University of Dhaka

Department of Computer Science and Engineering

CSE-3111 : Computer Networking Lab

Lab Report 9:

Implementation of BGP Protocol

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1 Introduction

The experiment focuses on the implementation and simulation of the Border Gateway Protocol (BGP), which is used for exchanging routing information between autonomous systems (ASes) in the Internet. The objectives of this lab are to understand the BGP routing mechanism, path selection, message exchange, and BGP attributes such as AS-PATH, NEXT-HOP, LOCAL PREF, and MED.

The experiment involves designing a network topology with multiple autonomous systems, implementing the main components such as routers, autonomous systems, and BGP messages. The BGP session establishment mechanism is implemented using the OPEN and KEEPALIVE messages, and the exchange of UPDATE messages is implemented between routers to share routing information. The BGP path selection algorithm is also implemented, which selects the best path based on the BGP attributes.

The input for the experiment will be the source and destination hosts, and the output will show the path taken for the packet delivery. The experiment aims to provide hands-on experience in implementing and simulating the BGP protocol, and to gain a deeper understanding of its mechanisms and concepts.

1.1 Objectives

- Explore the BGP protocol and its routing mechanism.
- Understand the message exchange between autonomous systems (ASes) in the Internet.
- Understand the basic concepts of BGP, such as autonomous systems, path vector routing, BGP messages, and BGP attributes.
- Design a simple network topology with multiple autonomous systems.

2 Theory

The experiment is focused on implementing the Border Gateway Protocol (BGP) and exploring its routing mechanism, path selection, and message exchange between autonomous systems (ASes) in the Internet. BGP is a path vector routing protocol that is used by Internet Service Providers (ISPs) and large enterprises to exchange routing information and make routing decisions based on policies.

The experiment starts by designing a simple network topology with multiple autonomous systems. Each AS will have at least one router, and these routers will exchange BGP messages to establish connections and exchange routing information. The main components required for the BGP simulation are routers, autonomous systems, and BGP messages.

BGP uses autonomous systems (ASes) to group IP networks and routers under the control of a single organization that presents a common routing policy to the Internet. Each AS is identified by a unique number called the Autonomous System Number (ASN). BGP is a path vector routing protocol, which means that it maintains a list of ASes that a route traverses instead of computing the shortest path like distance-vector or link-state routing protocols. This approach helps prevent routing loops and allows for more flexible policy-based routing.

There are four types of BGP messages that routers exchange with each other: OPEN, UPDATE, KEEPALIVE, and NOTIFICATION. The OPEN message is used to establish a BGP session between two routers. The UPDATE message is used to exchange routing information between routers. It contains the new routing information (prefixes and attributes) and withdrawn routes. The KEEPALIVE message is used to maintain the BGP session and to confirm that the connection is still alive. The NOTIFICATION message is used to signal an error or to close a BGP session due to an error.

BGP attributes are pieces of information that describe specific characteristics of a route. They are carried in UPDATE messages and are used in the BGP path selection process. Some common BGP attributes are AS-PATH, NEXT-HOP, LOCAL_PREF, and MULTI_EXIT_DISC (MED). The AS-PATH attribute represents the sequence of ASes that a route traverses. The NEXT-HOP attribute specifies the IP address of the next router in the path to reach the destination. The LOCAL_PREF attribute is used to indicate the preference of a particular route within an AS, with higher values being better. The MED attribute is used to convey the preference of an entry point into an AS.

The experiment involves implementing the BGP session establishment mechanism using the OPEN and KEEPALIVE messages. Routers will exchange these messages to establish a connection with their neighbors. The exchange of UPDATE messages between routers is also implemented to share routing information, such as the AS-PATH, NEXT-HOP, LOCAL_PREF, and MED attributes. Routers will update their routing tables based on the received information. The BGP path selection algorithm is implemented to select the best path based on the BGP attributes. The algorithm follows the standard BGP decision process, which gives preference to the path with the highest LOCAL_PREF value, the shortest AS-PATH, and the lowest MED (only between the same AS).

Finally, the experiment involves testing the BGP implementation by providing input as the source and destination hosts and showing the path taken for the packet delivery. The policy-based routing needs to be implemented, and source and destination hosts will be chosen from different ASes and from the same. The minimum Autonomous Systems to consider is four, and iBGP needs to be implemented at least in some ASes.

3 Methodology

1. **Formulate a research question or hypothesis:** This is the first step in the process of designing an experiment. The research question or hypothesis should be clear, specific, and testable.

2. **Design the experiment:** Once the research question or hypothesis has been established, the next step is to design the experiment. This involves deciding on the variables to be tested, selecting appropriate measures and instruments, and determining the sample size.

