

# Reducing convergence time along with improvement in path service quality of border gateway protocol

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## Abstract

Border Gateway Protocol (BGP) is an exterior gateway routing protocol used between various autonomous systems across the internet. BGP helps in selecting the best route for the transmission of data among the users. The transmission policy followed by BGP should be such that it should increase BGP routing performances. This work aims to reduce the convergence time of the network with the improvement of QoS (Quality of Service) in the routing of Border Gateway Protocol. Our results show that we can obtain a reduced framework environment which has a best routing path with better energy and quality, along with reduction in convergence time.

**Keywords:** Autonomous systems, BGP (Border Gateway Protocol), convergence, framework environment, QoS (Quality of Service).

## 1. Introduction

The architecture of Internet Routing consists of many Autonomous Systems (ASes) which uses the Border Gateway Protocol (BGP) to exchange information among them. Whenever the network topologies changes, which also effects the metrics of the protocol, thus creating the instability in the routing protocol. To avoid this, a lot of research work has been proposed which creates the dynamic topologies. The two points in BGP that should be considered as working within the BGP session, i.e., BGP convergence time and best path selection for information exchange. The further research paper is organized as follows: in Section II, previous work related to BGP convergence time and best path selection is discussed. In Section III, problem is stated for the BGP routing protocol. In Section IV, tools and software used in the implementation of problem is described. In Section V, system is proposed with the model diagram to overcome the problem. In Section VI, Green Algorithm is discussed along with the simulation model in Section VII. Finally, Section VIII presents the conclusion and the future work guidelines.

**Overview of BGP:** BGP came into existence in year 1989 (RFC 1105) and today its latest version used is BGP-4(RFC 4271) which was developed in year 2006. BGP-4 provides a set of various mechanisms for Classless Inter-Domain Routing (CIDR) [8]. The Border Gateway Protocol is stuck to Internet, but vulnerable to different types of attacks. Secure Border Gateway Protocol (S-BGP) was developed in late 1990s at BBN Technologies to ensure security mechanism in BGP, including authenticity and integrity of BGP communication by using IPsec and Public Key Infrastructure (PKI). BGP is an integral technology for logical routing tasks to provide connectivity all over the world [2]. BGP is used to exchange the routing messages between one or more autonomous systems. BGP works with multi- more autonomous systems. BGP works with multi-homed systems, i.e., where a corporation is connected to more than one service provider. BGP helps to make suitable routing decisions, in order to transmit the data packets from source to destination. The

design of BGP is far good enough as compare to other routing protocols, and many efforts have been made to replace BGP, but all attempts remained unsuccessful till today. An example of simple BGP topology has been depicted in Figure. 1., which shows a network topology consisting of three autonomous systems and have connections with the help of iBGP and eBGP routers.

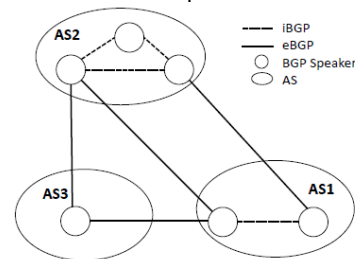


Fig. 1: BGP topology [6]

**Concept of BGP convergence time:** Convergence time is one of the important metric of the Border Gateway Protocol, where convergence time means to retransmit the data packet after the failure occurs. TCP connection is established to exchange the information between the routers. The four types of messages are exchanged in the BGP session, they are as follows:

1. OPEN: This message opens the BGP session between the two peers.
2. UPDATE: This type of message is also called as advertisement, as it advertises and withdraws, the new feasible path and an unfeasible path, respectively.
3. NOTIFICATION: This message leads to the closing of BGP session whenever an error is detected and a peer is notified [6].
4. KEEPALIVE: This message verifies regularly after a particular interval of time that the BGP session is alive.

The slow BGP convergence time was because of the link failure in the global internet, thus to improve or reduce the convergence time of BGP KEEPALIVE timer and HOLD time optimum values are obtained.

