

Building BT Network

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Lab Report**

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Abstract

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Chapter 1

Introduction

In this lab, our team set out to build BT Network, a small version of Tier-2 Internet Service Provider (ISP) located at Haslegrave Building, from scratch. Despite its limitations in terms of size and Internet access, we can proudly attest that BT Network is one of the leading providers at Haslegrave Building.

BT network is a Autonomous System (AS) as a whole and the AS Number is 2030. Its domain name is `bt.lbboro`.

1.1 Network Services

Our network provides the following services to each of our individual customers.

- IP addressing with a guaranteed range of 14 host addresses allocated from `23.0.0.0/8` (IPv4) and `2001:2300::/32` (IPv6) blocks.
- Intra-domain Internet connection with Intermediate System to Intermediate System (ISIS) routing protocol.
- Inter-domain Internet connection with Border Gateway Protocol (BGP).
- A reliable Domain name System (DNS) service with duplicated servers under domain `bt.lbboro`.
- A World Wide Web (WWW) service located at `http://bt.lbboro/`.
- Email service at `bt.lbboro`.

For neighbor ISPs who is a customer in our business relationships (see Section 1.2.3), we provide the following services.

- Internet connection to our domain as well as all the others'.

In addition, we provide secure remote access to our routers through Secure Shell (SSH) protocol on one of our laptops for administrative purposes.

1.2 Business Relationships with Neighbor ISPs

BT Network has three immediate neighbor ISPs and it's important to form business relationships with all three of them in order to gain economic benefits. The external routing policies of BGP protocol for each outside network are determined by the business relationship with which our network is connected to (see Section 3.2 for details). Our business relationships with neighbor ISPs are shown in Figure ?? and elaborated in the following.

1.2.1 Provider: Central Network

Since BT Network is a Tier-2 ISP, it need to be connected to a Tier-1 ISP to gain wider Internet connection. Therefore, BT is connected to Central Network as a customer, a Tier-1 ISP, which makes Central Network a "Network Provider".

1.2.2 Peer: Virgin Network

BT Network forms a Peer relationship with Virgin Network, which allows Virgin Network to connect to BT Network at zero cost and vice versa.

1.2.3 Customer: DT Network

BT Network forms a Provider-Customer relationship with DT Network, in which BT is the provider and DT is the customer. In other words, DT gains access to the border Internet through BT at a cost.

1.3 Roles of Network Components

There are 6 physical components in our network in total, of whcih 3 are Cisco routers and the other 3 are TOSHIBA laptops. Each component plays an important role in the network.

1.3.1 Routers

In terms of connection, each router is attached with one customer subnet and thus providing Internet service to one customer. Router 1 (BT-R001) is not physically conncted to any

outside network, while Router 2 (BT-R002) is connected to DT Network and Router 3 (BT-R003) is connected to Virgin Network and Central Network through cables.

In terms of routing, all routers are Level-1 routers in intra-domain ISIS routing protocol. In BGP routing protocol, Router 1 (BT-R001) acts as an Internal BGP (IBGP) router while Router 2 (BT-R002) and Router 3 (BT-R003) act as External BGP (EBGP) routers.

1.3.2 Laptops

All laptops are running a Ubuntu 16.04 system. Each of them is connected to a customer subnet though a cable. In terms of services, Laptop 1 (BT001) provides DNS service for `bt.lbورو` as a secondary DNS server. It also acts as a secure SSH access point to routers for administrative purposes. Laptop 2 (BT002) doesn't provide any service and thus acts as a normal user in the network. Laptop 3 (BT003) provides a DNS service for `bt.lbورو` as a primary DNS server. In addition, it provides WWW service at `http://bt.lbورو` and Email service at `bt.lbورو`.

1.4 Organisation of the Report

The report is organised as follows. We describe the architecture of BT Network on the network layer in Chapter 2. A Network Diagram involving all physical components and connections is drawn in the chapter. Then, IP addresses for interfaces in the network are carefully allocated and configured.

In order to allow packets to be forwarded within and outside the network, proper intra-domain and inter-domain routing protocols are set up and tested in Chapter 3.

In Chapter 4, we move up to the application layer and set up various services in the network as listed in Section 1.1.

Main conclusions drawn from the building process and possible further work are discussed in Chapter 5. At last, a summary of contributions for each group member is presented in Chapter 6.

Although the report does not necessarily reflect the actual order of steps in our building process (eg. remote SSH access was set up before BGP), readers can be assured that all results presented can be reproduced by following the natural order of the report.

To ensure readability, rationale behind important decisions made, problems we encountered and their respective solutions, alternative ways of configurations (if any) as well as reflective commentary for each step of implementation are documented in the report.

Chapter 2

Network Architecture

2.1 Network Diagram

2.1.1 Description

2.1.2 IP Addresses and Interfaces

2.1.3 Connections to Neighbor ISPs

2.2 IP Addresses of Interfaces

- 2.2.1 Design
- 2.2.2 Implementation
- 2.2.3 Evaluation
- 2.2.4 Commentary

Chapter 3

Routing Protocols in the Network

3.1 Intra-domain Routing Protocol: ISIS

- 3.1.1 Design
- 3.1.2 Implementation
- 3.1.3 Evaluation
- 3.1.4 Commentary

3.2 Inter-domain Routing Protocol: BGP

- 3.2.1 Design
- 3.2.2 Implementation
- 3.2.3 Evaluation
- 3.2.4 Commentary

Chapter 4

Applications in the Network

4.1 Secure Remote Access to Routers through SSH

4.1.1 Design

Accessing the routers through the physical "console" port is inconvenient and dangerous. Thus, remote access through Secure Shell (SSH) protocol to routers is needed.