3. **Obtain ethical approval:** It is important to ensure that any research involving human or animal subjects is conducted ethically and with appropriate consent. Researchers must obtain approval from relevant ethical committees before proceeding with the experiment.

4. **Recruit participants and collect data:** Participants should be selected based on predetermined inclusion and exclusion criteria. Data collection may involve a variety of methods, such as surveys, questionnaires, observation, or experimental manipulation.

5. **Analyze the data:** Once the data has been collected, it is important to analyze it using appropriate statistical techniques. This will allow researchers to determine if their hypothesis has been supported or not.

6. **Communicate the results:**Finally, researchers must communicate their results to the scientific community and the wider public. This may involve publishing papers in scientific journals, presenting at conferences, or creating educational resources.

4 Experimental Result

The experimental results of the implementation of the Distance Vector Algorithm were successful. The program was able to simulate a network of routers and compute the shortest path to each destination in the network using the Distance Vector Algorithm.

Screenshots and console output were obtained during the testing of the program in various network scenarios. These screenshots and console output demonstrated the correct functionality of the program in different situations, including changes in link costs and network failures. The output showed the gradual updates of the path in each node, which helped to verify the correctness of the computed shortest paths.

Initial Graph: This is the initial graph for this problem

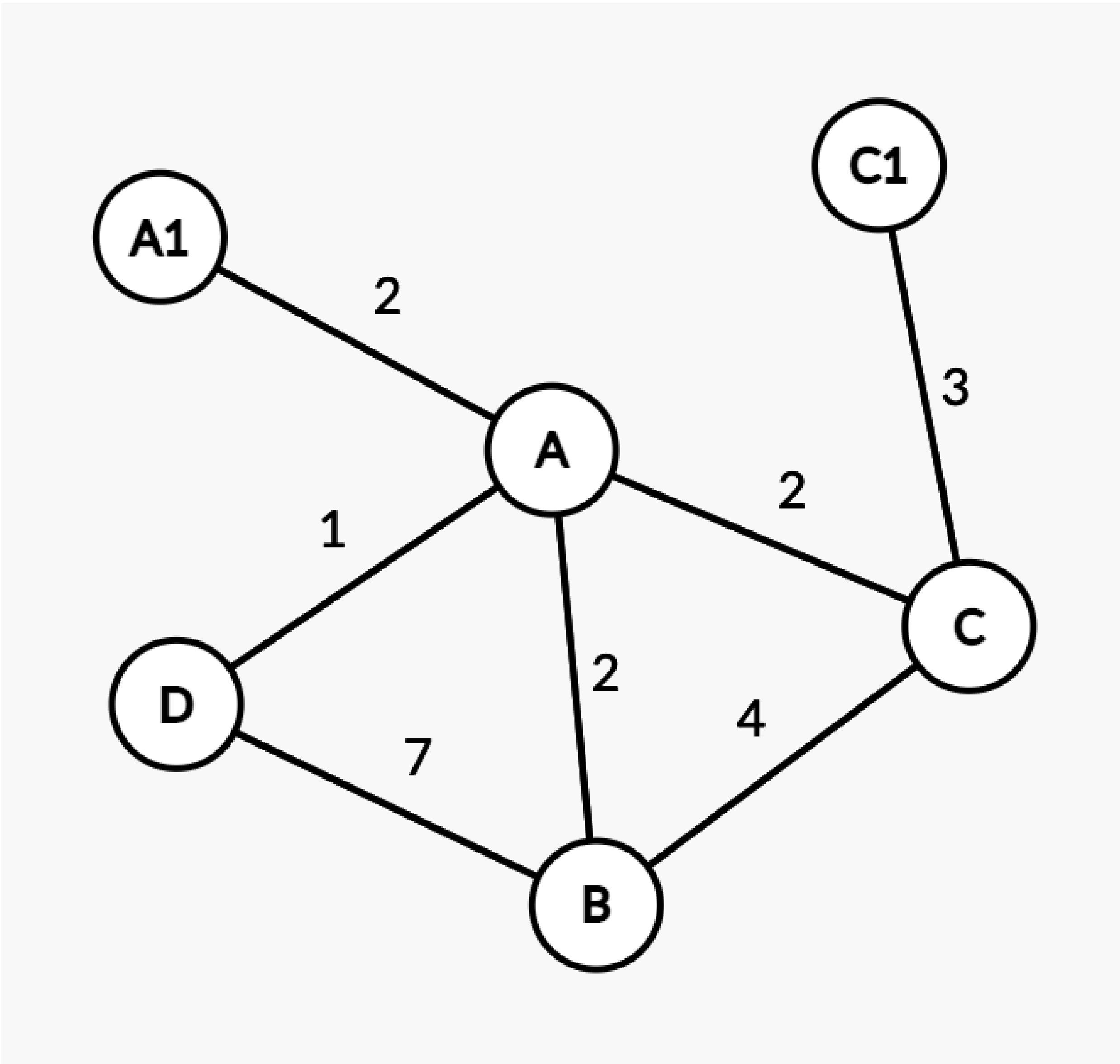

Figure 1: Initial Graph

4.1 Snapshots:

For AS A: This is the experimental result(path cost) of AS A's gateway router A for the initial graph

```
New Table for A:

A 0
A1 2
C1 9
B 2
C 6
D 1

dest: A1, path:  Local Pref 100
dest: C1, path: B C Local Pref 100

sending dv (each 20 sec)

New Table for A:

A 0
A1 2
C1 9
B 2
C 6
D 1

dest: A1, path:  Local Pref 100
dest: C1, path: D B C Local Pref 100

sending dv (each 20 sec)
```

Figure 2: A router's Initial path cost

For A's local router A1: This is the experimental result(path cost) of AS A's local router A1 for the initial graph

```
[LISTENING] sock is listening on :9775.

 DV updated


New Table for A1:

A 2
C1 inf
B 4
C inf
D 3
A1 0



New Table for A1:

A 2
C1 11
B 4
C 8
D 3
A1 0

dest: A1, path: A Local Pref 100
dest: C1, path: A B C Local Pref 100

sending dv (each 20 sec)
```

Figure 3: A1 router's Initial path cost

For As B: This is the experimental result(path cost) of AS B's gateway router B for the initial graph

```
New Table for B:

A 2
A1 inf
C1 inf
B 0
C 4
D 7