**Concept of OOS in selecting best route:** In selecting the best route for the data transmission taking some of the parameters in consideration which improves the efficiency and reduces power consumption. The parameters can be delay time, throughput, exchanged updates, stability, flexibility, fault tolerance, hop counts, etc.

In this paper, Green Path Selection Algorithm [1] has been proposed which improves the efficient quality service by selecting best route for the information between the source and destination peers.

## 2. Related work

- a. In [4], the authors have proposed and showed the simulated result for the reduction of convergence time in BGP without in the increment of traffic. The authors have aimed to reduce convergence time with the help optimal value of two parameters such as KEEPALIVE message timer and HOLD time. The KEEPALIVE message timer value and HOLD time is reduced to half in this paper i.e., 30 seconds instead of 60 seconds and 90 seconds instead of 180 seconds, respectively. Neuro\_Fuzzy System and Practical Swarm Optimization, both of MATLAB tool are used for the Simulink of BRITE and Real Internet topologies.
- b. In [1], the authors have proposed the model for the selection of best path among the various paths available among the Ingress router and Egress router which improves the quality of path based on some of the quality constraints and also optimizes the efficiency of energy of the path in the BGP. The implementation is performed using the NS2 network simulator. The algorithms proposed and implemented are:
  - Green Algorithm: Based on some values of the QoS constraints network model has been proposed for best path selection which is also the fastest route between the routers.
  - Powering-down Algorithm: The algorithm is to save the energy power consumption or reduce link utilization.
- c. In [3], the authors proposed an Improved Stable Path Selection (ISPS) approach which also utilizes the attributes of QoS for best path with the changing topologies of the network, without affecting the parameters such as delay, throughput, bandwidth, path uptime, packet loss rate, updates in routing tables, exchanged updates, etc. It enhances the flexibility of the system with the improved approach over SRS. The comparison of SRS and ISPS is shown, where ISPS has obtained improvement results in the various parameters using NS2 simulator between two autonomous systems using the multi-homed systems and devices.
- d. In [16], the authors have focused to reduce the convergence time of the dynamic network topologies, as in today's fast growing world topology keeps on changing, with the features such as stability, fault tolerance.

## 3. Problem statement

In [4], the author has reduced the convergence time of the BGP, i.e., KEEPALIVE timer and HOLD time optimum values are described and in [1], the authors proposed an algorithm for selecting best path considering constraints for service of quality. The two different algorithms are used for both the purposes, which makes complex, task difficult and time consuming for selection of best route instead of having lower convergence time. To overcome this issue, we have proposed an algorithm combining above both the approaches to obtain better results using one algorithm which

firstly, reduces convergence time and secondly, improves the path selecting approach with efficient energy consumption.

## 4. Tools and software description

The proposed model uses different software tools as well as several packages installed inside the tools to deploy the functioning of the various network topologies, network frameworks, graph representation of results, calculation of convergence time, calculation of improved service quality and finally obtain output with validate results. The software tools used are as follows:

- a. OPNET Modular- OPNET is one of the Network Simulator tool used to test and simulate the performances of the networks by creating a network scenario with different network topologies and also configuring the network environment. The set of protocols are predefined inside the simulator which cannot be modified, or any new protocols cannot be created. It is also used for application troubleshooting and validating hardware architecture.
- b. NS2 Network Simulator- NS is a name of the series of network simulators, where NS1, NS2 and NS3 are specified. NS2 stands for Network Simulator Version 2. It is a discrete open-source simulation tool that can run on both Linux and Windows, but primarily it was UNIX based. It is commonly used for networking research purpose and provides a sustainable environment for different routing, multicast and other IP routing protocols. It can be used to configure both wired and wireless networks. NS2 is a combination of two languages such as: C++ and Object-oriented Tool Command Language (OTcl).
- c. MATLAB Tool- MATLAB provides the multi-programming computing environment for numerical analysis. Its programming language was developed by Math Works. This tool allows the programming in many languages such as: Visual Basic, C++, C, Java, C#, Python and FORTRAN. It performs matrix multiplications, implementation of algorithms, evaluating of functions and data. It may consists of a function with any number of input and output. The functioning can be performed on the command line.
- d. Neuro\_Fuzzy System- Neuro\_Fuzzy is one of the system application available inside the MATLAB Tool. It uses the fuzzy logic concepts for designing, analyzing and simulating systems for applications and functions. Fuzzy-clustering and adaptive neuro-fuzzy learning are provided by Neuro\_Fuzzy. Fuzzy inference blocks can be used in Simulink and simulation of fuzzy system can be done within a comprehensive model of the entire dynamic system.

