Faculty of Engineering and Technology

Department of Electrical and Computer Engineering

ENCS3320-Computer Networks

Project #2: Cisco Packet Tracer

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Abstract

The aim of the project is to focus on creating and testing computer networks, to understand and apply key networking concepts like IP addressing, subnetting, routing, switching, VLANs, and network security, using Cisco Packet Tracer, through this project, a network is designed to simulate real-world scenarios, where devices like routers, switches, and computers are configured and tested. Packet Tracer allows us to simulate data flow, troubleshoot issues, and explore advanced networking protocols such as OSPF and EIGRP.

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Theory

• Subnetting

Subnetting involves breaking a large IP address range into smaller, more manageable sub-networks. This approach helps optimize IP address usage, reduce network congestion, and improve security by isolating different parts of the network. In this project, subnetting ensures that each part of the network, such as the servers, ECE subnet, CS subnet, and backbone has enough addresses for all devices while minimizing wasted space. Subnet sizes are defined using CIDR notation, for example /24 for 256 IPs and subnet masks, for example 255.255.255.0.

• Domain Name System (DNS)

DNS is essential for making the internet user-friendly by translating easy-to-remember domain names, like gmail.com, into the IP addresses that computers use to communicate. It also manages key domain records, such as A records (linking domain names to IP addresses), NS records (defining authoritative name servers), and CNAME records (creating domain aliases). In this project, the DNS server is set up to handle domain resolution for addresses like www.it.birzeit.edu and gmail.com. It also plays a crucial role in supporting email servers and other services, ensuring smooth communication across the network.

• Email Services

Email services make communication possible by using protocols like SMTP and POP3. SMTP is responsible for sending emails, while POP3 is used to retrieve messages from a server to a client device. In this project, email servers are configured with fixed IP addresses and domain-specific names, such as mail.it.birzeit.edu, along with user accounts for team members. To ensure everything works correctly, the setup is tested by sending and receiving emails between domains like gmail.com and it.birzeit.edu, while also verifying that DNS resolves the mail servers properly.

- ## Web Services

A web server plays an important role in any network, hosting websites and delivering web pages to users when requested. It relies on protocols like HTTP and HTTPS to transfer data between the server and client devices, ensuring secure and smooth access to websites. In this project, the web server is set up to host the Faculty of Engineering and Technology's website at www.it.birzeit.edu. To ensure reliable access, the server is assigned a static IP and configured to handle both HTTP and HTTPS requests, enabling secure communication through encryption. The website's homepage is customized with details about the faculty, including information on the Electrical and Computer Engineering (ECE) and Computer Science (CS) departments. It features visuals, formatted text, and other elements to create a user-friendly and professional experience. Testing includes making sure the website is accessible from different devices on the network and verifying that the DNS correctly resolves the domain name to the server's IP address for seamless user access.

- ## Dynamic Host Configuration Protocol (DHCP)

DHCP streamlines the process of assigning IP addresses to devices within a network by automating the task, eliminating the need for manual configuration. This efficiency is achieved through DHCP servers, which dynamically allocate IP addresses from predefined pools, along with essential network details such as the subnet mask, default gateway, and DNS server settings. By doing so, it reduces the potential for errors, accelerates deployment, and enables devices to easily join and leave the network. In this project, distinct DHCP pools are established for the ECE and CS subnets, ensuring that devices in each subnet are dynamically assigned IP addresses while still reserving a few static addresses for essential devices like printers and servers.

- ## Network Address Translation (NAT)

NAT (Network Address Translation) acts like a gateway for devices within a private network, allowing them to access the internet using just one public IP address. Instead of each device needing its own public IP, NAT translates the private IP addresses of all the devices in the network into a single public IP when they connect to the internet. This helps save valuable public IP addresses and adds an extra layer of security by hiding the internal network's details from the outside world.

- ## BGP (Border Gateway Protocol)

BGP is designed to manage how data is routed between different networks, often across the internet, making it essential for communication between multiple autonomous systems (AS). Unlike protocols that work within a single network, BGP helps decide the best path for data to travel between separate networks by exchanging information based on attributes like the AS path. It also uses policies to determine the most efficient route. In this project, BGP is set up to ensure smooth communication between various networks, such as Google, the Faculty of Engineering, and Home-ISP, allowing data to flow efficiently across diverse and distant networks.

- ## OSPF (Open Shortest Path First)

OSPF (Open Shortest Path First) is a link-state protocol that helps routers within the same network (autonomous system or AS) figure out the best routes to send data. It works by sharing detailed information about the network's layout, allowing each router to create a complete map of how the network is structured. By considering factors like bandwidth and delay, OSPF calculates the most efficient path for data to travel. In this project, OSPF is set up for routing within the network, with different areas defined (such as Area 0 for the backbone) to improve routing efficiency and boost overall network performance.

Procedure

- ## Subnetting

In As-100, it assigned 180.39.72.0/24 for all IPs in the AS, the AS divided into 4 subnets with different sizes as follows: first, we Sort Subnets from Highest to Lowest:

- ECE Subnet: 120 IP Required
- CS Subnet: 55 IP Required
- Servers Subnet: 28 IP Required
- Backbone Subnet: 4 IP Required

We take the first Client Bit from the left and add it to the Network Bits

- The first split: 180.39.72.0/24 -> 180.39.72.00000000 there are two possibilities 0 and 1:

  180.39.72.00000000 -> 180.39.72.0/25 (128 Available IP)

  180.39.72.10000000 -> 180.39.72.128/25 (128 Available IP)

  We assigned to the ECE Subnet 180.39.72.128/25

- The second split:180.39.72.0/24->180.39.72.00000000 there are two possibilities 0 and 1:

  180.39.72.00000000 -> 180.39.72.0/26 (64 Available IP)

  180.39.72.01000000 -> 180.39.72.64/26 (64 Available IP)

  We assigned to the CS Subnet 180.39.72.64/26

- The third split: 180.39.72.0/24 -> 180.39.72.00000000 there are two possibilities 0 and 1:

  180.39.72.00000000 -> 180.39.72.0/27 (32 Available IP)

  180.39.72.00100000 -> 180.39.72.32/27 (32 Available IP)

  We assigned to the Servers Subnet 180.39.72.32/27

- The fourth split:180.39.72.0/24->180.39.72.00000000 there are two possibilities 0 and 1:

  180.39.72.00000000 -> 180.39.72.0/28 (16 Available IP)

  180.39.72.00010000 -> 180.39.72.16/28 (16 Available IP)

But we need more optimization, so we split it again

- The fifth split: 180.39.72.0/24 -> 180.39.72.00000000 there are two possibilities 0 and 1:

  180.39.72.00000000 -> 180.39.72.0/29 (8 Available IP)

  180.39.72.00001000 -> 180.39.72.8/29 (8 Available IP)

  We assigned to the BackBone Subnet 180.39.72.8/29

Table 1: Subnetting for AS-100

Subnet Name	Subnet IP	Subnet Mask	Broadcast IP	First Usable IP	Last Usable IP
ECE	180.39.72.128/25	255.255.255.128	180.39.72.255	180.39.72.129	180.39.72.254
CS	180.39.72.64/26	255.255.255.192	180.39.72.127	180.39.72.65	180.39.72.126
Servers	180.39.72.32/27	255.255.255.224	180.39.72.63	180.39.72.33	180.39.72.62
BackBone	180.39.72.8/29	255.255.255.248	180.39.72.15	180.39.72.9	180.39.72.14

- ## Building the Topology

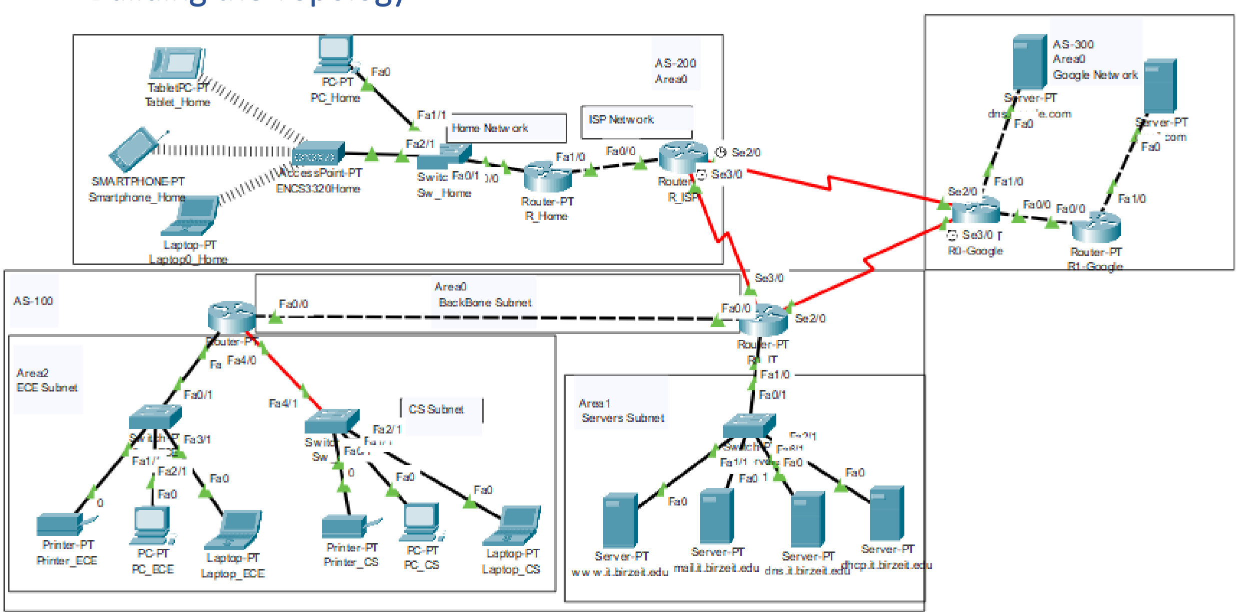

Figure 1: Topology

Results & Discussions

- ## Google Network AS-300:
- ## Discussion:

The Google network is a vital part of the topology, acting as a hub for domain name resolution and email services. By setting up a DNS server (dns.google.com), the network ensures that domain names like gmail.com are translated into IP addresses, making communication smooth and intuitive for users. The email server allows team members to send and receive emails using standard protocols like SMTP and POP3, reflecting real-world scenarios. Static IP configurations ensure reliability and predictability, while OSPF handles routing efficiently within the network. BGP enables the Google network to communicate with other autonomous systems, like the Faculty and Home-ISP networks, ensuring everything stays interconnected.

- ## Results:

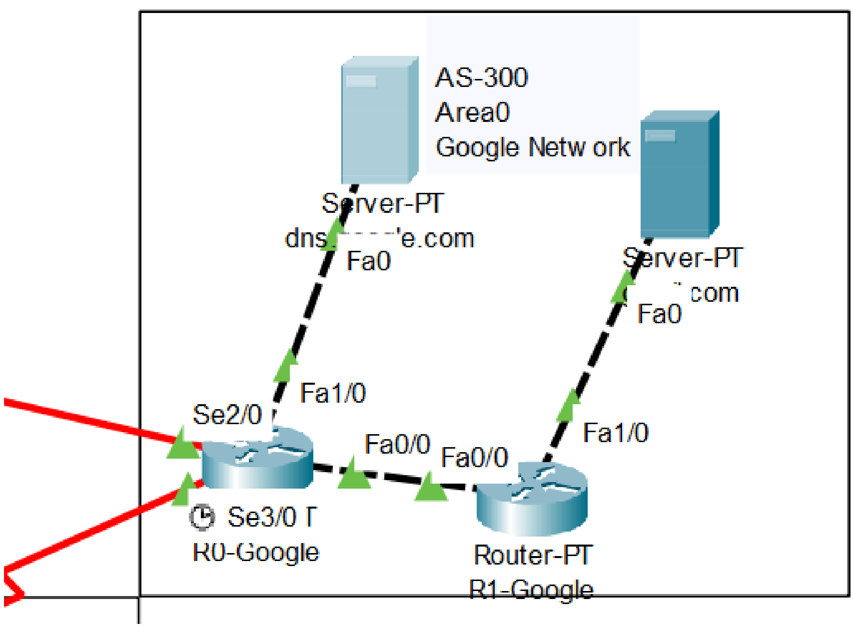

Figure 2: Google Network AS-300 Topology

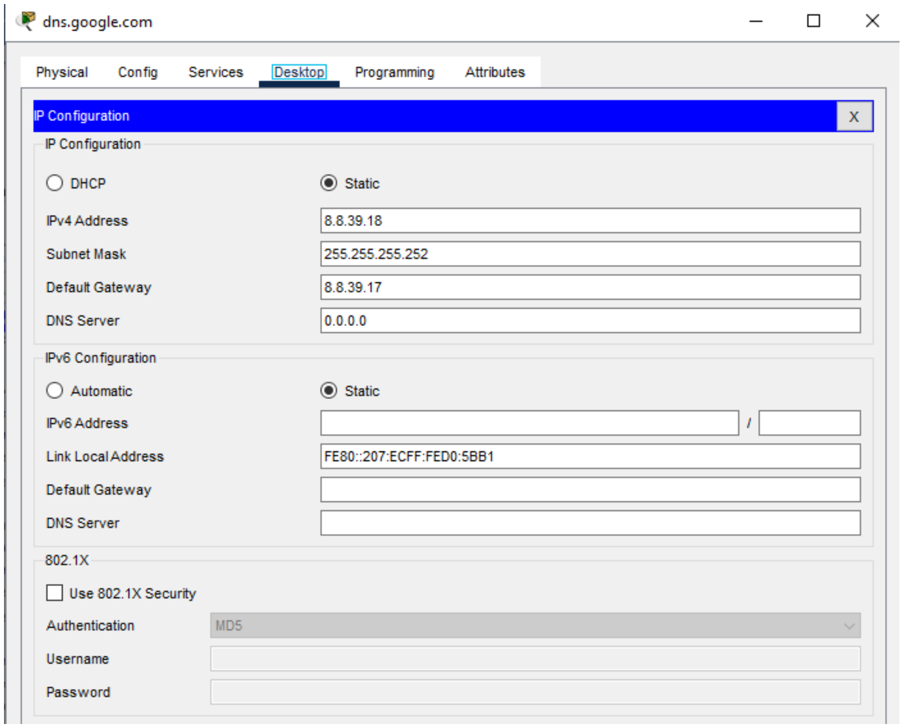

Figure 3: dns.google.com server IP configuration

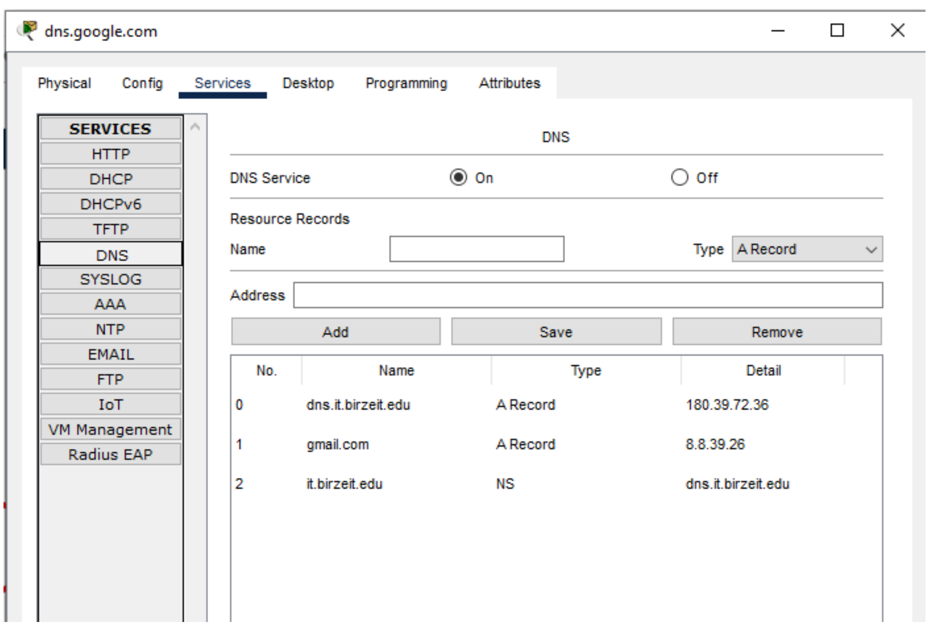

Figure 4: dns.google.com server DNS services

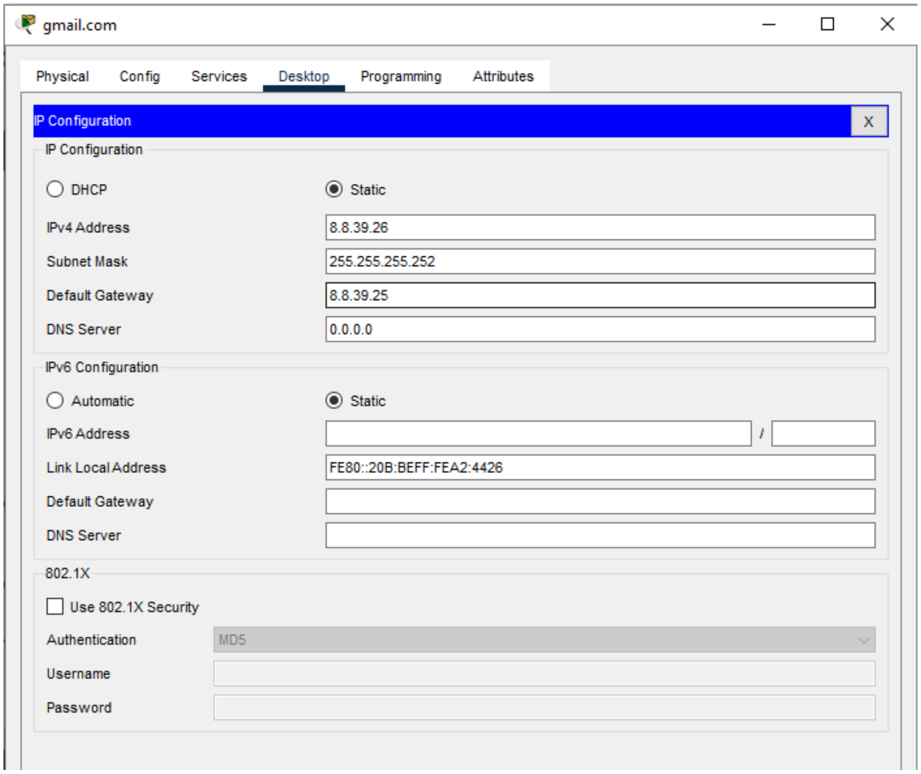

Figure 5: gmail.com server IP configuration

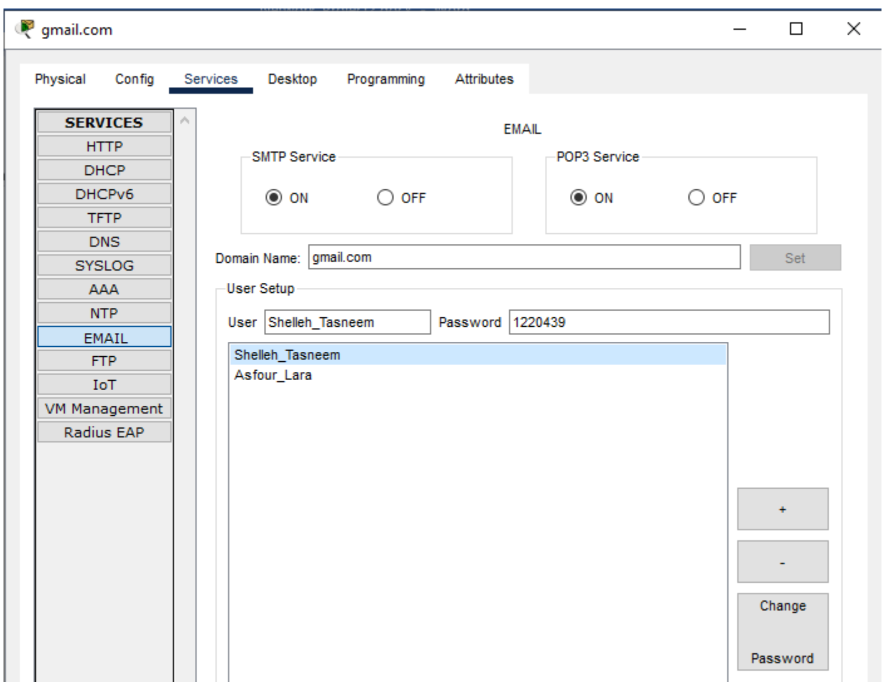

Figure 6: gmail.com server EMAIL services

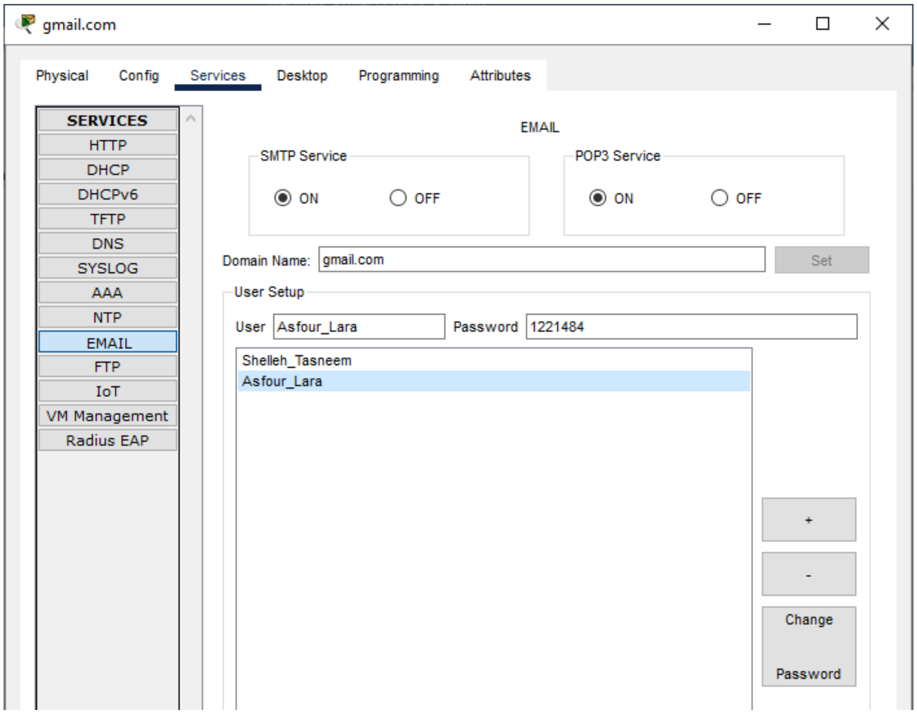

Figure 7: gmail.com server EMAIL services

- ## Faculty of Engineering and Technology Network (AS-100)

- ## Discussion:

The Faculty network is where things get a bit more intricate. It's divided into subnets designed for specific purposes, like the Electrical and Computer Engineering (ECE) and Computer Science (CS) departments. This setup helps keep things organized and ensures devices get the resources they need. The DHCP server simplifies the process of assigning IP addresses to devices, while the DNS server resolves local domain names like it.birzeit.edu to their respective IPs. The email server provides a professional email service for team members, and the web server hosts a customized page for the Faculty. OSPF is used here in a more complex way, with multiple areas to ensure scalability. It's a well-thought-out network that balances functionality and future-proofing.

