

Netsim4: OSPF Module Extension to Scalable Cisco IOS Simulator for Virtual Networks

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Abstract—Open Shortest Path First module was implemented in Scalable Cisco IOS Simulator for Virtual networks to help the students configure networks using this dynamic routing protocol aside from RIP. OSPF is used to calculate the best path to be taken by the packets passing through networks using Dijkstra's Algorithm.

Index Terms—OSPF, routing protocol, network simulator, simulator, dijkstra, shortest path fist

I. INTRODUCTION

A. Background of the Study

Networking is one of the major areas in Computer Science which covers the concepts under a network – a set of devices or nodes connected by communication links [1]. Networking is widely used in different institutions since it makes data sharing more efficient.

In order to avoid the use of hardware devices in designing the network setup which may be expensive, Network Simulator, a program which provides configuration of virtual networking devices that can serve as substitute to the actual devices, is developed.

The Institute of Computer Science in the University of Philippines Los Baños(UPLB) has been using an open-source network simulator called Scalable Cisco IOS Simulator for Virtual Networks in teaching CMSC 137: Data Communications and Networking. The software was originally developed by M. Detras and V. Lee in 2006. The most recent update made was last 2007 by R. Lacanienta [2] followed by L. Tirazona [3].

The existing IP routing protocols implemented in the software are static Routing, Routing Information Protocol(RIP), Interior Gateway Routing Protocol(IGRP), and Enhanced Interior Gateway Information Protocol(EIGRP), [4]. Open Shortest Path First(OSPF) has been a well-known IP routing protocol for its performance. However, it is not yet implemented in the system.

B. Statement of the Problem

Scalable Cisco IOS Simulator for Virtual Networks was being used by ICS since 2007 in teaching CMSC 137: Data Communications and Networking. The software has an open platform for upgrades so that it can adapt with the recent advancements in networking technologies.

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However, the latest update was made in 2007, so the available routing protocols are limited to Static Routing, Routing Information Protocol (RIP), Interior Gateway Routing Protocol (IGRP), and Enhanced Interior Gateway Routing Protocol (EIGRP). Open Shortest Path First(OSPF), a widely used routing algorithm, is not yet implemented in the system.

C. Objectives of the Study

The main objective of this study is to implement Open Shortest Path First(OSPF) module in Scalable Cisco IOS Simulator for Virtual Networks. Specifically, it aimed to:

- 1) simulate OSPF routing IP configuration in routers.
- 2) be able to provide interface to enable students to use OSPF in the software.
- 3) test the implementation of OSPF routing IP configuration in the software.

D. Scopes and Limitations

The study is limited to OSPF routing protocol implementation and its User Interface in the system to the Scalable Cisco IOS Simulator for Virtual Networks. This is conducted only for the use of Institute of Computer Science, University of Philippines Los Baños(UPLB).

E. Significance of the Study

Open Shortest Path First (OSPF) is a dynamic routing protocol which finds the optimal path in sending the data, thus, increasing the speed of data transfer. Since it is efficient, it is widely used in corporate networks [5].

Implementing OSPF in the software enables students to experience the implementation of OSPF hands-on. This will increase the learning of the students on the concept, enabling them to get bigger job opportunities in networking field. Moreover, it will be much more easier to the professors to teach the concept of this module.

II. REVIEW OF RELATED LITERATURE

A. Network Simulator

A network simulator basically consists of planning and designing the model, implementing the simulation programs and testing the model. The simulation performance is measured by its execution speed, cost, fidelity, repeatability and scalability [6]. Some of the known network simulators are: NS2, MATLAB and Opnet. These network simulators are continuously being developed to meet the increasing demands and standards of real-life networking technology.

B. Scalable Cisco IOS Simulator for Virtual Networks

Originally developed by Detras and Lee (2006) [4], Scalable Cisco IOS Simulator for Virtual Networks is designed for learning network simulations using virtual networking devices instead of the actual ones. It has features which enables students to learn how to configure some low-level routing protocols like Static Routing, Routing Information Protocol (RIP), Interior Gateway Routing Protocol (IGRP), and Enhanced Interior Gateway Routing Protocol (EIGRP). The software also offers configuration of access lists and virtual LANS.

Currently on its third version, the software also offers Dynamic Host Configuration Protocol(DHCP) and HyperText Transfer Protocol(HTTP) between client and server [3].

C. IP Protocol

Internet Protocol(IP) is a standardized set of rules regarding the addressing, routing, and data sending throughout interconnected networks [7]. IP is a fundamental concept in networking, therefore, IP routing should be understood further by the students by experiencing IP routing protocols in the software.