Table 1: Software Requirements

Software requirements for simulation of proposed work	
Parameters	Requirements (minimum)
Operating system	Windows, Linux, MAC
Simulator	MATLAB v16 (Matrix Laboratory) Network Simulator (NS2) OPNET

Table 2: Hardware Requirements

Hardware requirements for simulation of proposed work	
Parameters	Requirements (minimum)
Processor	Pentium –IV
Speed	1.4 GHz
RAM	2 GB
Hard Disk	200-300 GB
Keyboard	Standard windows keyboard
Mouse	Two or three button mouse
Monitor	SVGA (Super Video Graphics Array)

### 5. Proposed system

In this work, we propose the model which combines the concept of reducing BGP convergence and the Green algorithm. This model combines several network topologies to create a hybrid network system which can be accessed by the user at application level. The proposed system is explained in Figure 2. The steps involved in this model are as follows:

- i. **Different network scenarios** – Several network topologies (network 1, network 2, ..., network n; where n is the pre-defined number of topologies required by the user) are combined in this stage to make the hybrid network system. Let us name the system as *hyb\_net\_sys*. This hybrid system is the framework that is used to deduce different network models.
- ii. **Network framework validation** – In this step, the *hyb\_net\_sys* framework is validated by applying the Neuro\_Fuzzy system in MATLAB. The output from this validation reduces the risk of network model failure as it already takes into account about all the possible data driven models which are based on the historically obtained input-output results.
- iii. **Validation output** – The output obtained from the network framework validation is then further optimized by applying the PSO (Particle Swarm Optimization) and green algorithm [details are described in the simulation model section]. As a result, the network model is improved both in case of time consumption and QoS parameters.
- iv. **Reduced framework** – Once the above steps are passed successfully, the framework is reduced to the maximum optimization level. This reduced framework is the best possible optimized model which will drastically reduce the convergence time. This model, if meets all the criteria set by the user, now sent to the user for further verification of the requirements. If the model fails to meet the criteria set by user, then we repeat the steps from framework validation to gain more accurate result.

