International Islamic University Chittagong

Department of Computer Science and Engineering

Course: Computer Networks Lab
Course Code: CSE-3634
Section: 7BM Semester: Autumn Year: 2021

A Project Report on

Design and implementation of VLSM of Campus Network with GNS3

Authors: C183061 (Mushfiqus Salehin Afnan), C183085 (Mahir Shadid)

Team Name: 0to255

Team Leader: Mahir Shadid (C183085)

Members:

1. Mahir Shadid (C183085)
2. Mushfiqus Salehin Afnan (C183061)
3. Md. Abul Bashar (C183077)
4. Mahafujul Alam (C183043)
5. Pritom Saha (C193063)

Completion Date: 19.04.22

Course Instructor	**Course TA**
______________________________ **Abdullahil Kafi** **Assistant Professor** **Department of CSE, IIUC**	______________________________ **Mohammad Irfat Chowdhury** **Student** **Department of CSE, IIUC**

Abstract

The main goal of this project was to create a fully functional campus network system where all the assigned PCs of different departments can communicate with each other. Mainly what we have done here is connected all the PCs to switches and all the switches are connected to routers and lastly all the routers are connected to a core router. And then we assigned the VLSM subnetted IPs to the PCs and the routers. Then we did the routing so that all the routers can communicate with each other. Then for testing, we used the ping command to ping the pc and routers and we thus we got our desired results.

Acknowledgements

It has been a very challenging project for us due to its sequential procedure. Without the help of the team mates it’d be very hard for me to complete this project without any hassle. Thanks to Mushfiqus Salehin Afnan, Mahafujul Alam, Md. Abul Bashar and Pritom Saha, my fellow team mates to help me finish the project and to follow my lead.

Table of Contents

1. **Introduction**:

   In the project 1 we were instructed to create a campus network which includes various departments and make all the PCs communicate with each other without any faults. For this, our group were given an IP address to do the subnetting. So, firstly we did the subnetting, then we made our topology / design. Then we did the routing and assigning of IP addresses to routers and PCs. Then to test the network we pinged the pc and routers with each other and noted down the results we got.

   After analyzing the results we came to a conclusion that our network system is working perfectly fine without any faults.

   In this report we are describing in details on how we made our project a success meaning what were the procedures and the technical parts of it.

2. **Background**:

   The importance of our project pretty significant because by the perfect execution of our project we can make it very easy, simple and secure communication between the devices of different departments of our campus.

   The main tool that was used in building the project was a simulation software called GNS3. This mainly used by network developers to emulate their network structures in real time. This a pretty heavy software which requires high end PC if the network system is a major one containing huge amount of devices.

   The method to develop the campus network is called VLSM (Variable Length Subnet Mask) and IPv4 (Internet Protocol Version 4). These are further discussed down below.

3. **Literature Review**:

3.1. Campus Network:

We have to design a functional campus network where there are different departments that contains PCs and our job is to make the network in such ways so that the PCs can communicate with each other and send packets at ease.

3.2. IPv4 and VLSM:

IPv4: IPv4 stands for Internet Protocol version 4. It is the underlying technology that makes it possible for us to connect our devices to the web. Whenever a device accesses the Internet, it is assigned a unique, numerical IP address such as 99.48.227.227. To send data from one computer to another through the web, a data packet must be transferred across the network containing the IP addresses of both devices.

VLSM: Variable Length Subnet Mask (VLSM) is a subnet -- a segmented piece of a larger network -- design strategy where all subnet masks can have varying sizes. This process of "subnetting subnets" enables network engineers to use multiple masks for different subnets of a single class A, B or C network.
With VLSM, an IP address space can be divided into a well-defined hierarchy of subnets with different sizes. This helps enhance the usability of subnets because subnets can include masks of varying sizes.
A subnet mask helps define the size of the subnet and create subnets with very different host counts wit

3.3. GNS3:

The software we used for our project is called GNS3. GNS3 is used by network engineers worldwide to emulate, configure, test and troubleshoot virtual and real networks. GNS3 allows us to run a small topology consisting of only a few devices on our laptop, to those that have many devices hosted on multiple servers or even hosted in the cloud.

3.4. Routing:

Network routing is the process of selecting a path across one or more networks. The principles of routing can apply to any type of network, from telephone networks to public transportation. In packet-switching networks, such as the Internet, routing selects the paths for Internet Protocol (IP) packets to travel from their origin to their destination. These Internet routing decisions are made by specialized pieces of network hardware called routers.

3.5. Cisco images:

IOS image files contain the system code that your router uses to function, that is, the image contains the IOS itself, plus various feature sets (optional features or router-specific features). However, the features are not configured in any way. In our project, we are using the Cisco 7200 router ISO image as routers in our campus network system. This is downloaded from the official Cisco website / marketplace.

4. **Problem Statement**:

We were assigned an IP address that we must use to design the network. First problem that occurred was doing the subnetting. While doing the subnetting table we had to make extra slots to route between the routers which are called ‘segments’. Moreover we knew that we could use minimum of 4 and maximum of our desire. But we also had to keep in mind that we must not waste any resource as it would result in extra delay and latency while pinging. So, after analysis we came to the decision that we will use segments that will use increment of 4. Thus we were able to overcome the problem.

In terms of the number of networks and their sizes, we needed 6 networks for 6 departments, where the IP pool given was subnetted specifically for them. So, the number of network is 6 and size is not fixed. Because, each department requires different number of hosts.

Routing has been the most interesting part in this project. It is because for the CORE we needed to assign 6 IPs for 6 interfaces, then we had to make 6 IP routes. Now, this is normal. But in case of the department routers to reach each other we had to make the IP route 5 times for each router.

Gateways were added for the Hosts after assigning the gateway IP to the department routers. This is quite straightforward.

Shortly, the main problem or challenge was the Subnetting Table for us. As we had to use VLSM method, we needed to be careful not to waste IPs.

5. **Designs**:

5.1. VLSM: VLSM is a subnet design strategy that allows all subnet masks to have variable sizes. In VLSM subnetting, network administrators can divide an IP address space into subnets of different sizes, and allocate it according to the individual need on a network. This type of subnetting makes more efficient use of a given IP address range. VLSM is the defacto standard for how every network is designed today.
VLSM fundamental terms: subnet mask, subnetting and supernetting:

- Subnet Mask: Every device on a network has an IP address. A subnet mask splits this IP address into the host and network addresses. This helps define which part of the IP address belongs to the network, and which part belongs to the device. The subnet mask is a 32-bit number, where all the host bits are set to 0, and the network bits are set to 1. So, the subnet mask consists of a sequence of 1s followed by a block of 0s, where the 1s represent the network prefix and the 0s mark the host identifier.

- Subnetting: In subnetting, a large network is logically or physically divided into multiple small networks or "subnets." The reason for subnetting a large network is to address network congestion and its negative impact on speed and productivity. Subnetting also improves efficiency due to the way an address space is utilized in a small network. Finally, the divisions between subnets allow organizations to enforce access control, which improves network security, and helps contain security incidents.

- Super netting: In super netting, multiple contiguous networks are combined into a single large network known as a super net. Super netting advertises many routes in one summarized advertisement or routing entry, instead of individually. This routing entry encompasses all the networks in the super net, and provides route updates very efficiently. Super netting is especially useful in route aggregation to reduce the size of routing tables, and to reduce the size of routing updates exchanged by routing protocols.

5.2. Calculations: The available IP address block is 169.110.224.0/21, and the requirement is to create subnets for six departments:

CSE: 225 hosts

EEE: 100 hosts

BBA: 70 hosts

Administrative: 50 hosts

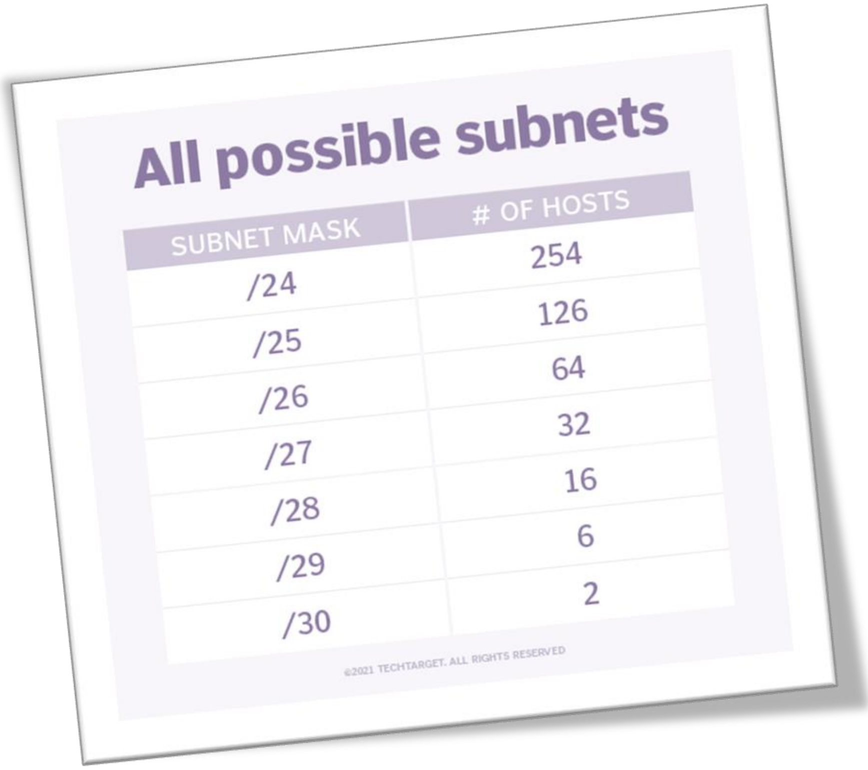
ELL: 40 hosts

Civil: 28 hosts

Here are the steps to allocate the IPs for departments using VLSM:

1. Select the block size for each segment. This must be greater than or at least equal to the sum of the host addresses, broadcast addresses and network addresses.

2. List all possible subnets:



All possible subnets

SUBNET MASK	# OF HOSTS
/24	254
/25	126
/26	64
/27	32
/28	16
/29	6
/30	2

Figure-1

3. Keeping the block size in mind, arrange all the segments in descending order, i.e. list the highest first, then the second highest, and so on, all the way down to the subnet with the lowest requirement. For this example, the order would be:

CSE: 225 hosts

EEE: 100 hosts

BBA: 70 hosts

Administrative: 50 hosts

ELL: 40 hosts

Civil: 28 hosts

4. Assign the appropriate subnet mask to each subnet. Identify the highest IP available and allocate it to the highest requirement. So, here, 169.110.224.0/24 has 256 valid IP addresses that can be assigned to the 225 hosts required by CSE.

5. For the next segment, an IP is required that can handle 100 hosts. The IP subnet mask /25 is the next highest in the list. It can accommodate 128 hosts, so it should be assigned to the 100-host requirement of EEE.

6. Similarly, other departments requirements are also fulfilled within 2^11=2048 hosts.

5.3. IP Table:

Building	NET ID	FIRST ADD.	LAST ADD.	BROAD. ADD.	NET MASK
CSE	169.110.224.0	169.110.224.1	169.110.224.254	169.110.224.255	255.255.255.0
EEE	169.110.225.0	169.110.225.1	169.110.225.126	169.110.225.127	255.255.255.128
BBA	169.110.225.128	169.110.225.129	169.110.225.254	169.110.225.255	255.255.255.128
ADMINISTRATIVE	169.110.226.0	169.110.226.1	169.110.226.62	169.110.226.63	255.255.255.192
ELL	169.110.226.64	169.110.226.65	169.110.226.126	169.110.226.127	255.255.255.192
CIVIL	169.110.226.128	169.110.226.129	169.110.226.158	169.110.226.159	255.255.255.224
CSE-SEG	169.110.226.160	169.110.226.161	169.110.226.162	169.110.226.163	255.255.255.252
EEE-SEG	169.110.226.164	169.110.226.165	169.110.226.166	169.110.226.167	255.255.255.252
BBA-SEG	169.110.226.168	169.110.226.169	169.110.226.170	169.110.226.171	255.255.255.252
ADMIN-SEG	169.110.226.172	169.110.226.173	169.110.226.174	169.110.226.175	255.255.255.252
ELL-SEG	169.110.226.176	169.110.226.177	169.110.226.178	169.110.226.179	255.255.255.252
CIVIL-SEG	169.110.226.180	169.110.226.181	169.110.226.182	169.110.226.183	255.255.255.252

5.4. Software and hardware:

The software used is GNS3. GNS3 is used by hundreds of thousands of network engineers worldwide to emulate, configure, test and troubleshoot virtual and real networks. GNS3 allows you to run a small topology consisting of only a few devices on your laptop, to those that have many devices hosted on multiple servers or even hosted in the cloud. GNS3 is open source, free software that you can download from http://gns3.com. It is actively developed and supported and has a growing community of over 800,000 members. GNS3 has allowed network engineers to virtualize real hardware devices for over 10 years. Originally only emulating Cisco devices using software called Dynamips, GNS3 has now evolved and supports many devices from multiple network vendors including Cisco virtual switches, Cisco ASAs, Brocade vRouters, Cumulus Linux switches, Docker instances, HPE VSRs, multiple Linux appliances and many others.

The hardware used is above average Computer or Laptop that provides efficient emulation of the routers as the routers requires virtual RAM and they have high CPU usage. Shortly, More threads, more performance.