D. Open Shortest Path First

OSPF is a dynamic routing protocol which uses Dijkstras shortest path first as routing algorithm in finding the optimal path in the network. RIP was widely used during the early usage of networking, however, OSPF surpasses its advantages since it is more efficient when implemented in a larger network and it also chooses the path with lowest cost [5]. There is a continuous development in the networking field of technology. OSPF can be used as a routing protocol that will provide faster routing of data in the network.

OSPF is known for using Link-state advertisement, which is in charge for data exchange among routers. The set-up is that every router under the routing domain will have a database consisting the list of the routers under the network, which will be used for finding the optimal path. OSPF may be hard to configure and may have larger memory requirements, however, it has many advantages. Aside from it makes the data transfer faster, it also utilizes only small bandwidth amount, it considers the cost of each path, supports Variable Length Subnet Mask, and supports multiple routes even for single network destination [8]. Thus, OSPF must be experienced hands on by the students taking up CMSC 137.

III. METHODOLOGY

A. Development Tools to be Used

- 1) Java
- 2) Eclipse Java Oxygen

B. Network Configuration Familiarization

The existing source code of Scalable Cisco IOS Simulator for Virtual Networks was analyzed to understand the architecture of the software. The configuration of Open Shortest Path First (OSPF) was familiarized using the book released by Cisco Press [9] and Request For Comments (RFC) 2328.

C. System Design and Development

The system already has logical devices(routers, switches, hosts and their attributes) needed in virtual networks. A router has a feature which can execute dynamic routing such as RIP, IGRP and EIGRP, in which OSPF will be added. The following steps taken in the implementation of OSPF:

- 1) Establish neighbor adjacencies.
Each device will have a table which contains the devices adjacent to them.
- 2) Create Link State Database
This contains the following information of all the OSPF-enabled routers:
 - a) Link ID
This ID gives name to the entity from the other side of the link.
 - b) Advertising Router
The router ID that originated the Link State Advertisement(LSA). This is equal to the link ID.
 - c) Sequence number
This checks the duplication of LSAs.
 - d) Link Count
This counts the number of times an LSA has occurred.
- 3) Execute Shortest Path First Algorithm
After establishing the adjacent devices, the computation for the shortest path was made. Dijkstra Algorithm is used for computation, in which the devices were treated as the vertices while the cost of each path is computed by:

$$cost = referencebandwidth \div interfacebandwidth \quad (1)$$

in which the cost used for reference and interface bandwidth is default.

- 4) Routing Table
Routing table already exists in the system. This contains the possible paths in transferring data within the network. This is being updated once the shortest path is found.

5) Trace Route command

This will show the users the path from one device to another using the destination's IP address.

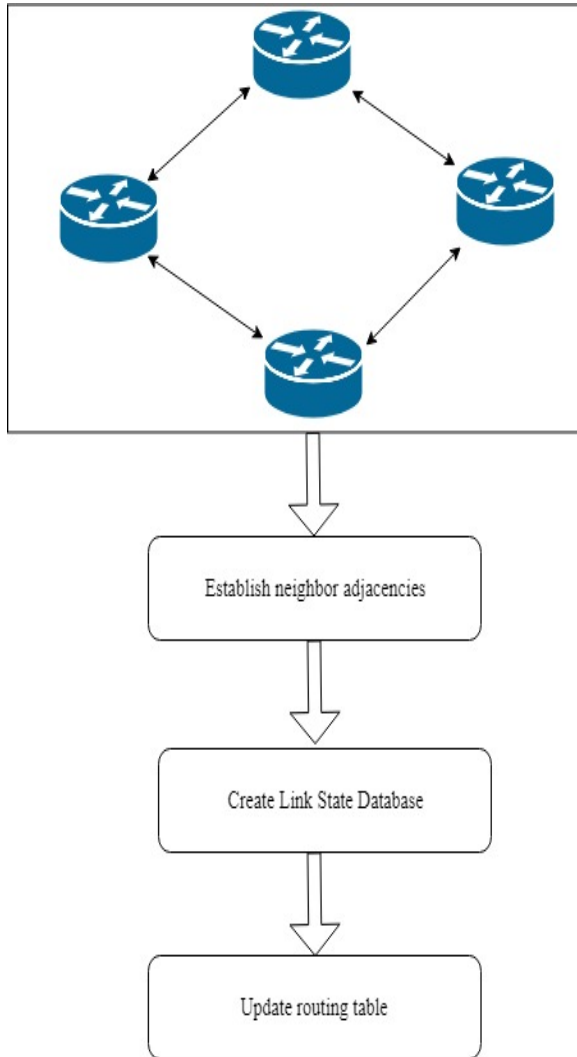


Fig. 1. OSPF Implementation

D. Testing

The configuration of OSPF protocol was tested by using IP route command and the connectivity of one device to another using OSPF. This will be verified by using the ping command and the path taken will be traced by trace route command.