* Results:

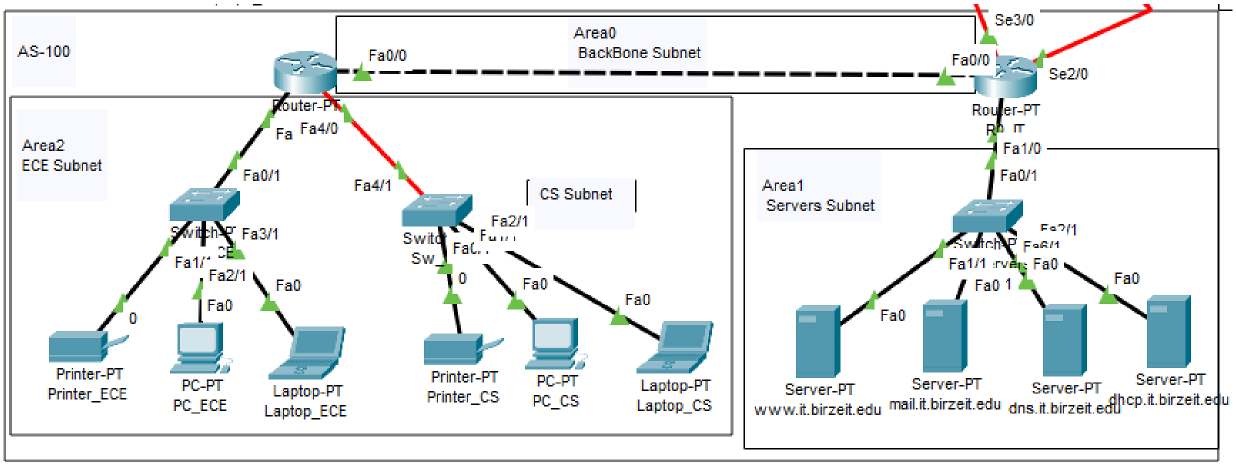

Figure 8: AS-100 Topology

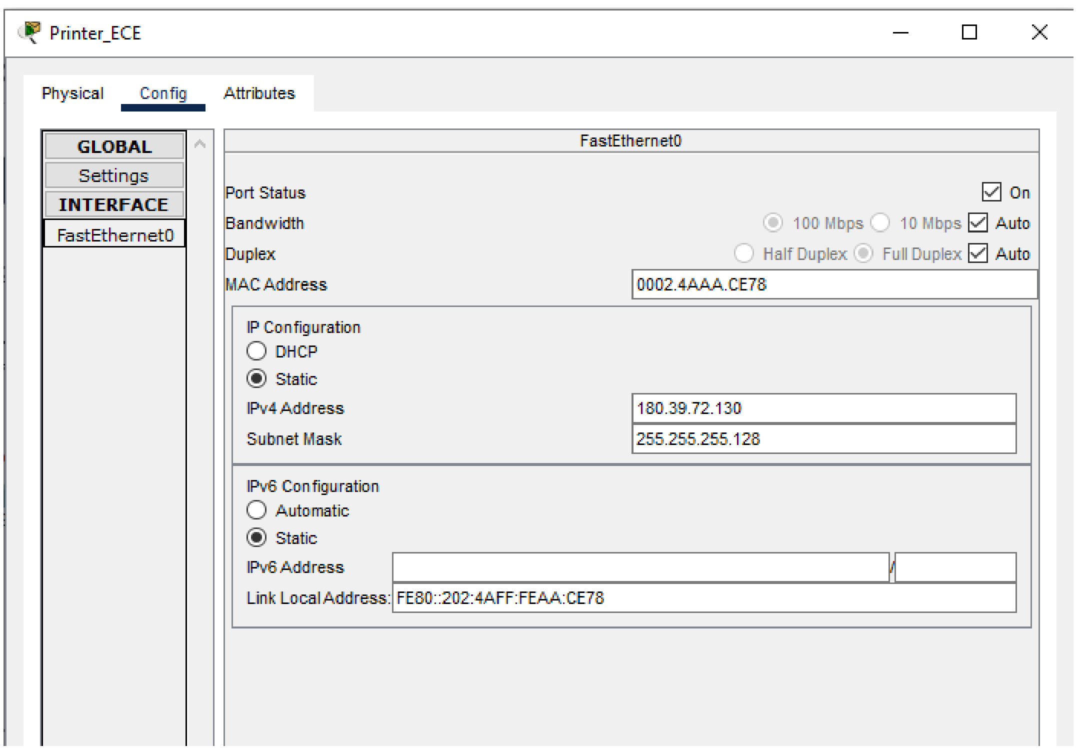

Figure 9: Printer_ECE IP configuration

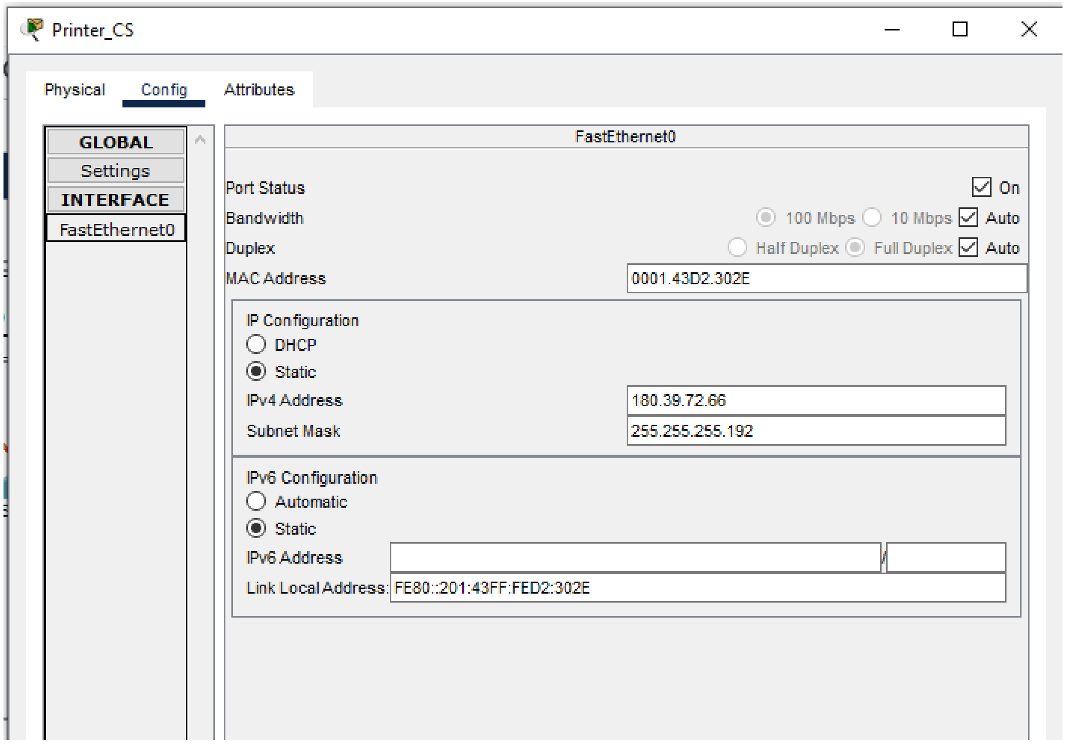

Figure 10: Printer_CS IP configuration

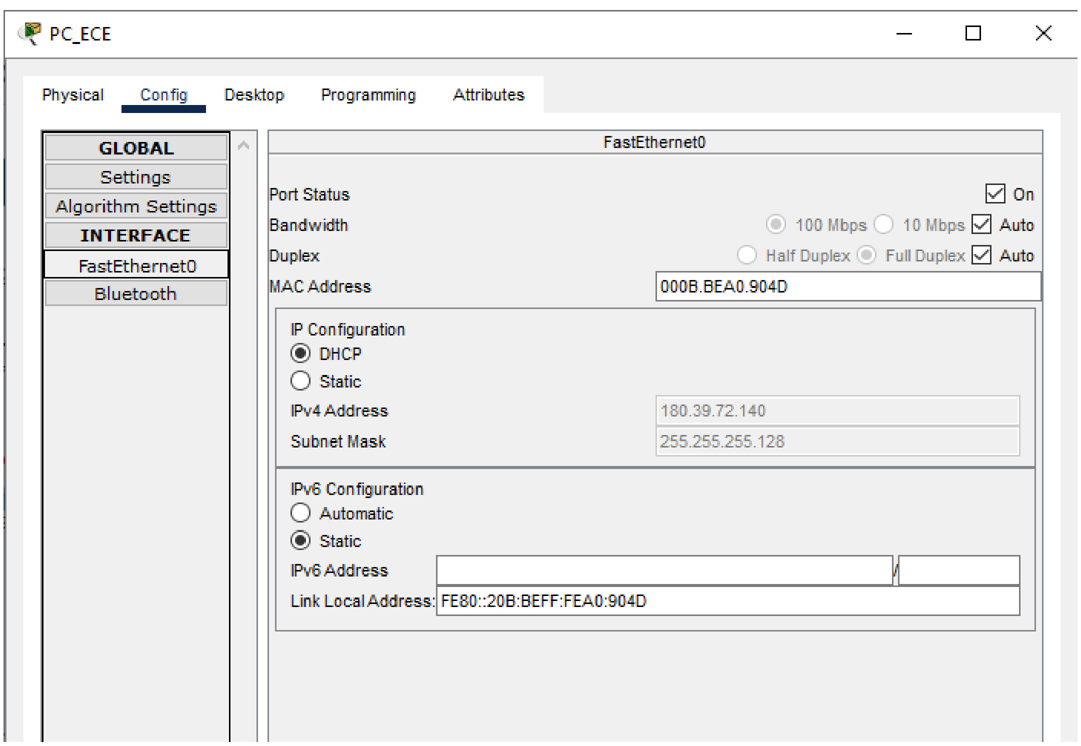

Figure 11: PC_ECE IP configuration

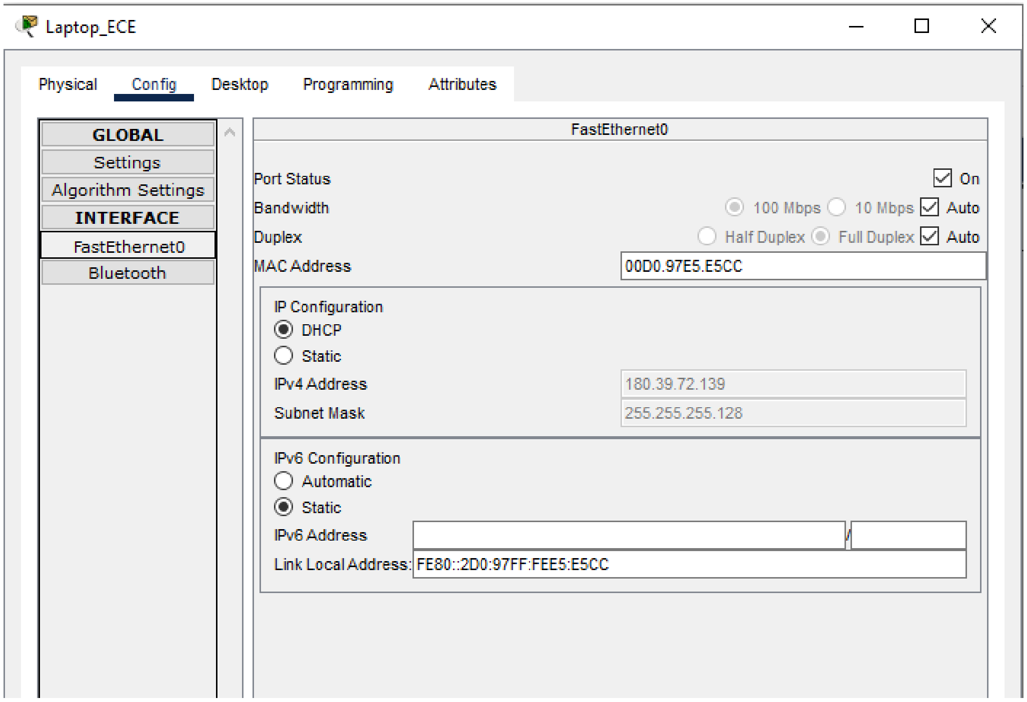

Figure 12: Laptop_ECE IP configuration

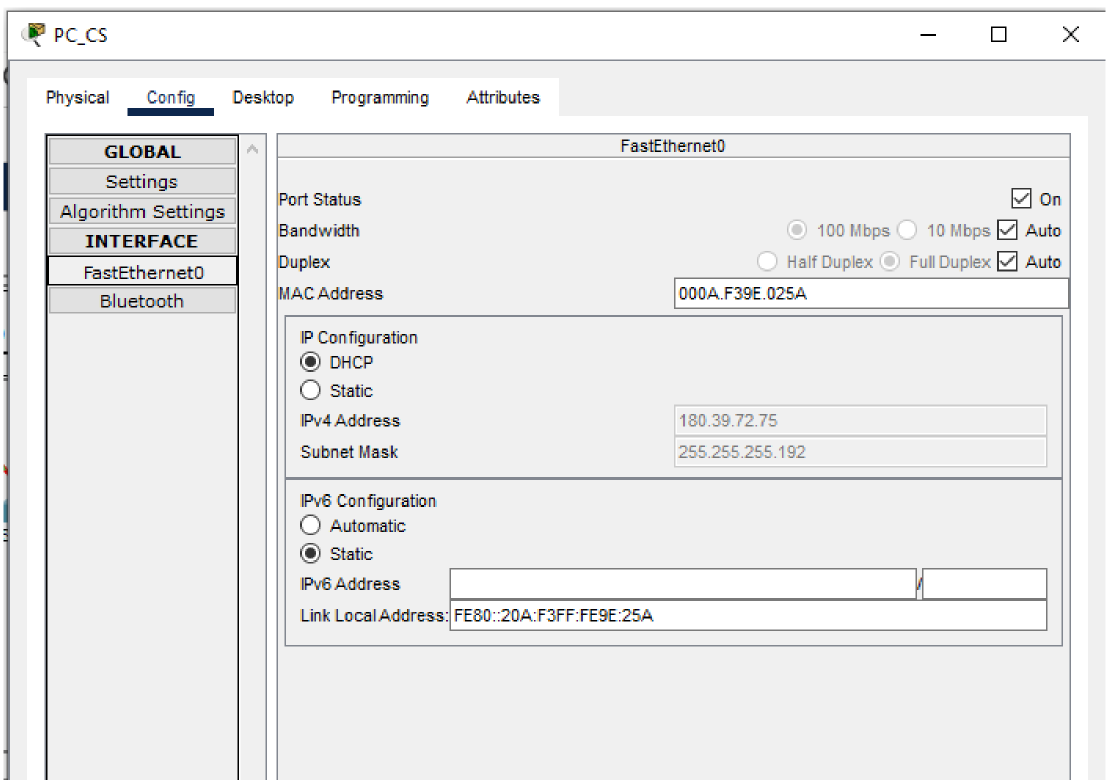

Figure 13: PC_CS IP configuration

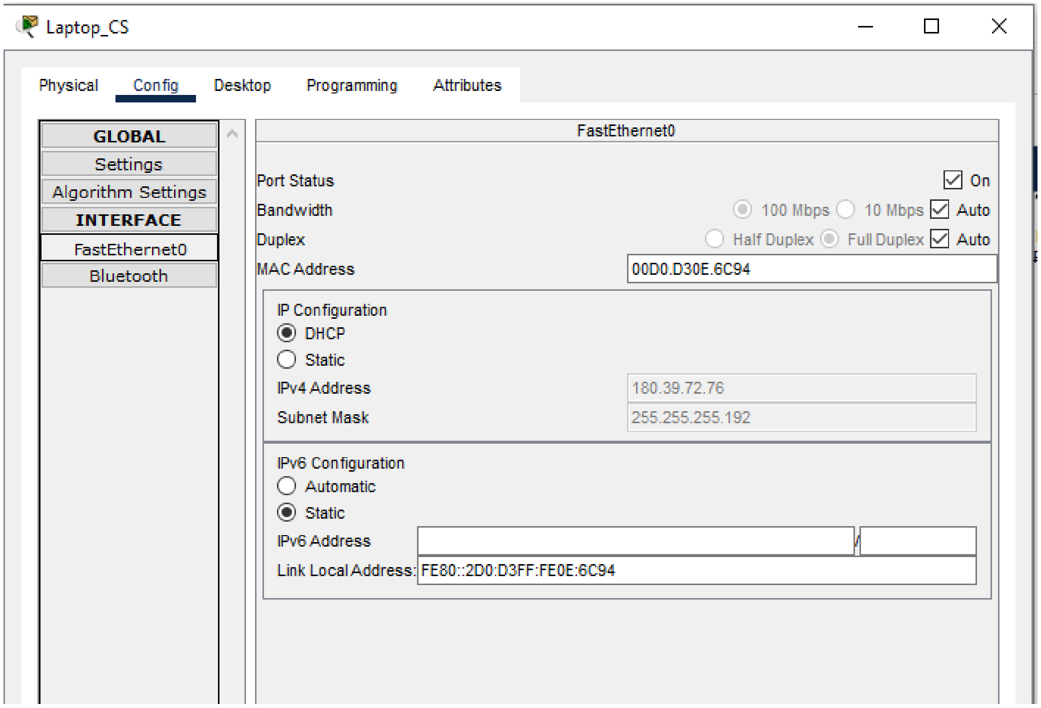

Figure 14: Laptop_CS IP configuration

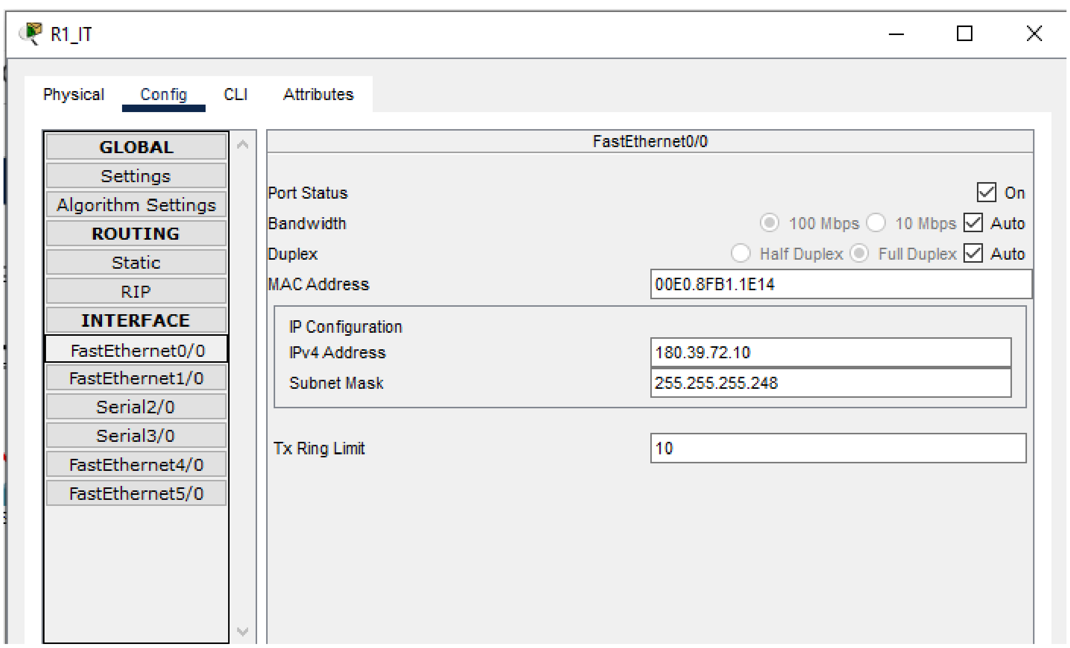

Figure 15: R1_IT BackBone Port

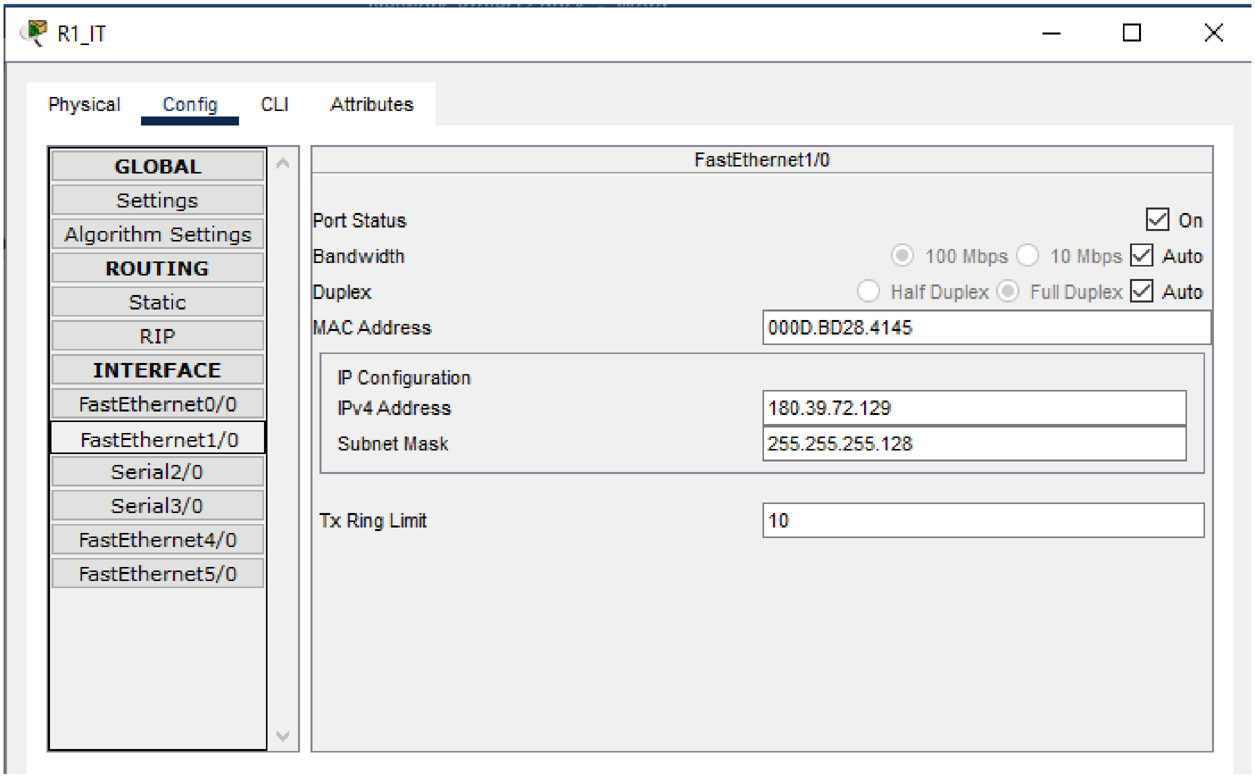

Figure 16: R1_IT ECE Port

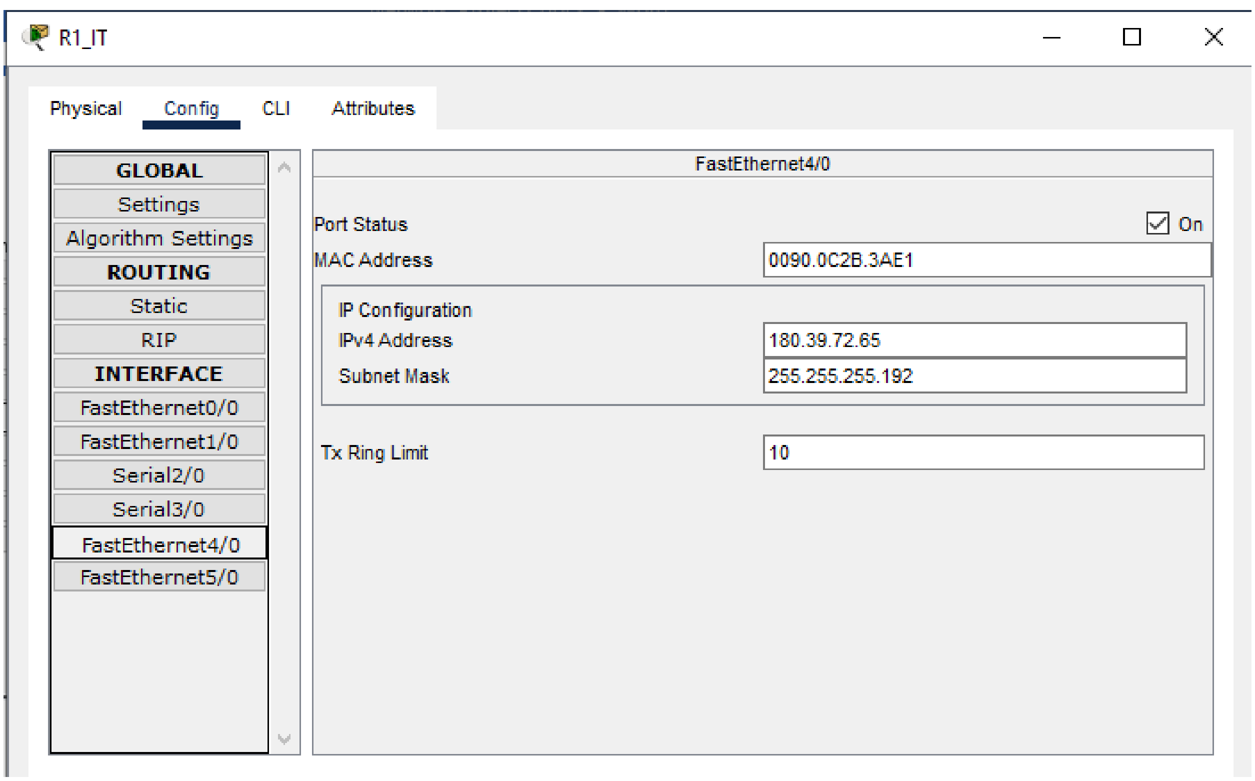

Figure 17: R1_IT CS Port

