Birzeit University
Faculty of Engineering & Technology
DEPARTMENT OF Electrical & Computer Engineering
Computer Network
ENCS3320
Project 2
Cisco Packet Tracer

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Section: 3

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Abstract

This project aims on designing and simulating a computer network using Cisco Packet Tracer to develop proficiency in advanced networking concepts such as subnetting, routing, wireless security, and key network services. The objective is to integrate multiple autonomous systems ASs into a cohesive network with seamless communication. Each AS including the Google network, Faculty of Engineering and Technology network, and Home-ISP network, will employ static and dynamic routing protocols such as OSPF and BGP to ensure reliable data exchange. Key services such as DNS, DHCP, Web, and Email servers will be configured to meet real-world requirements, enhancing the functional capabilities of the network. Additionally, network address translation (NAT) and wireless LAN configurations will be implemented to support connectivity and security. By this project we will able to enhance our practical networking skills, and teamwork.

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1. Theory

1.1 Network of Networks:

The network of networks shown in figure 1 represents a scalable and interconnected system that integrates multiple autonomous systems AS, including business, home, and cellular networks, to ensure seamless communication and resource sharing. Each subnetwork is designed for specific needs. the business network supports operations with servers, printers, and workstations, interconnected through switches and wireless access points for flexibility, the home network focuses on residential connectivity with wireless devices managed through routers offering NAT and DHCP services, and the cellular network enables mobile connectivity for devices like smartphones and tablets through base stations linked to regional and global networks. These subnetworks are connected through a robust backbone of routers, ensuring efficient data flow, high reliability, and scalability. Advanced routing protocols like OSPF and BGP enable seamless communication between ASs, while security measures such as encryption, NAT, and firewalls protect data and prevent unauthorized access. This interconnected system highlights the complexity and versatility of modern networking, meeting diverse demands while maintaining efficiency and security, and our project depend totally of the concept of network of network

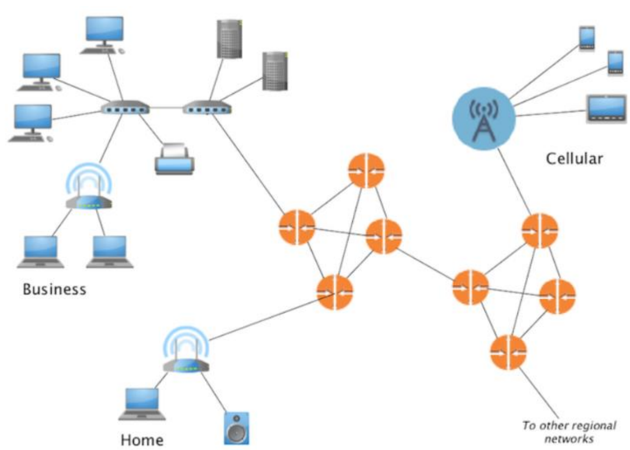


Figure 1: Network of Network

1.2 IP Addressing and Subnetting

IP addressing and subnetting are fundamental concepts in network design that allow efficient utilization and organization of IP addresses within a network. IP addressing assigns a unique identifier to each device on a network, enabling communication between them. Subnetting divides a larger network into smaller, more manageable subnets by borrowing bits from the host portion of an IP address. This process helps optimize IP address usage, reduce broadcast traffic, and enhance network performance and security. Each subnet is defined by a subnet mask, which specifies the division between the network and host portions of the address. Subnetting also supports hierarchical addressing, allowing networks to scale efficiently and enabling better routing decisions. It ensures the isolation of different network segments, reducing the scope of potential network issues and enhancing security, we will discuss the mane IP address of our project in details later.

1.3 Dynamic Host Configuration Protocol (DHCP)

Dynamic Host Configuration Protocol (DHCP) is a network management protocol that automates the process of assigning IP addresses and other network configuration parameters to devices on a network. Instead of requiring manual configuration, DHCP dynamically provides devices with a valid IP address, subnet mask, default gateway, and DNS server information. This process occurs through a client-server model, where a device DHCP client requests an IP configuration, and a DHCP server assigns an address from a pre-configured pool. DHCP simplifies network administration by reducing the need for manual IP assignments minimizing configuration errors and saving administrative time. It also enables efficient reuse of IP addresses by leasing them for a specific period, after which they can be reassigned to other devices. DHCP supports both IPv4 and IPv6 but for our project we need IPv4 networks and is particularly useful in dynamic environments where devices frequently join and leave the network as Shown in figure 2. It enhances scalability by automating address management, ensuring seamless device connectivity even in large and complex networks. By automating IP address allocation and configuration, DHCP ensures efficient use of address space, reduced conflicts, and seamless connectivity for network devices.

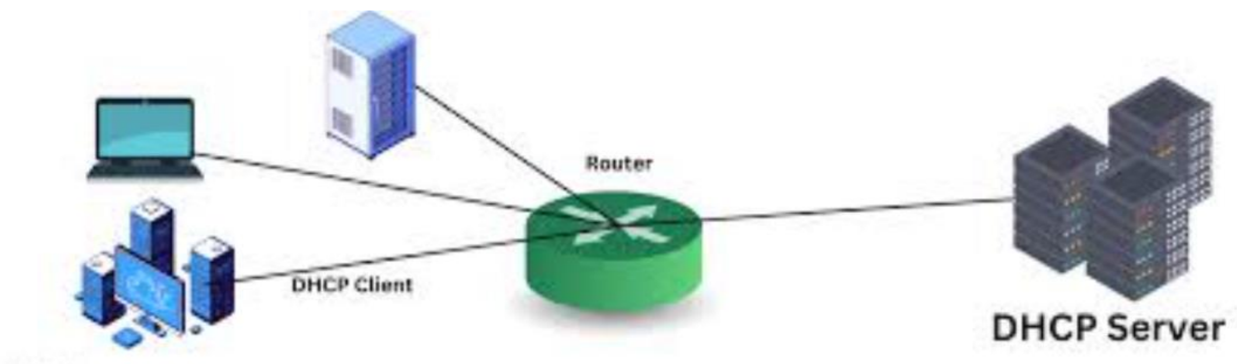


Figure 2: DHCP

1.4 Domain Name System (DNS)

The Domain Name System DNS is a critical network service that translates human-readable domain names www.google.com into machine readable IP addresses 192.168.1.1, allowing users to access resources on the internet or private networks easily. DNS operates through a hierarchical system of servers, including root servers, top level domain TLD servers, and authoritative name servers, each playing a role in resolving domain queries. When a user enters a domain name, the DNS server queries its database or forwards the request to other DNS servers to retrieve the corresponding IP address. DNS simplifies network navigation, eliminating the need for users to memorize complex IP addresses. It also supports essential functionalities like load balancing and redundancy by mapping multiple IP addresses to a single domain name. DNS resource records RRs, such as A address, CNAME canonical name, NS name server, and MX mail exchange, shown in figure 3