Figure 2 shows how to set up the routing protocol of a router into OSPF. It follows the format:

Router1(config)# router ospf *Process ID*

Router1(config-router)# network *IP address* area *Area ID*

```

Router1 Console

Router con0 is now available

Press RETURN to get started.

Router1>enable
Router1#configure terminal
Router1(config)#router ospf 1
Router1(config-router)#network 20.10.10.0 0.0.0.3 area 0
Router1(config-router)#network 10.10.10.0 0.0.0.3 area 0
Router1(config-router)#network 10.10.4.0 0.0.0.3 area 0
  
```

Fig. 2. OSPF Configuration using IP Route Command.

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Ping Command

ping <ip address> ip address
ping <ip address>

IP Address: 192.168.3.3 [Ping]

Console Output

Pinging 192.168.3.3 with 32 bytes of data:
Reply from 192.168.3.3: bytes=32 time=60ms TTL=241
Reply from 192.168.3.3: bytes=32 time=60ms TTL=241
Reply from 192.168.3.3: bytes=32 time=60ms TTL=241
Reply from 192.168.3.3: bytes=32 time=60ms TTL=241
Reply from 192.168.3.3: bytes=32 time=60ms TTL=241
Ping statistics for 192.168.3.3:
    Packets: Sent = 5, Received = 5, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 50ms, Maximum = 60ms, Average = 55ms

