "a particle", is a "bird" in the search space. For all the particles there are fitness values which are evaluated by the fitness function to be optimized, and have velocities that direct the passage of the particles. The particles pass through the problem space by following the current optimum particles.

First initialization is done with a group of random particles, then searches for optima by updating generations. At every iteration, each particle is updated by following two "best" values. The first one is pbest, which is the best solution (fitness) it has achieved so far. The other is the gbest, which is the best value obtained so far by any particle in the population. This best value is a global value. When a particle takes part of the population as its topological neighbors, thebest value is a local best, and is called lbest.

The algorithm finally identified 30 seconds as the best value for the KEEPALIVE message timer and 90 seconds for the HOLD time, which balance between the convergence time and the traffic.

## 5. RESULTS AND DISCUSSON

Figure 3 shows the result with the x-axis displaying the time, as the scenario took 20 min, starting at 15:32 and stopped at 15:52. The y-axis displayed the number of seconds took the BGP protocol to converge. After 10 minutes At 15:42 when one of the links failed the BGP protocol needed to converge. The original BGP with the default KEEPALIVE message timer and the HOLD time value as we can see in the figure, the blue curve, has reached 73 seconds to converge, while the optimized BGP, with the proposed KEEPALIVE message timer and the HOLD time value, the convergence curve in red reached 46 seconds.

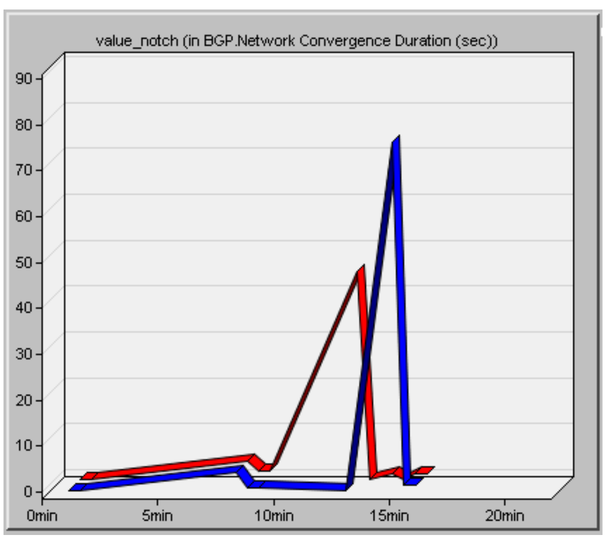


Figure 3: Convergence time for the original and the proposed BGP

Figure 4 shows the result with the x-axis displaying the time, as the scenario took 20 min, starting at 15:32 and stopped at 15:52. The y-axis displayed the BGP traffic. After 10 minutes At 15:42 when one of the links failed the BGP protocol needed to converge. The original BGP with the default KEEPALIVE message timer and the HOLD time, the blue curve, and the optimized BGP, with the proposed KEEPALIVE message timer and the HOLD time, curve in red, sent the same amount of bits. This similarity in the tow curves proof that is the proposed KEEPALIVE message timer and the HOLD time value dos not harm the network traffic.

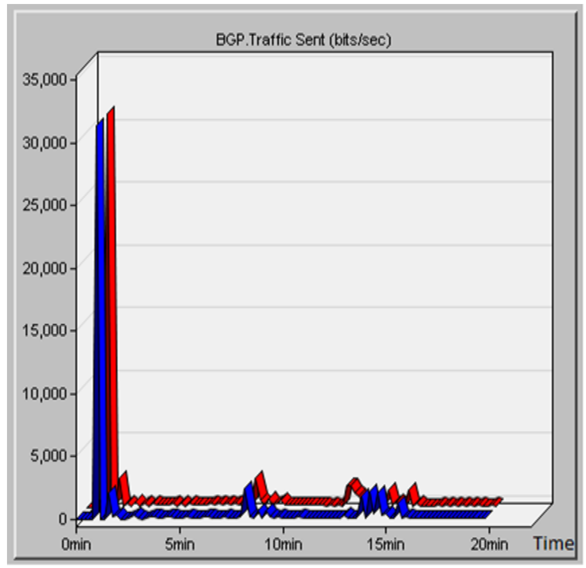


Figure 4: The traffic for the original and the proposed BGP

## 6. CONCLUSION

This paper aimed to identify the optimum value for the KEEPALIVE message timer and the HOLD timethat maximally reduces the convergence time without increasing the traffic. To this end, there was a need to examine different networks with different configurations. For each network a different scenario was configured using the OPNET tool. And then for each scenario a different values of the KEEPALIVE message timer and the HOLD time were applied and the results were collected for the convergence time and the traffic. The results were used to train the neuro-fuzzy system in order to provide two modules: for the convergence time and for the update messages number. The PSO algorithm was applied on the two models to find the optimum value for the KEEPALIVE message timer and the HOLD time.

The main conclusion is that the optimum value for KEEPALIVE message timer is 30 seconds and the HOLD time is 90 seconds. With this value, the convergence time was reduced by 37% as seen in figure 5, and traffic was the same as seen in figure 6. This result proves how sensitive the BGP is to minor modification of some of its parameters.

Future work will be related to the path exploration, as there is a need to improve this process in order to speed it up, which will certainly reduce the time required for the BGP convergence.

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