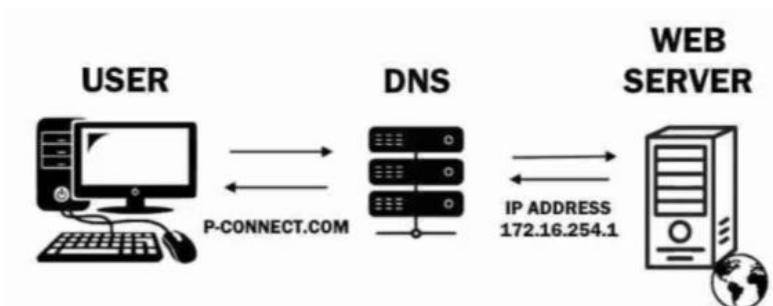


Figure 3: DNS

1.5 Web and Email

Web and email services are essential components of modern networking, enabling communication and access to resources over the internet. Web services are hosted on web servers, which deliver content such as websites and applications through HTTP and HTTPS protocols. These servers store and serve web pages, multimedia, and dynamic content to users based on their requests. Web services often incorporate security features like SSL/TLS encryption to ensure secure data exchange. Email services, on the other hand, facilitate the exchange of messages between users through protocols such as SMTP Simple Mail Transfer Protocol for sending emails, and POP3 or IMAP for receiving them shown in figure 4. Email servers manage user accounts, mail storage, and message delivery across networks. They often work with DNS to resolve domain names for mail exchange MX records, directing emails to the appropriate servers. Both services rely on robust configurations to ensure reliability, scalability, and security, with features like spam filtering, authentication, and encryption for protecting sensitive communication. Together, web and email services form the backbone of online communication, supporting personal, professional, and business interactions across the globe.

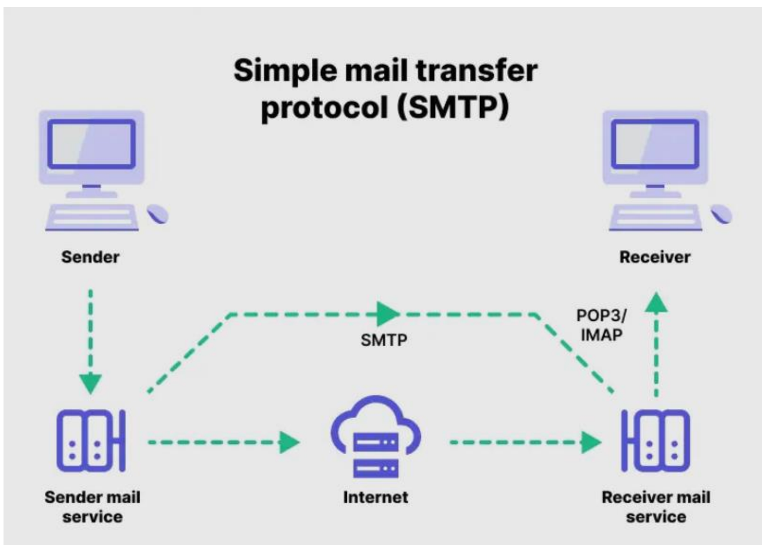


Figure 4: Email protocols

1.6 NAT

Network Address Translation NAT is a critical networking technique that allows multiple devices on a local network to share a single public IP address for accessing external networks, such as the internet. By mapping private IP addresses to a public address, NAT helps conserve the limited pool of IPv4 addresses. NAT operates by modifying IP headers in packets as they pass through a router or firewall, translating private source addresses to public ones for outgoing traffic and reversing the process for incoming traffic. It enhances network security by masking internal IP addresses, making it difficult for external entities to directly access devices within the network. NAT is commonly used in homes, businesses, and data centers to connect internal networks to the internet. It supports various modes, including static NAT for one-to-one mappings and dynamic NAT or PAT Port Address Translation for many-to-one mappings. While NAT is highly effective, it can introduce challenges for peer-to-peer communication and certain applications, requiring specialized solutions like port forwarding.

1.7 OSPF & BGP

Open Shortest Path First OSPF and Border Gateway Protocol BGP are two widely used routing protocols in modern networks. OSPF is a dynamic, link-state routing protocol designed for internal network routing within an Autonomous System AS. It uses Dijkstra's algorithm to calculate the shortest path, ensuring efficient and loop free routing. OSPF is highly scalable, supports hierarchical network design through areas, and converges quickly, making it suitable for large enterprise networks. On the other hand, BGP is an external gateway protocol used for routing between Autonomous Systems on the internet. Known as the "protocol of the internet, BGP determines the best path based on policies and attributes rather than just shortest-path metrics. It ensures reliable communication between different networks, supports path redundancy, and handles scalability for the vast number of routes in the global internet. Together, OSPF and BGP enable seamless communication within and between networks, ensuring flexibility, scalability, and efficient data exchange in diverse networking environments.