[Clear All] [Exit]
  
```

Fig. 3. Connectivity of one device to another using OSPF.

IV. RESULTS AND DISCUSSION

The Open Shortest Path First(OSPF) routing protocol was implemented in the system and it enables the user to use dynamic routing using OSPF module. For testing, OSPF was used as a routing protocol in different configured topologies.

A. OSPF as routing protocol to be used

Using the console in router configuration, enable the router first then allow the router to be configured. Then, the user can choose the routing protocol to be used. Then, the user should enter the IP networks for routing and then its area.

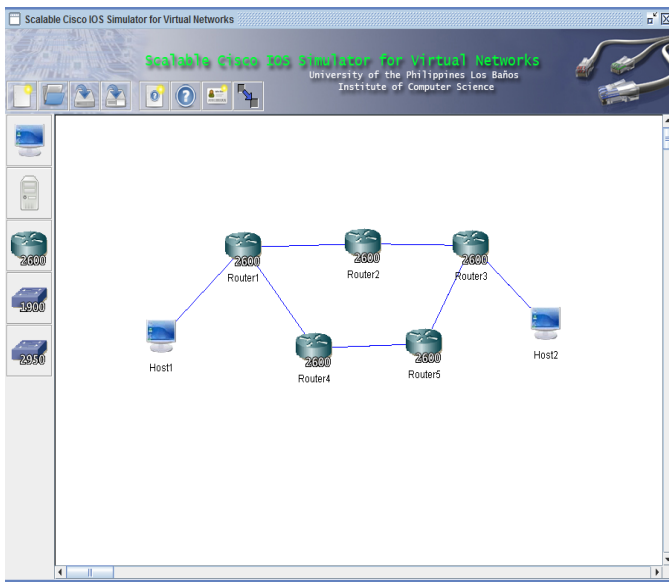


Fig. 4. Sample Topology.

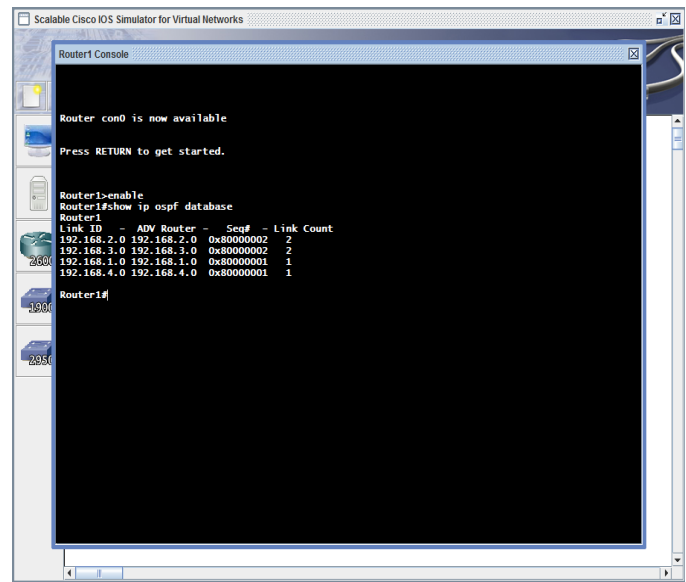


Fig. 6. Show Link State Database using show ip ospf database command

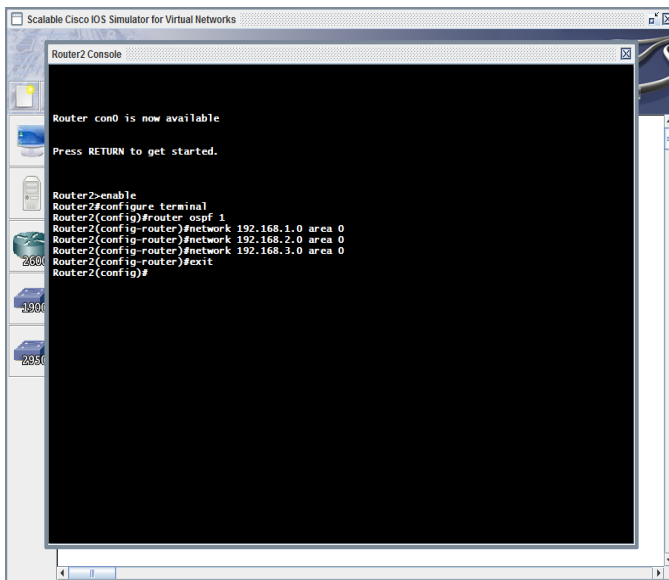


Fig. 5. Using OSPF command to enable OSPF as routing protocol.

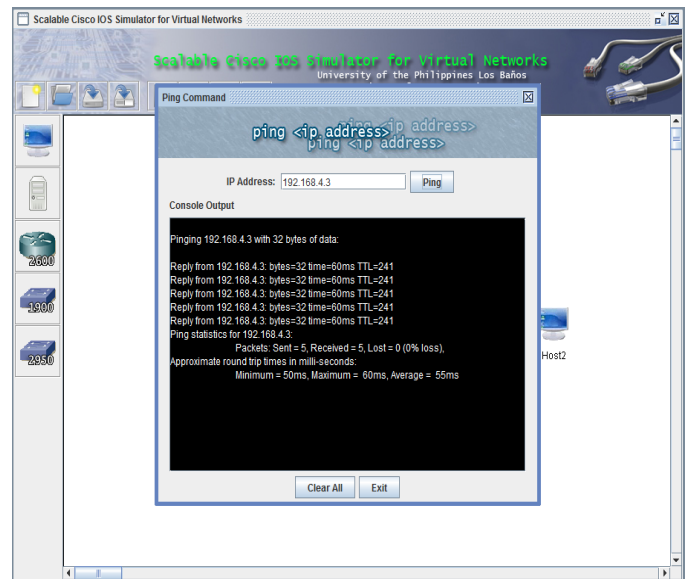


Fig. 7. Ping one host to another

B. Link State Database of each router

After having the router use OSPF as the routing protocol, the user can use "show ip ospf database" command to display the information contained in each router.

C. Connectivity by OSPF

After having a correctly configured topology and setting up the routing protocol for each router, the source host should be able to ping the receiving host.

D. Shortest Path

Using trace route command, the shortest path taken by the packets from the selected source host to the destination will be shown. The user should enter the IP address of the destination.

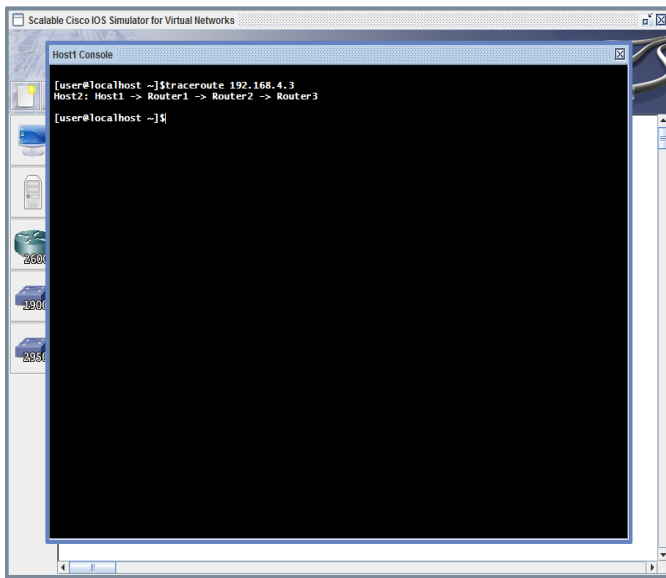


Fig. 8. Using Trace Route command to see the path taken

PLACE
PHOTO
HERE

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V. CONCLUSION AND FUTURE WORKS

OSPF was added as one of the dynamic routing protocols implemented in the system. It can find the shortest path within a network topology. Instead of connecting up to two devices only, the routers were added an interface, in order to connect to up to three devices.

For future studies, Border Gateway Protocol (BGP), a dynamic routing protocol may be implemented. Also, additional features such as clock rates and aging may be added to the system.

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