In BT network, remote SSH access is enabled on all 3 routers. Separate combinations of username and password on each router are used to ensure the independence of security of each router.

In addition, SSH public key authentication is set up on Laptop 1 (BT001), which allows the root user on the laptop to login in to all routers without entering passwords.

4.1.2 Implementation

We first set up Remote SSH access was first set up as instructed in Reference Guide on all 3 routers. Below is the configuration commands for Router 1 (BT-R001).

```

1 hostname BT-R001
2 ip domain name bt.lboro
3 username r001 priv 15 secret <secret>
4 line vty 0 4
5 transport input ssh telnet
6 login local
7
8 ip ssh version 2
9 crypto key generate rsa general-keys
10 ip ssh dh min size 4096

```

We then generate a pair of public and private keys on Laptop 1 (BT001).

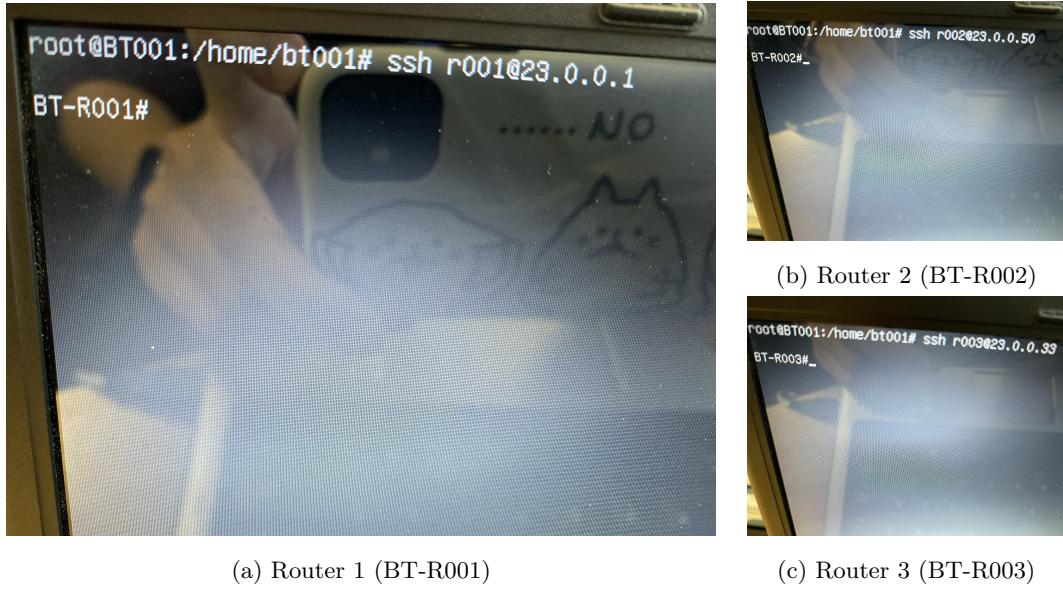


Figure 4.1: Sucessful remote SSH access to all 3 routers from Laptop 1 (BT001).

```
1 ssh-keygen
```

After that, the pair of keys is written into files `~/.ssh/id_rsa` and `~/.ssh/id_rsa.pub`. We use the generated public key (`id_rsa.pub`) to set up SSH public key authentication on all 3 routers.

```
1 ip ssh pubkey-chain
2 username r001
3 key-string
```

4.1.3 Evaluation

Once remote SSH access is set up on 3 routers, one should be able to access them on Laptop 1 (BT001) without entering the password using the following commands.

```
1 # access Router 1
2 ssh r001@23.0.0.1
3 # access Router 2
4 ssh r002@23.0.0.50
5 # access Router 3
6 ssh r003@23.0.0.33
```

Screenshots of successful remote access to all 3 routers are shown in Figure 4.1.

4.1.4 Commentary

4.1.4.1 Problem: Maximum Limit of Characters per Line

When we tried to set up SSH public key authentication on routers, we failed at our initial attempt. It turned out that Cisco router has maximum limit of characters for each command line. Thus, a public key in a single long line was not accepted by the router.

To solve this problem, `fold` command is used to split the public key into multiple lines before re-uploading the key and SSH public key authentication was successfully set up on the router.

4.2 World Wide Web Service

- 4.2.1 Design
- 4.2.2 Implementation
- 4.2.3 Evaluation
- 4.2.4 Commentary

4.3 Domain Name System Service

4.3.1 Design

4.3.2 Implementation

4.3.3 Evaluation

4.3.4 Commentary

4.4 Email Service

4.4.1 Design

4.4.2 Implementation

4.4.3 Evaluation

4.4.4 Commentary

Chapter 5

Discussion

5.1 Conclusions

5.2 Further Work

Chapter 6

Contributions

6.1 Group Leader: Zhihao DAI

6.2 Technical Director: Yunsong ZHANG

6.3 Network Engineer: Huijing LEI

6.4 Network Engineer: Changrong CHEN

6.5 Network Engineer: Yan HUANG

REFERENCES

References

Appendix A

Routers Configuration

A.1 Router 1 Configuration

A.2 Router 2 Configuration

A.3 Router 3 Configuration

Appendix B

Laptops Configuration

B.1 Laptop 1 Configuration

B.2 Laptop 2 Configuration

B.3 Laptop 3 Configuration