2. Procedure & Data Analysis:

2.1 Building the Topology

As out project involve with many subnets, we ask to build the main topology and its shown in figure 5:

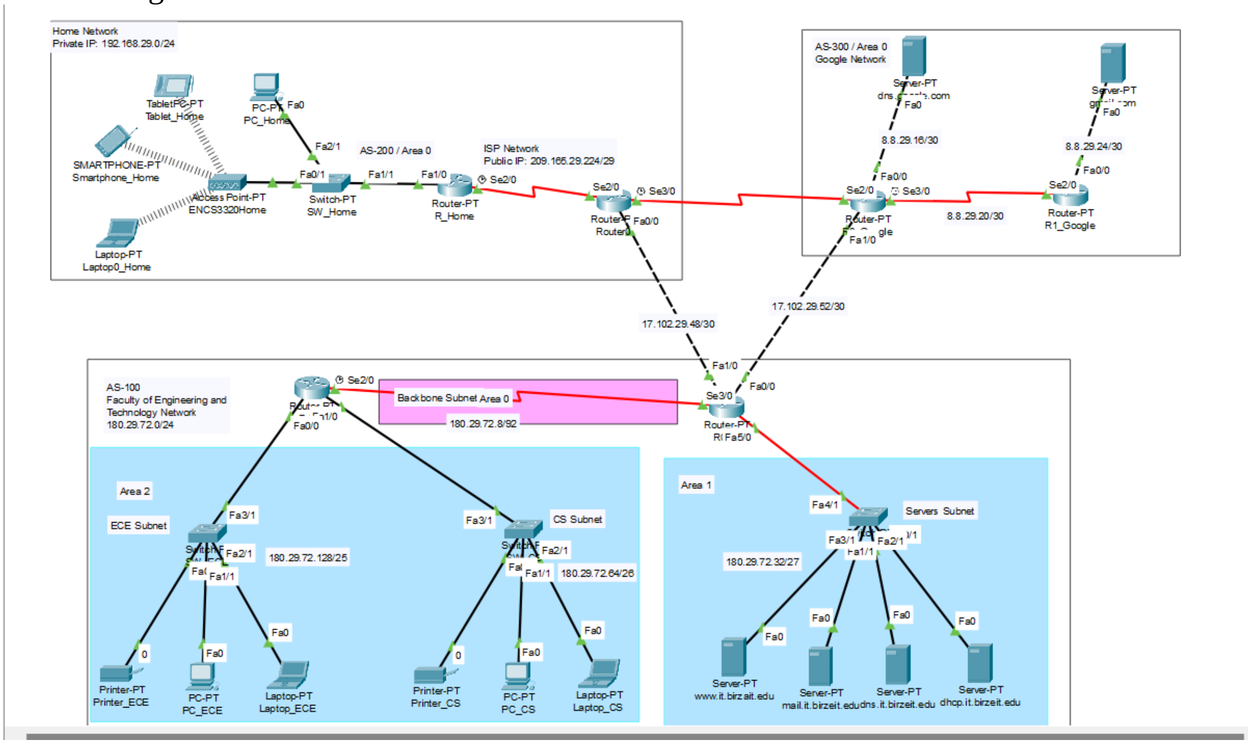


Figure 5: Topology

- Subnetting Steps according to our AES 100 Subnet in the project is as following:

1. Sort Subnets by Size:
   - ECE Subnet: Requires 120 IPs.
   - CS Subnet: Requires 55 IPs.
   - Servers Subnet: Requires 28 IPs.
   - Backbone Subnet: Requires 4 IPs.
2. Start with the Largest Subnet (ECE):
   - Step 1: Divide the /24 block into two /25 subnets.
     - ECE Subnet: Assign 180.29.72.128/25 (128 total IPs, 126 usable).
     - Remaining block: 180.29.72.0/25.
3. Divide the Remaining Block for CS:
   - Step 2: Divide 180.29.72.0/25 into two /26 subnets.
     - CS Subnet: Assign 180.29.72.64/26 (64 total IPs, 62 usable).
     - Remaining block: 180.29.72.0/26.
4. Divide the Next Block for Servers:
   - Step 3: Divide 180.29.72.0/26 into two /27 subnets.
     - Servers Subnet: Assign 180.29.72.33/27 (32 total IPs, 30 usable).
     - Remaining block: 180.29.72.0/27.
5. Allocate the Smallest Subnet for Backbone:
   - Step 4: Divide 180.29.72.0/27 into two /30 subnets.
     - Backbone Subnet: Assign 180.29.72.8/30 (4 total IPs, 2 usable).

2.2) AS 300

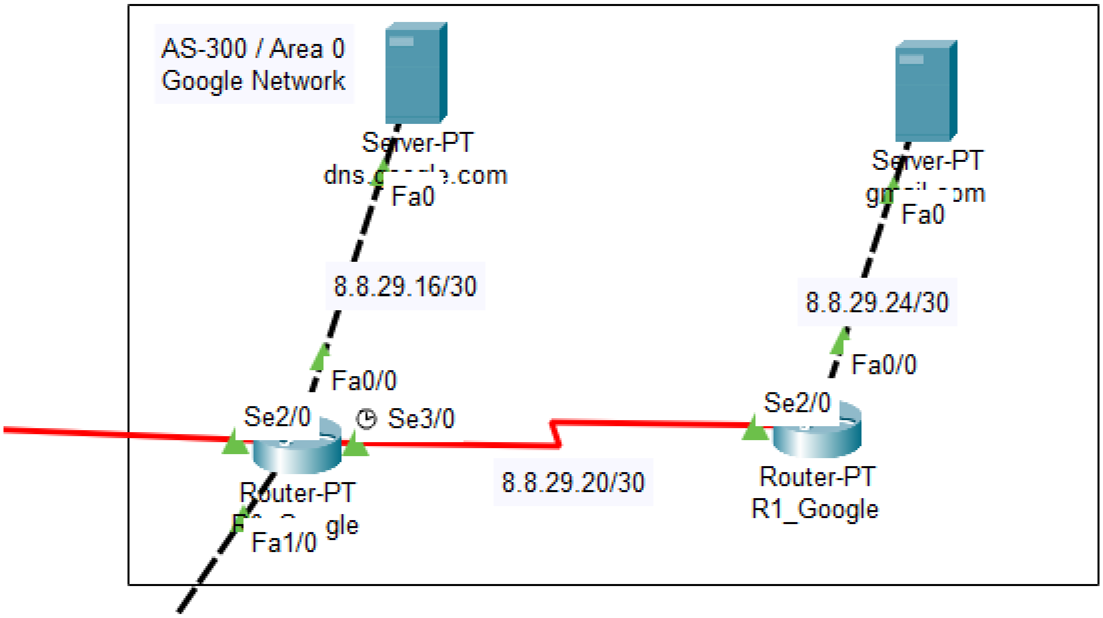


Figure 6: AS 300 /Area 0

For Router 1 (R0_Google), the following IP address configurations have been applied:

- **FastEthernet0/0**: Assigned the IP address **8.8.29.17** with a subnet mask of **255.255.255.252**.
- **FastEthernet1/0**: Assigned the IP address **17.102.29.54** with a subnet mask of **255.255.255.252**.
- **Serial2/0**: Configured with the IP address **17.102.29.57** and a subnet mask of **255.255.255.252**.
- **Serial3/0**: Assigned the IP address **8.8.29.21** with a subnet mask of **255.255.255.252**.