5.5. Topology:

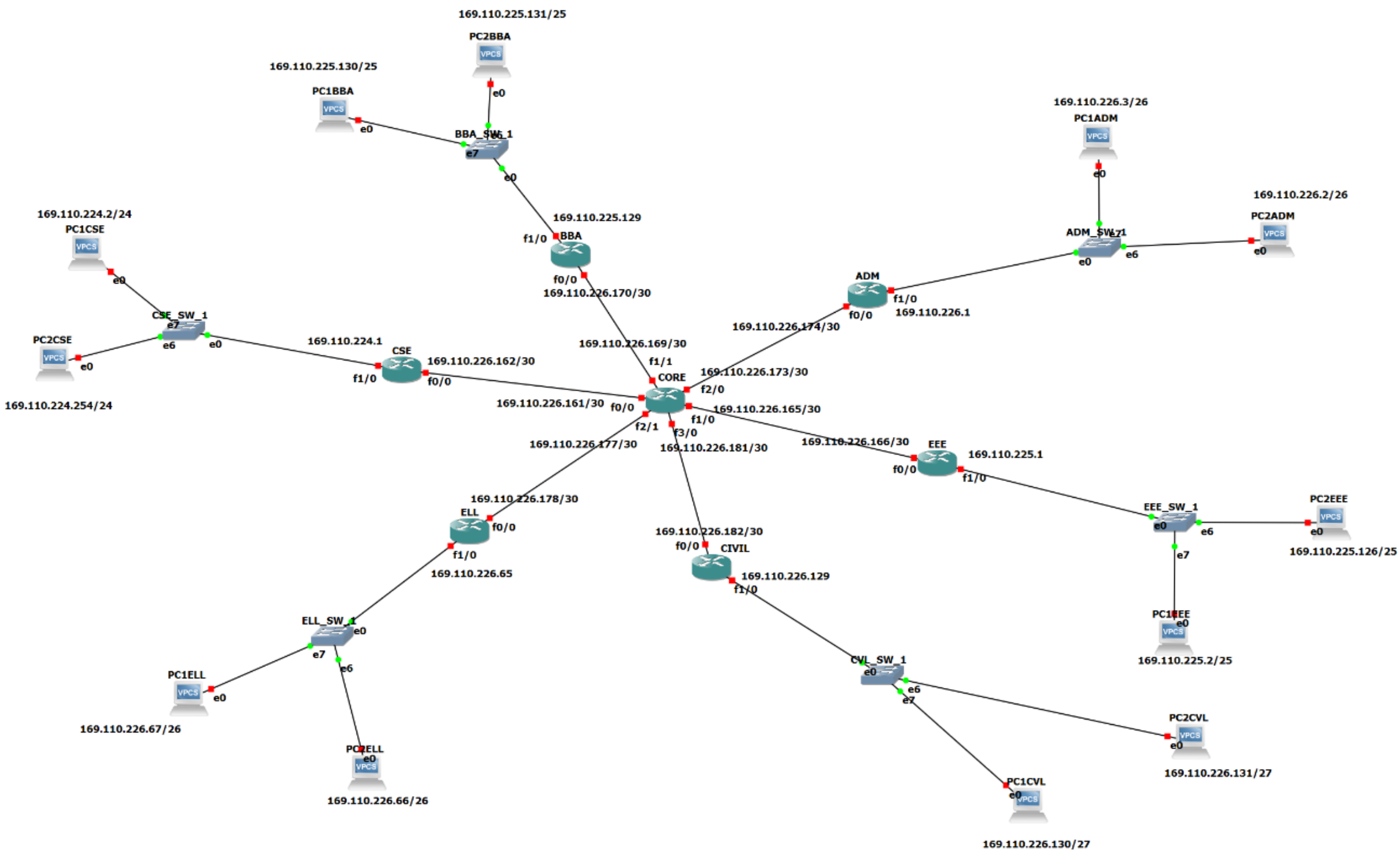


Figure-2

6. **Implementation**:

6.1. Install GNS3: We downloaded GNS3 from the official website.

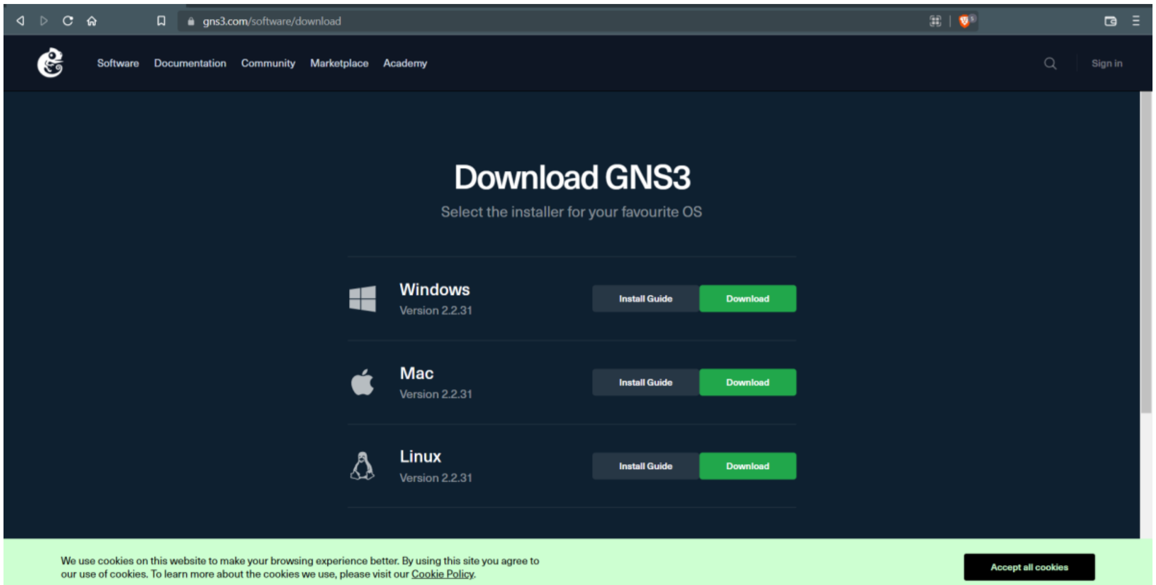


Figure-3

And then followed the instructions that are given in their website to successfully install GNS3 in windows operating system. The link is: https://docs.gns3.com/docs/getting-started/installation/windows/

6.2. Importing Routers: The router we used to build the campus network is Cisco 7200. To import the router in GNS3 we have to get the ISO file of this router from the official marketplace of Cisco. Then we have follow the instruction that are given in the following link: https://www.cybrary.it/blog/0p3n/installing-cisco-ios-router-gns3-vm/#:~:text=STEP%201%3A%20Open%20the%20GNS3,by%20clicking%20on%20%E2%80%9CBrowse%E2%80%9D

6.3. Configurations:

1. The interface of GNS3 looks like this:

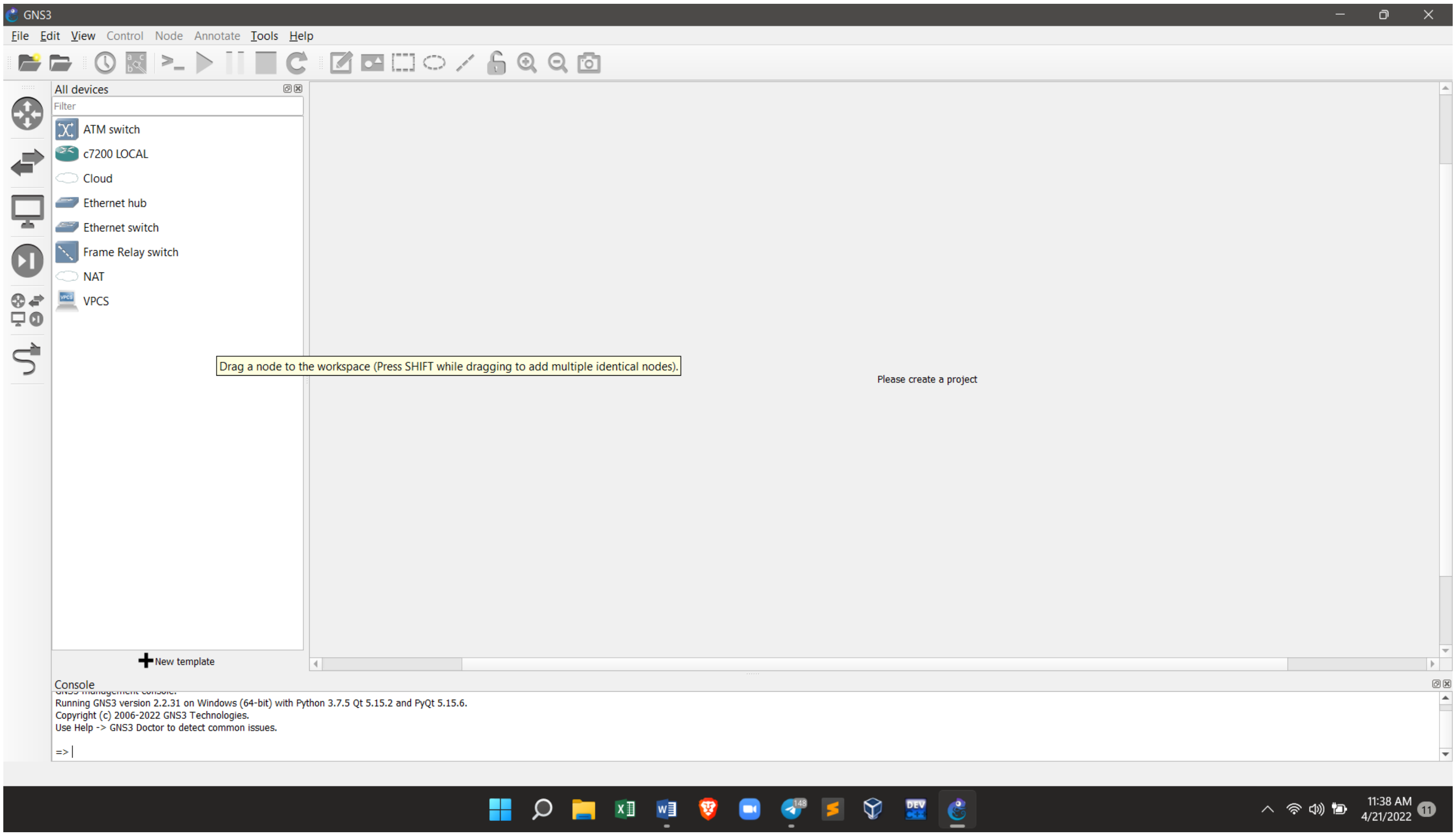


Figure-4

2. The device sets: We used the devices shown in the snapshot below.

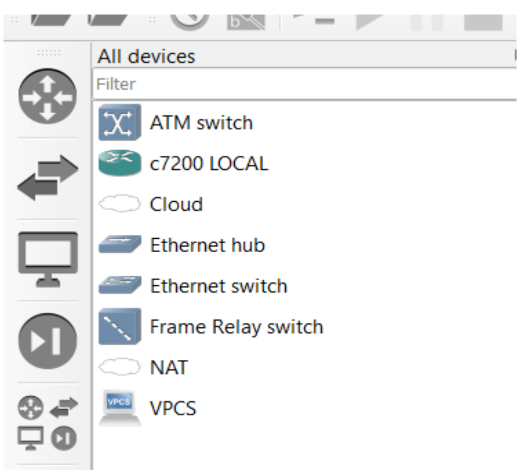


Figure-5

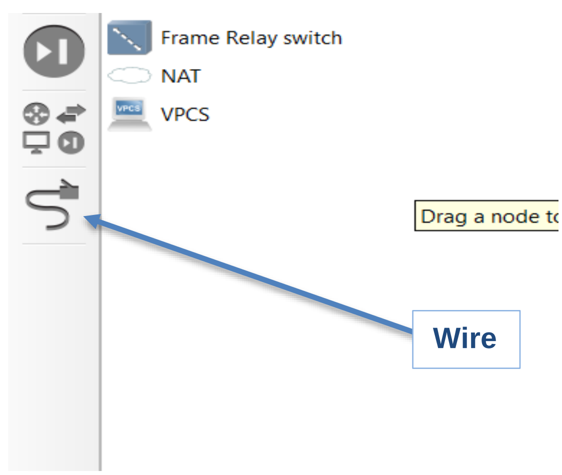


Figure-6

7. **Experimental and Theoretical Results**:

7.1. Ping tool: After designing the network we use the ping tool to configure the PC and routers. To do this we use various syntaxes. They are given below:
For routers:
R1#config t
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)#int f1/0
R1(config-if)#ip add 169.110.226.161 255.255.255.252
R1(config-if)#no shut
R1(config-if)#exit
R1(config)#

For PCs:

PC1> ping 169.110.225.1

7.2. Pinging in the same Network:

Here, we are testing the connection in same network using the ping commands. The snap shots are given below.
Admin to Admin:

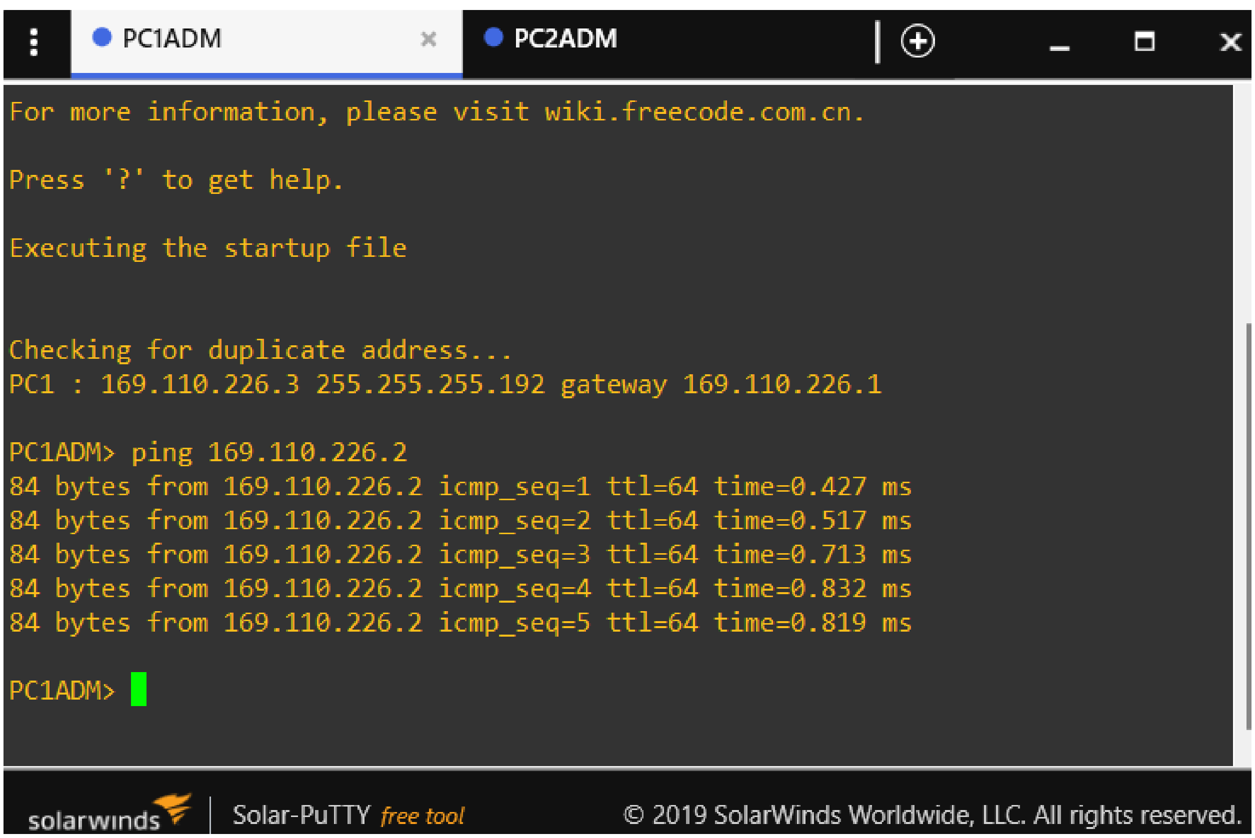


Figure-7

BBA to BBA:

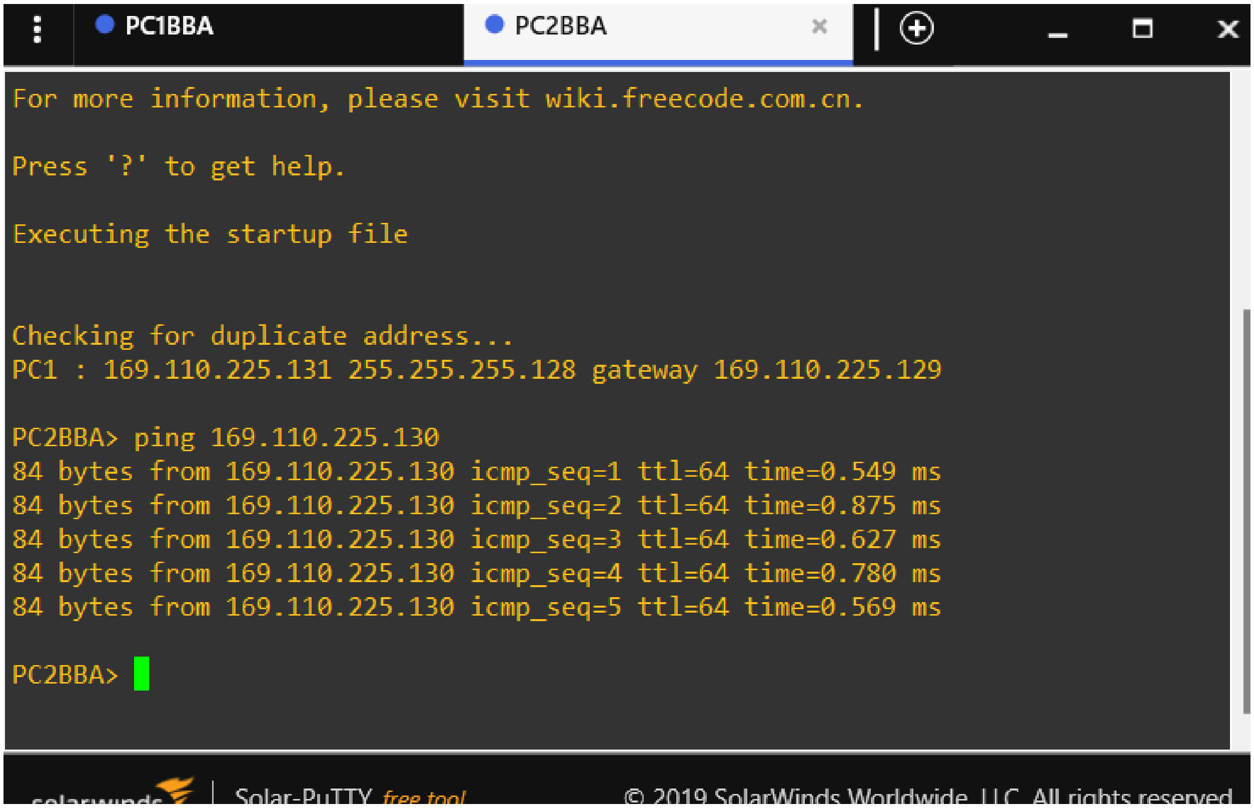


Figure-8

CSE to CSE:

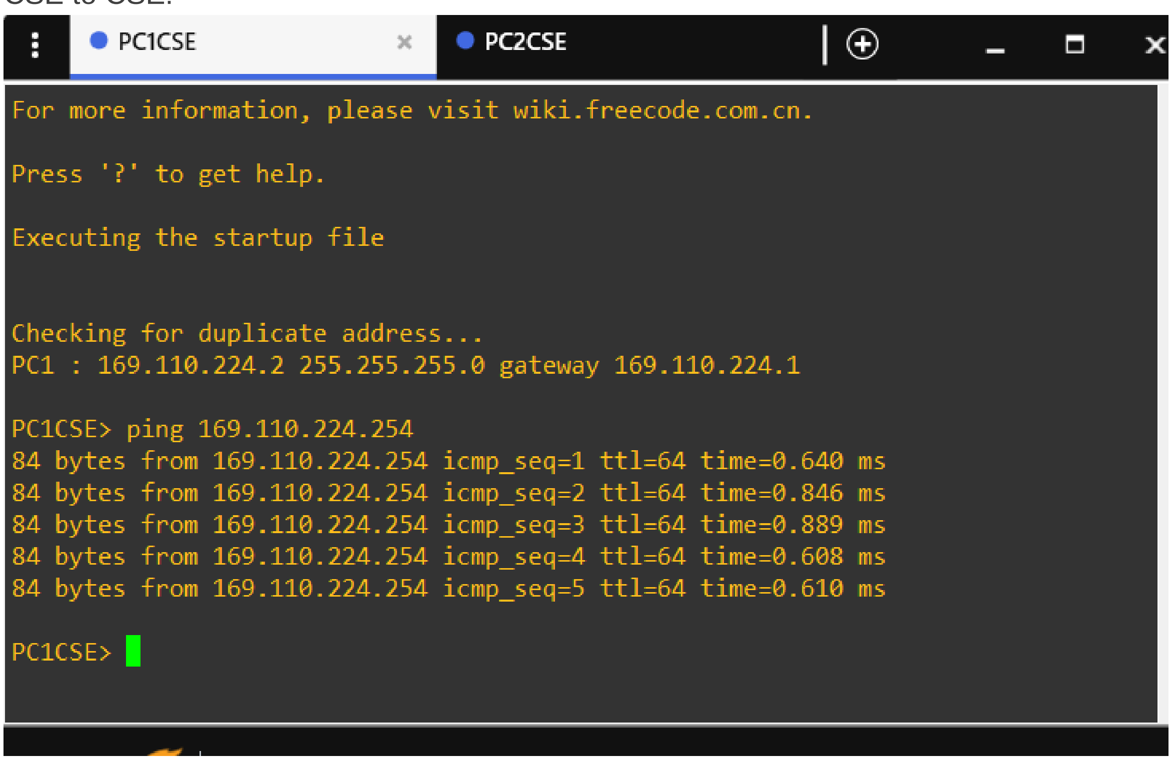


Figure-9

CIVIL to CIVIL:

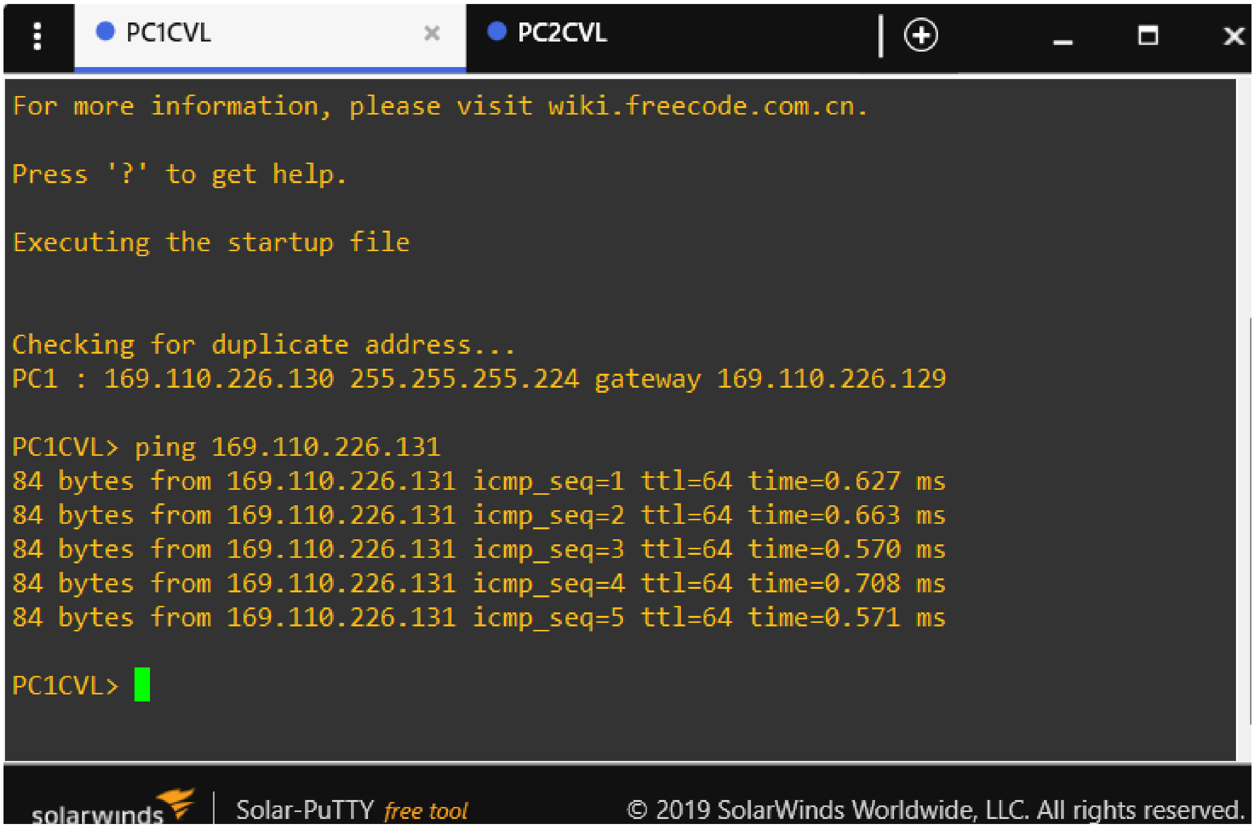


Figure-10

EEE to EEE:

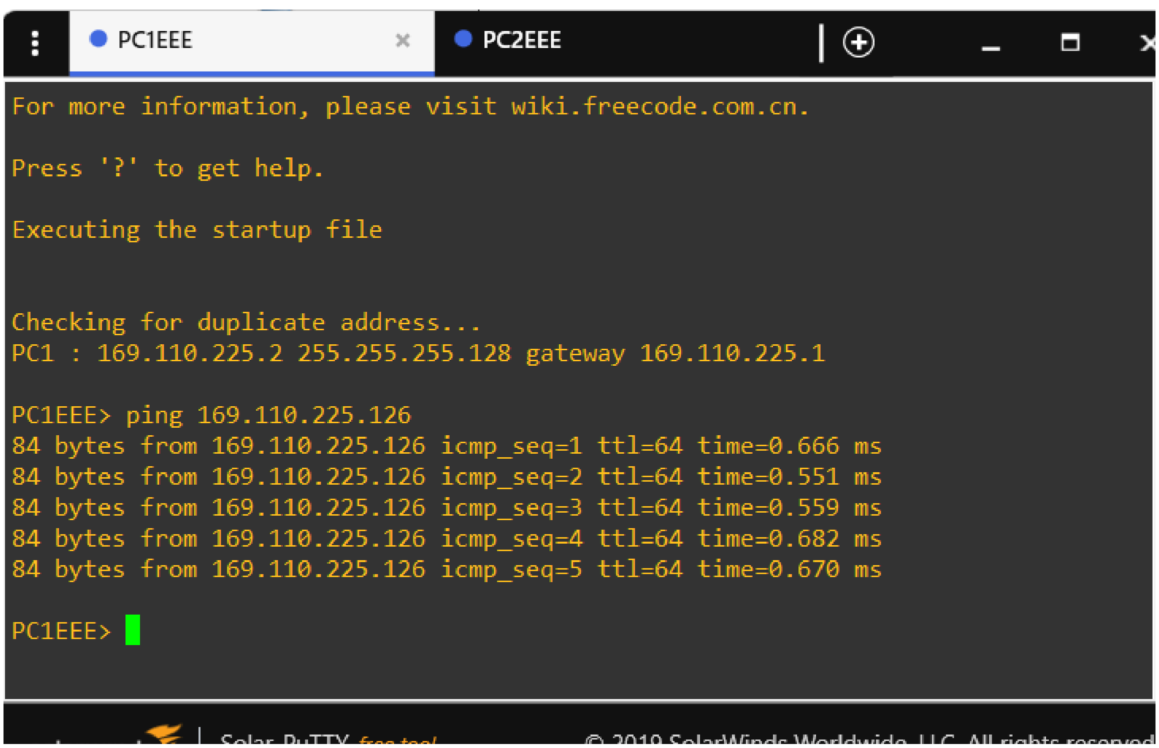


Figure-11

ELL to ELL:

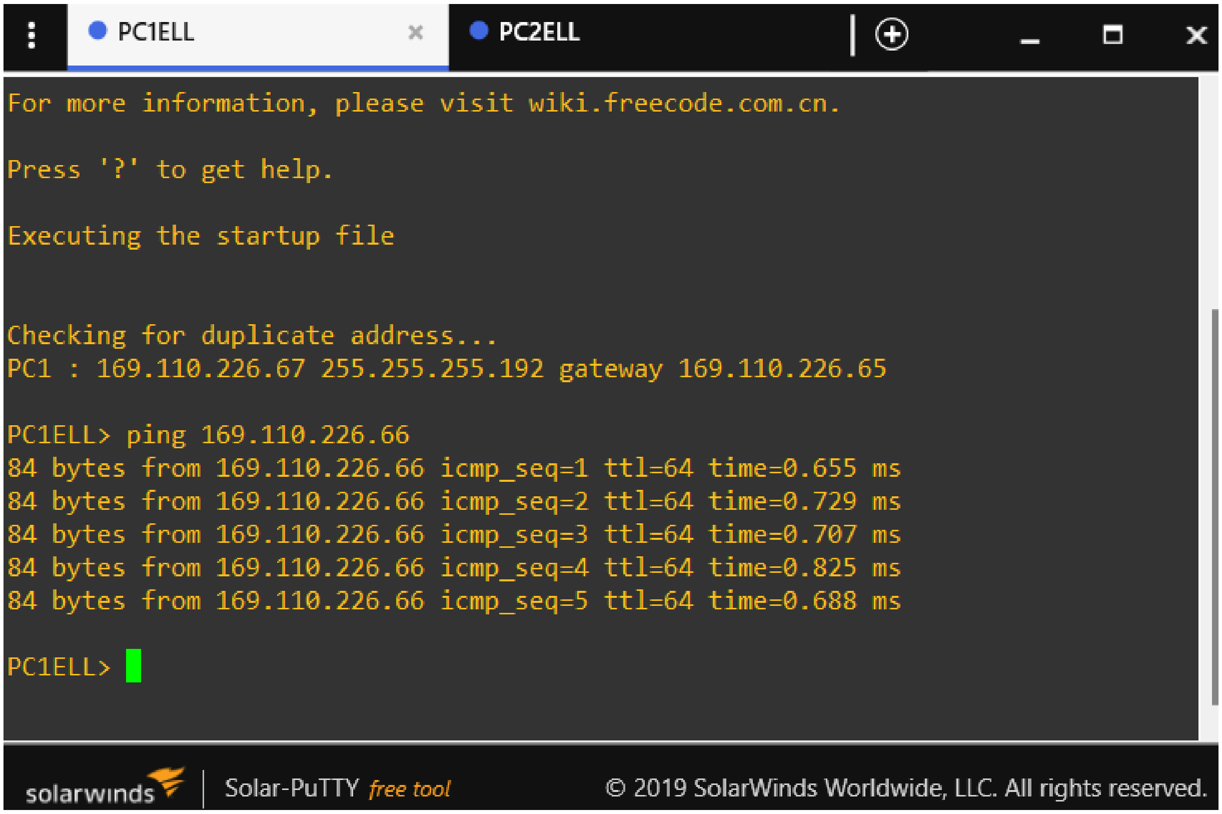


Figure-12

7.3. Pinging the Gateway:

Admin gateway ping:

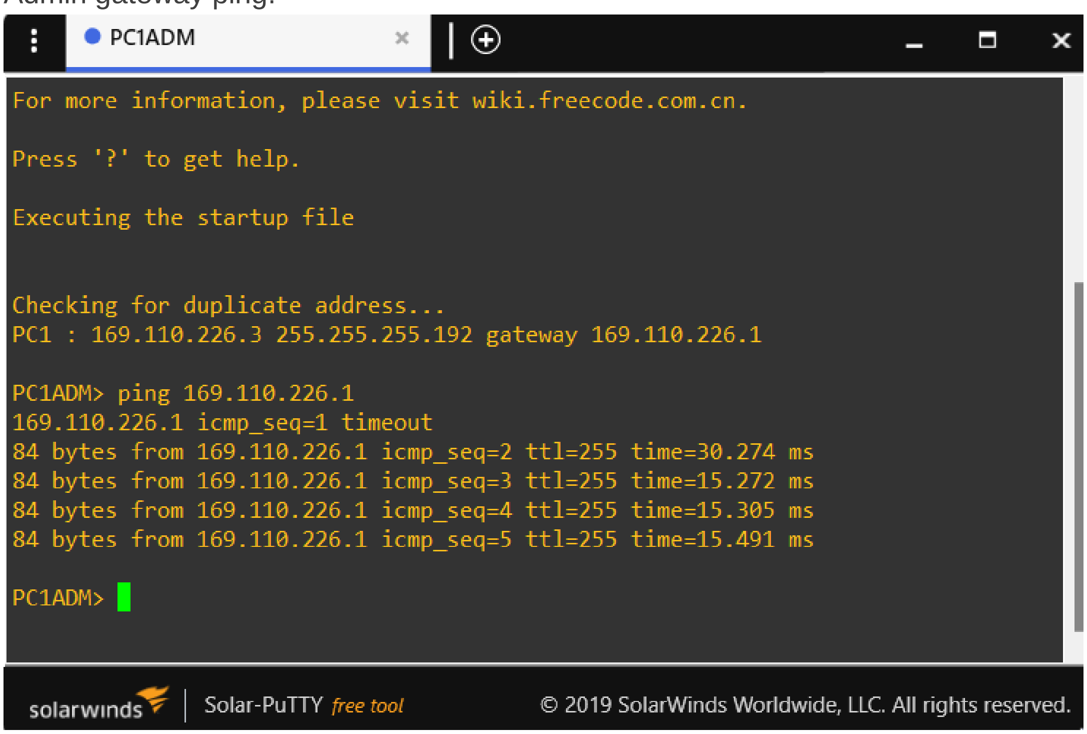


Figure-13

BBA:

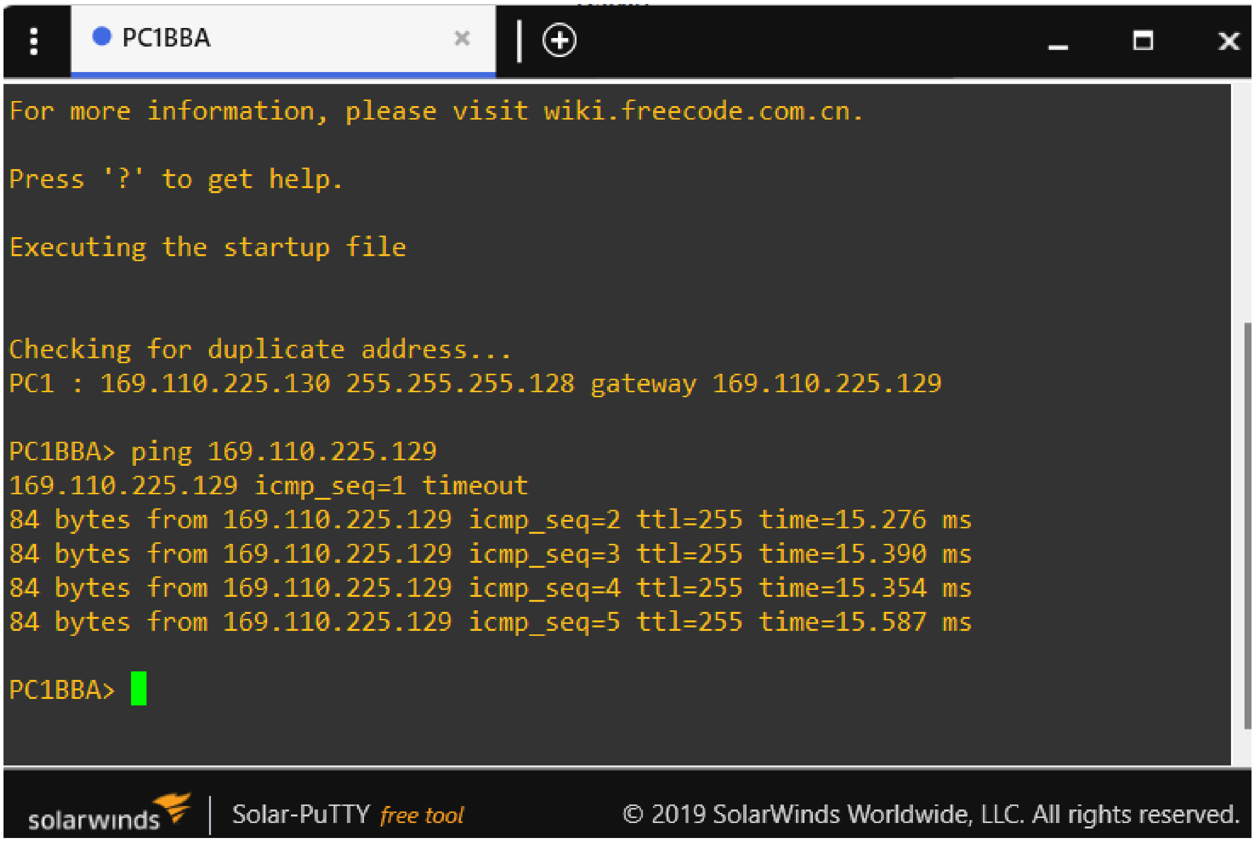


Figure-14

CSE:

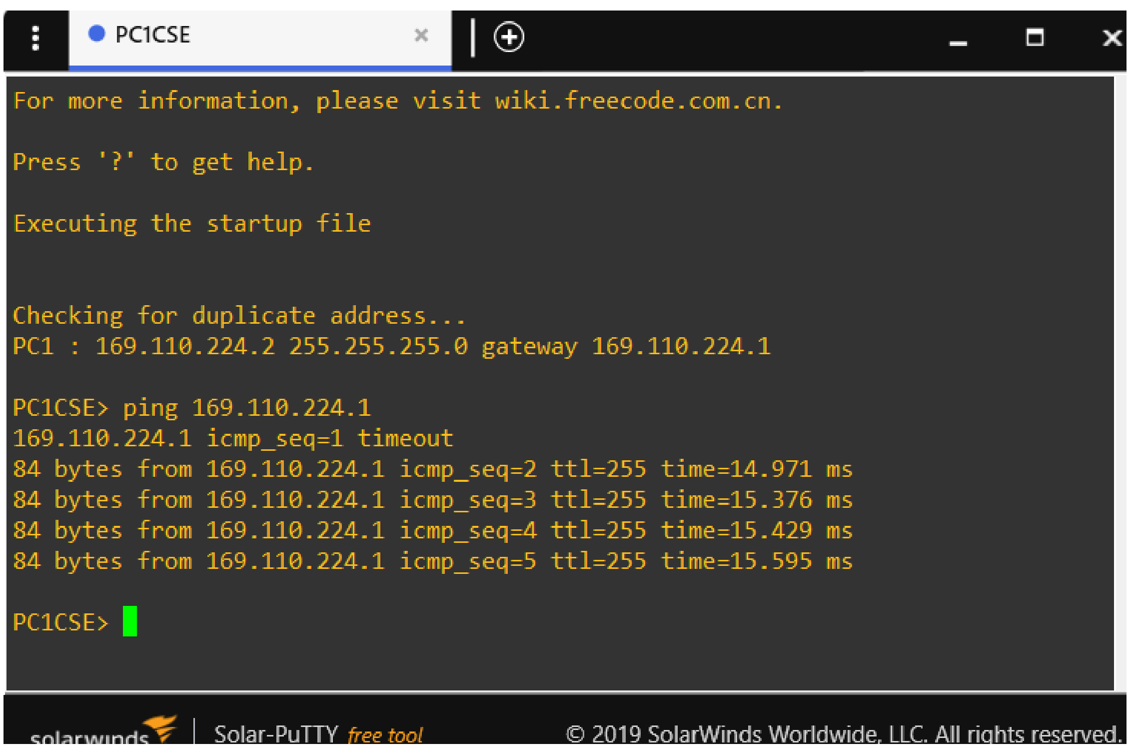


Figure-15

CIVIL:

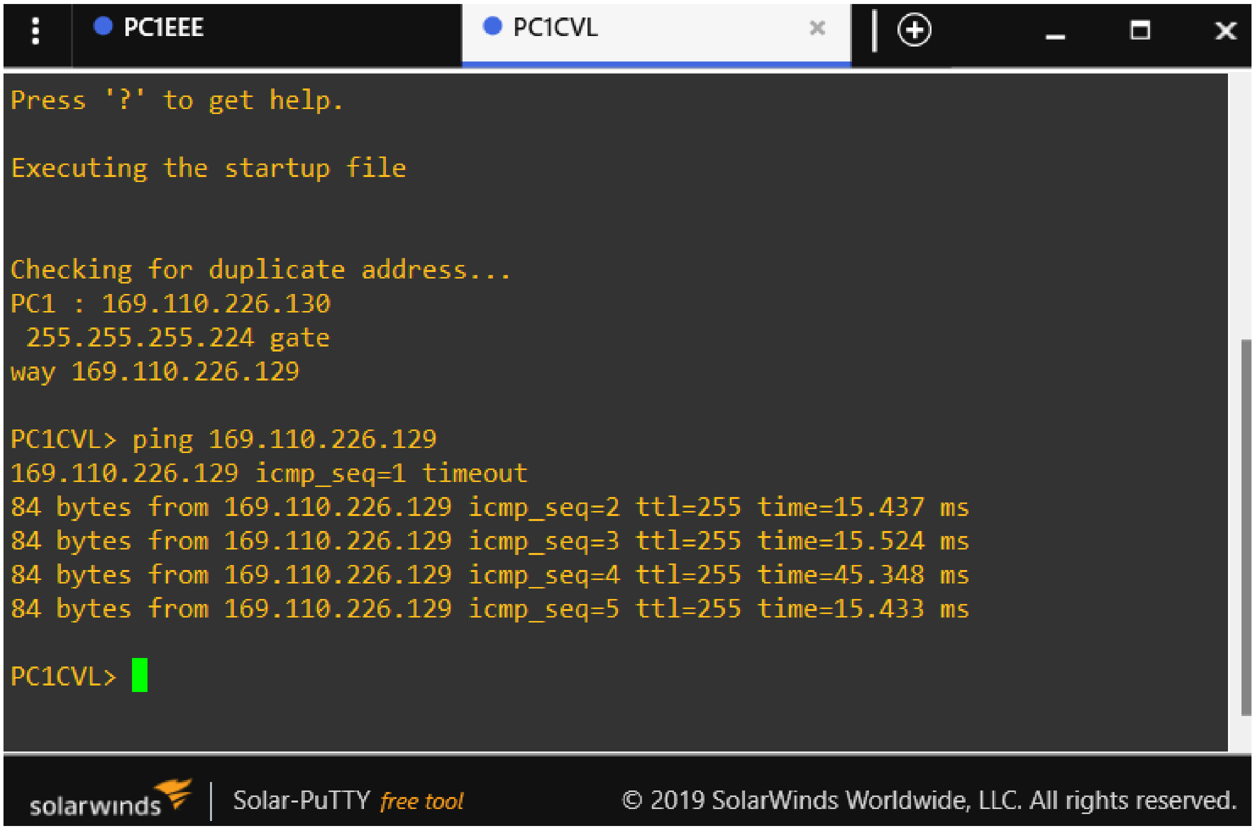


Figure-16

EEE:

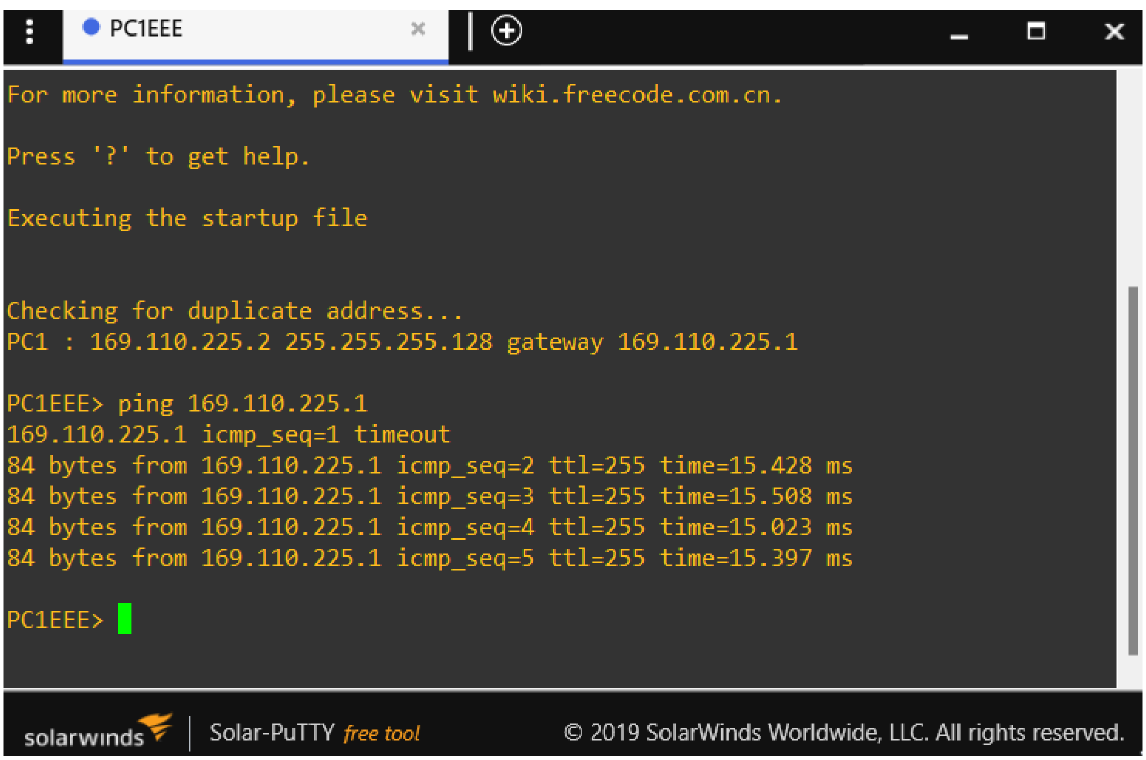


Figure-17

ELL:

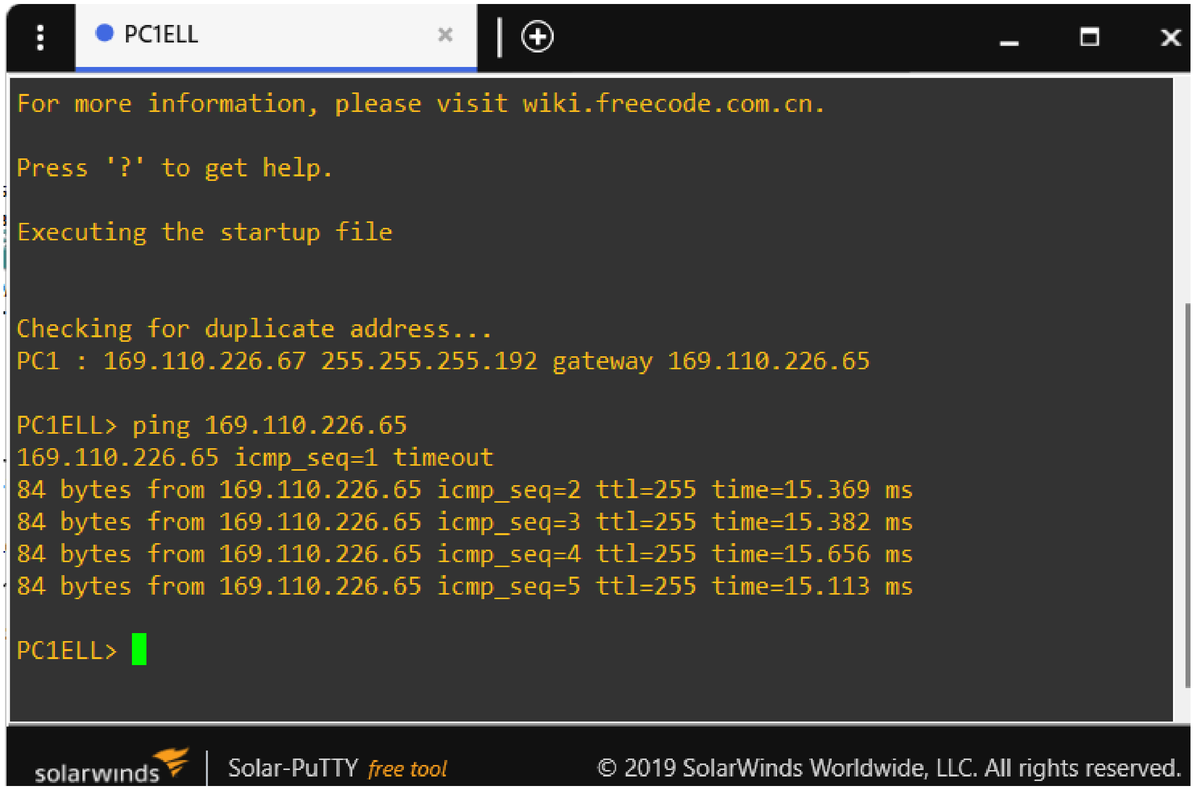


Figure-18

7.4. Pinging the Core router:

Admin:

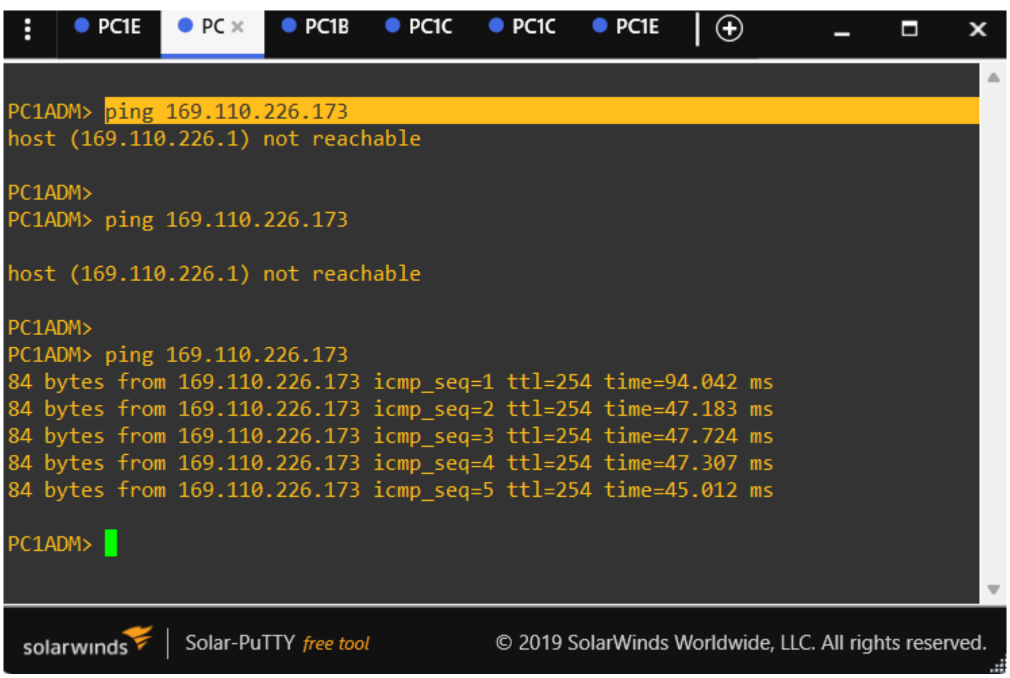


Figure-19

BBA:

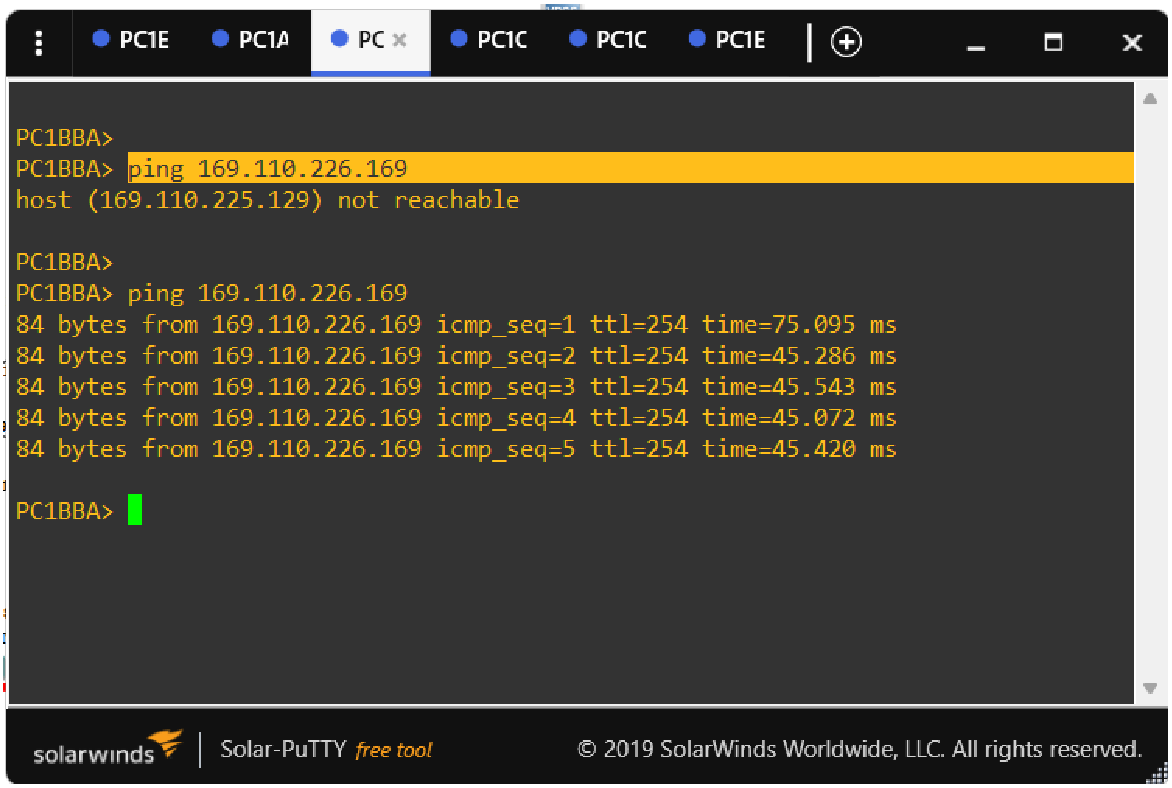


Figure-20

CSE:

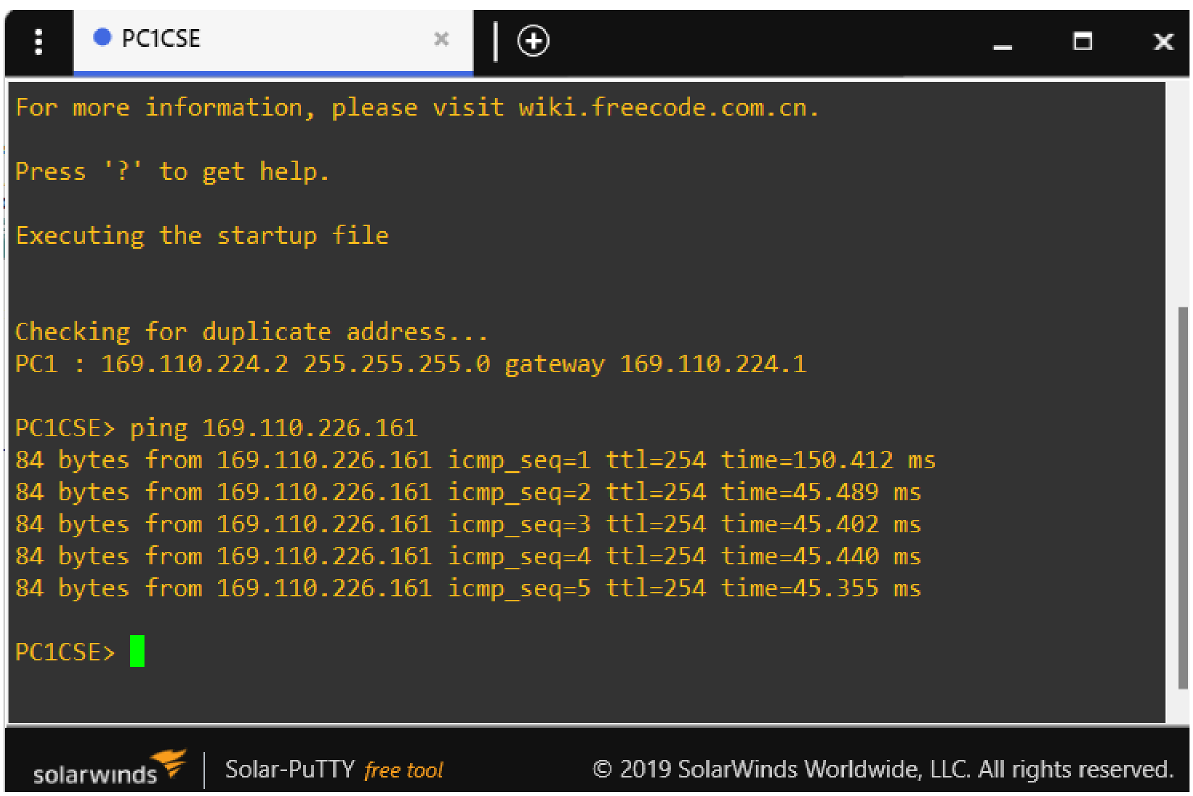


Figure-21

CIVIL:

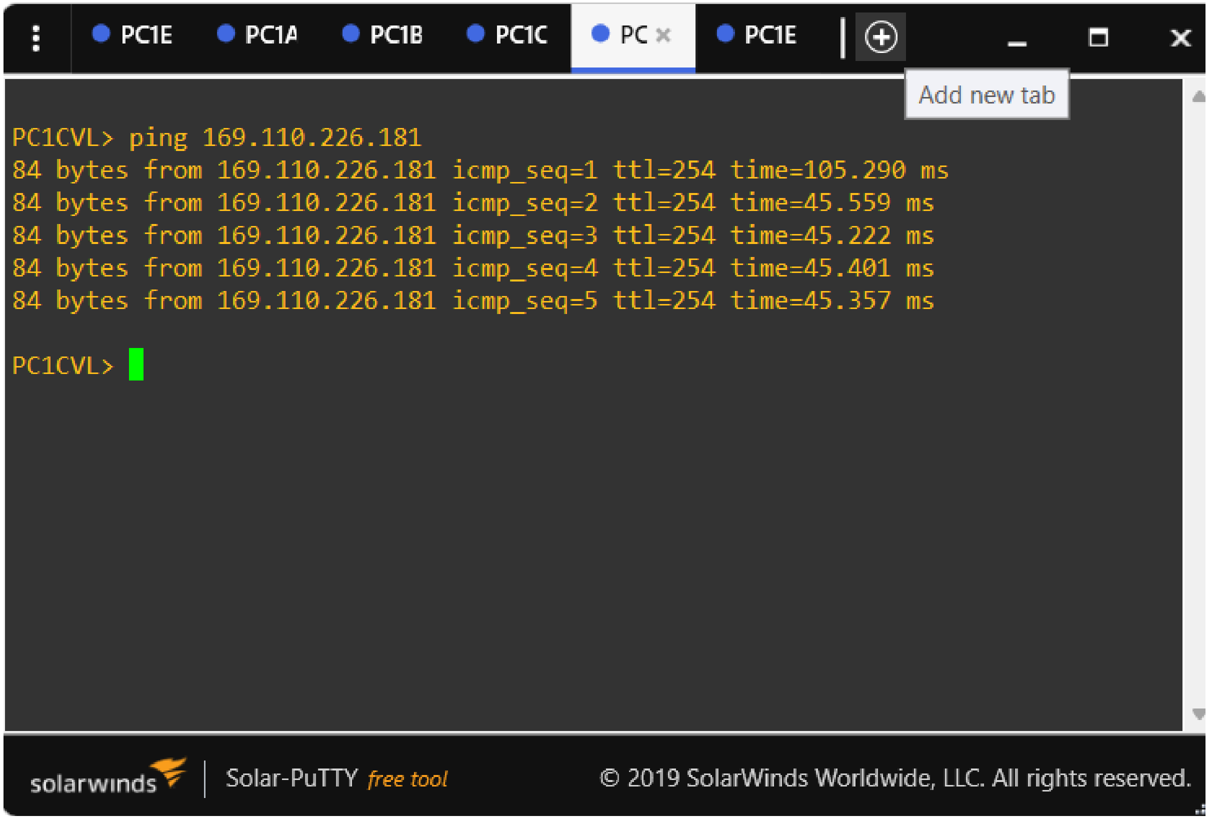


Figure-22

EEE:

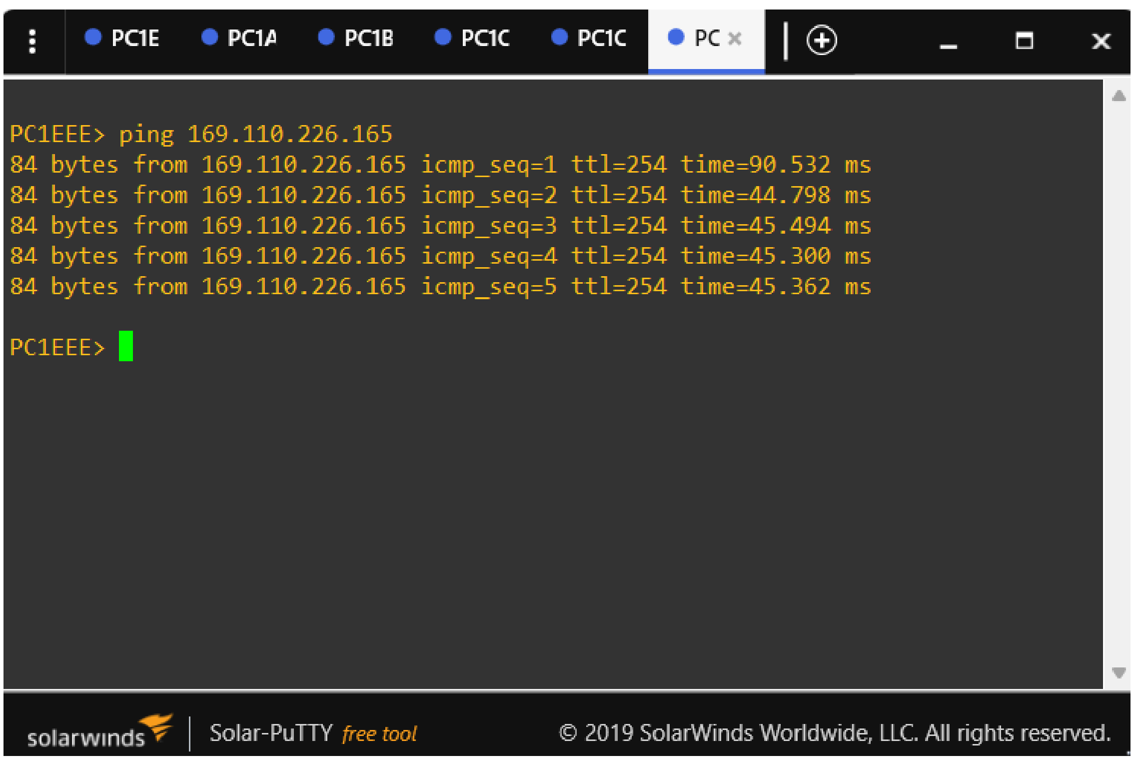


Figure-23

ELL:

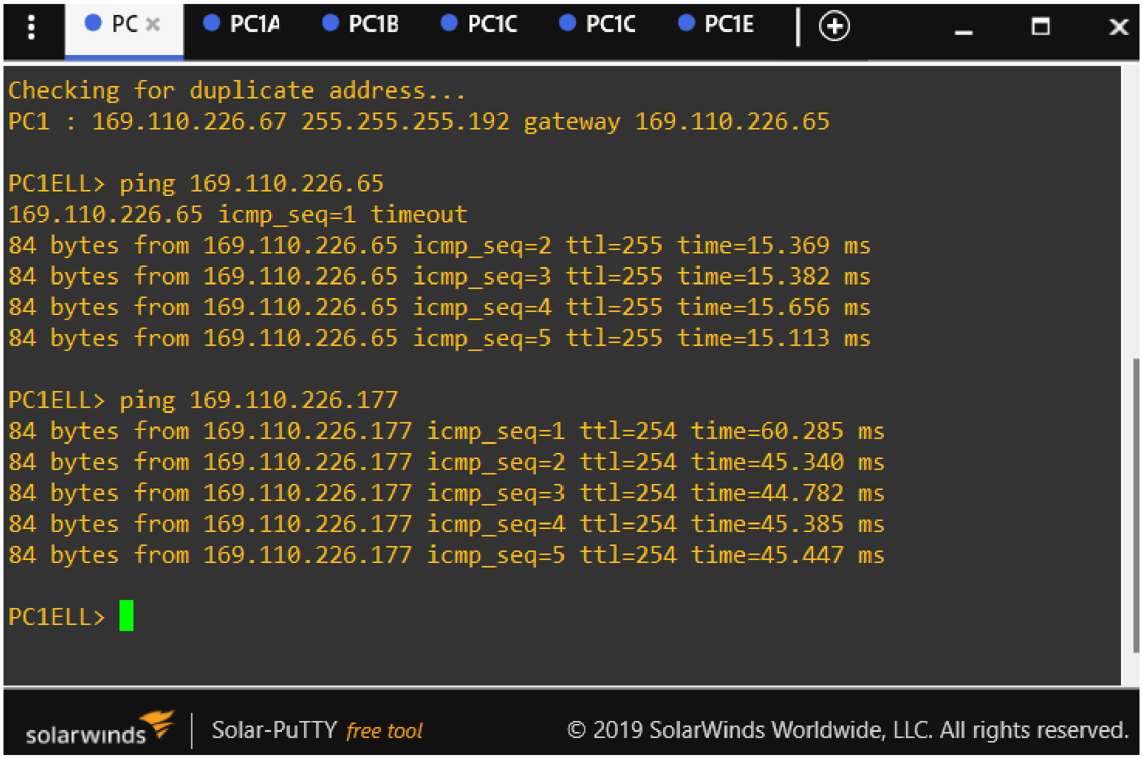


Figure-24

7.5. Pinging the host on other network:

Admin to CSE:

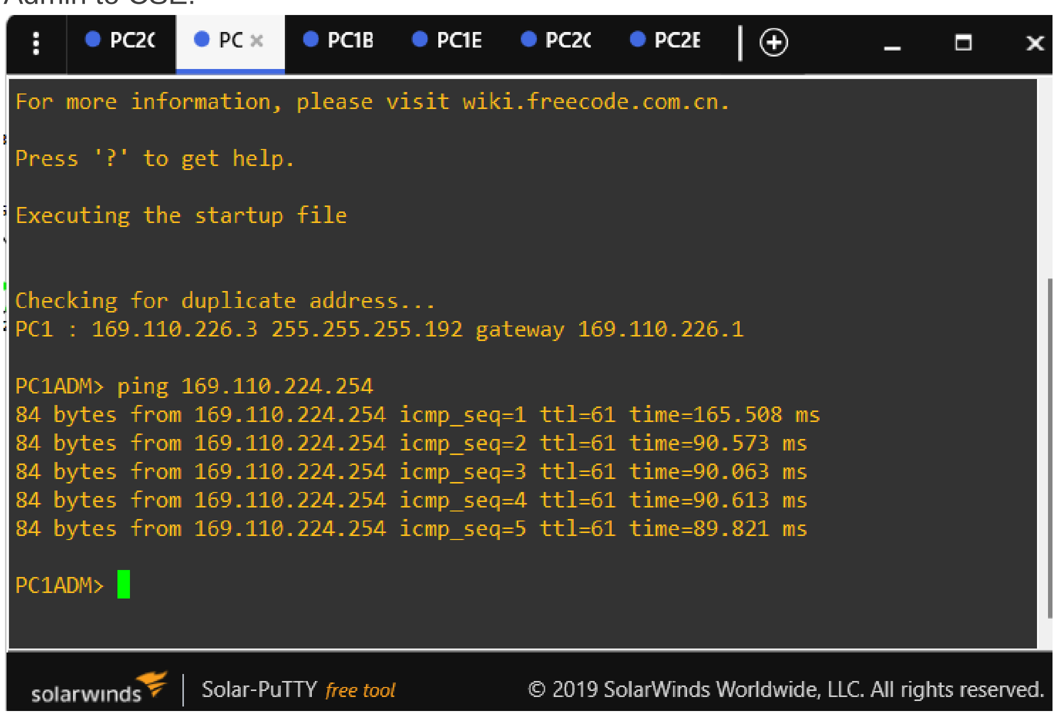


Figure-25

BBA to Admin:

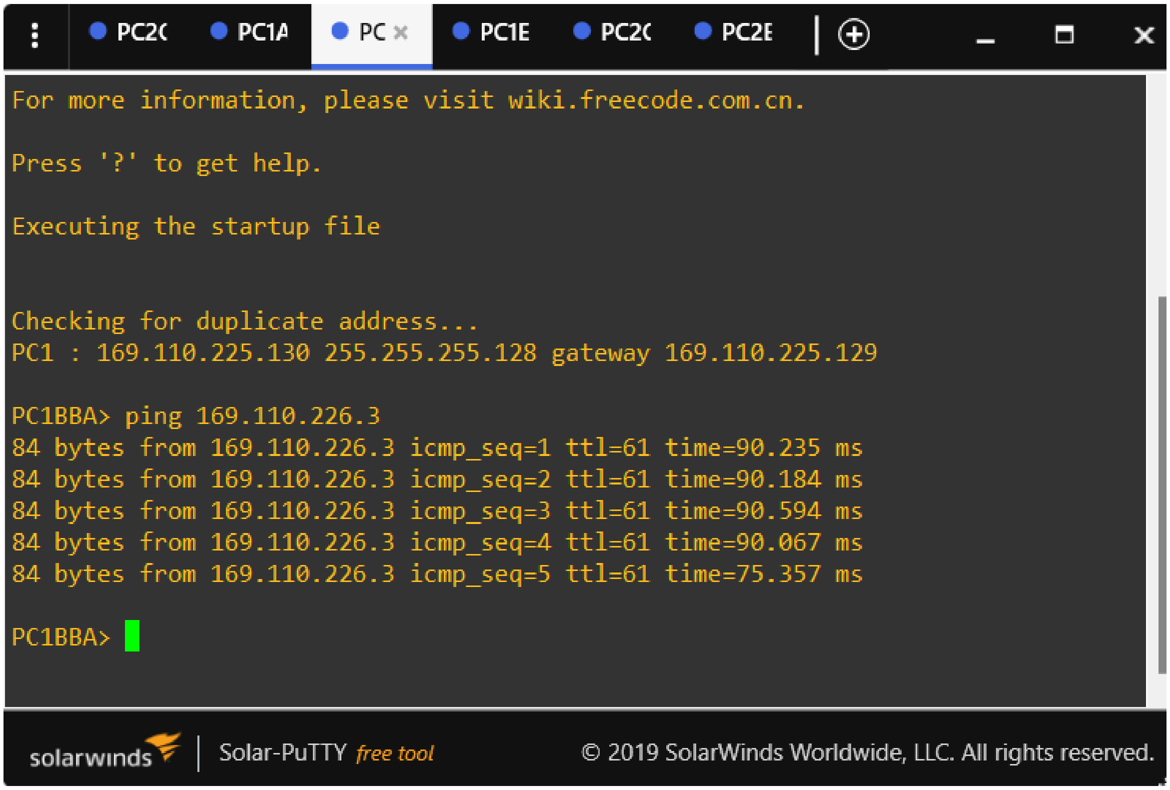


Figure-26

CSE to BBA:

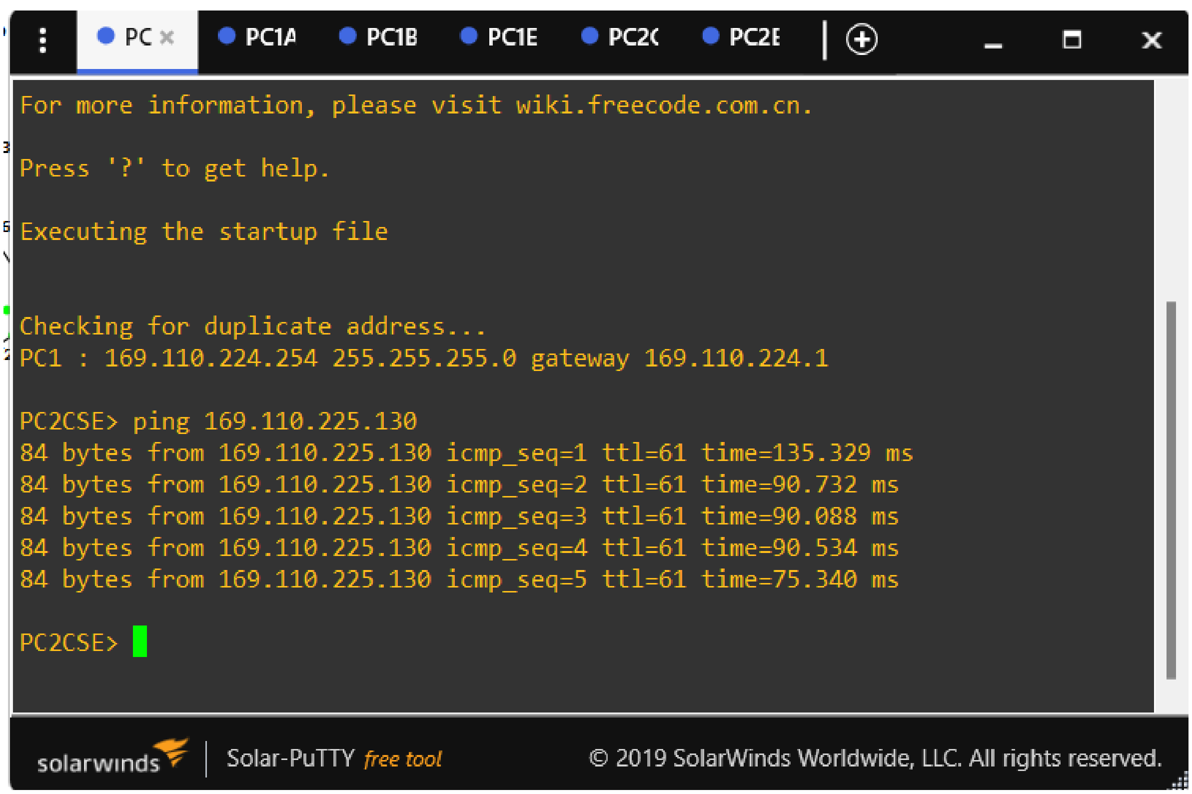


Figure-27

CIVIL to Admin:

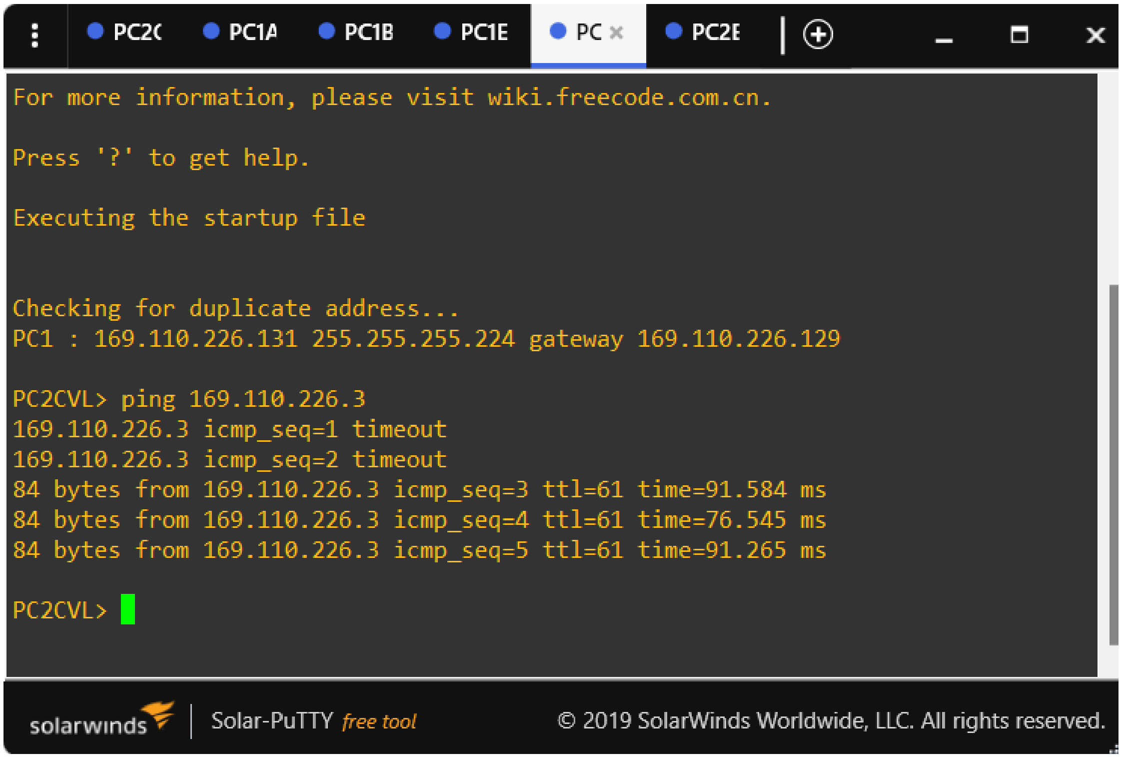


Figure-28

EEE to ELL:

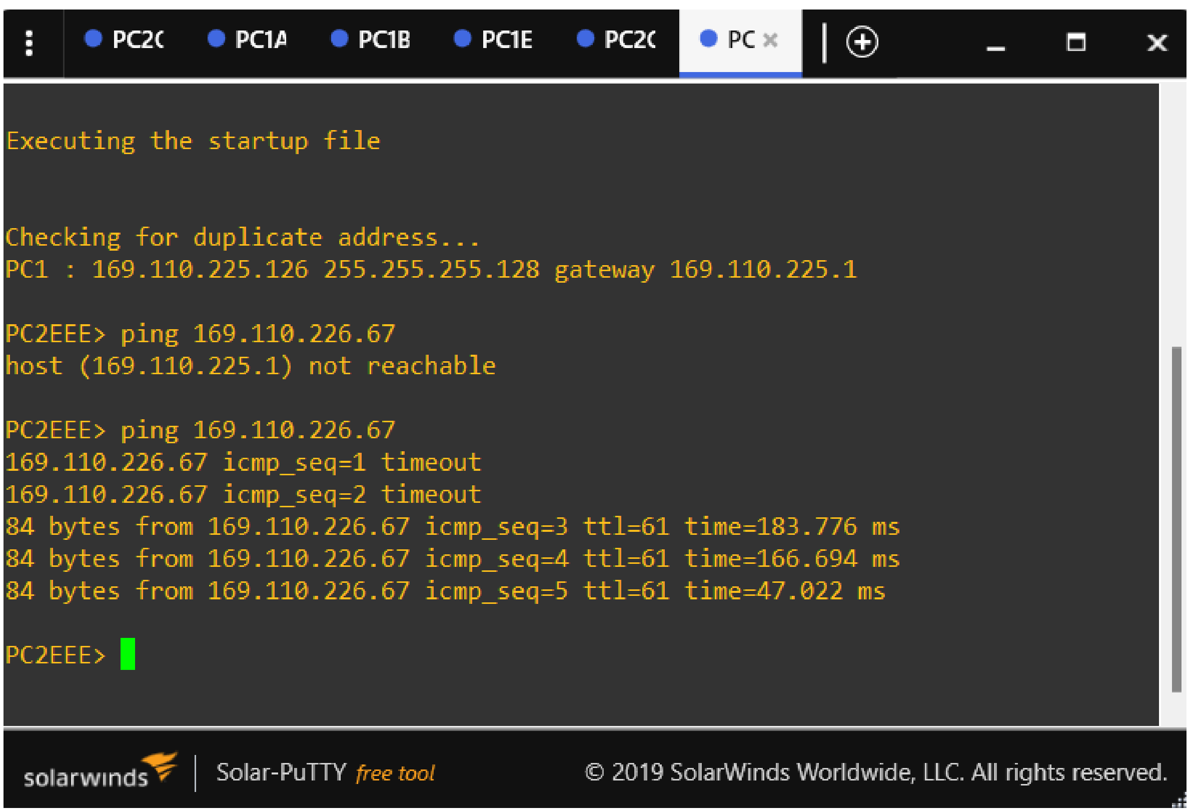


Figure-29

ELL to CSE:

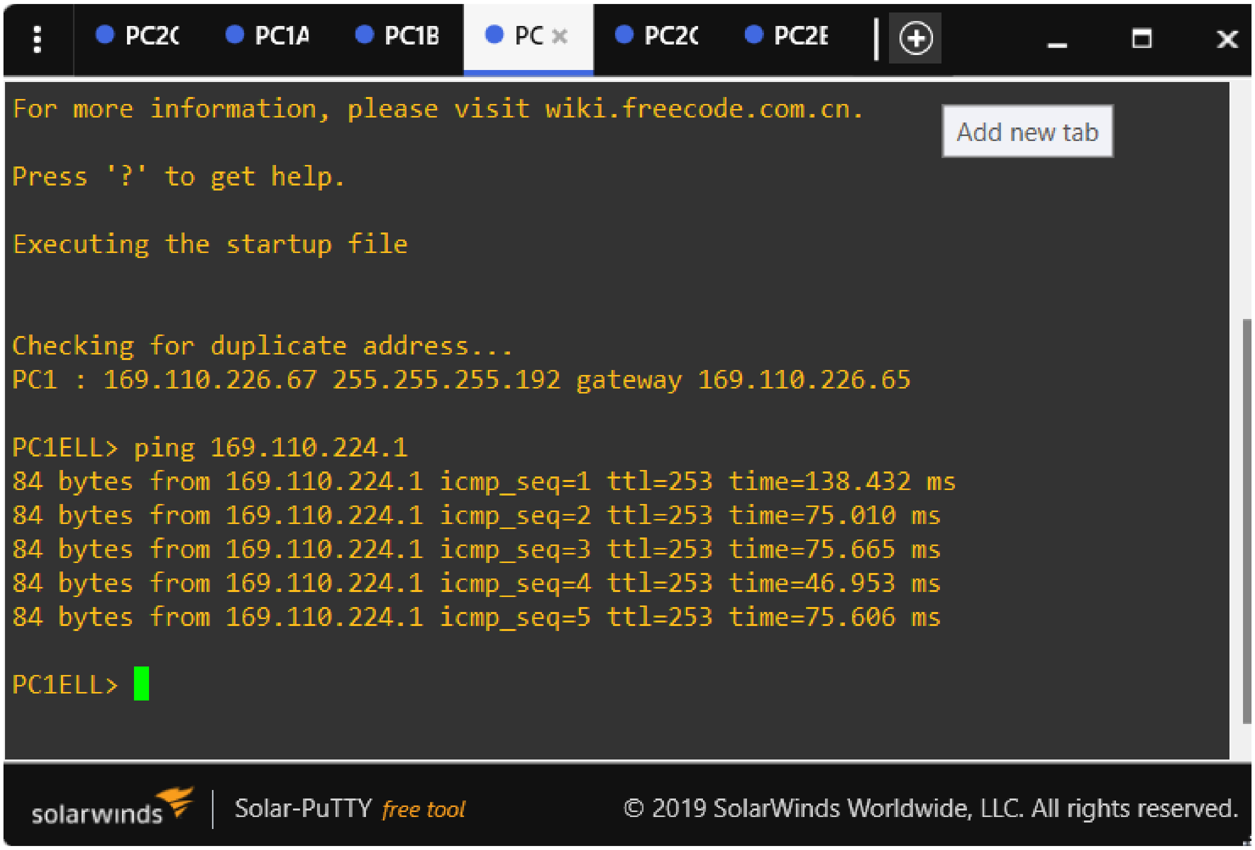


Figure-30

7.6. Table of ping results:

Ping in the same network:

Packet No.	CSE-to-CSE (ms)	EEE-to-EEE (ms)	BBA-to-BBA (ms)	Adm-to-Adm (ms)	ELL-to-ELL (ms)	CIVIL-to-CIVIL (ms)
1	0.640	0.666	0.549	0.427	0.655	0.627
2	0.846	0.551	0.875	0.517	0.729	0.663
3	0.889	0.559	0.627	0.713	0.707	0.570
4	0.608	0.682	0.780	0.832	0.825	0.708
5	0.610	0.670	0.569	0.819	0.688	0.571

Pinging Gateway Table:

Packet No.	CSE-to-CSE gateway (ms)	EEE-to-EEE gateway (ms)	BBA-to-BBA gateway (ms)	Adm-to-Adm gateway (ms)	ELL-to-ELL gateway (ms)	CIVIL-to-CIVIL gateway (ms)
1	timeout	timeout	timeout	timeout	timeout	Timeout
2	14.971	15.428	15.276	30.274	15.369	15.437
3	15.376	15.508	15.390	15.272	15.382	15.524
4	15.429	15.023	15.354	15.305	15.656	45.348
5	15.595	15.397	15.587	15.491	15.113	15.433

Core Router Ping Table:

Packet No.	CSE-to-CORE (ms)	EEE-to-CORE (ms)	BBA-to-CORE (ms)	Adm-to-CORE (ms)	ELL-to-CORE (ms)	CIVIL-to-CORE (ms)
1	150.412	90.532	75.095	94.042	60.285	105.290
2	45.489	44.798	45.286	47.182	45.340	45.559
3	45.402	45.494	45.543	47.724	44.782	45.222
4	45.440	45.300	45.072	47.307	45.385	45.401
5	45.355	45.362	45.420	45.012	45.447	45.357

Ping to the Hosts to other networks:

Packet No.	Adm-to-CSE (ms)	BBA-to-Adm (ms)	CSE-to-BBA (ms)	CIVIL-to-Adm (ms)	EEE-to-ELL (ms)	ELL-to-CSE (ms)
1	165.508	90.235	135.329	timeout	timeout	138.432
2	90.573	90.184	90.732	timeout	timeout	75.010
3	90.063	90.594	90.088	91.584	183.776	75.665
4	90.613	90.067	90.534	76.545	166.694	46.953
5	89.821	75.357	75.340	91.265	47.022	75.606

7.7. Bar chart of Ping results:

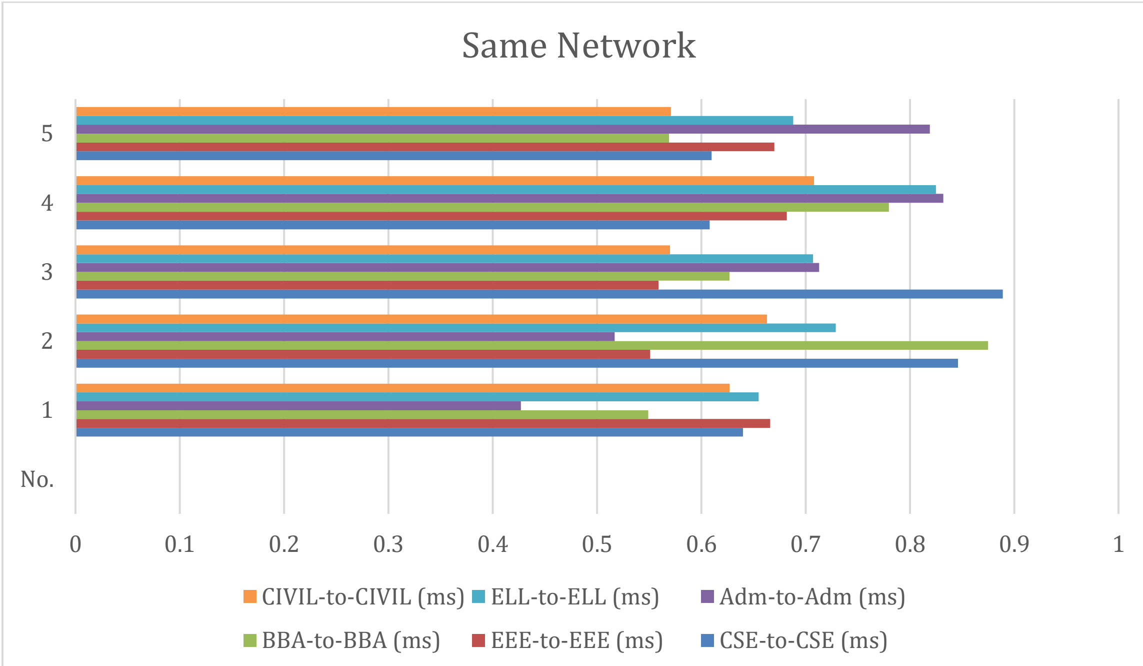


Figure-31

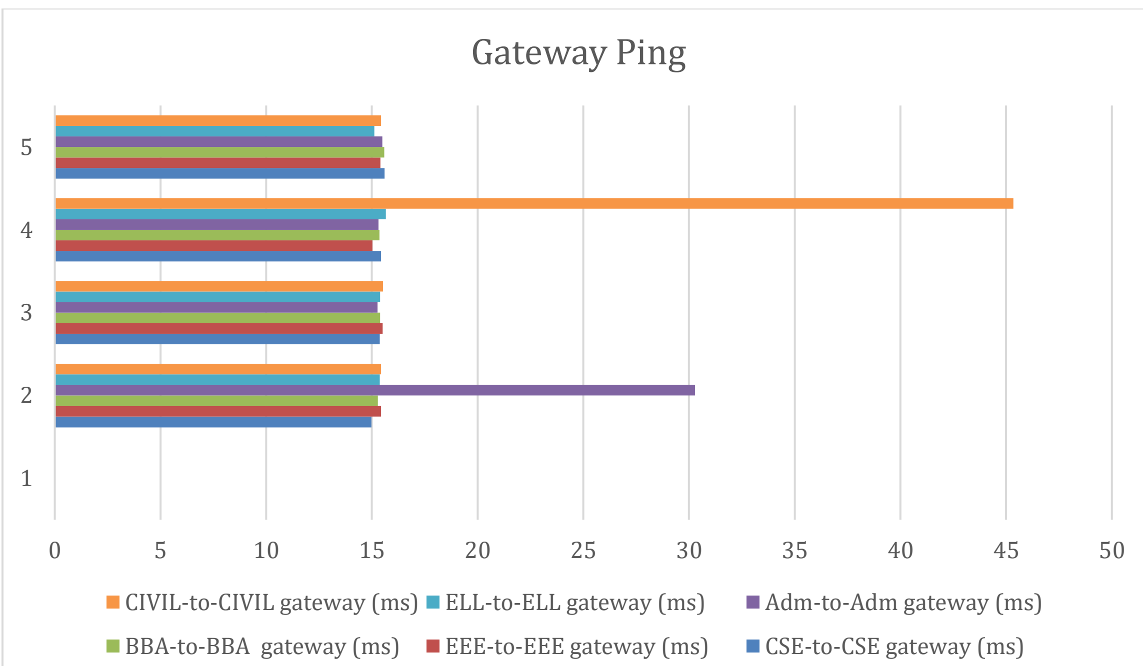


Figure-32

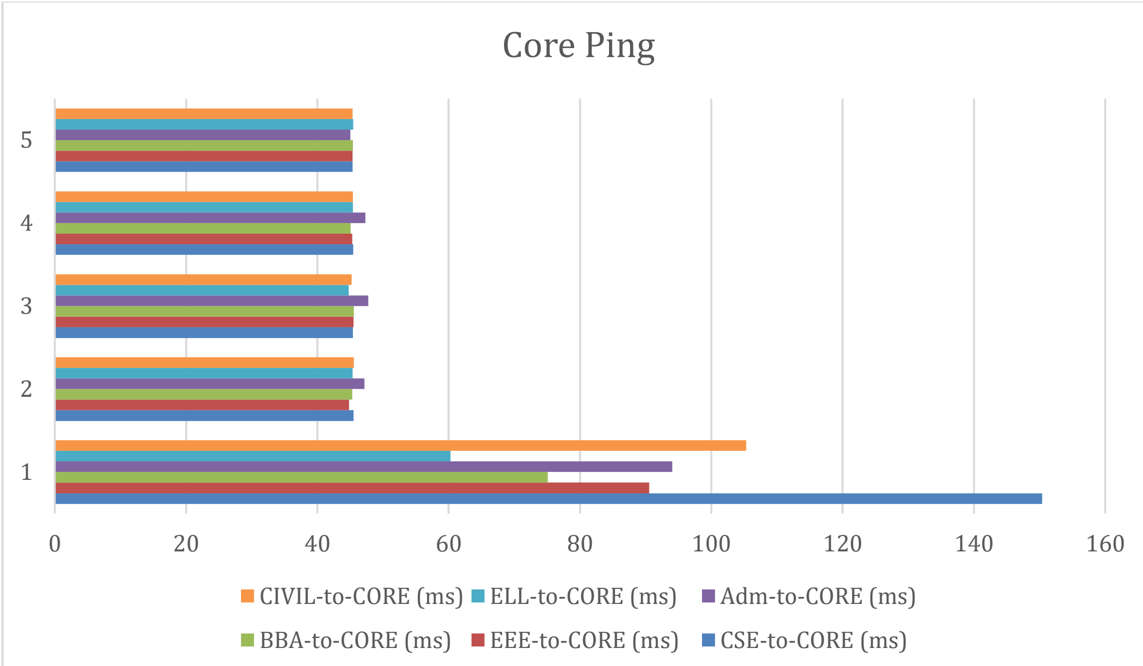


Figure-33

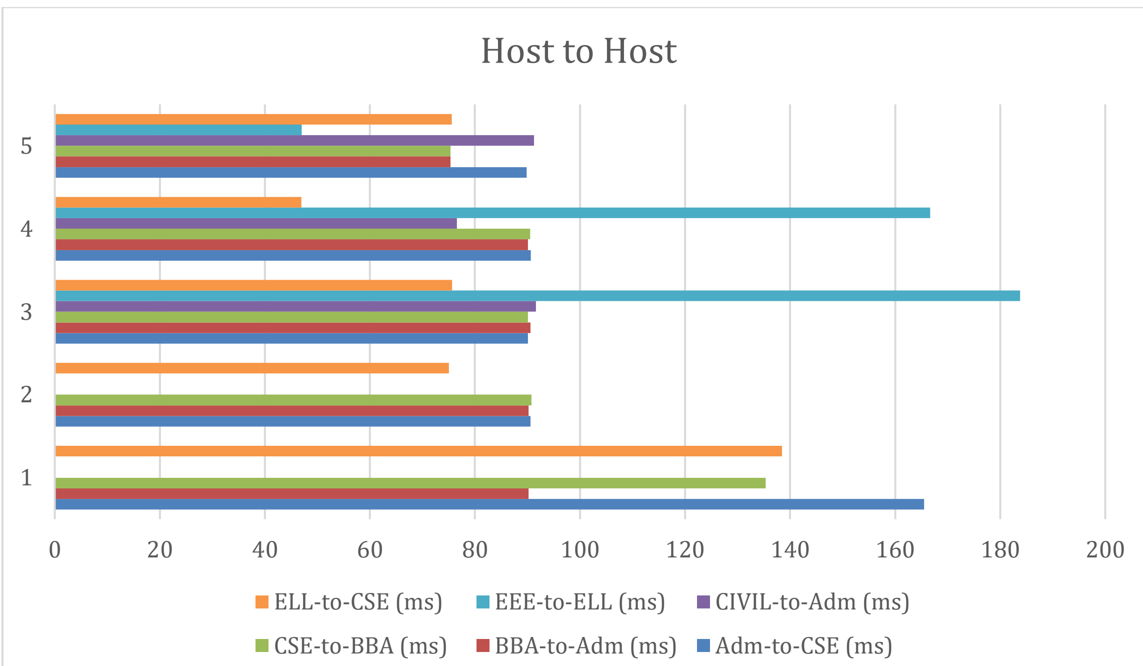


Figure-34

7.8. Discussion on result: After pinging the core router, hosts, on same networks, we can see that there were no faults as in there not a single result where the other device didn't ping back. Also we included the detailed timings of the pings. So we can say that our results are accurate and the network works perfectly.

8. **Future Work**: Future work can include doing the same network but this time we can make it dynamic rather than static. We can also extend the network if necessary.

9. **Conclusions**: After doing all the designing, subnetting, routing, IP assigning, result analysis we can say that our project is a success. Because by looking at the results we can see that all the devices and routers of all the departments can communicate with each other without any problem and that was our main goal when we started the project.

10. **References**:

- GNS3 doc: https://docs.gns3.com/docs/
- Project Format: https://docs.google.com/document/d/1XYSfDQnW0E2sAnnB1_5auTSHXd9CAIhDbgRZt5EYgY0/edit
- Yaser Rahmati's Exercise on commands: https://yaser-rahmati.gitbook.io/gns3/lab-3-configure-static-route-in-gns3
- Dr. AK session: https://www.youtube.com/watch?v=HkizT7oNLtE&feature=youtu.be
- Documentation of GNS3: https://gns3.com/community/discussions/gns3-documentation