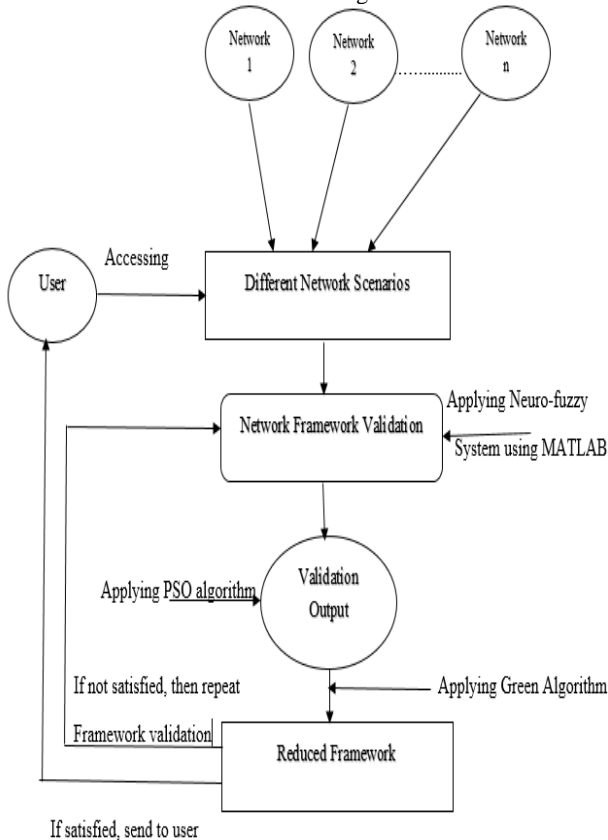


Fig. 2: Proposed model

### 6. Green algorithm

The proposed algorithm helps in the modification of selection of best path between the peers of internal BGP and external BGP routers within an autonomous system. The policy uses the QoS constraints [1].

The symbols and their explanation is summarized in the Table 1. Let  $G(Ver,Ed)$  be the set of undirected graphs of the network topology where  $Ver=\{Ver_1,Ver_2,Ver_3...Ver_n\}$  represents routers set and  $Ed=\{Ed_1,Ed_2,Ed_3...Ed_n\}$  is the representation of links set among two routers[1].

Table 3: Symbols and Description

Symbols and description.	
Symbol	Description
P1	Internal router
P2	External router
$\Theta$	Path Uptime
$g_n$	Creates a peer that to represent P1-P2 path
$K_t$	Set of available paths
$S_p$	Shortest path
$(r, s)$	Pair for source and destination for peer path
$(m, n)$	Set of routers
B	Buffer Limit
$\lambda$	Path uptime in seconds for a link
$K_t'_{Sp}$	Shortest path among the set of available paths

The path uptime ( $\Theta$ ) can be defined as the sum of all uptime path links in path set  $(r,s)$  at a particular point of time.

$$\Theta = \sum_{r,s \in V} \lambda_{i,j} * B_{i,j} \tag{2}$$

Input:  $G^l(V,R), P1,P2$

Output:  $G^o(V,E)$

Begin:

1. for all P1 nodes do
2. Determine path uptime ( $\Theta$ ) for all P1,P2 peers at each P1 node
3. End for
4. At a particular time, traffic demand is shared with different peer nodes
5. for each P1 do
6. while P1 to P2 peer exists do
7. // Create a peer tree  $g_n$  that represents P1-P2 path based on constraints
8. Calculate  $K_t = (K_1, K_2, K_3, \dots, K_n)$
9. Init = 0;
10. If  $K_t \neq \text{Null}$ ;
11. Then  $S_p$  is the shortest path where  
Distance [ i,j ] + cost < distance[ m,n];  
Distance [m,n] := distance [i,j] + cost;  
Predecessor [m,n] = i,j  $\rightarrow S_p$   
{i,j and m,n are two different peers }
12. Else
13. Init = Init + 1;
14. End if
15. Let the graph is  $g_n$ . Calculate the shortest path  $K_t'_{Sp}$  in  $g_n$ , where  
 $K_t'_{Sp} = \min (K_t'_{Sp} \cup K_t)$
16. End while
17. End for
18. End for
19. Merge  $(g_1, g_2, g_3, \dots, g_n)$
20. Share time updates with other peers.

End.

The main objective of the proposed algorithm is to find the paths with maximum efficiency and minimum QoS parameters usage between node to node (for e.g., in this case it is P1 and P2 routers) with minimum traffic flow that introduce a balanced level of energy power consumption and different QoS parameters of the network.

Path selection policy is used by path selection algorithm to find best path. Bellman ford algorithm is applied to find the shortest path among all the available paths. The path selection policy was modified and presented.

The algorithm focuses on time and power consumption level. Energy is conserved, as the algorithm helps to identify common redundant links that combines both link's traffic and leftover links based upon some constraints. It identifies the path sharing mechanism. The BGP convergence mainly focuses on shortest path selection but green algorithm focuses on QoS parameters. The algorithm identifies P1 and P2 routers. There is one egress router for a set of ingress routers. Each P1 router indicates a high path uptime ( $\Theta$ ) to P2 router.