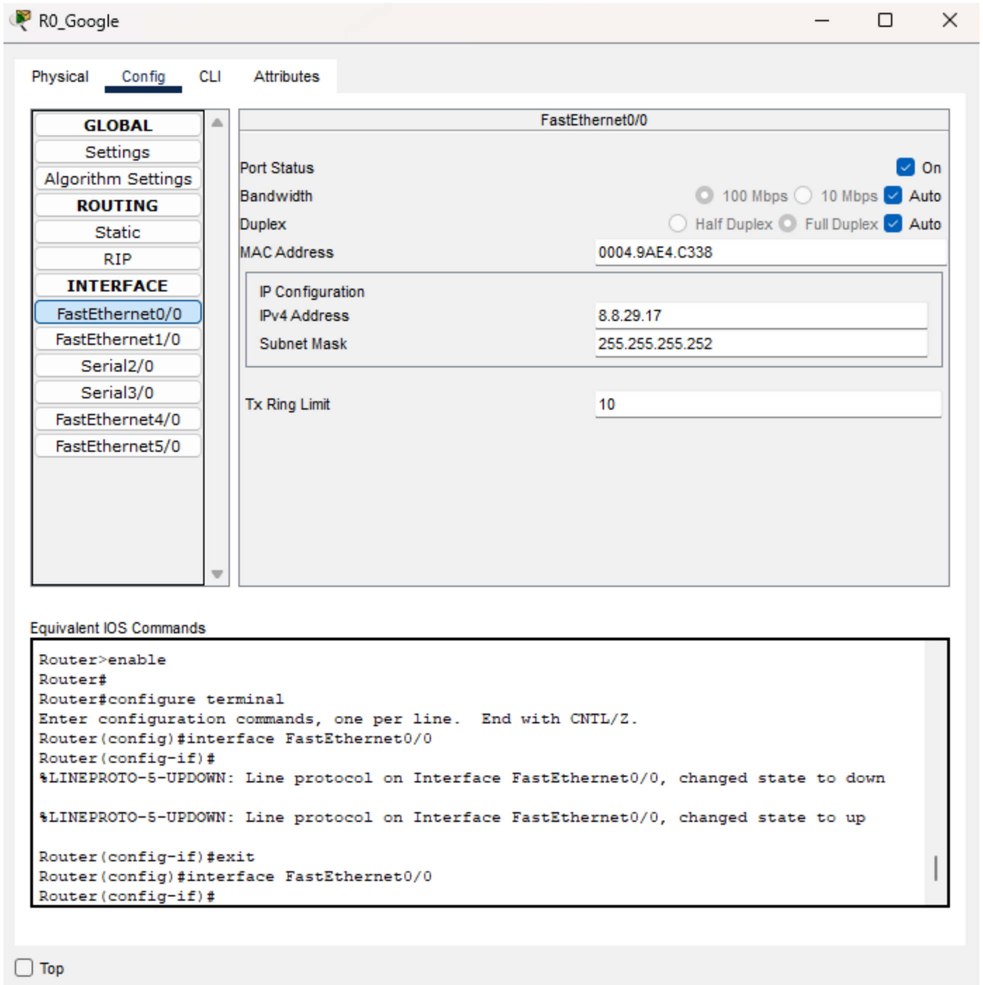


Figure 7: R0_Google Ethernet0/0 Configurations

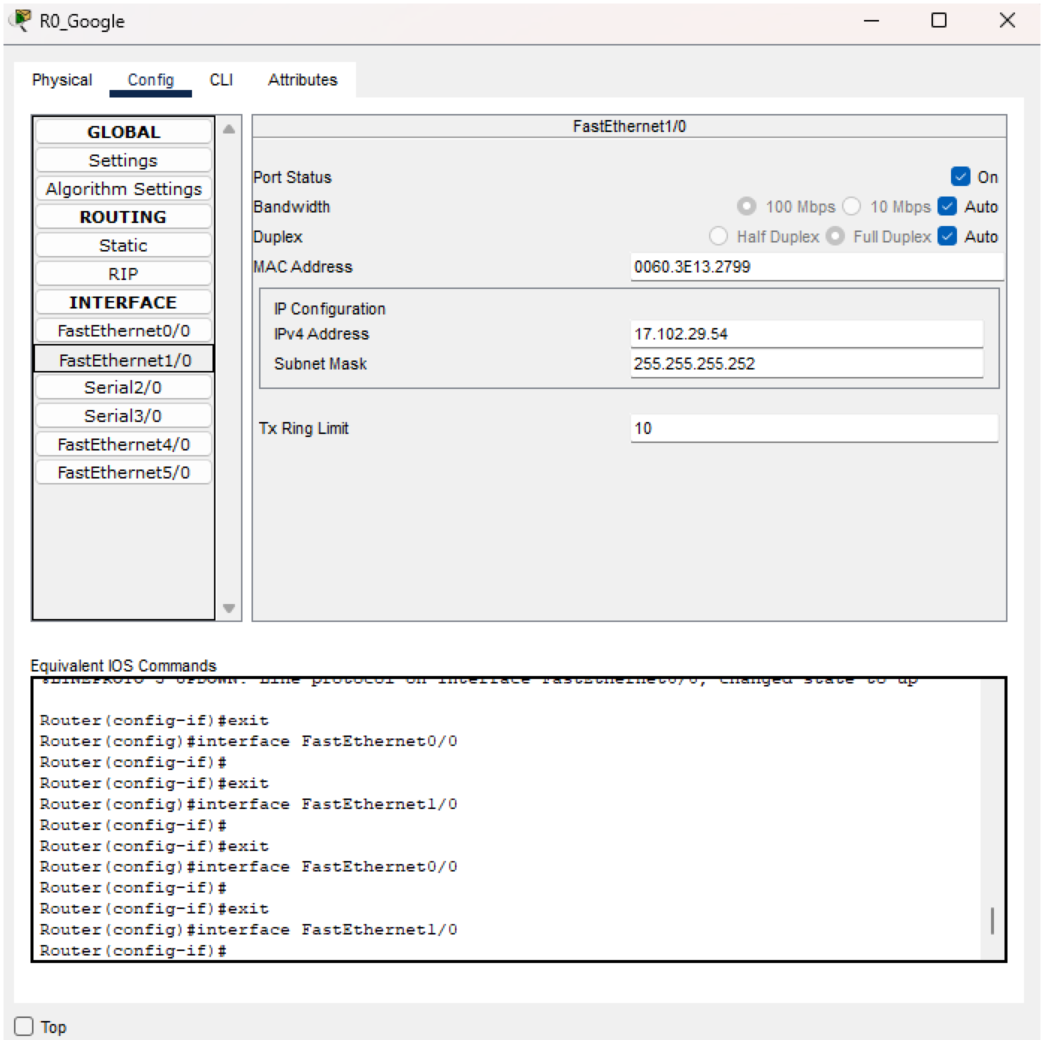


Figure 8: R0_Google Ethernet1/0 Configurations

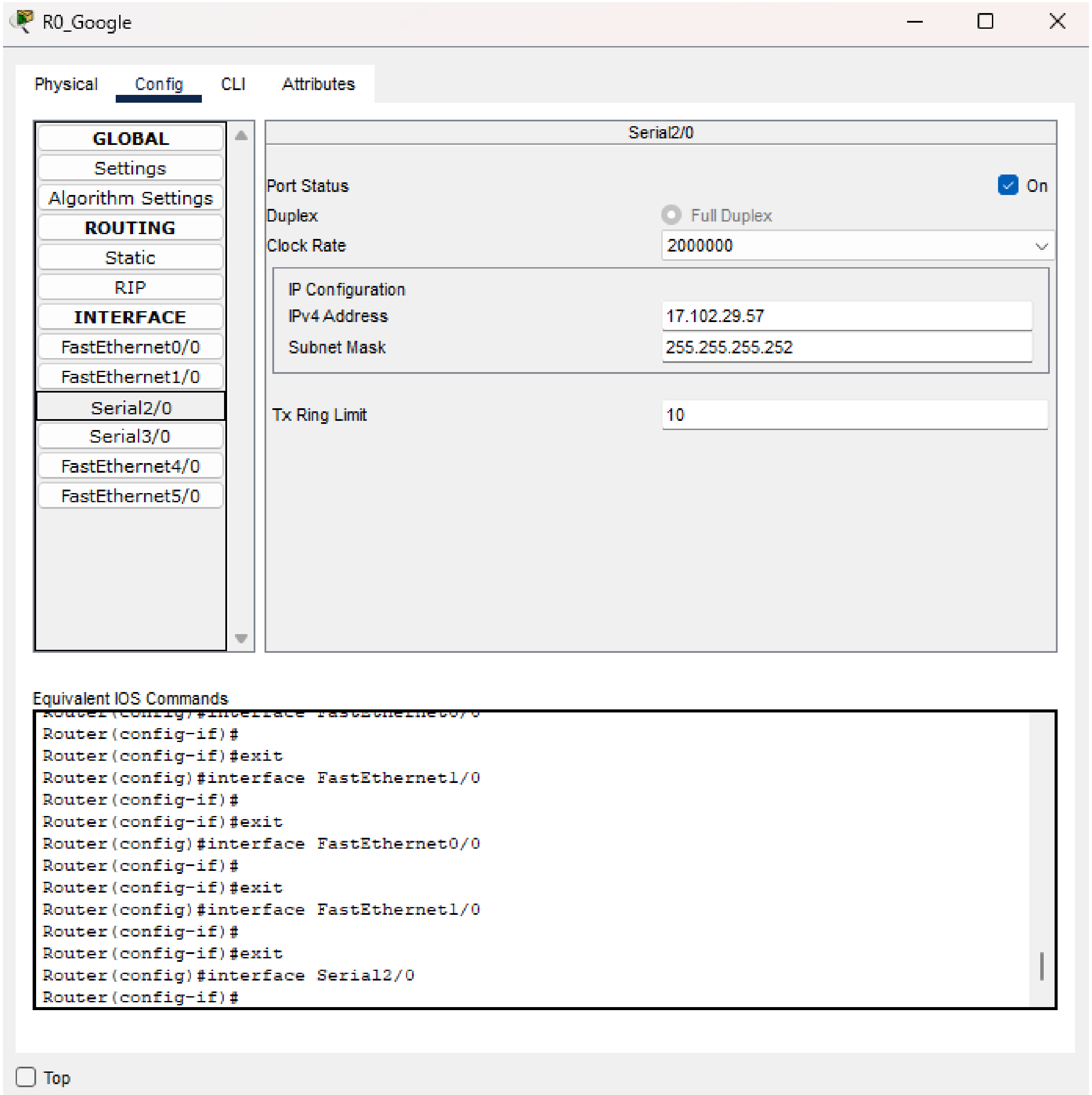