[STARTING] Server is starting
[LISTENING] Server is listening on :9772.

New Table for B:

A 2
A1 inf
C1 7
B 0
C 4
D 7

dest: C1, path: C Local Pref 100
dest: A1, path: A Local Pref 100

sending dv (each 20 sec)
```

Figure 4: B router's Initial path cost

For Router C: This is the experimental result(path cost) of AS C's gateway router C for the initial graph

```
New Table for C:

A 2
A1 4
C1 3
B 4
C 0
D 3

dest: C1, path:  Local Pref 100
dest: A1, path: A Local Pref 100

sending dv (each 20 sec)

New Table for C:

A 2
A1 4
C1 3
B 4
C 0
D 3

dest: C1, path:  Local Pref 100
dest: A1, path: A Local Pref 100
```

Figure 5: C router's Initial path cost

For Router D: This is the experimental result(path cost) of AS D's gateway router D for the initial graph

```
[STARTING] Server is starting
[LISTENING] Server is listening on :9774.

New Table for D:

A 1
A1 inf
C1 inf
B 7
C inf
D 0


sending dv (each 20 sec)

New Table for D:

A 1
A1 3
C1 10
B 3
C 7
D 0

dest: C1, path: B C Local Pref 100
dest: A1, path: B A Local Pref 100
```

Figure 6: D router's Initial path cost

4.2 Issues or challenges

The implementation of the BGP Protocol is a network simulation project that aims to explore the BGP Protocol and its features. The project requires designing a simple network topology with multiple autonomous systems where each AS will have at least one router. The routers will exchange BGP messages to establish connections and exchange routing information, such as the AS-PATH, NEXT-HOP, LOCAL_PREF, and MED attributes. The project has several objectives, such as understanding the routing mechanism, path selection, and message exchange between autonomous systems (ASes) in the Internet. Additionally, it will help understand basic concepts like autonomous systems, path vector routing, BGP messages (OPEN, UPDATE, KEEPALIVE, and NOTIFICATION), and BGP attributes.

To implement the BGP Protocol, the following steps should be taken:

1. Design the network topology with multiple autonomous systems.
2. Implement the main components, including Router, Autonomous System, and BGPMessage.
3. Implement the BGP session establishment mechanism using the OPEN and KEEPALIVE messages.
4. Implement the exchange of UPDATE messages between routers to share routing information.
5. Implement the BGP path selection algorithm, which selects the best path based on the BGP attributes.

   To test the BGP Protocol implementation, the input will be "Host A of Router X" and "Host B of Router Y," and the output will show the path that will be taken for the packet delivery. It is also recommended to test different scenarios, such as testing policies based routing, testing source and destination hosts chosen from different ASes, and testing iBGP. The minimum Autonomous Systems to consider is 4.

References

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