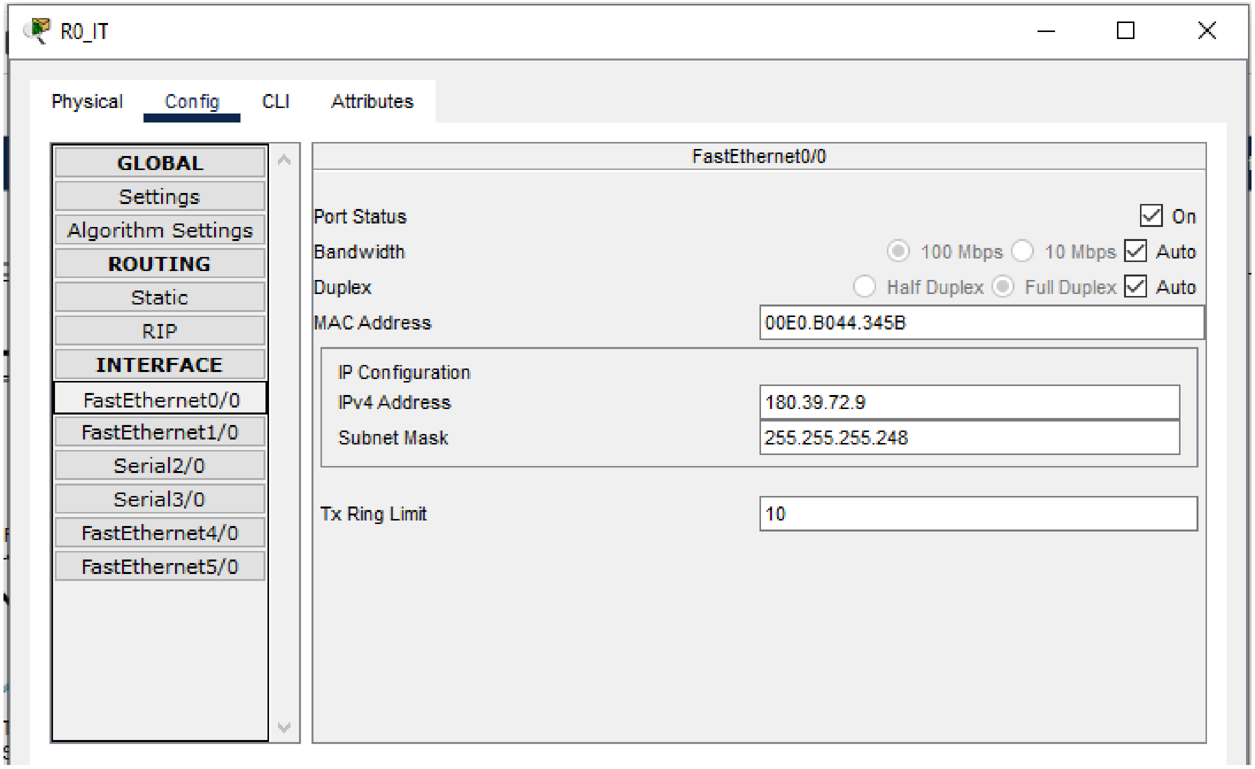

Figure 18: R0_IT BackBone Port

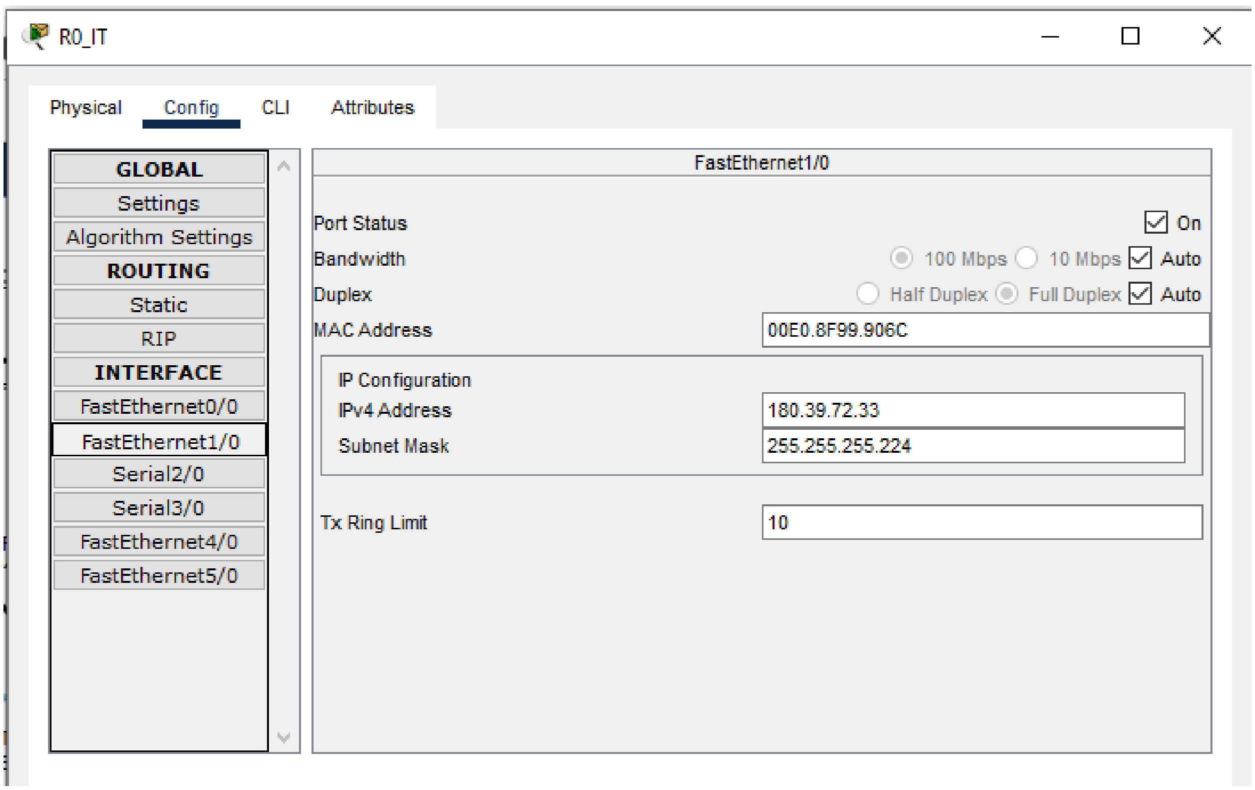

Figure 19: R0_IT Servers Port

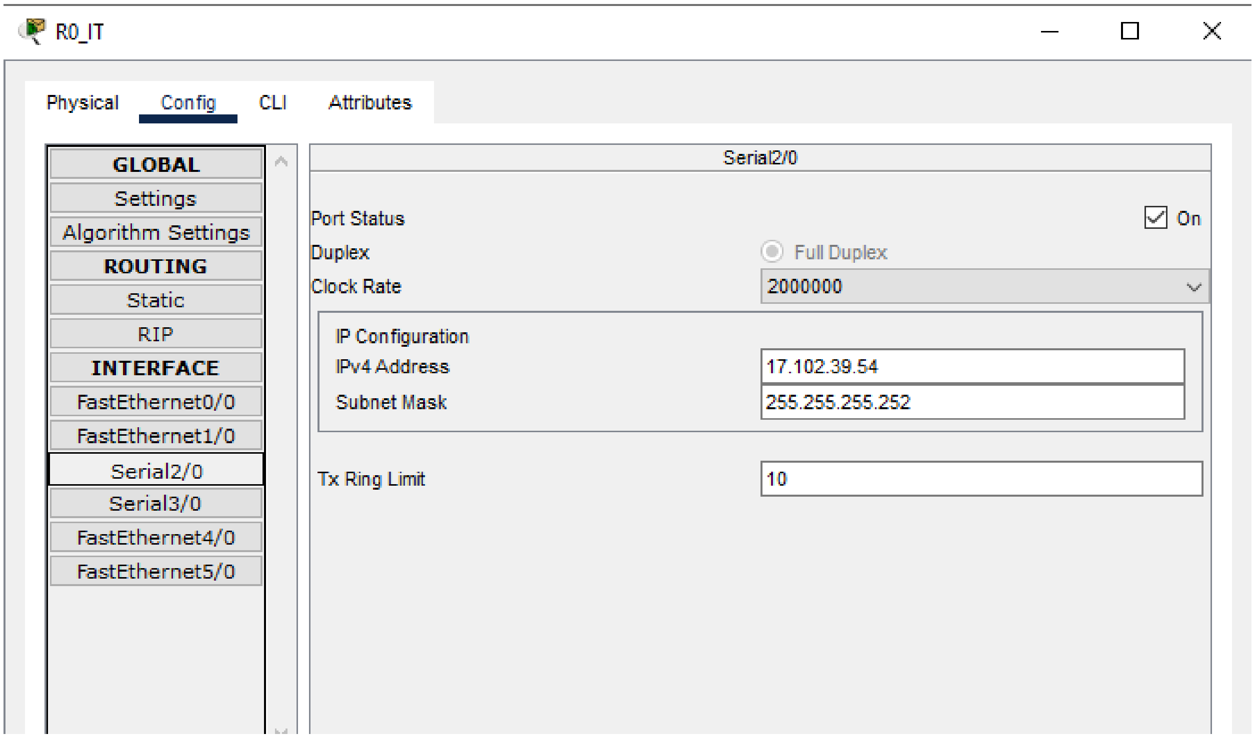

Figure 20: R0_IT Port connected with AS-300

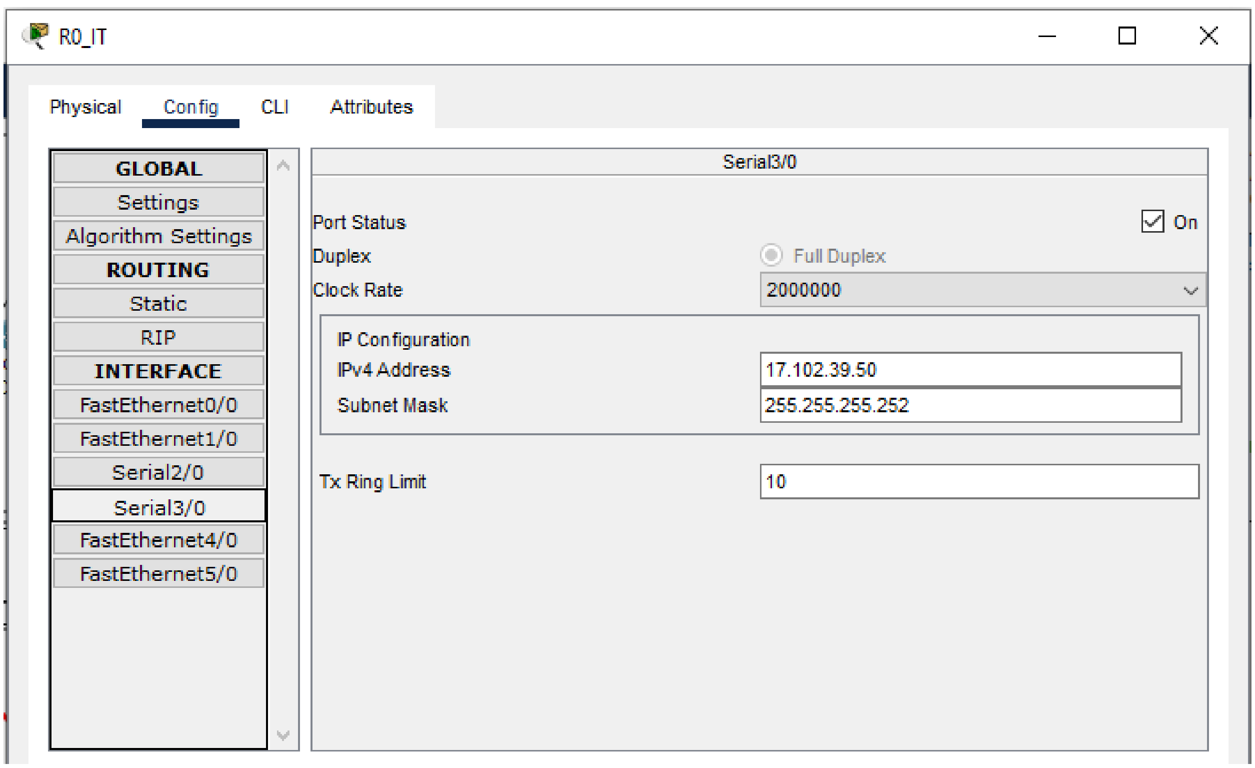

Figure 21: R0_IT Port connected with AS-200

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num	Edit
	Successful	R1_IT	PC_ECE	ICMP		0.000	N	0	(edit)
	Successful	R1_IT	Printer_CS	ICMP		0.000	N	1	(edit)
	Successful	R1_IT	mail.it.birz...	ICMP		0.000	N	2	(edit)

Figure 22: R1_IT Successful Ping results

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num	Edit
	Successful	R0_IT	Laptop_ECE	ICMP		0.000	N	0	(edit)
	Successful	R0_IT	PC_CS	ICMP		0.000	N	1	(edit)
	Successful	R0_IT	dns.it.birz...	ICMP		0.000	N	2	(edit)