Figure 9: R0_Google Serial2/0 Configurations

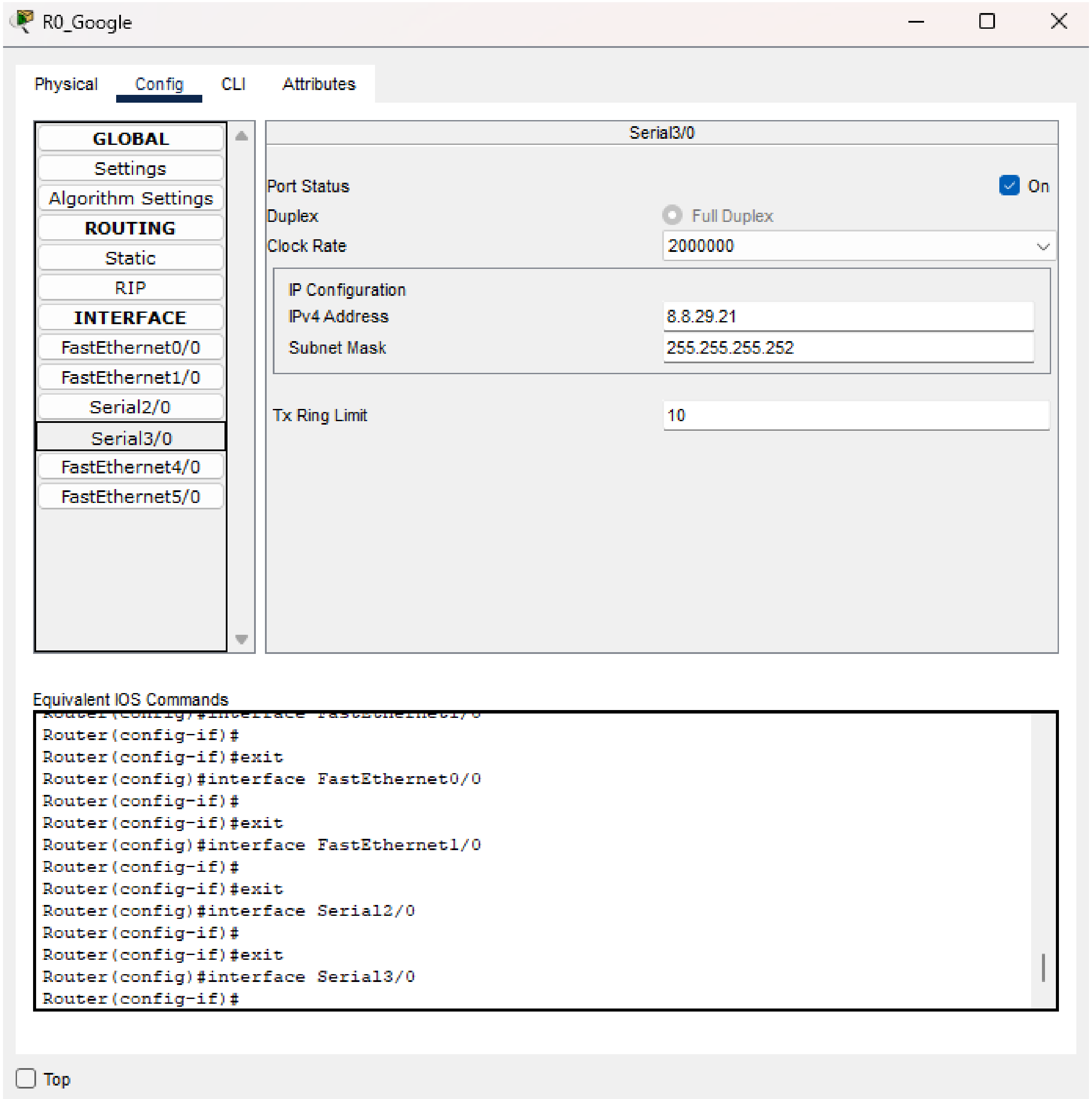


Figure 10: R0_Google Serial3/0 Configurations

- For Router 2 (R1_Google), the following IP address configurations have been applied:

- **FastEthernet0/0**: Assigned the IP address **8.8.29.25** with a subnet mask of **255.255.255.252**.

- **Serial2/0**: Configured with the IP address **8.8.29.22** and a subnet mask of **255.255.255.252**