In steps 1–3 of the algorithm path uptime is determined for all the P1-P2 routers. In step 4, both traffic load and path information of P1's is available among the routers. Subsequently, if there are many paths available between a P1-P2 router pair, and the P1 router compares the power-bandwidth availability ( $L_c$ ) of all available paths in steps 6–15. The step 15 calculates the shortest path as  $K_{i,sp}$  in  $g_n$ .

In step 19, all routers shares the best selected path. Subsequently, all graphs  $\{g_1, g_2, \dots, g_a\}$  generated by the P1 router are merged. The energy and different QoS constraints are uphold by the selected P1-P2 path at any particular point of time.

$O(1)$  is the computed time for the path attributes in every P1-P2 pairs. The constraints individually satisfied of the P1-P2 router paths.  $O(n)$  is the initialization time for the sub graph $_a$ .  $O(\log n)$  is the updation time for graph  $G^i$ , in each and every step of the algorithm. Merging is done by creating the 'n' logically connected components. The best common path is selected by the algorithm and leftover paths are leaved.  $O(1)$  time is taken by the algorithm to update graphs for P1-P2 haing common paths. Hence,  $O(n \log n)$  is the time complexity in total.

## 7. Simulation model

The simulation of the proposed model as mentioned, follows some predetermined steps. Several network topologies/ are created (using OPNET) to setup the environment of a hybrid network. The diagram of simulation model is described in Figure 3. The steps are as follows:

- i. **Creating network topologies in OPNET** – We have created several network topologies to maximize the accuracy of the simulation result. More than one topologies will be combined to create a hybrid network framework which ultimately will be used for validation, and that hybrid model called as *hyb\_net\_sys*.
- ii. **Graph representation** – The hybrid network will then be converted to the topological structure of networks to develop and analyze the internetworking model. The extracted graphs from OPNET which the result of the combination of several network topologies. The graphs help in creating the accurate network scenario by comparing the performance and the QoS parameters.
- iii. **Framework validation** – Once the framework (combination of several topologies) is created, the various parameters and limitations need to be verified. We use the extracted graphs from OPNET to compare the measures and to deduce the accurate network model in the framework. Once the network model is decided, we apply the *Neuro\_Fuzzy system* approach using MATLAB to further validate the deduced network model.
- iv. **Apply PSO algorithm** – If the output from the validation process matches the predetermined criteria set by the

user, than the next step is to apply the PSO (Particle Swarm Optimization) algorithm using MATLAB simulator. It solves the optimization problems. It focuses on reducing the time consumption of the particles that pass through the problem space.

- v. **Apply green algorithm** – The optimized output from applying the PSO algorithm reduces the time consumption. But, for improving the QoS measures (for e.g., cost, power consumption etc.), we now apply the *green algorithm* [1].