Figure 23: R0_IT Successful Ping results

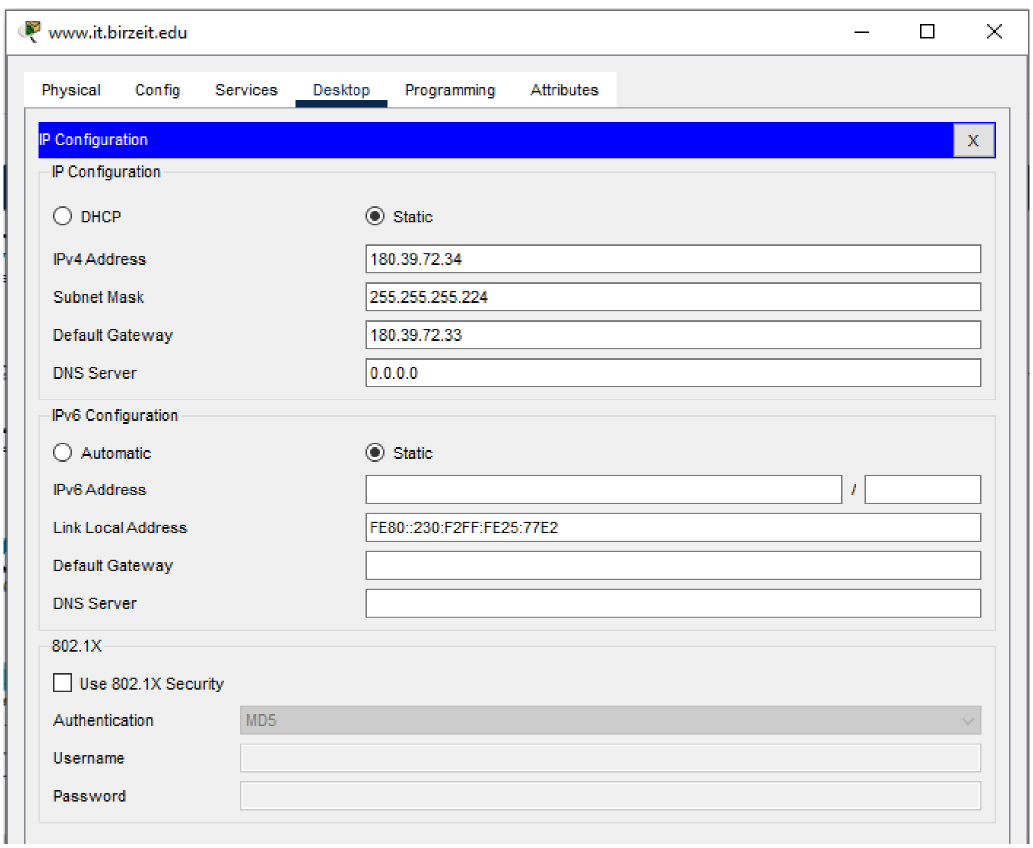

Figure 24: Web server IP configuration

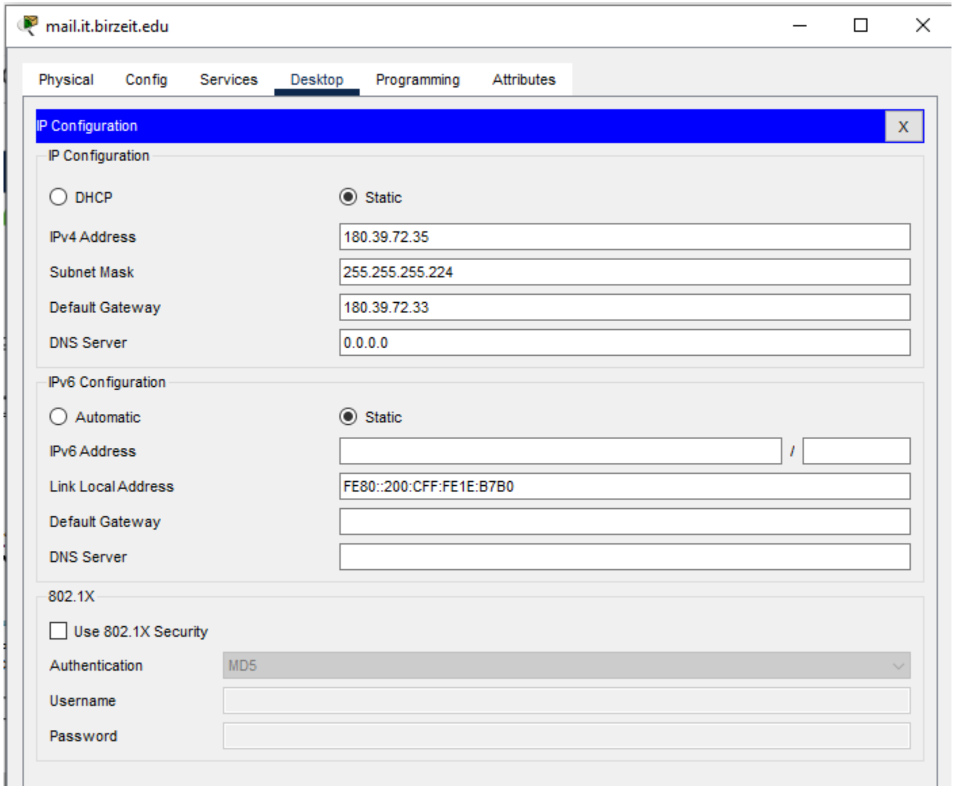

Figure 25: Email server IP configuration

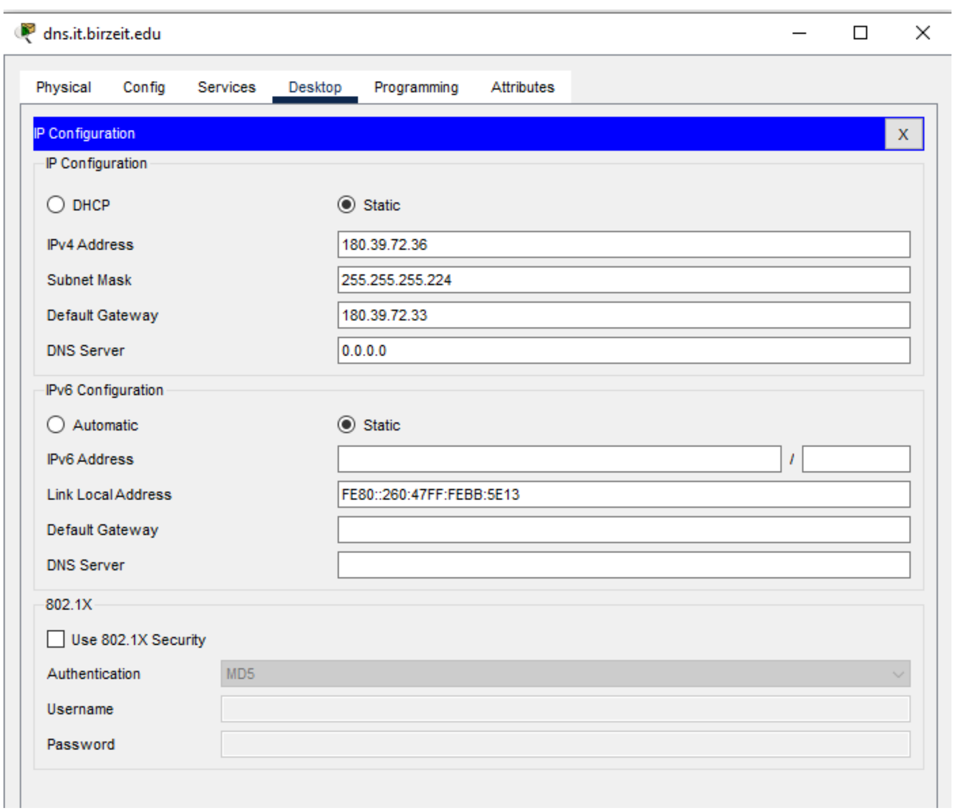

Figure 26: DNS server IP configuration

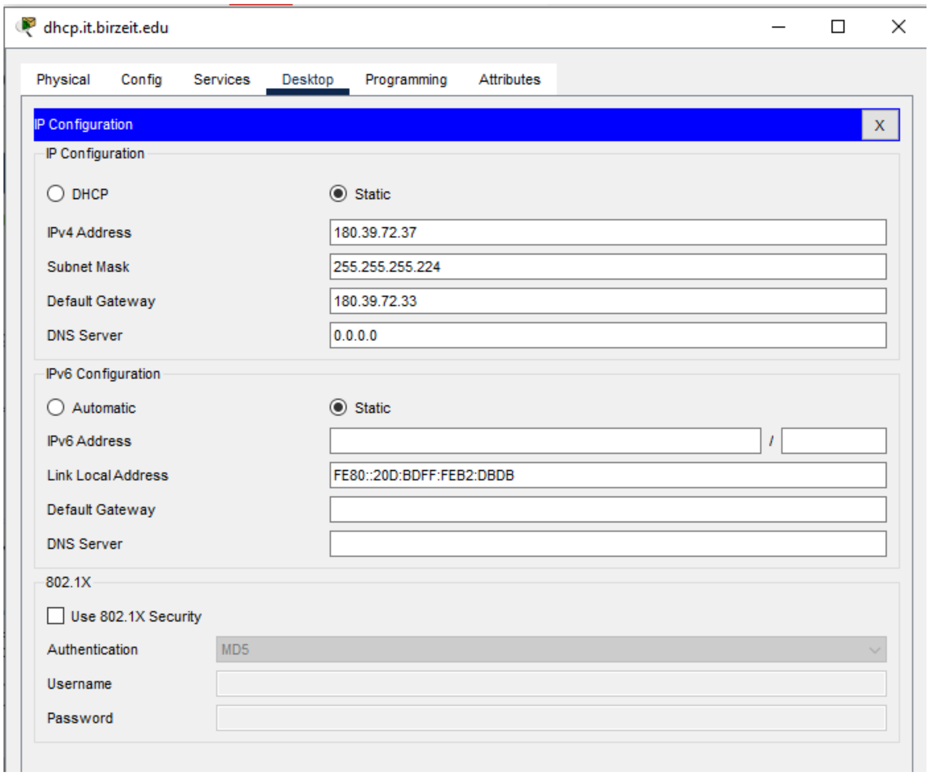

Figure 27: DHCP server IP configuration

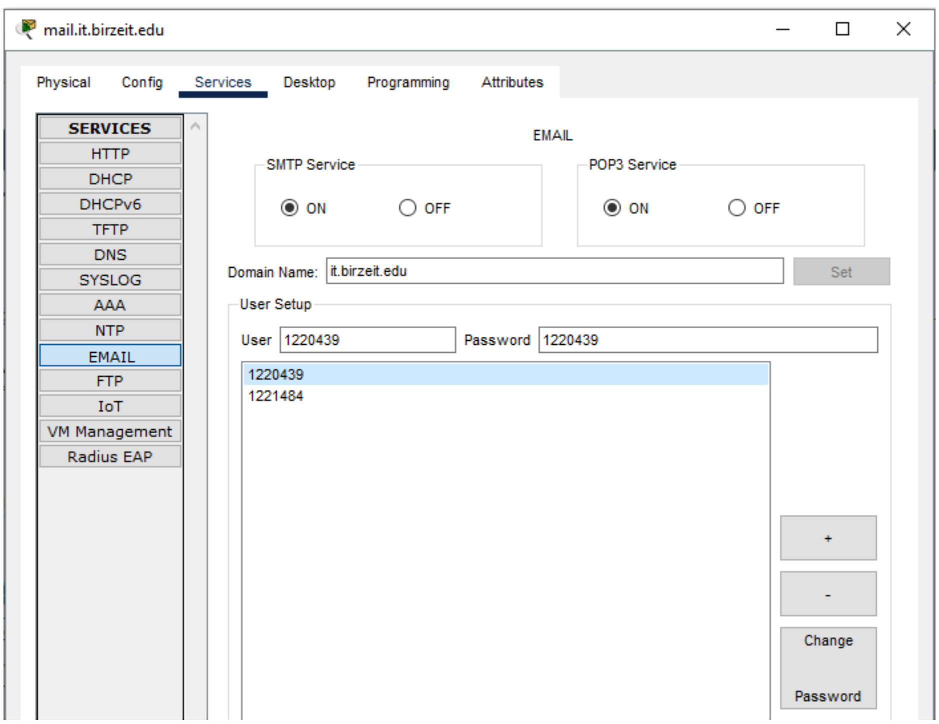

Figure 28: Email service with the user setup

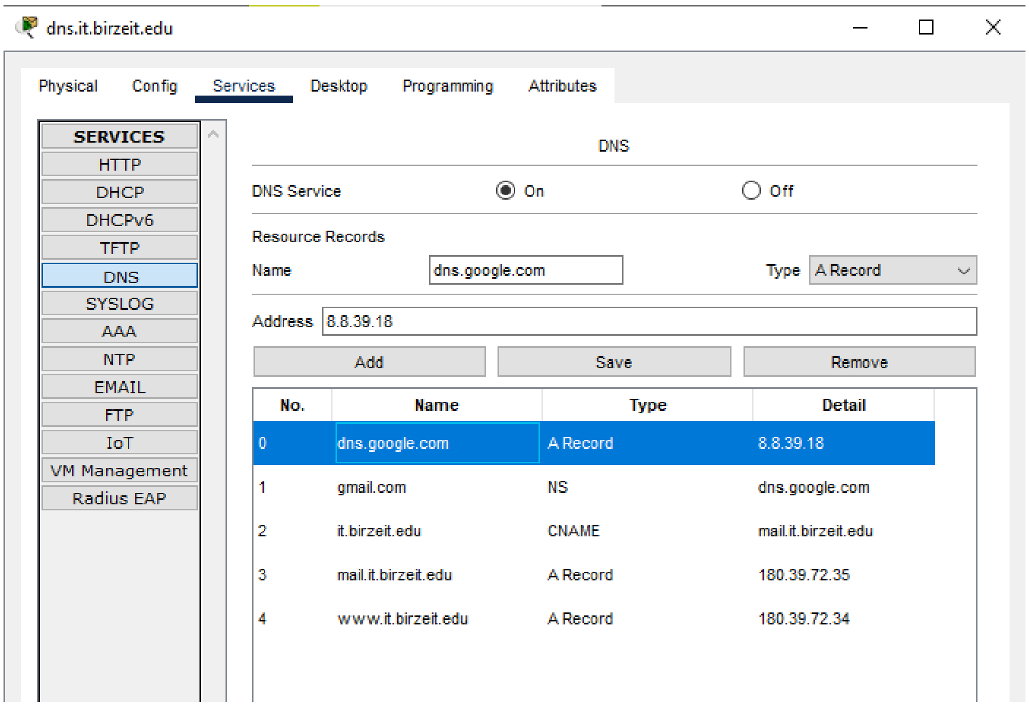

Figure 29: DNS service with the RRs

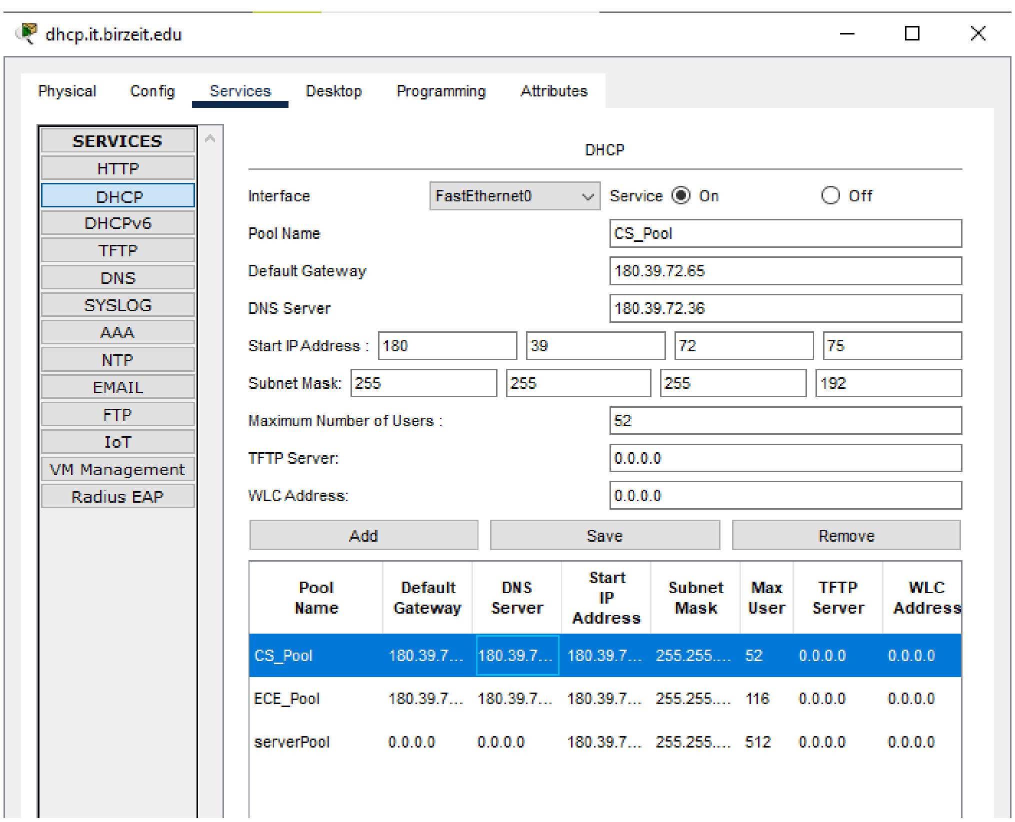

Figure 30: DHCP service with the pools

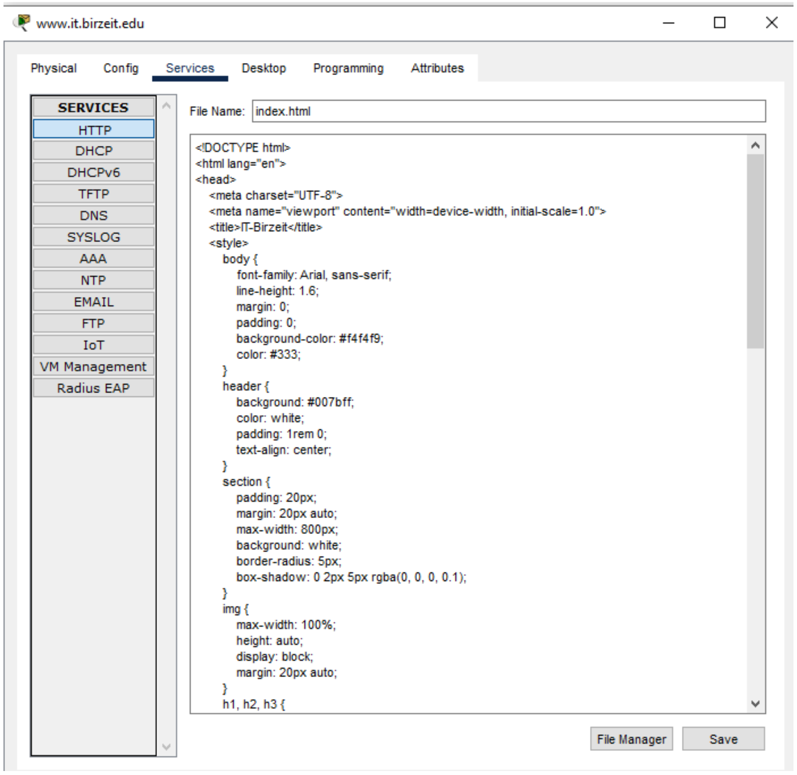

Figure 31: index.html code

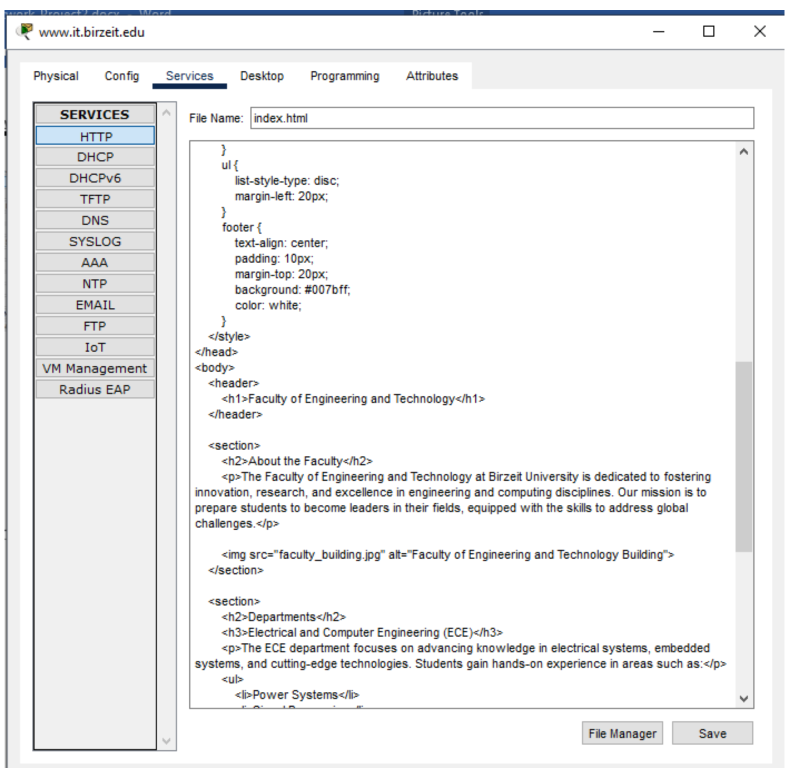

Figure 32: index.html code

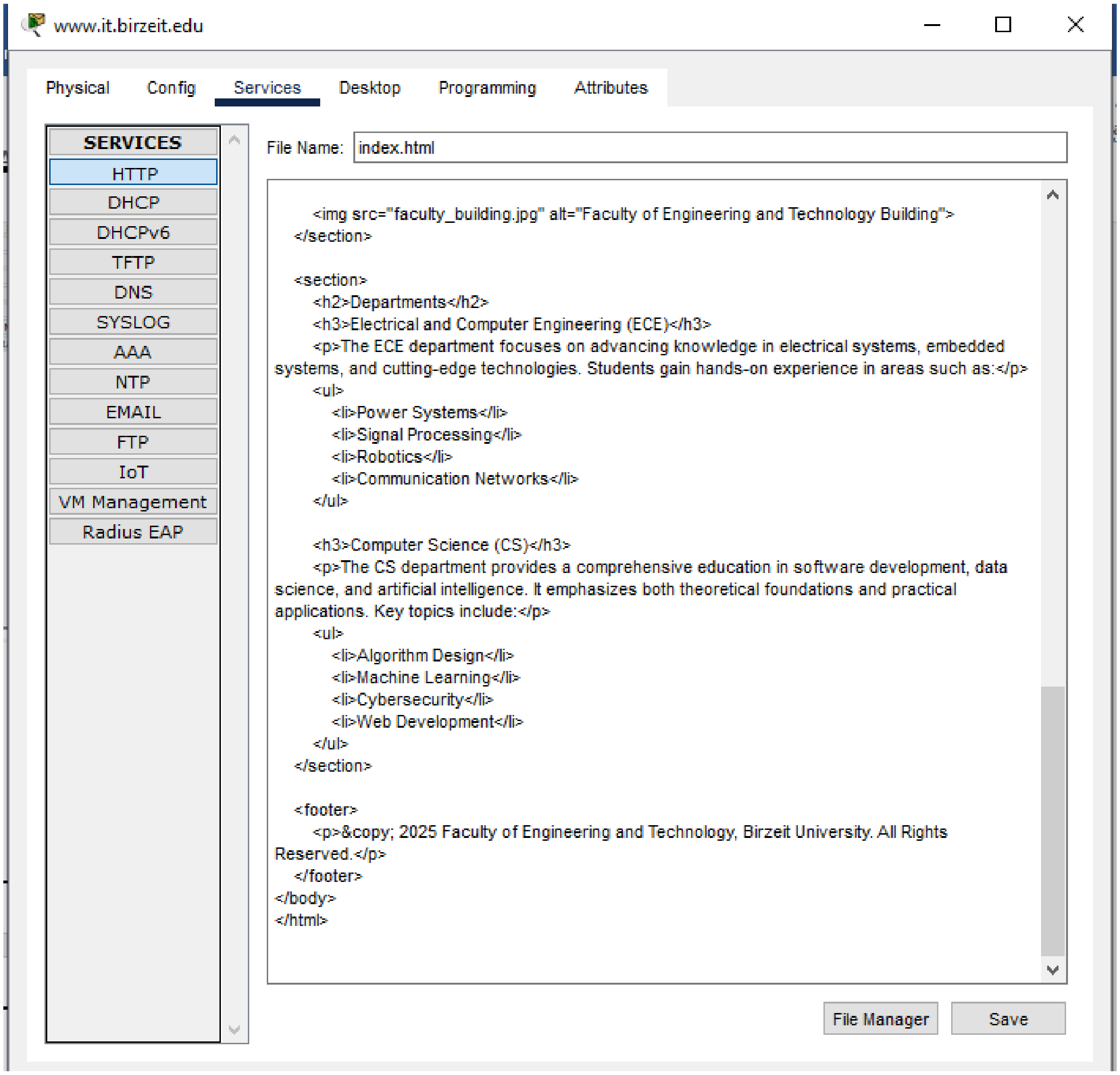

Figure 33: index.html code

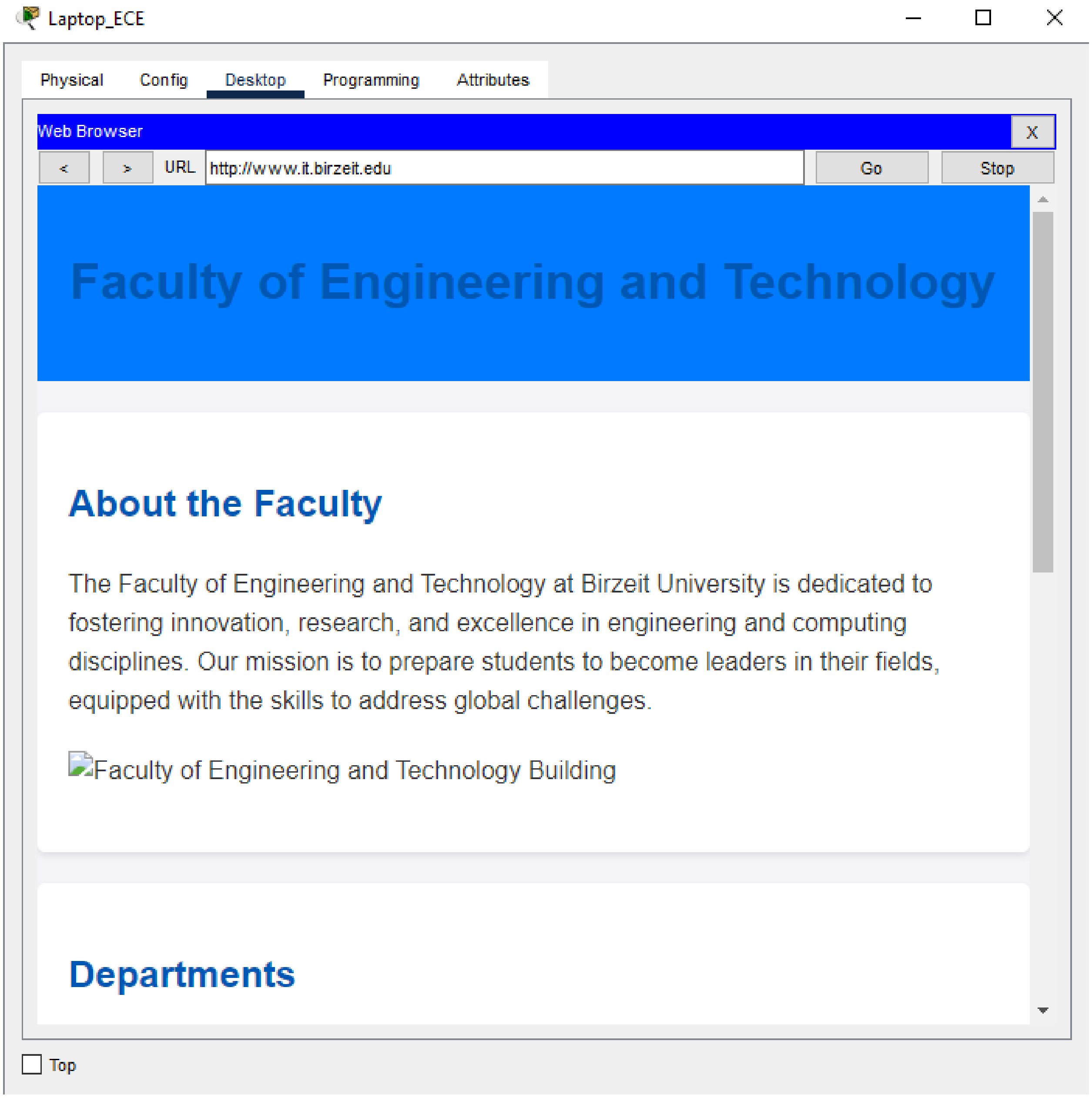

Figure 34: Successful access to www.it.birzeit.edu from Laptop_ECE

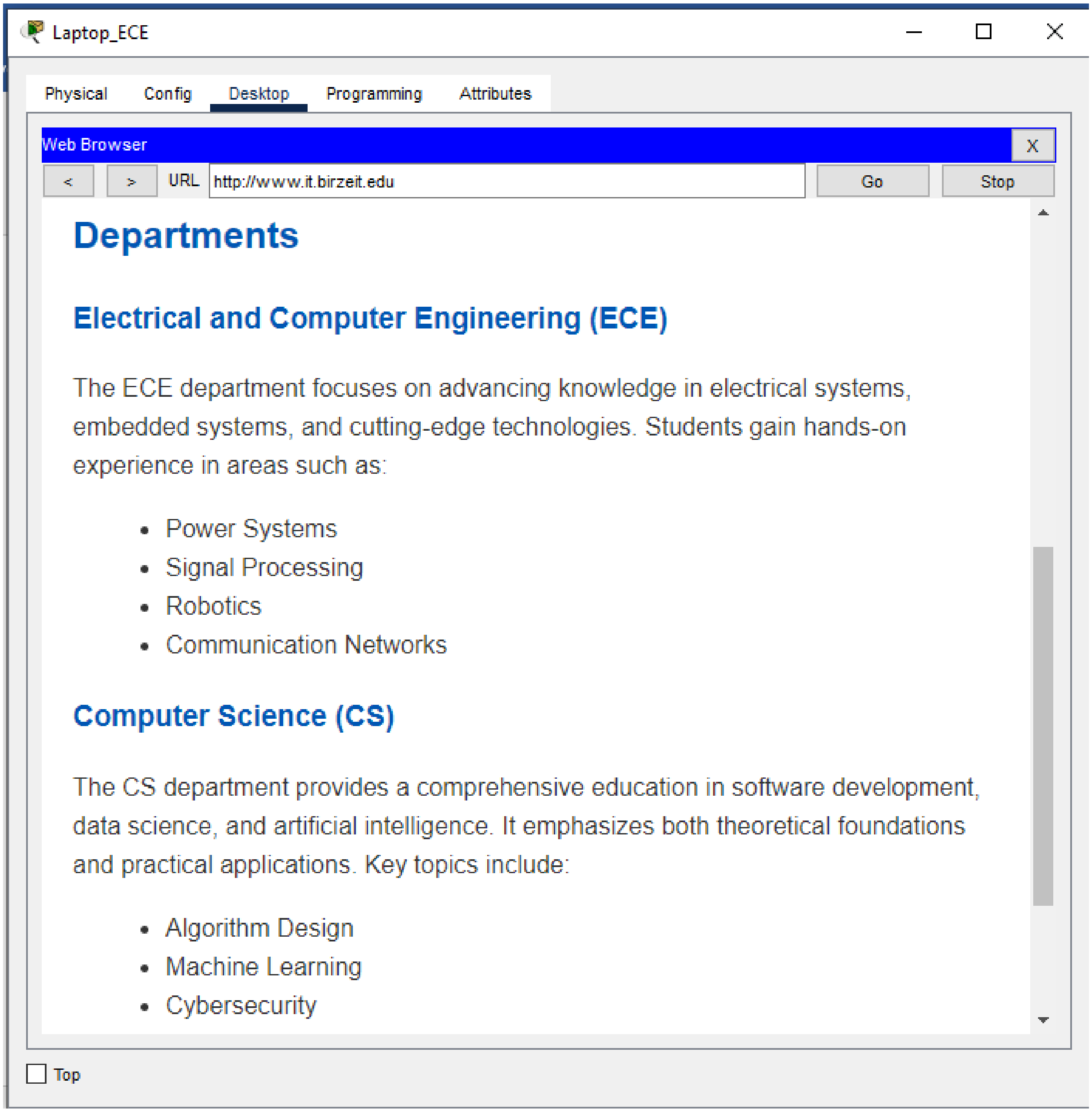

Figure 35: Successful access to www.it.birzeit.edu from Laptop_ECE

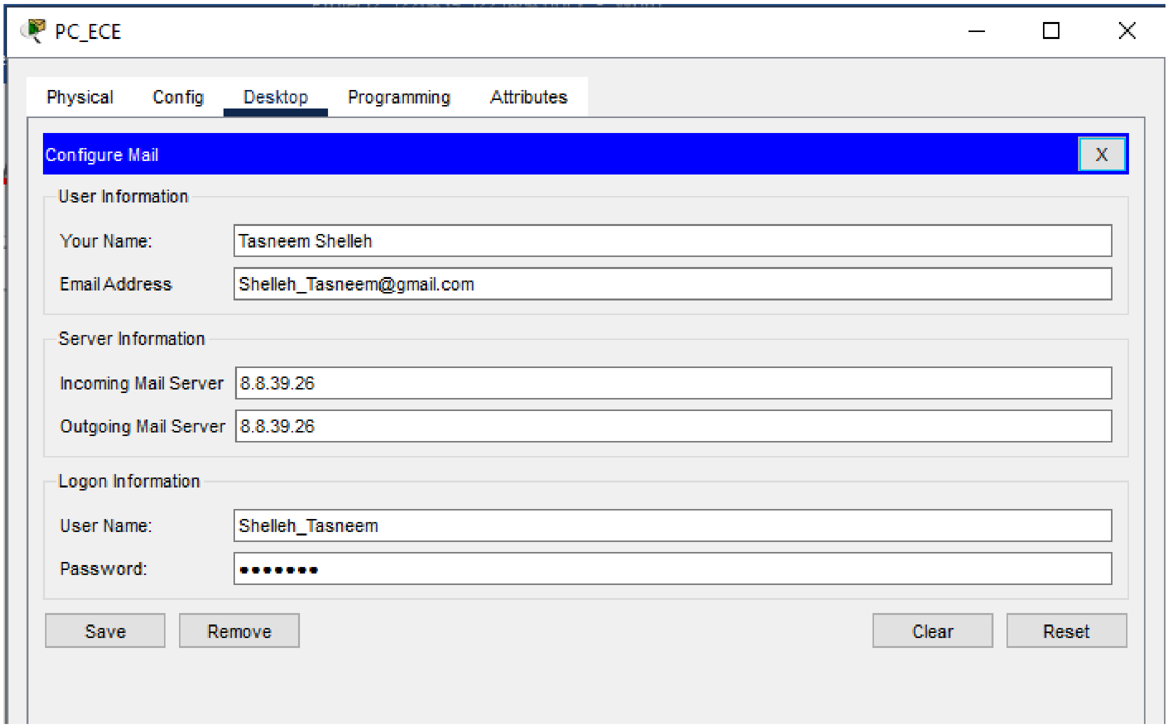

Figure 36: PC_ECE configuration for gmail.com

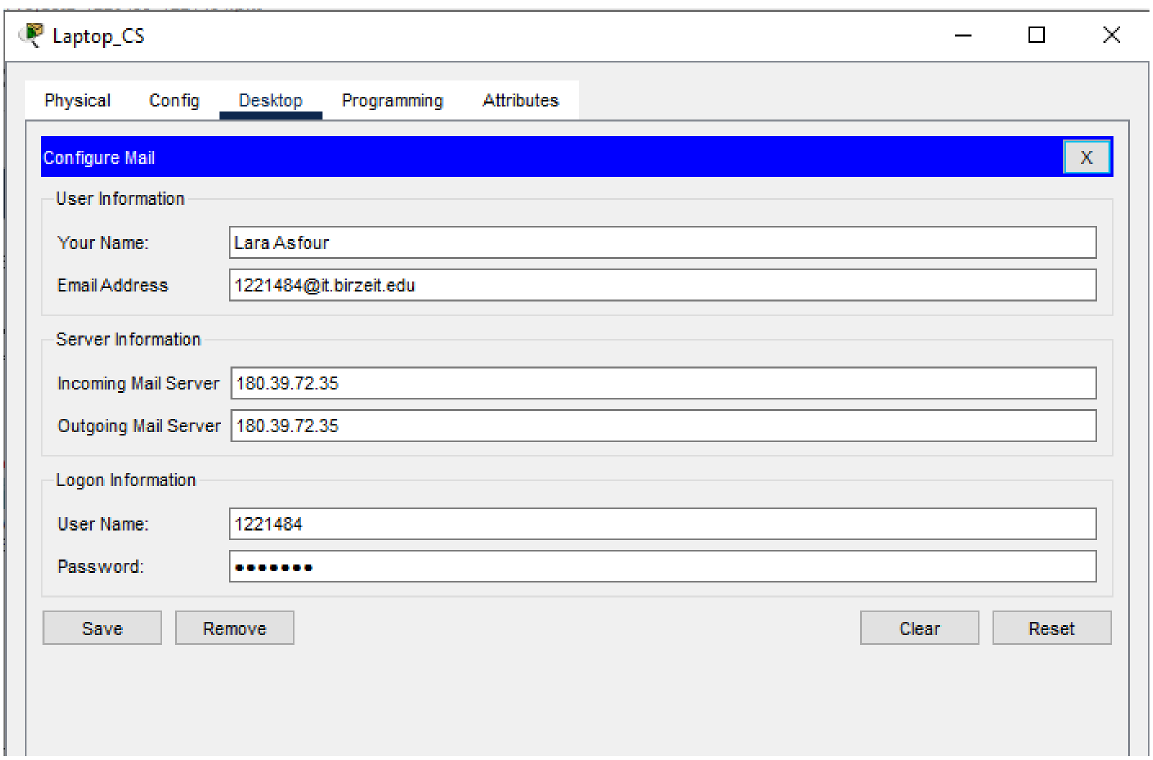

Figure 37:Laptop_CS configuration for it.birzeit.edu