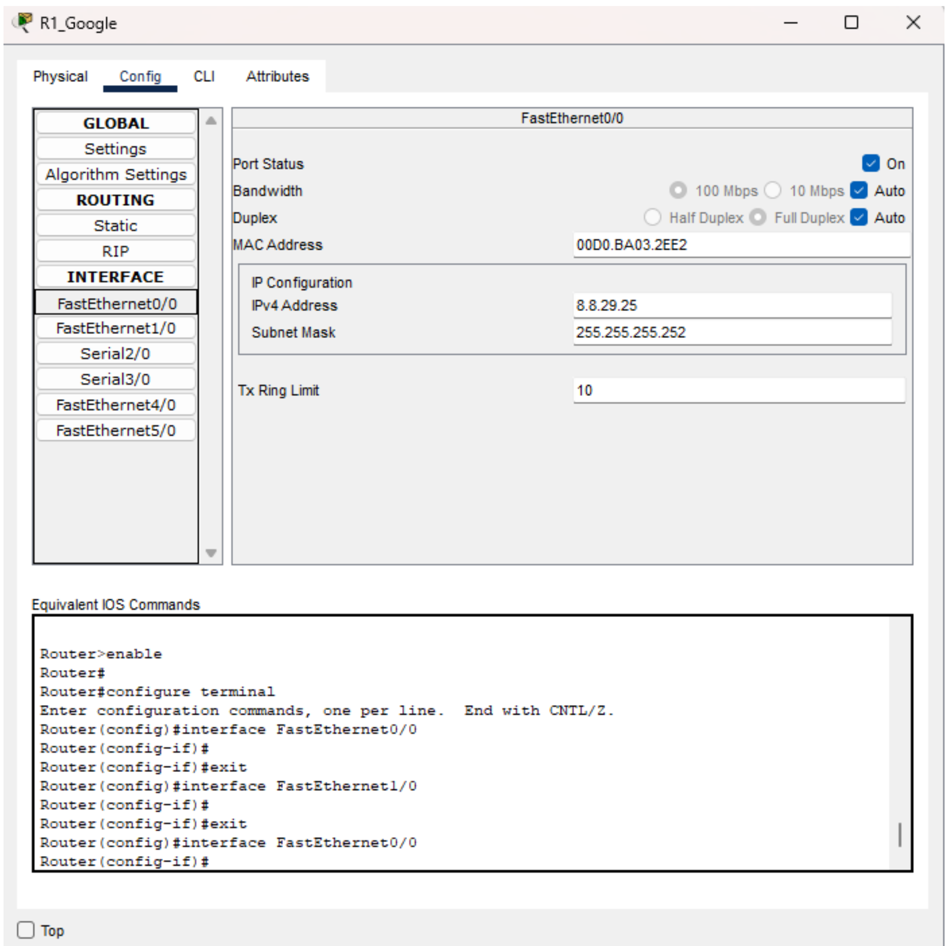


Figure 11: R1_Google Ethernet0/0 Configurations

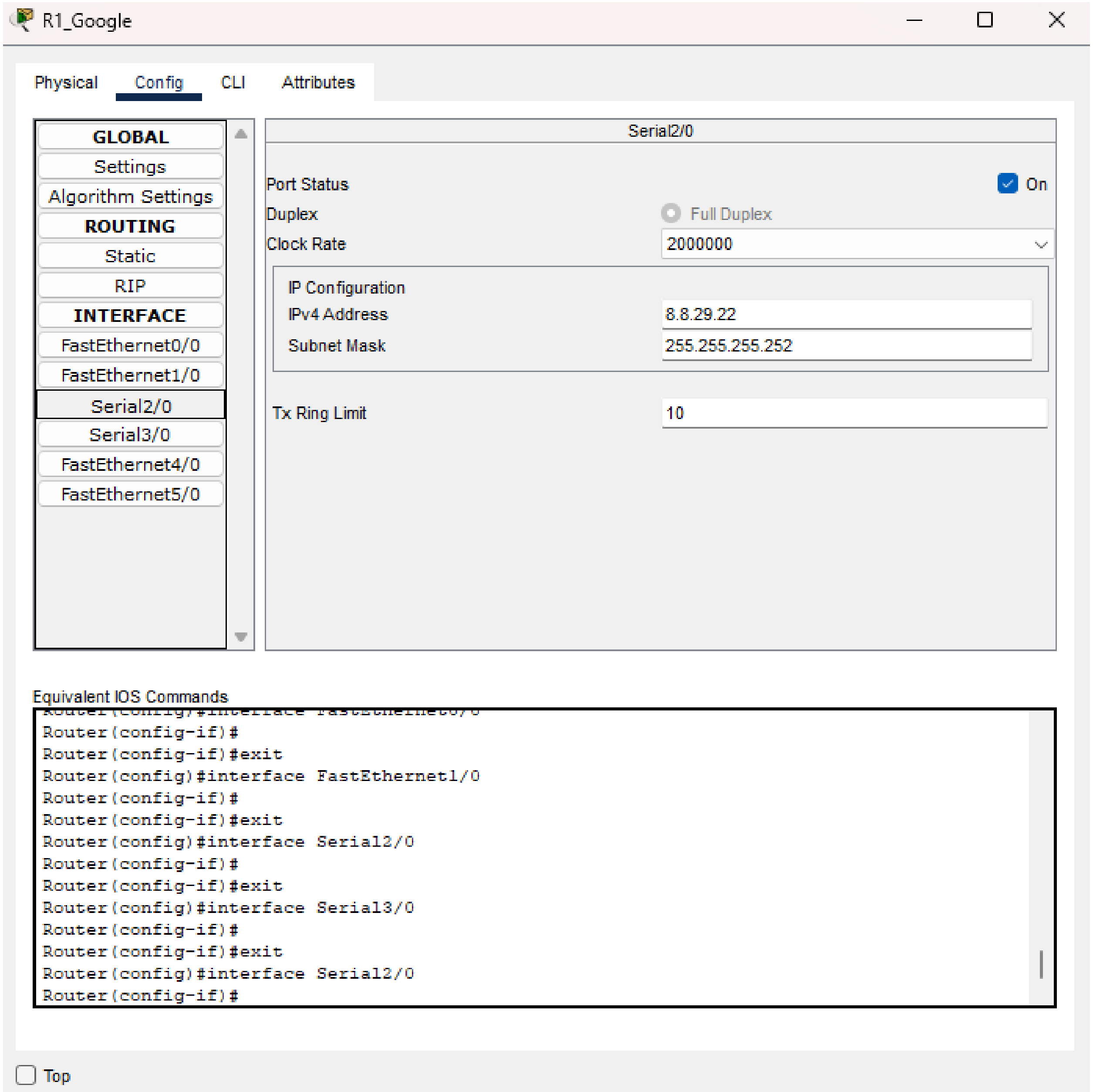


Figure 12: R1_Google Serial2/0 Configurations

- In this figure we Enable only the DNS service on this server (dns.google.com).