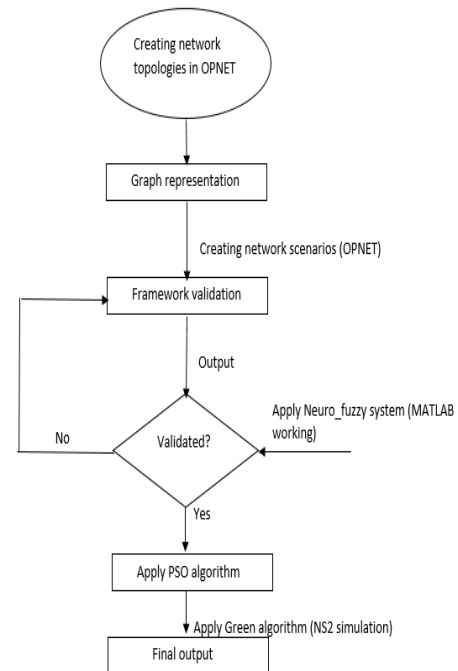


Fig. 3: Simulation Model

## 8. Conclusion and future work

The proposed model presents a balanced relationship between power consumption and QoS parameters. It mainly focuses on reducing the convergence time as well as reducing the maximum level of QoS usage. The model includes the green algorithm path selection policy which finds the shortest path between peers and reduces the amount of power consumption and cost. The path selection approach considers the traffic combines a peer from another connected peers. The performance of the model was measured and observed in a simulated environment using MATLAB and NS2 simulators. It considers the different QoS constraints such as power consumption, path uptime, delay and power-bandwidth ratio during path selection.

In future, this work can be extended in the following ways:

1. Implementing the proposed model discussed in this paper.
2. The performance evaluation of the QoS parameters can be done with the multi-homing devices.
3. The energy power consumption can also be reduced along with different QoS parameters.

## References

- [1] Shuk, S & Kumar M, "An improved energy efficient quality of service routing for border gateway protocol", *Computers & Electrical Engineering*, (2018).
- [2] Moubarak MT, Elbayoumy AD & Megahed MH, "Design and implementation of BGP novel control mechanism (BGP-NCM) based on network performance parameters", *Ain Shams Engineering Journal*, (2017).
- [3] Shukla S & Kumar M, "An Improved Quality Path Selection Approach for Border Gateway Protocol", *International Journal of*

- Intelligent Engineering and Systems*, Vol.10, No.5, (2017), pp.11-18.
- [4] Alabdulkreem EA, "Reduce BGP Convergence Time", *International Journal of Innovative Research in Engineering & Management (IJIREM)* Vol.5, No.1, (2018), pp.15-18.
- [5] Shukla S & Kumar M, "Improving Convergence in iBGP Route Reflectors", *Advances in Electronics, Communication and Computing*, (2018), pp. 381-388.
- [6] Da Silva RB & Mota, ES, "A Survey on Approaches to Reduce BGP Interdomain Routing Convergence Delay on the Internet", *IEEE Communications Surveys & Tutorials*, Vol.19, No.4, (2017), pp.2949-2984.
- [7] Green T, Lambert A, Pelsser C & Rossi D, "Leveraging Interdomain Stability for BGP Dynamics Analysis", *International Conference on Passive and Active Network Measurement (PAM)*, (2018).
- [8] Rekhter Y, Li T & Hares S, *A border gateway protocol 4 (BGP-4)* (No. RFC 4271), (2005).
- [9] Dimitropoulos XA & Riley GF, "Efficient large-scale BGP simulations", *Computer Networks*, Vol.50, No.12, (2006), pp.2013-2027.
- [10] Medina A, Lakhina A, Matta I & Byers J, "BRITE: An approach to universal topology generation", *Ninth International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems*, (2001), pp.346-353.
- [11] Route views project pages, available at: [www.routeviews.org](http://www.routeviews.org), 1994.
- [12] Rahman MA, Pakštas A & Wang FZ, "An Integrated Environment for Network Design and Simulation", *Advances in Computer, Information, and Systems Sciences, and Engineering*, (2007), pp.316-322.
- [13] Calvert KL, Doar MB & Zegura EW, "Modeling internet topology", *IEEE Communications magazine*, Vol.35, No.6, (1997), pp.160-163.
- [14] [https://www.cs.bu.edu/brite/user\\_manual/node26.html](https://www.cs.bu.edu/brite/user_manual/node26.html)
- [15] Wang, B, "The research of BGP convergence time", *6th IEEE Joint International Conference on Information Technology and Artificial Intelligence (ITAIC)*, Vol.2, (2011), pp.354-357.
- [16] Devikar RN, Patil DV & Chandraprakash V, "Study of BGP Convergence Time", *International Journal of Electrical and Computer Engineering*, Vol.6, No.1, (2016).