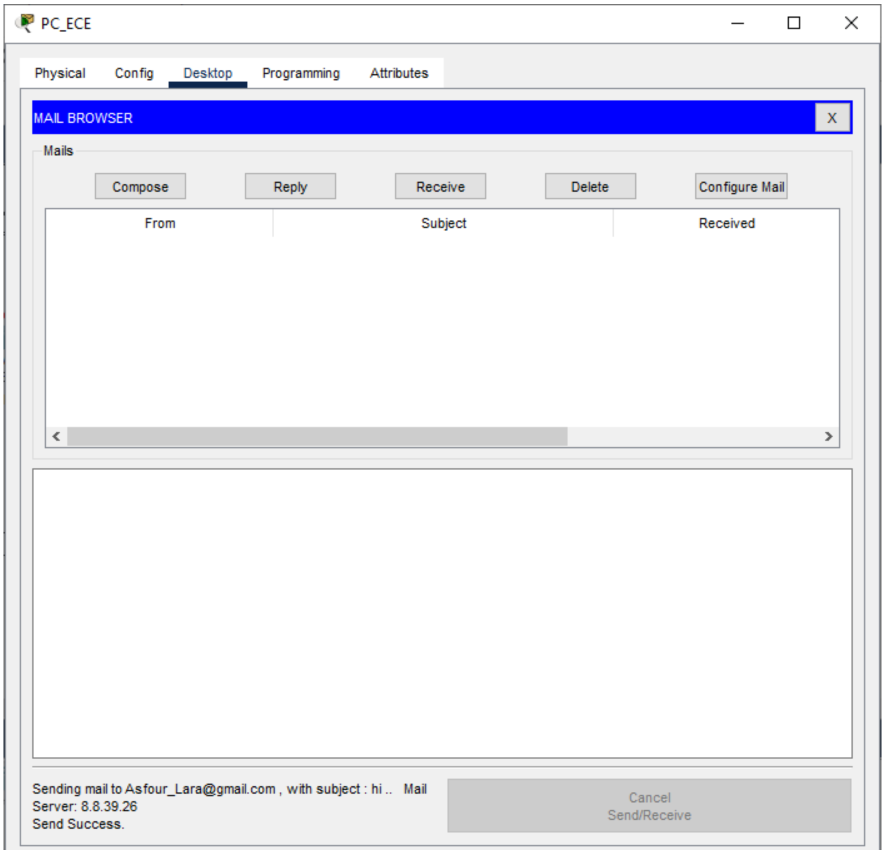

Figure 38: successful sending Between Gmail accounts

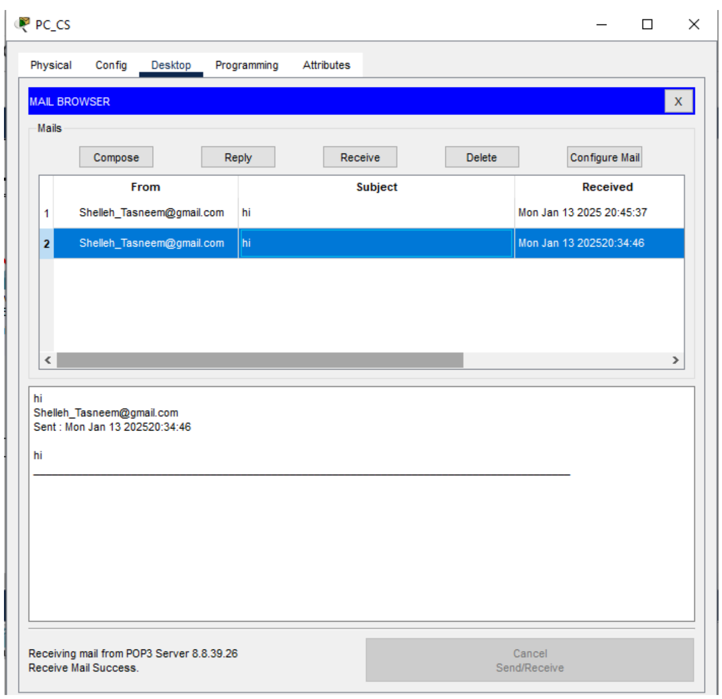

Figure 39: successful receiving Between Gmail accounts

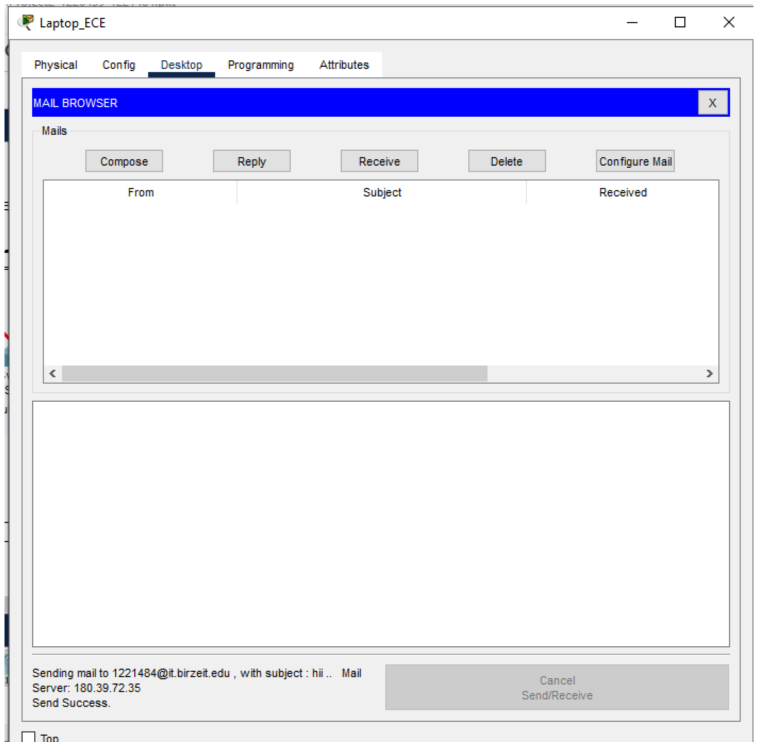

Figure 40: successful sending Between Birzeit accounts

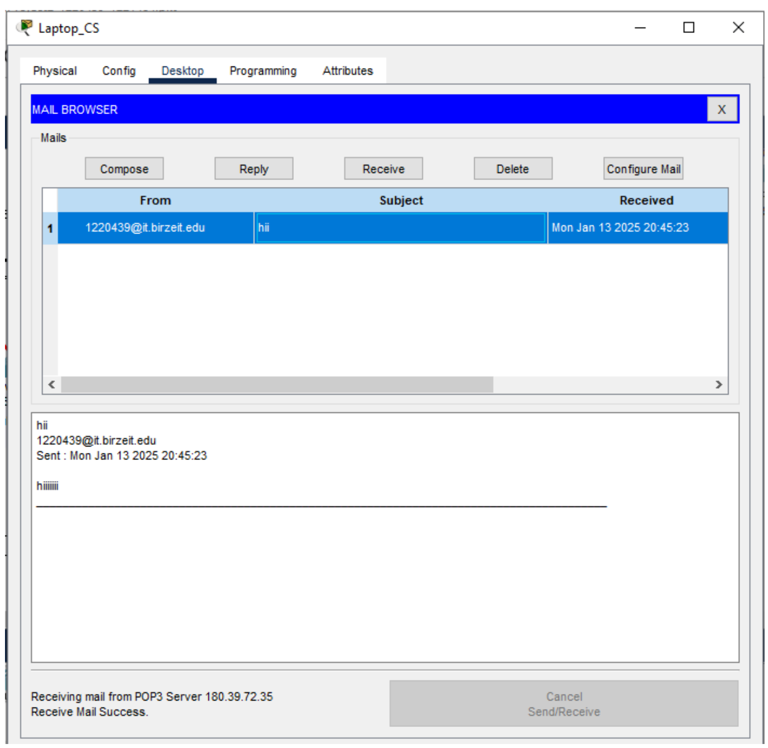

Figure 41: successful receiving Between Birzeit accounts

- ## Home-ISP Network AS-200

- ## Discussion:

  The Home-ISP network brings it all together on a smaller scale, focusing on connecting devices within a home environment while also allowing access to the wider internet. The wireless network setup is especially relevant here, as it mirrors a typical home Wi-Fi scenario with secure encryption to keep connections safe. Dynamic NAT with PAT ensures private home devices can communicate with public networks by sharing a single public IP address. The DHCP server takes care of assigning IPs automatically, making life easier for users who just want their devices to work without extra configuration. With OSPF managing internal routing and BGP handling external connections, the Home-ISP network is both simple and effective. It's a great demonstration of how home networks can integrate seamlessly with larger systems.

- ## Results:

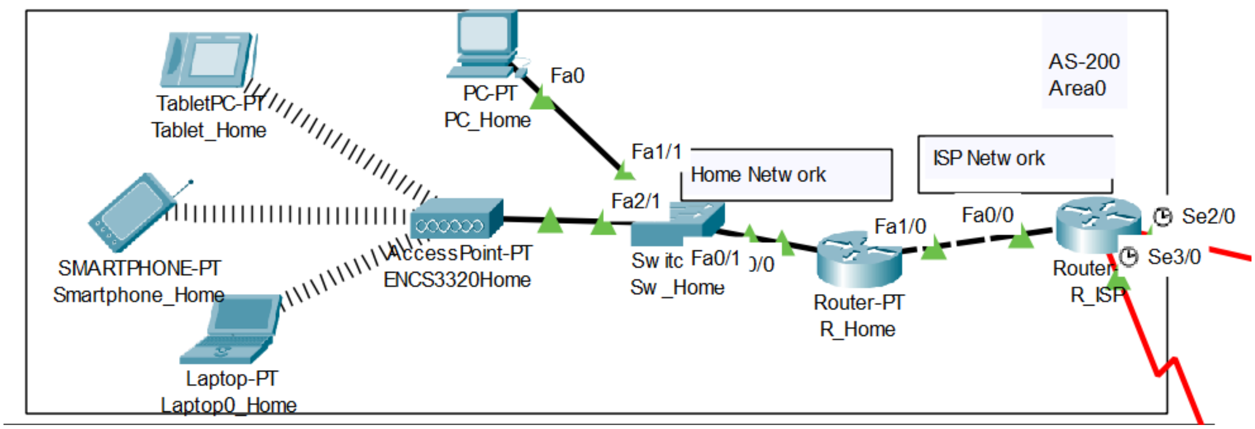

Figure 42: AS-200 Topology

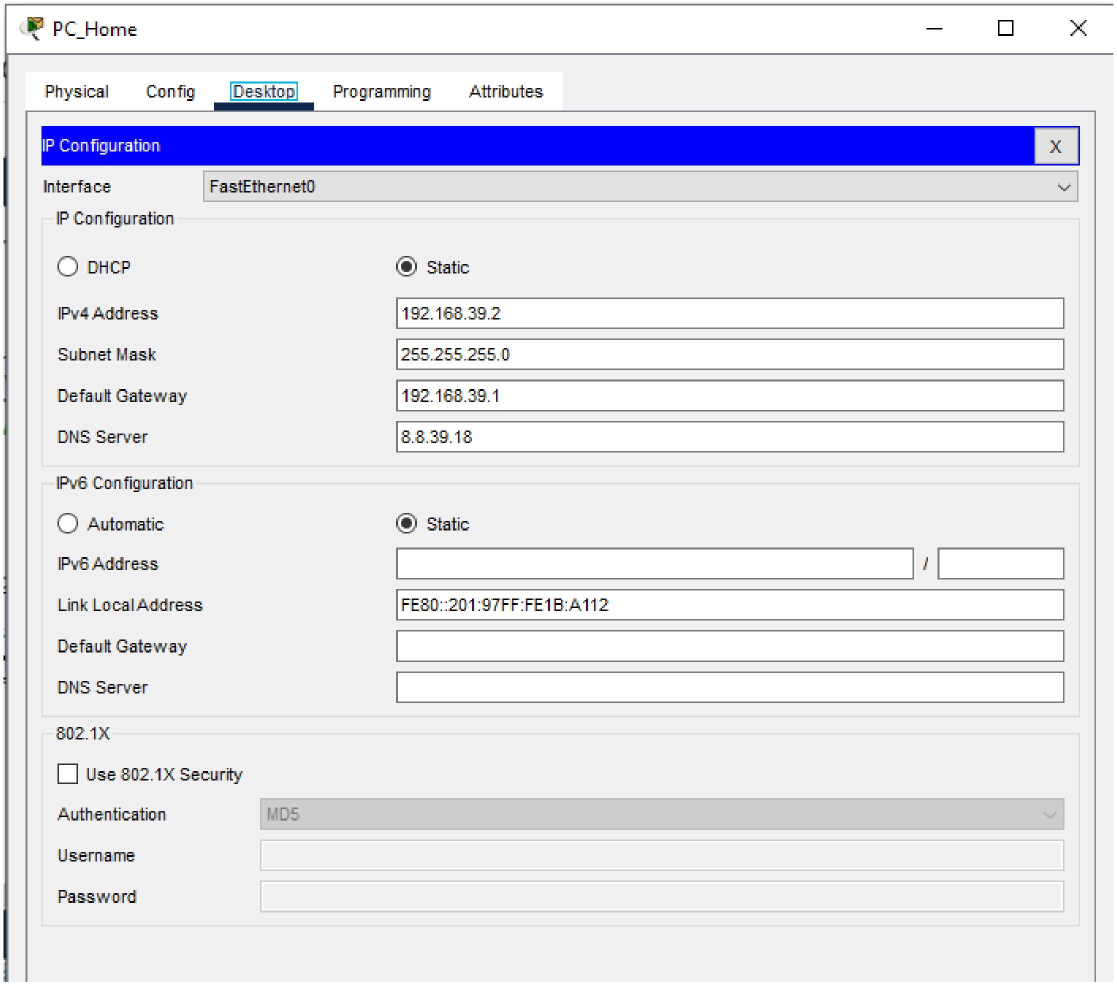

Figure 43: PC_Home static IP configuration

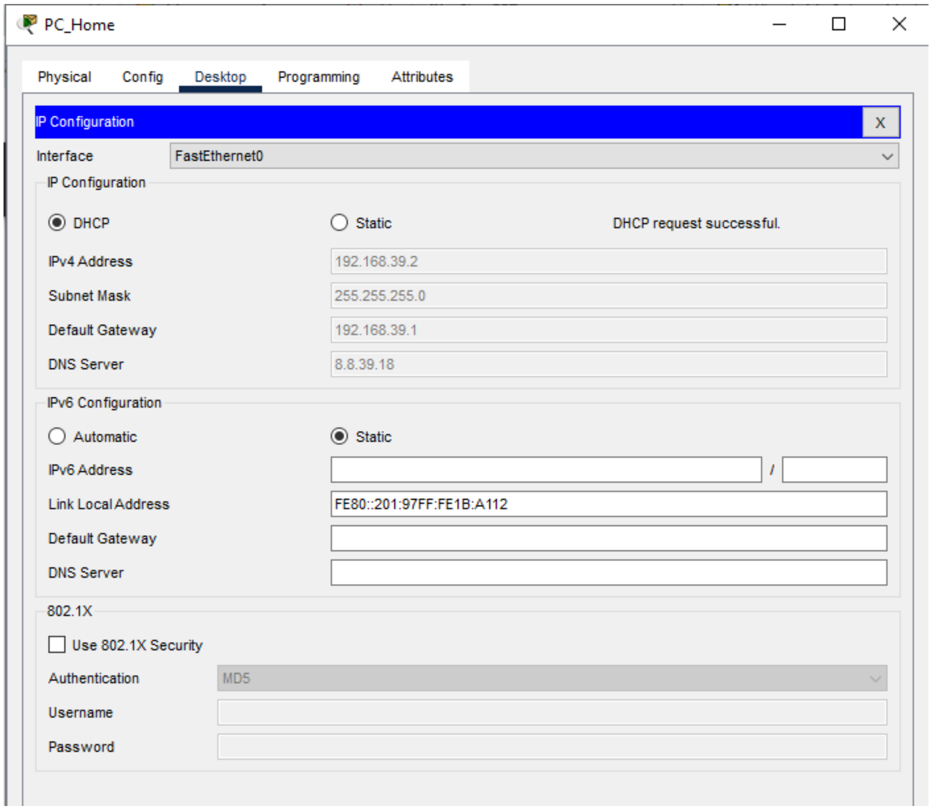

Figure 44: PC_Home Dynamic IP configuration

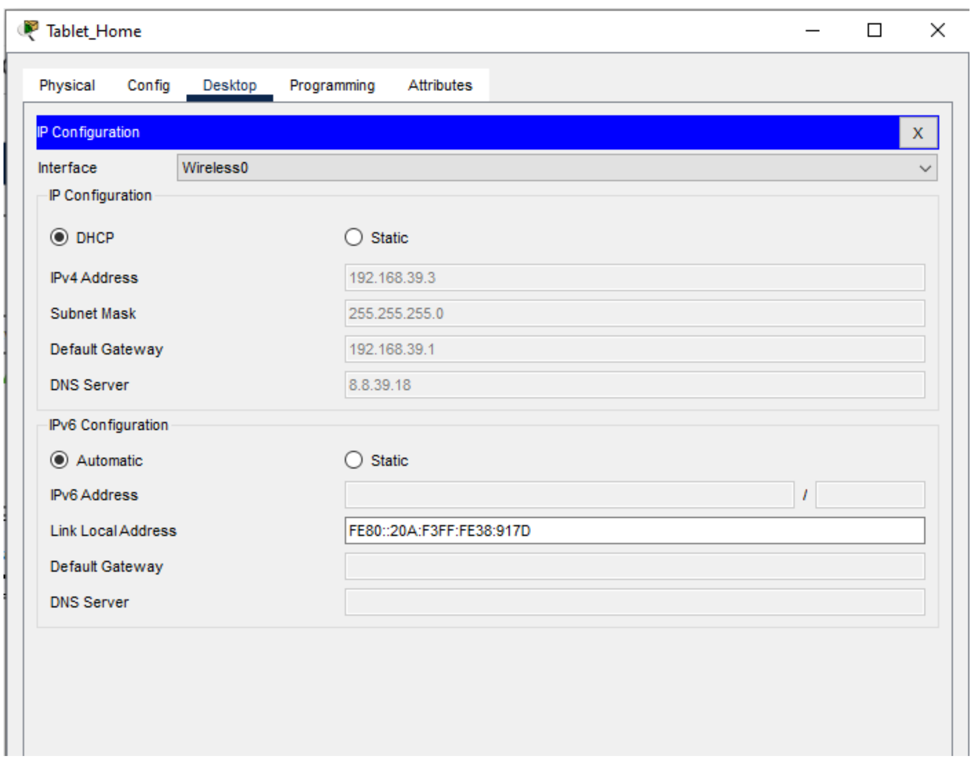

Figure 45: Tablet_Home Dynamic IP configuration

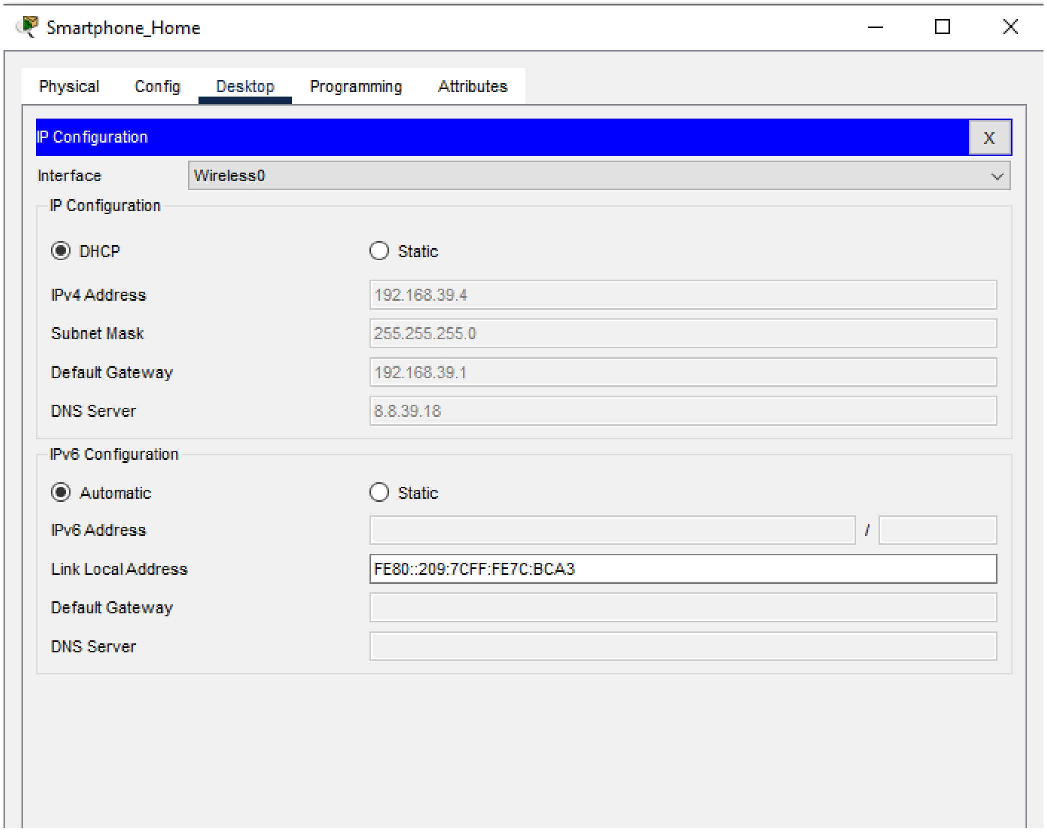

Figure 46: Smartphone_Home Dynamic IP configuration

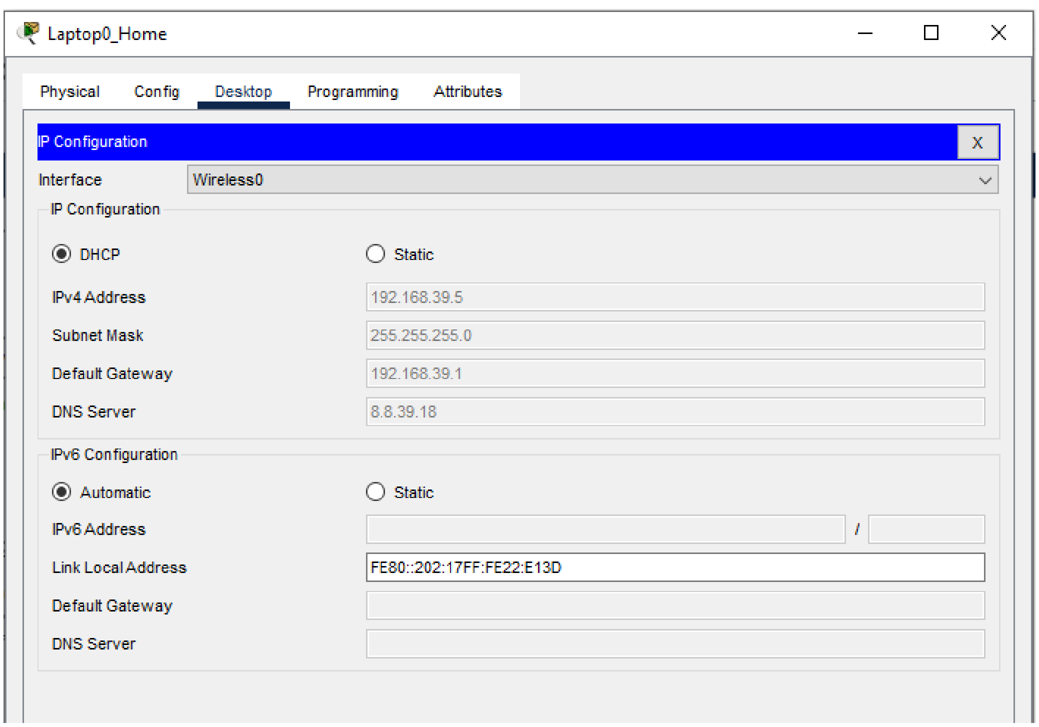

Figure 47: Laptop0_Home Dynamic IP configuration

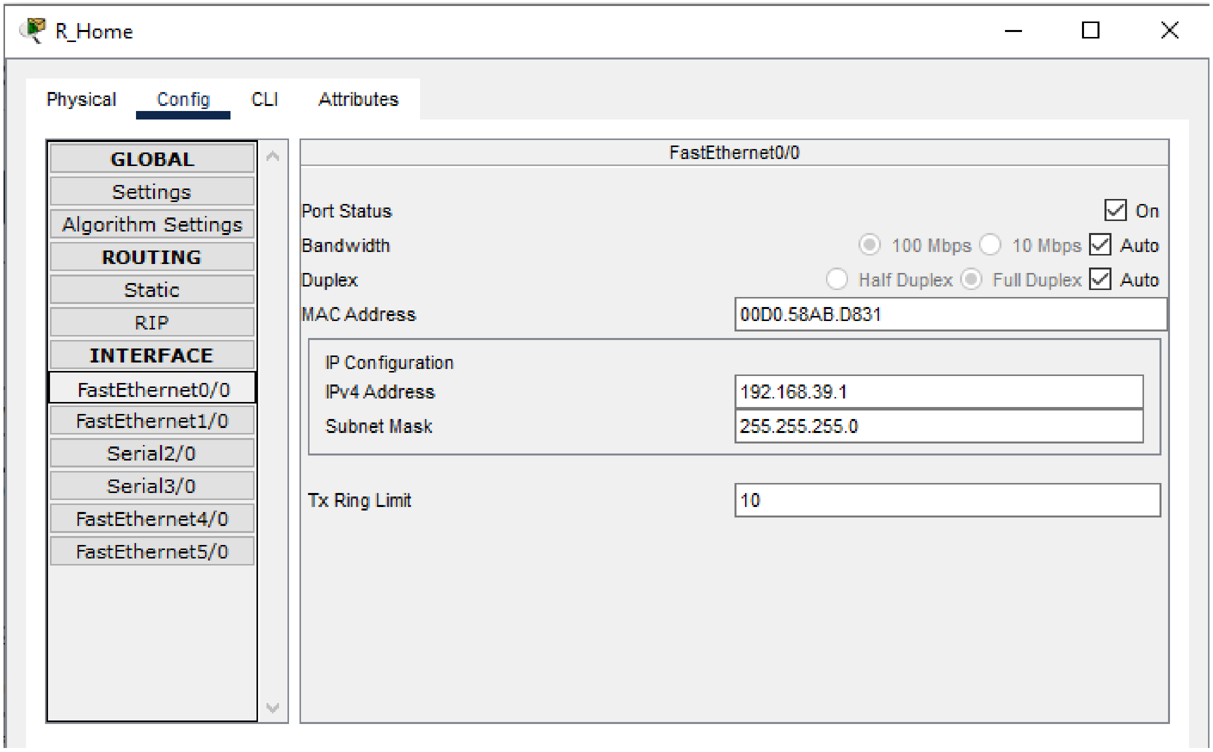

Figure 48: R_Home Static IP configuration Home Network Port

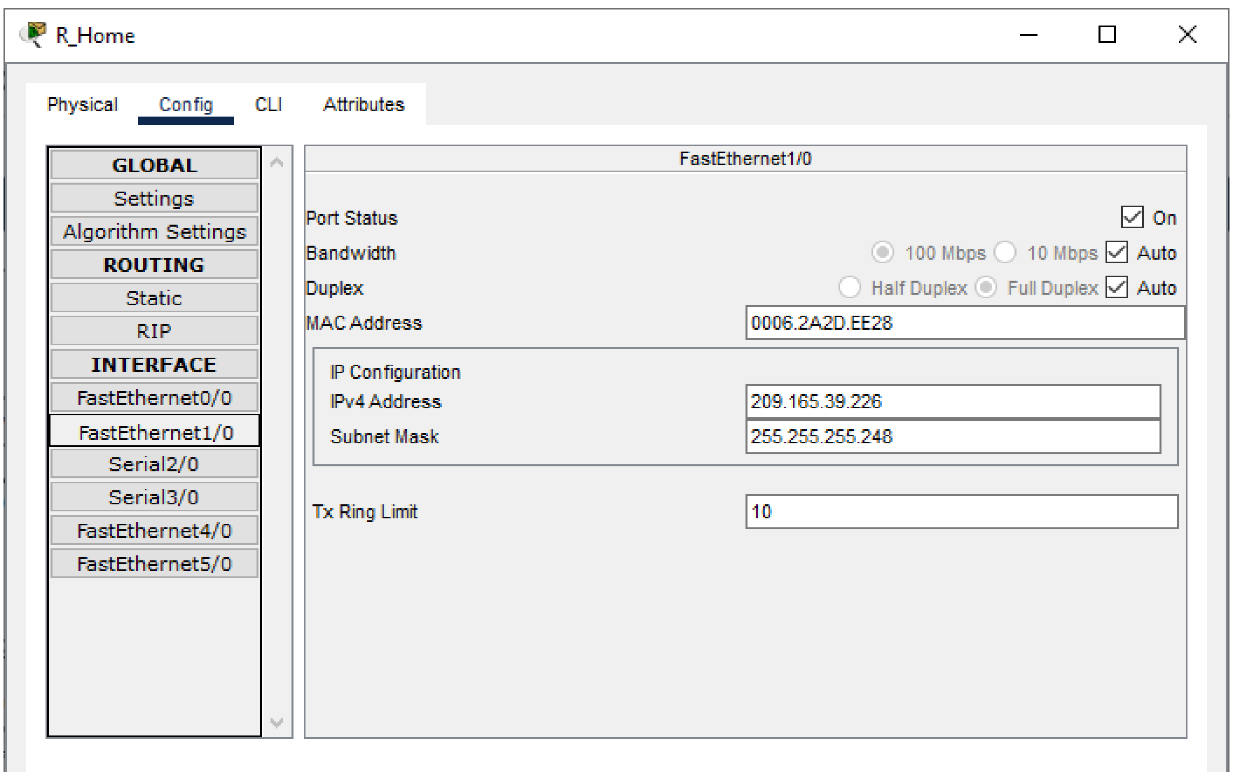

Figure 49: R_Home Static IP configuration ISP Network Port

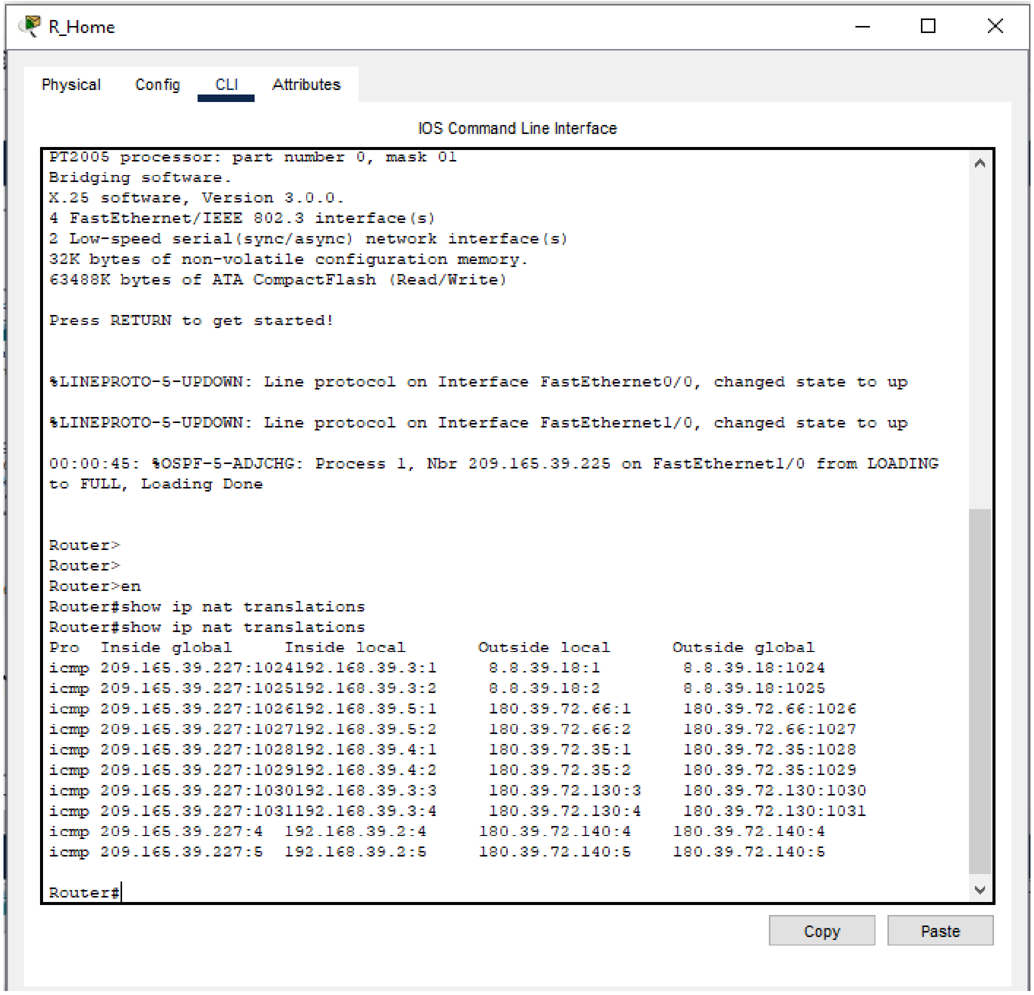

Figure 50: NAT table of R_Home router

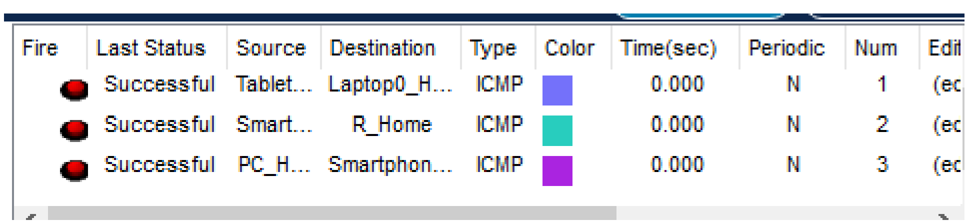

Figure 51: Successful Ping results between home network devices.

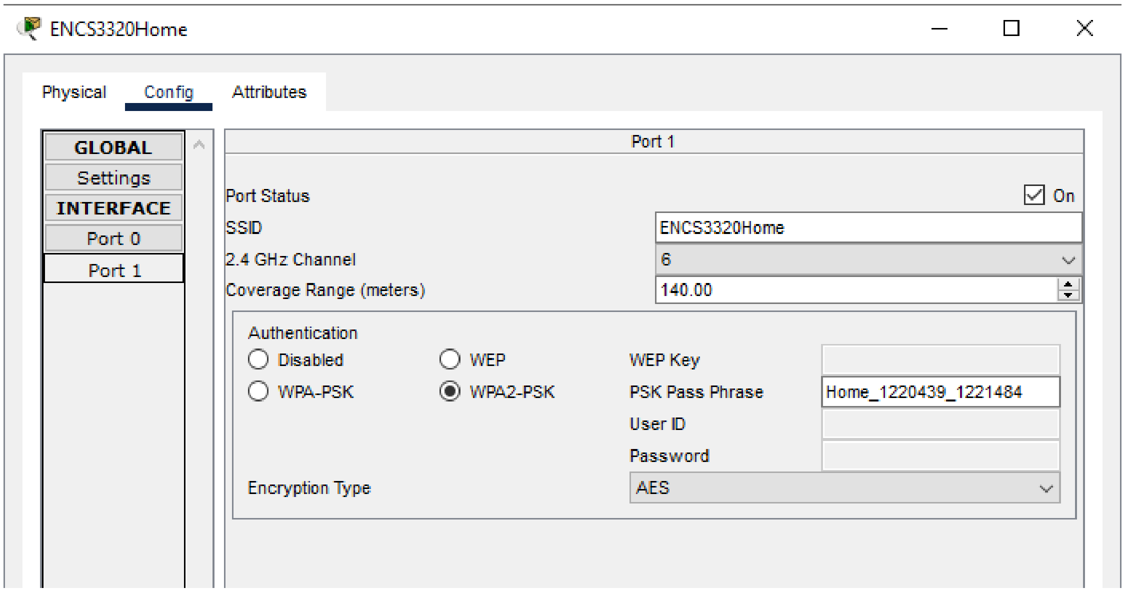

Figure 52: ENCS3320Home Wireless network configuration

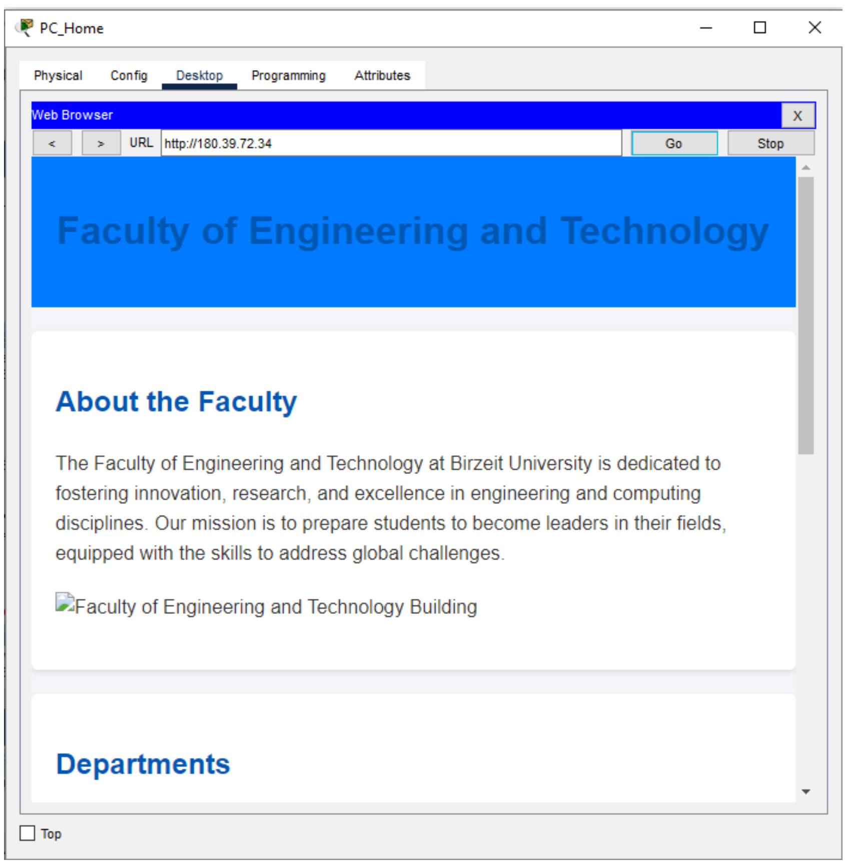

Figure 53: Successful access to www.it.birzeit.edu

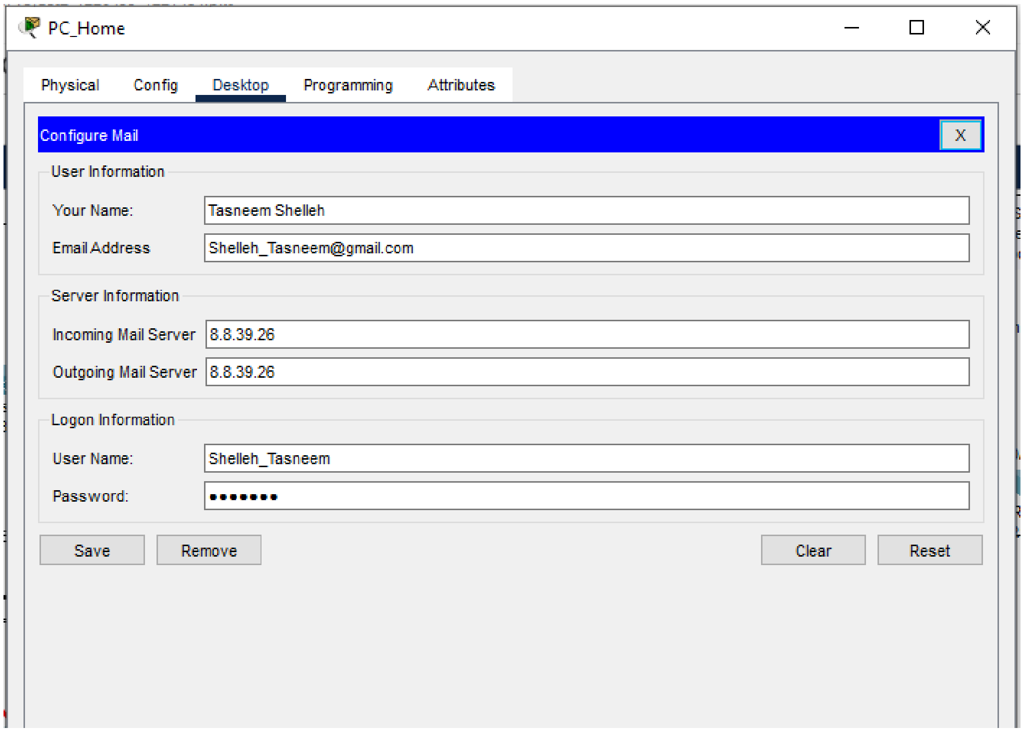

Figure 54: PC_Home Email client configuration for gmail.com

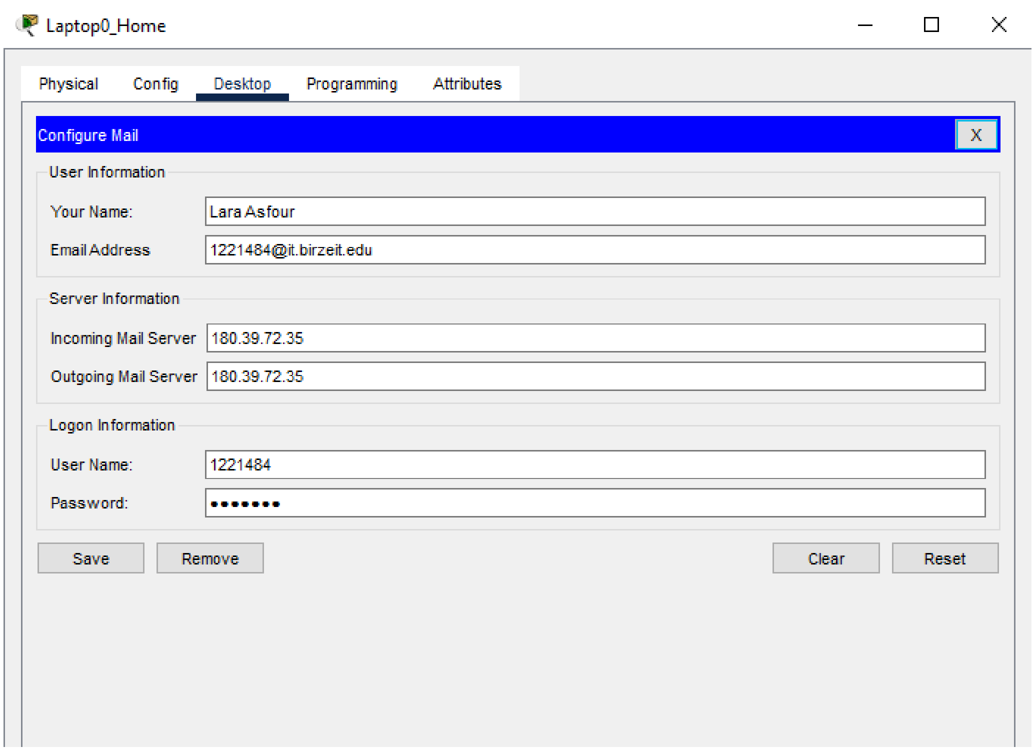

Figure 55: Laptop0_Home Email client configuration for it.birzeit.edu

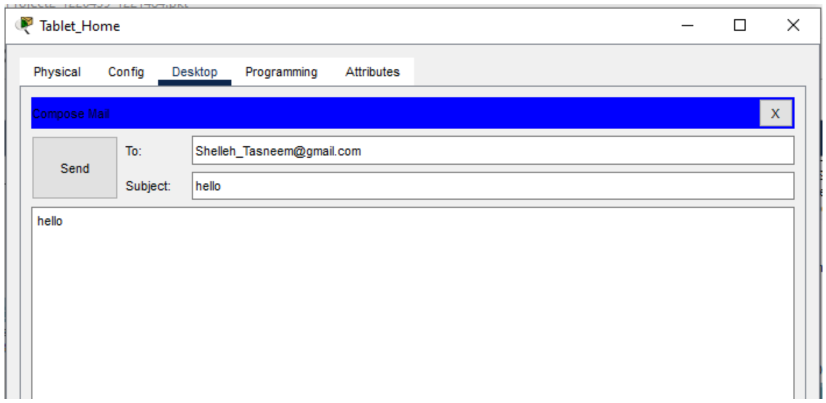

Figure 56: send Email between gmail.com accounts within the Home-ISP network

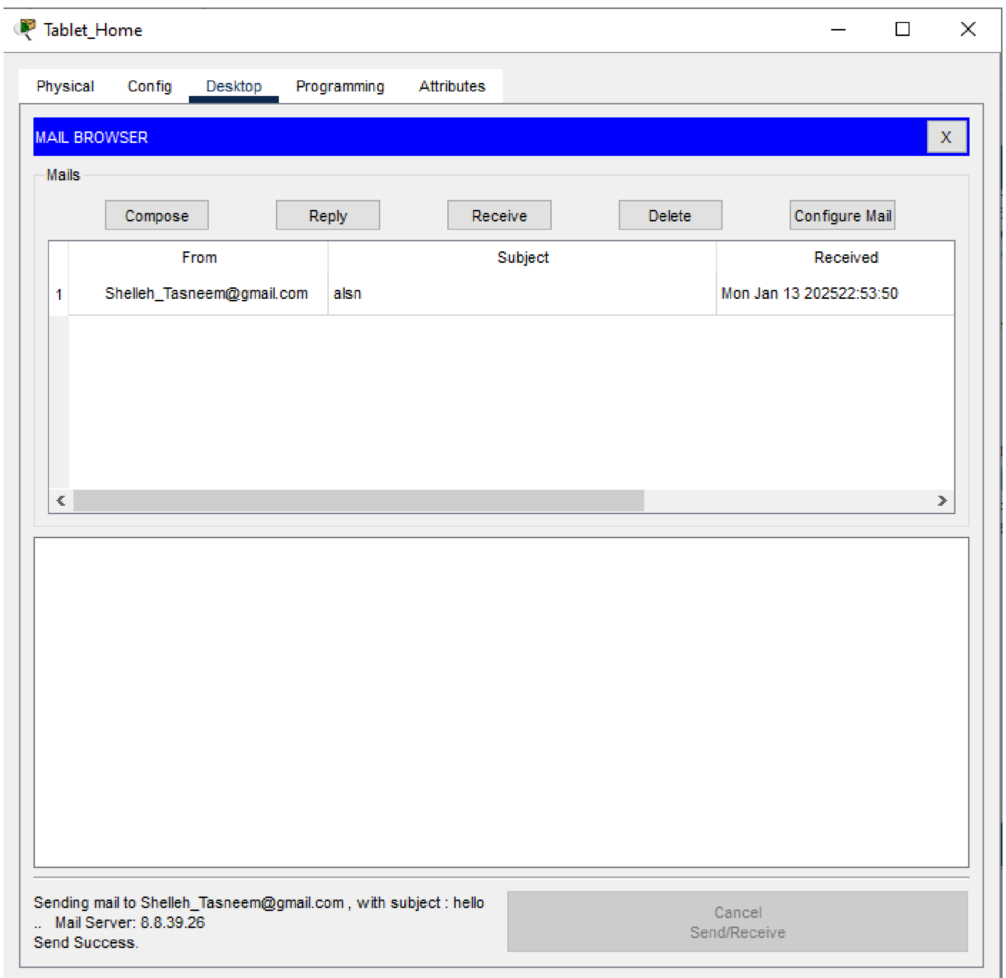

Figure 57: Successful sending between gmail.com accounts within the Home-ISP network.

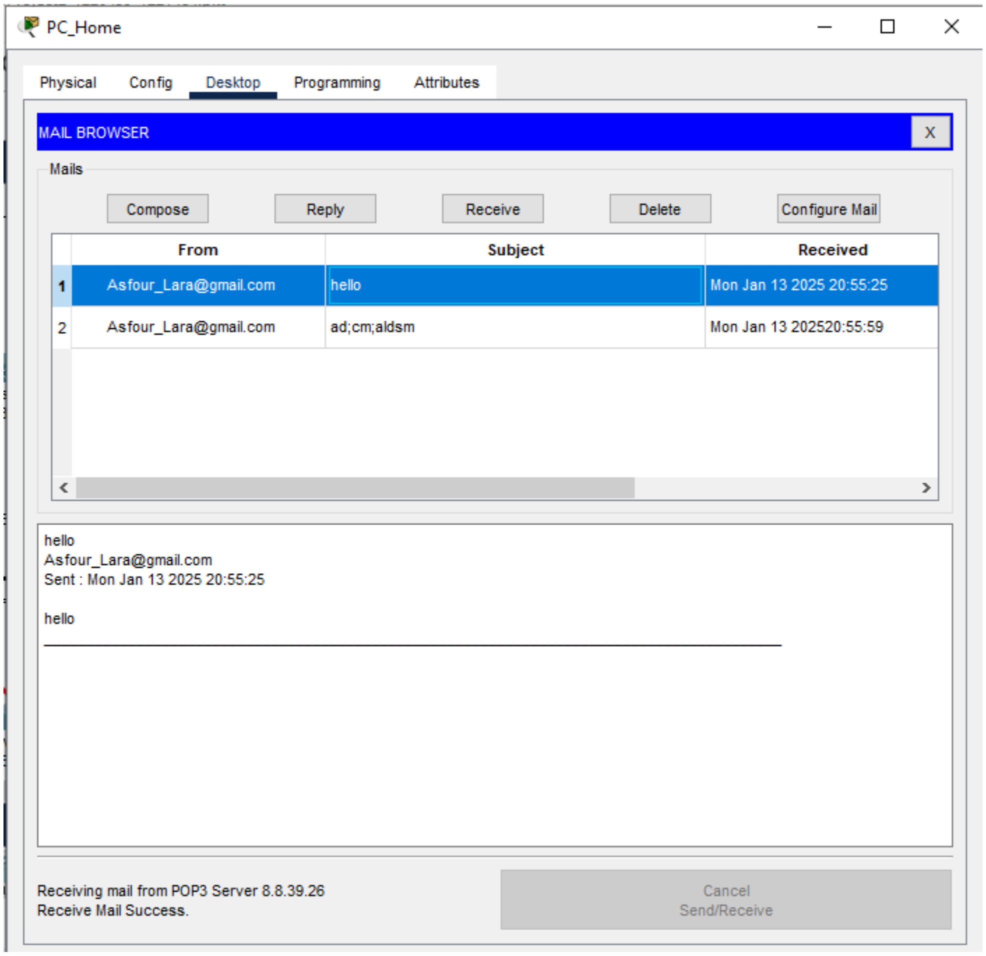

Figure 58: Successful receiving between gmail.com accounts within the Home-ISP network.

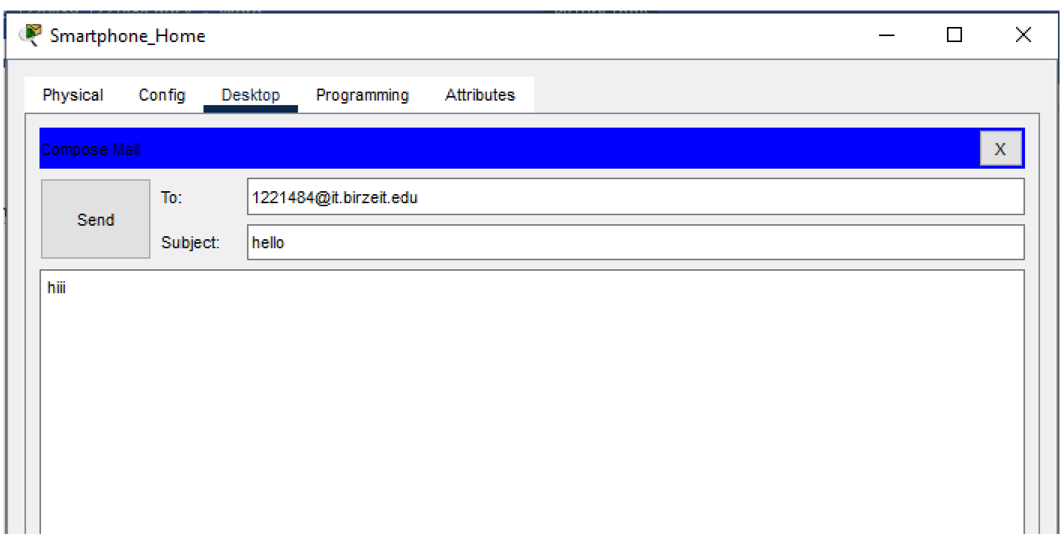

Figure 59: send Email Between it.birzeit.edu accounts within the Home-ISP network.

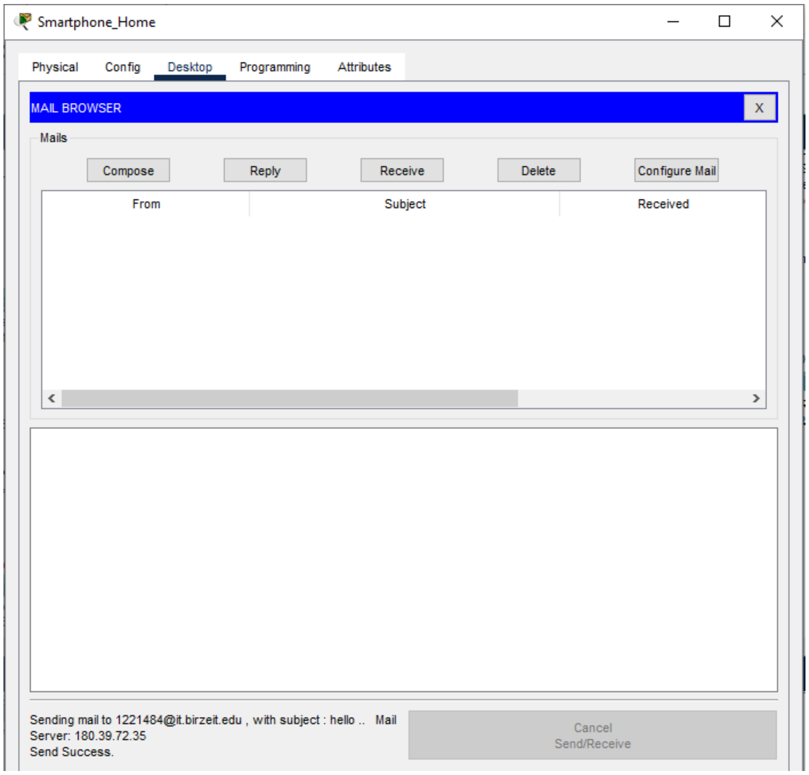

Figure 60: Successful sending between it.birzeit.edu accounts within the Home-ISP network.

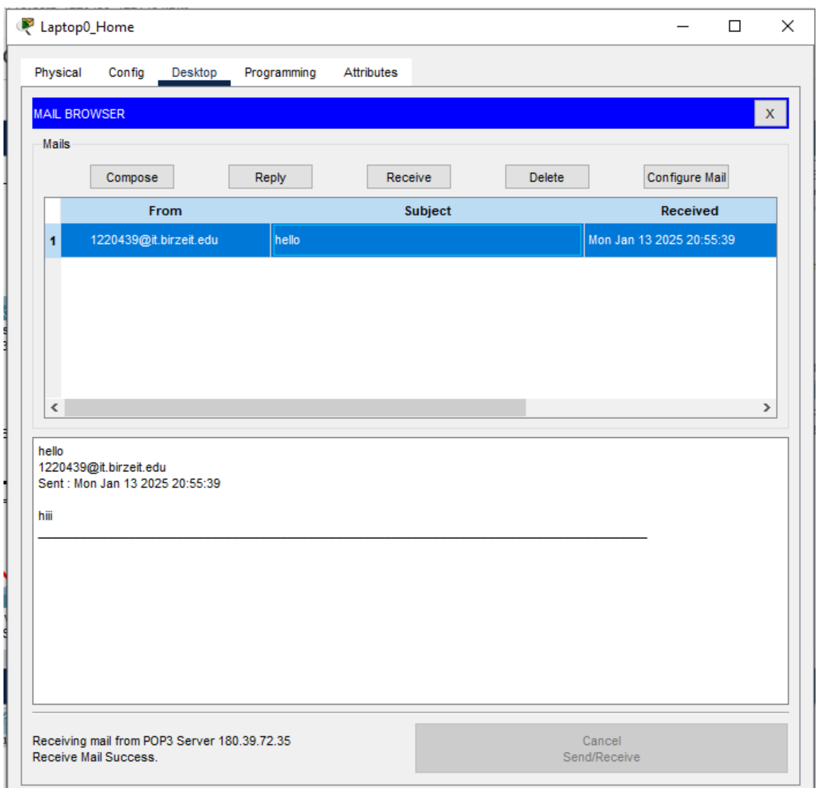

Figure 61: Successful receiving between it.birzeit.edu accounts within the Home-ISP network.

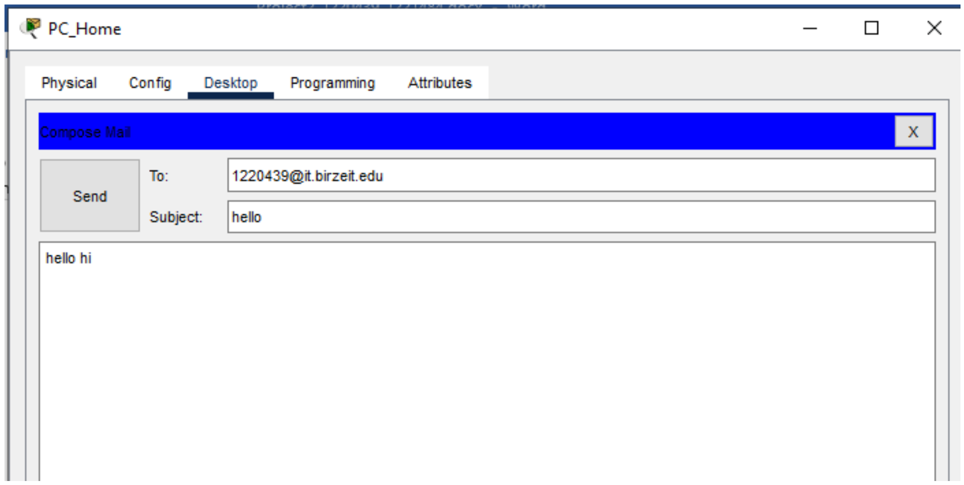

Figure 62: send Email Between gamil.com and it.birzeit.edu accounts within the Home-ISP network.

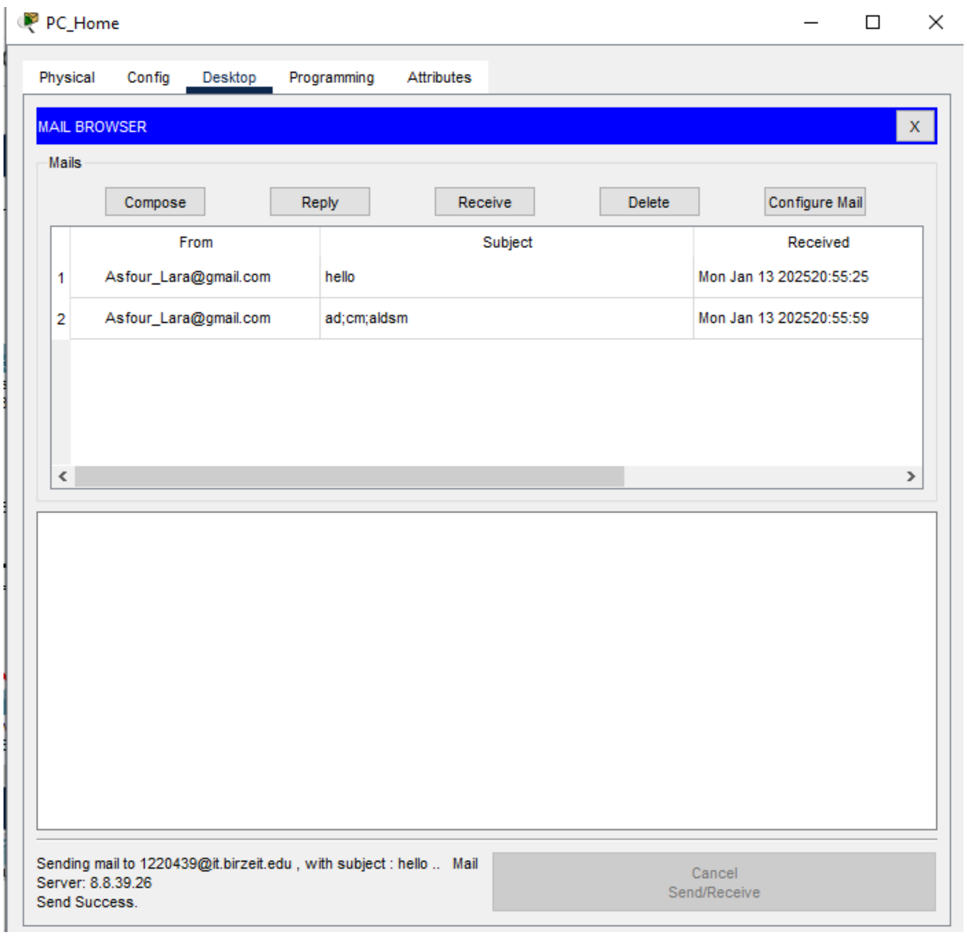

Figure 63: Successful sending between gmail.com and it.birzeit.edu accounts within the Home-ISP network.

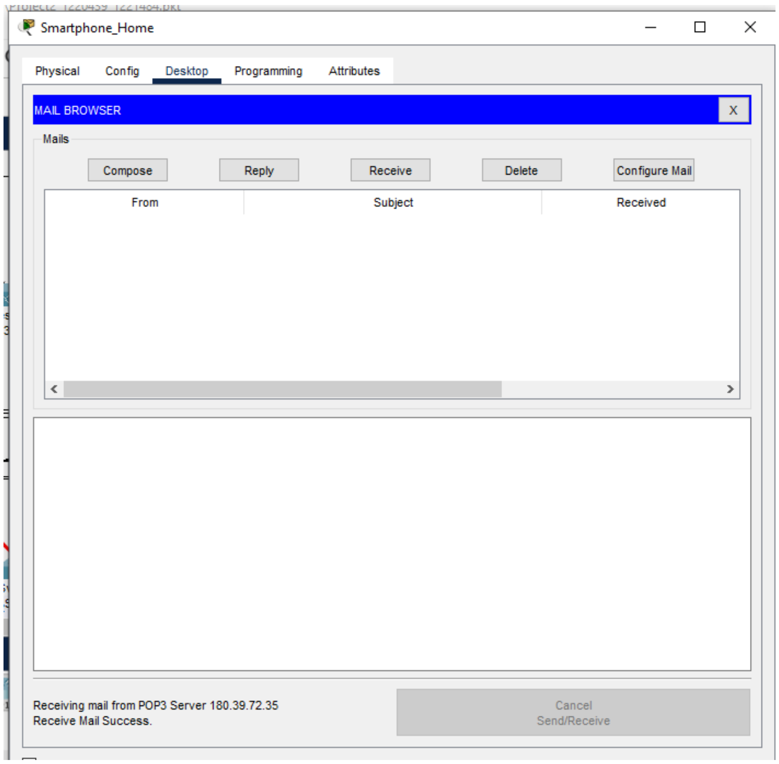

Figure 64: Successful receiving between gmail.com and it.birzeit.edu accounts within the Home-ISP network.

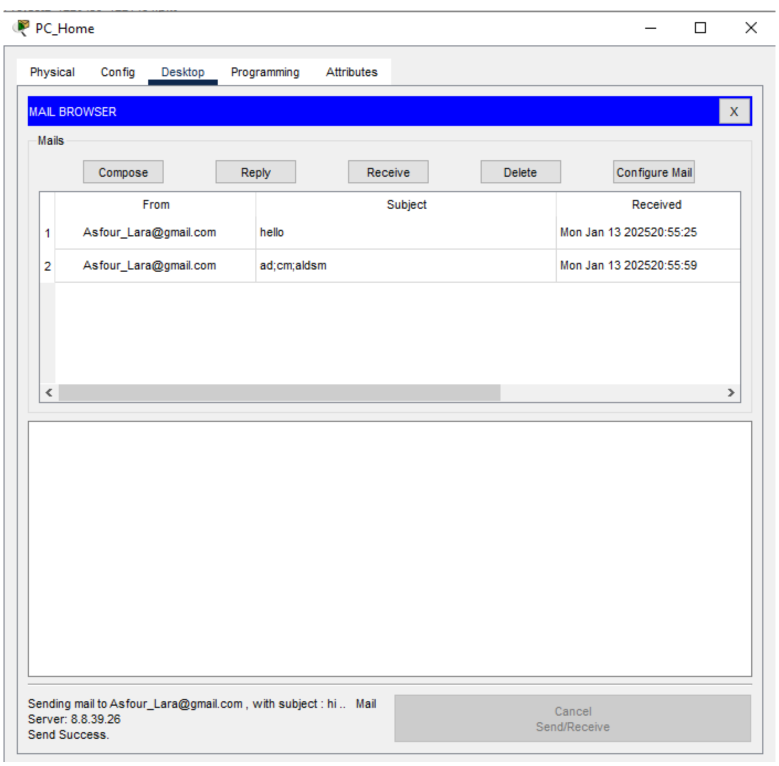

Figure 65:successful sending between Gmail accounts within the Home-ISP network and the Faculty of Engineering

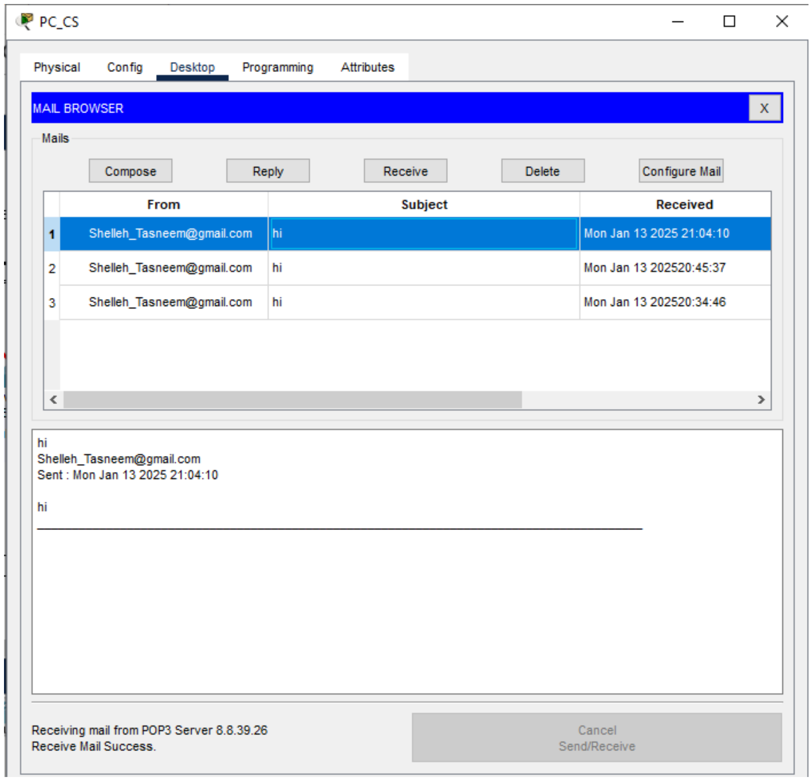

Figure 66: successful receiving between Gmail accounts within the Home-ISP network and the Faculty of Engineering

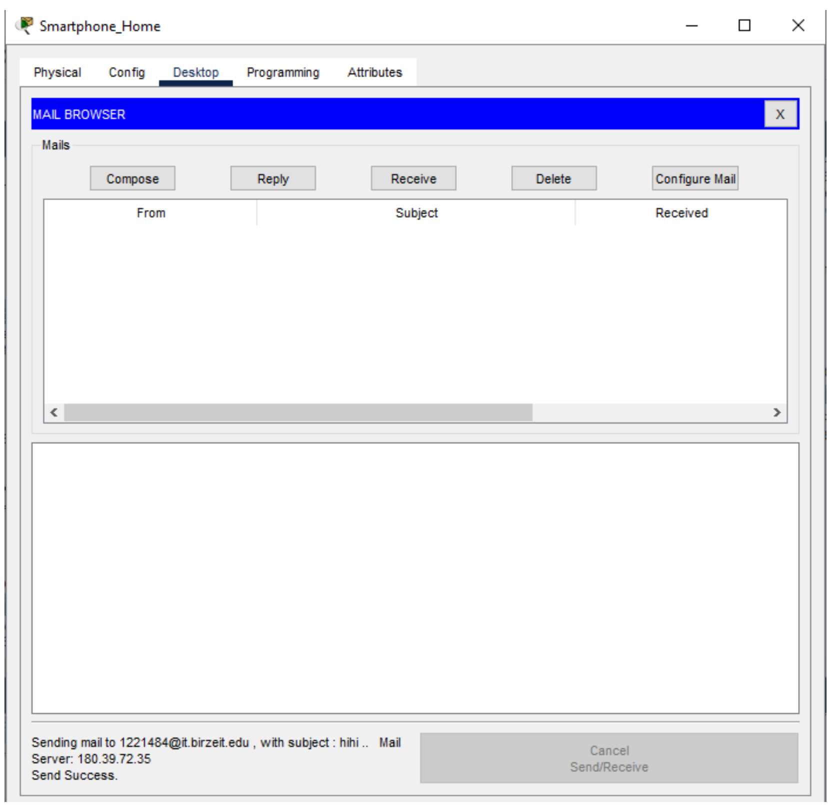

Figure 67: successful sending between Birzeit accounts within the Home-ISP network and the Faculty of Engineering

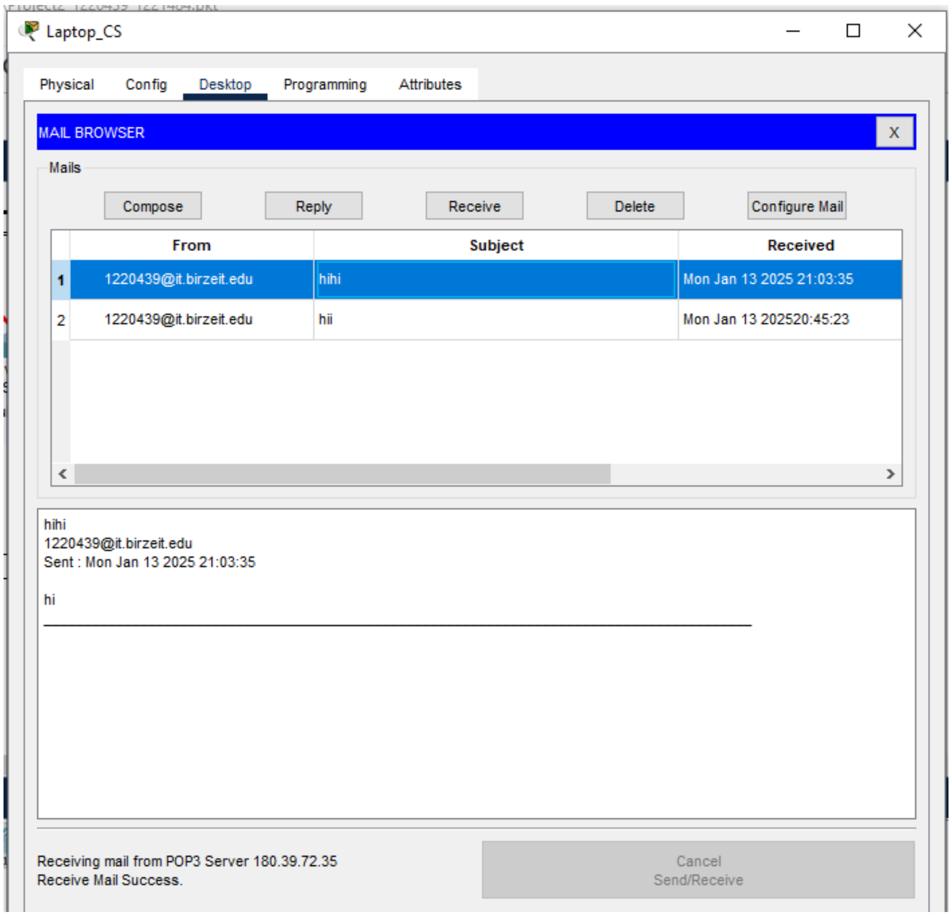

Figure 68: successful receiving between Birzeit accounts within the Home-ISP network and the Faculty of Engineering

- ## Central routers

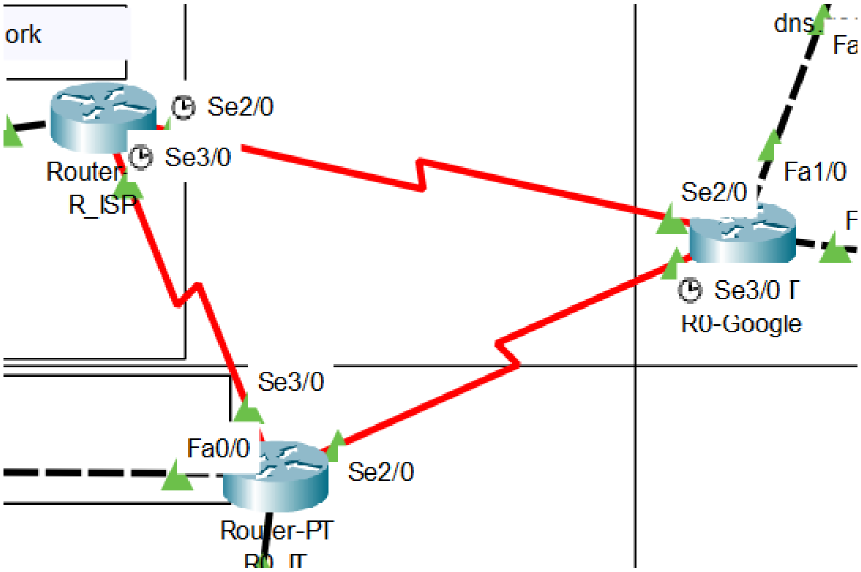

Figure 69: central routers

IP configuration of them:

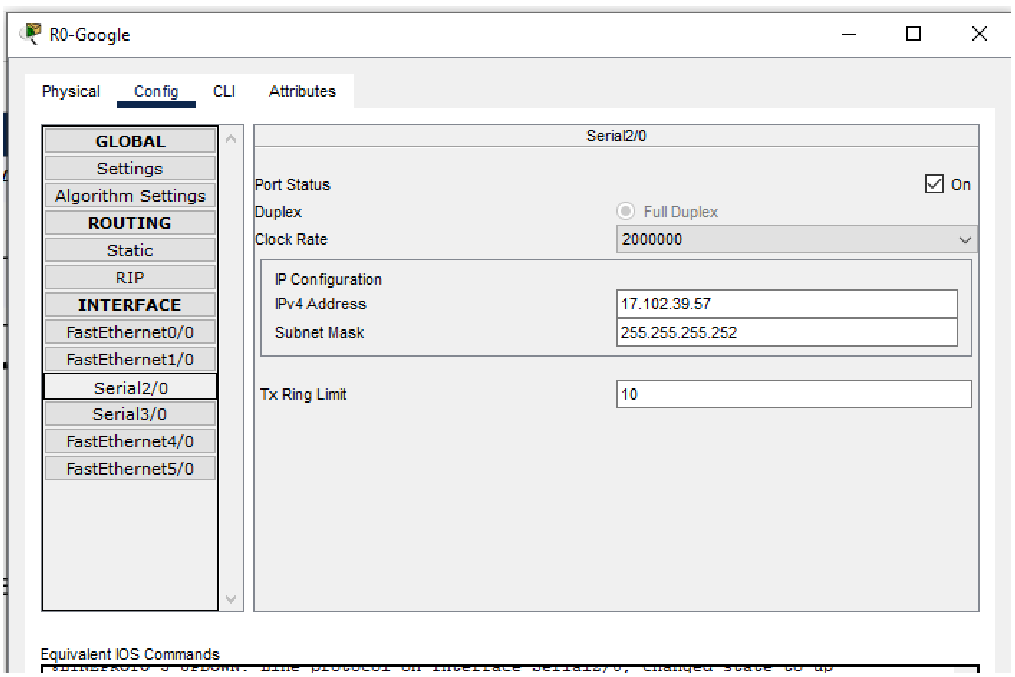

Figure 70: R0_google IP configuration between AS-300 and AS-200

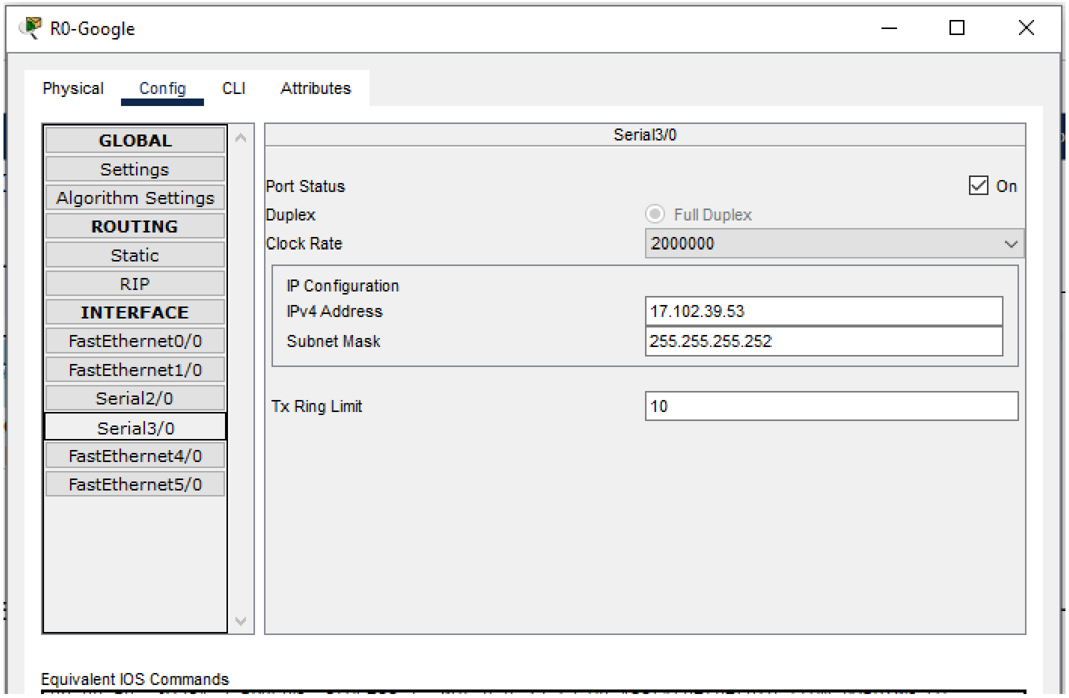

Figure 71: R0_google IP configuration between AS-300 and AS-100

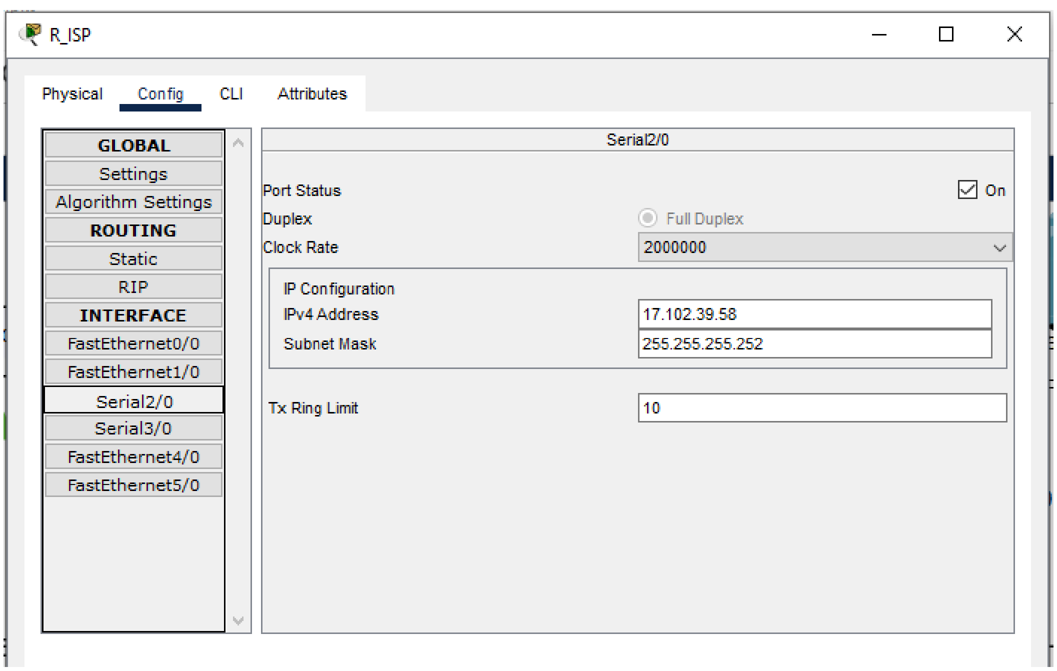

Figure 72: R_ISP IP configuration between AS-200 and AS-300

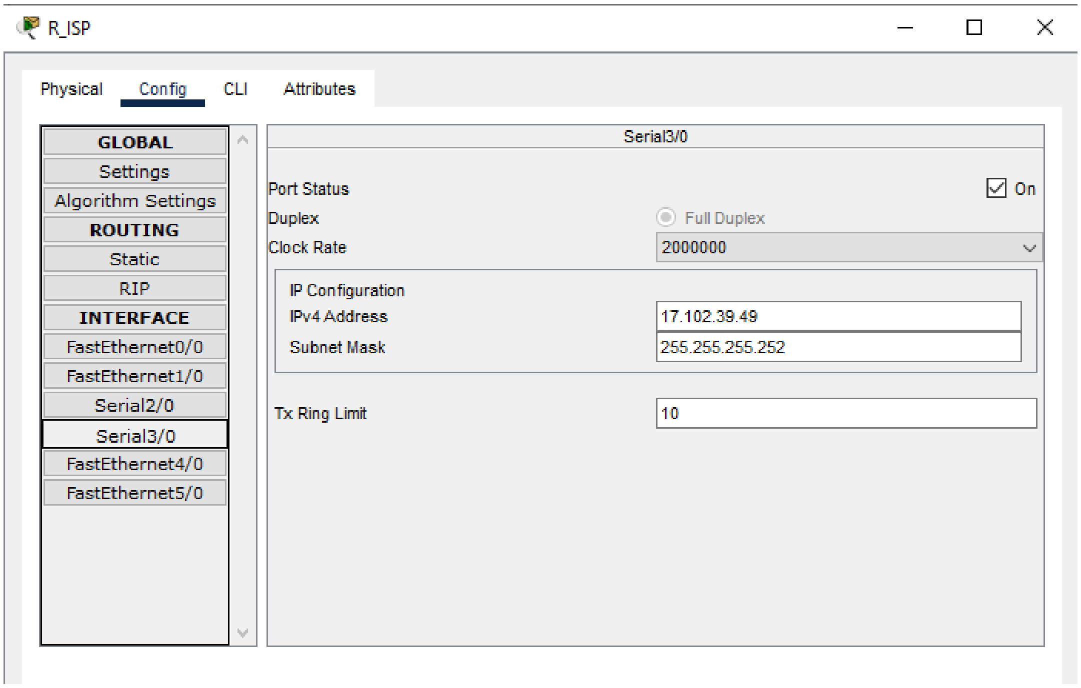

Figure 73: R_ISP IP configuration between AS-200 and AS-100

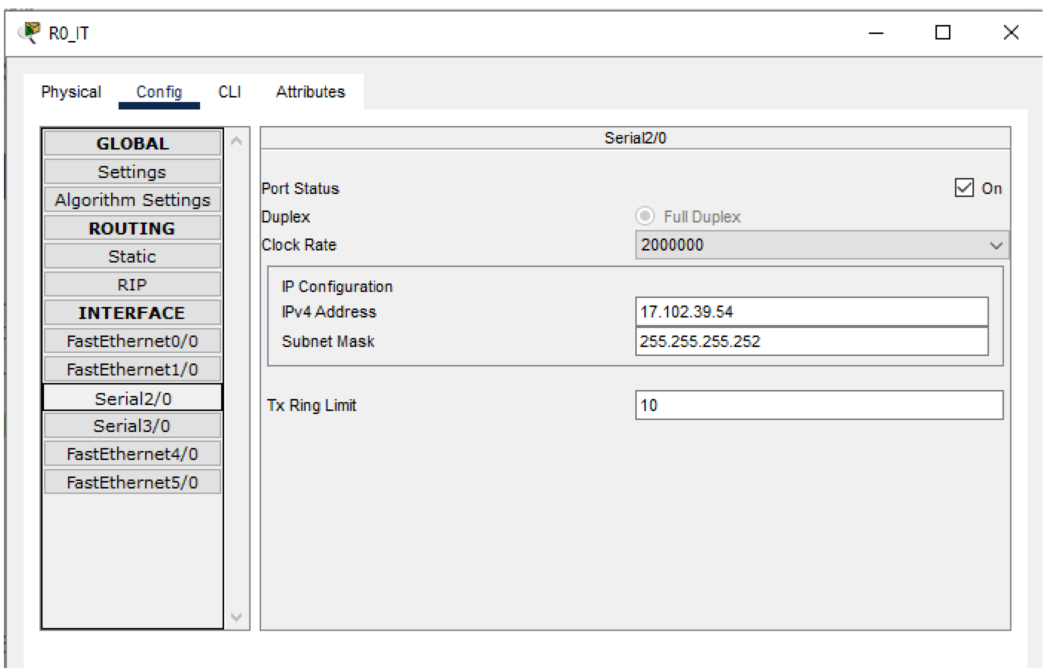

Figure 74: R0_IT IP configuration between AS-100 and AS-300

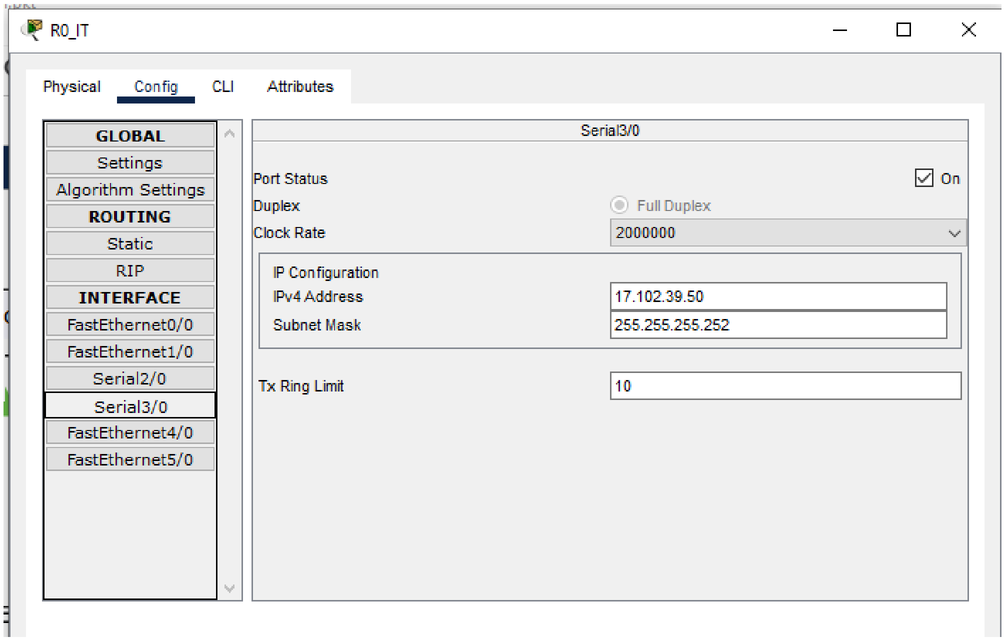

Figure 75: R0_IT IP configuration between AS-100 and AS-200

Issues and Limitations

Some problems that we faced it, then solved it:

- Overlaps occurred when try to set the IP address for ECE and CS subnets in AS-100, that we were mistaken in calculating the subnets, then we recalculate them.
- We could not connect more than 3 ports (servers) with the switch in servers subnet in As-100, then we changed the physical settings if the switch to make accept 4 ports.
- When we try to set the IP configuration of the end devices on DHCP (Dynamically), it gave us that DHCP Failed, until we set all the OSPF and BGP protocols it success.

Conclusion

This project focused on creating and testing computer networks to deepen our understanding and application of key networking concepts, including IP addressing, subnetting, routing, switching, VLANs, and network security. Using Cisco Packet Tracer, we designed a network to simulate real-world scenarios, configuring and testing devices such as routers, switches, and computers. The platform allowed us to simulate data flow, troubleshoot network issues, and explore advanced protocols like OSPF and EIGRP, providing valuable hands-on experience in network design and management.

Teamwork

For our project, we formed a team of two students to make sure everyone had an equal share of the work. We were open meetings and worked together on every task of the project, from connecting the networks until the results shown. By working closely together, we made sure to do the project completely. We was in project 1, three partners, but in this project one student went to another team, so the name of the team changed to our student IDs.

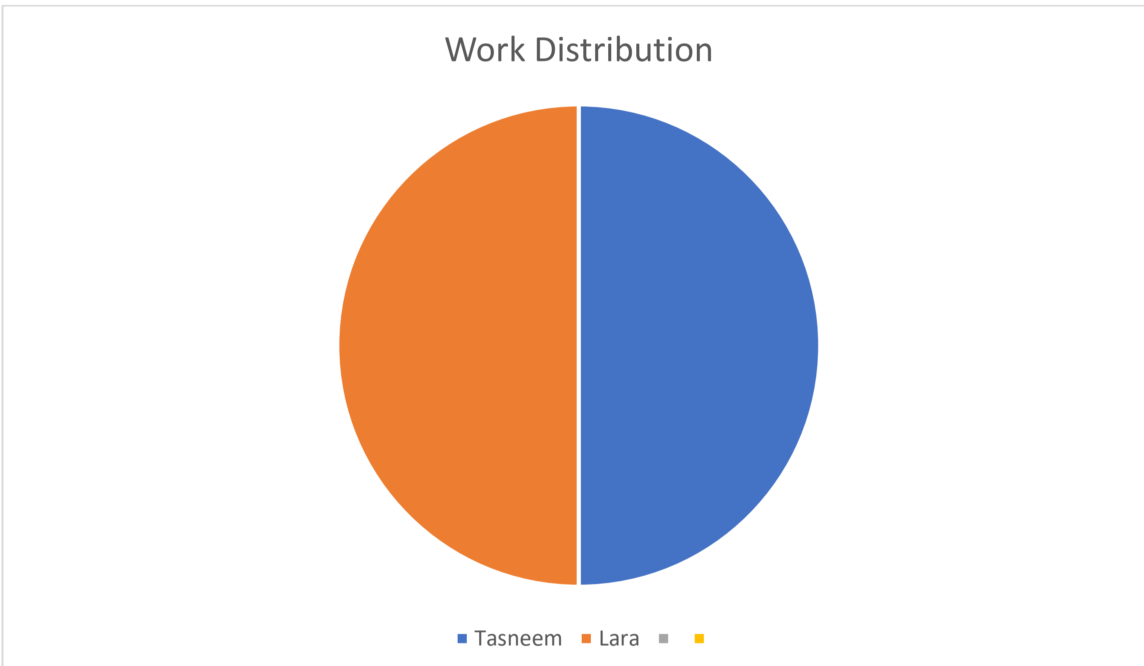

Figure 76: Team Work

References

- Cisco Networking Academy, *Subnetting: IPv4 and IPv6 Concepts*, https://www.netacad.com/
- Internet Engineering Task Force (IETF), RFC 1034: *Domain Names - Concepts and Facilities,* https://www.rfc-editor.org/
- Internet Engineering Task Force (IETF), RFC 5321: *Simple Mail Transfer Protocol,* https://www.rfc-editor.org/
- HTTP/1.1: RFC 2616, *Hypertext Transfer Protocol,* https://www.rfc-editor.org/
- https://www.techjunkie.com/what-is-my-subnet-mask/