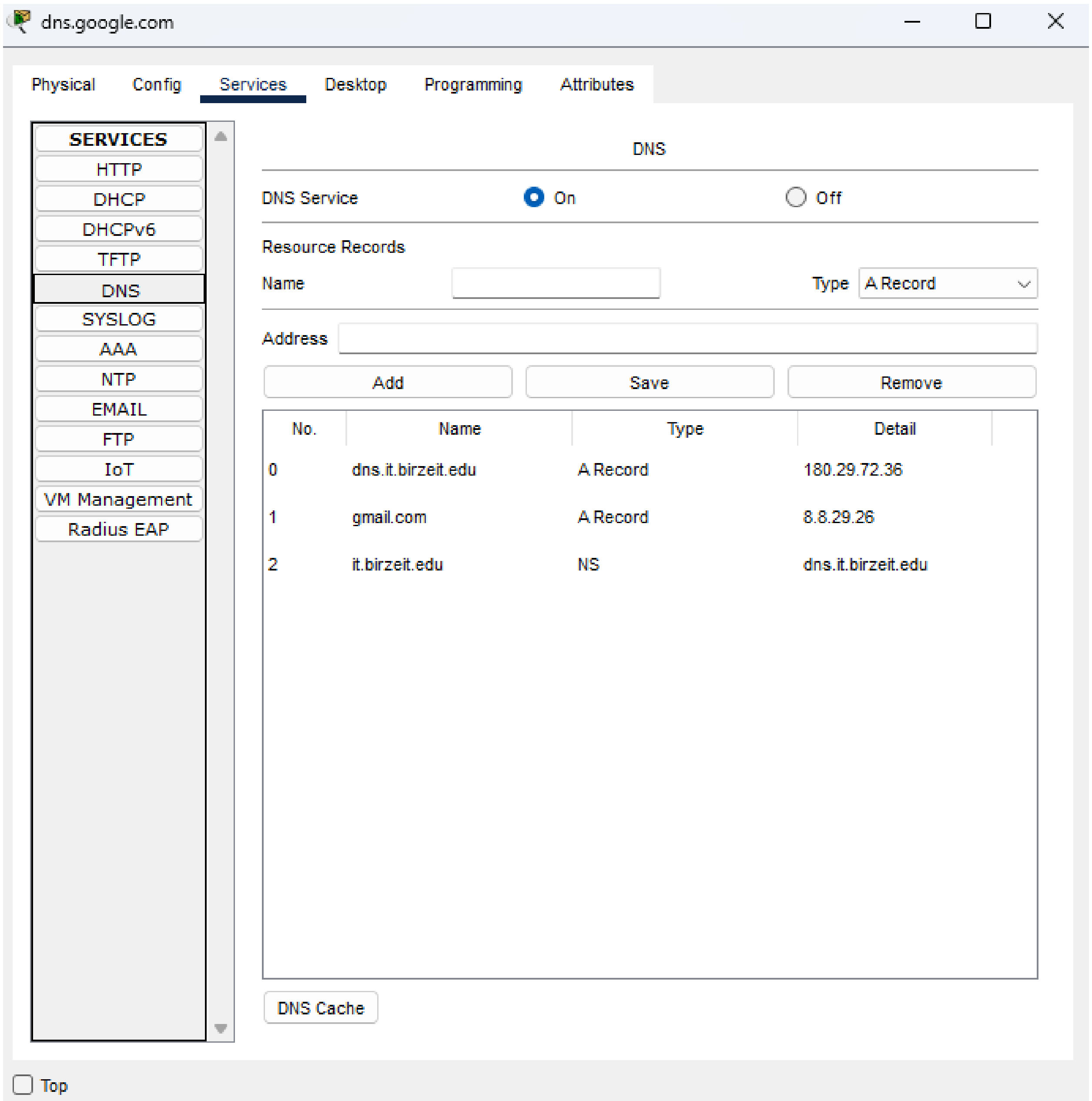


Figure 13: DNS of AES 300

- In this figure we assign a static IP configuration.

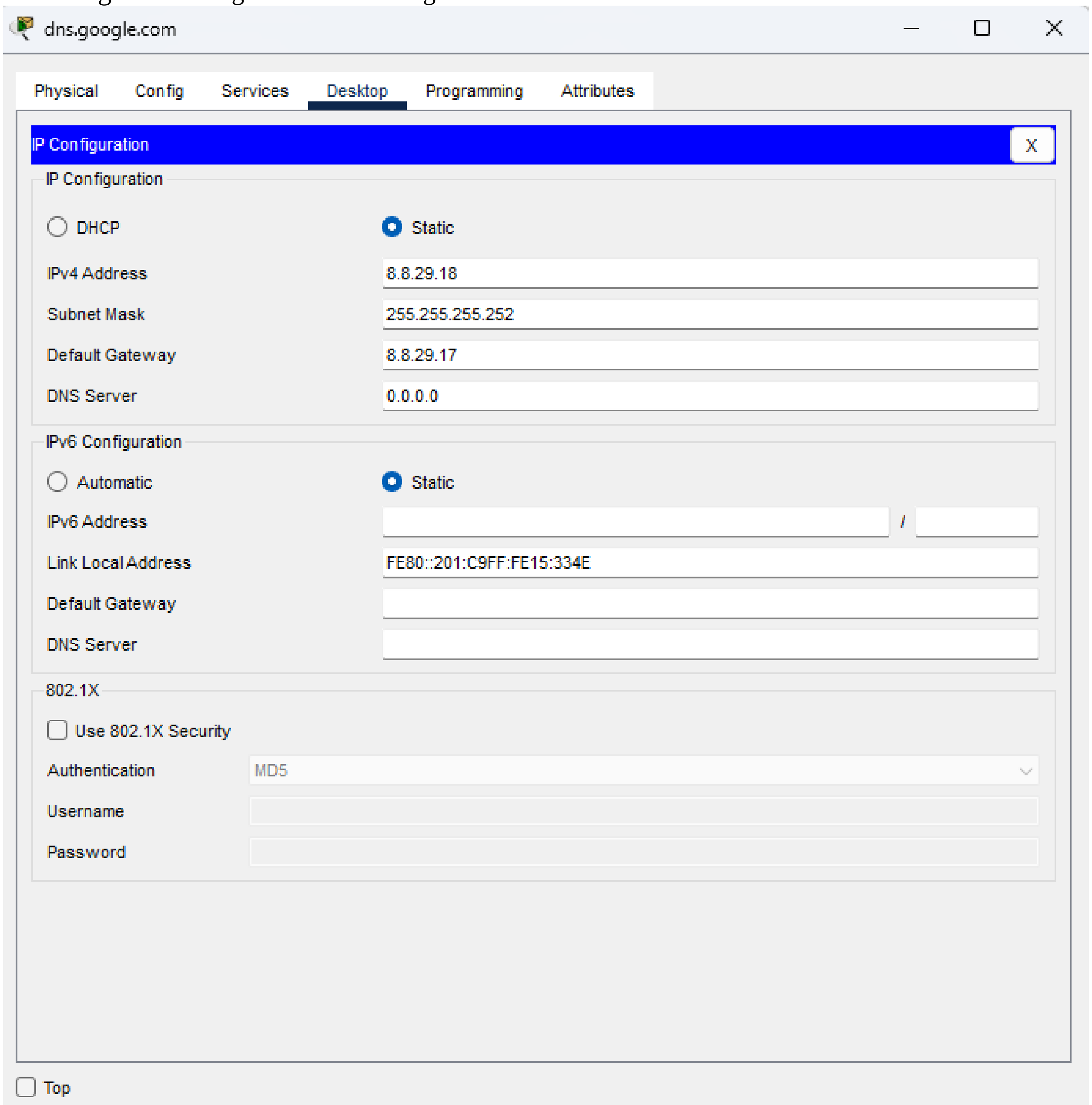


Figure 14: assign a static IP configuration for the DNS server

- In this figure we Add the following recourse records (RRs) required in project.

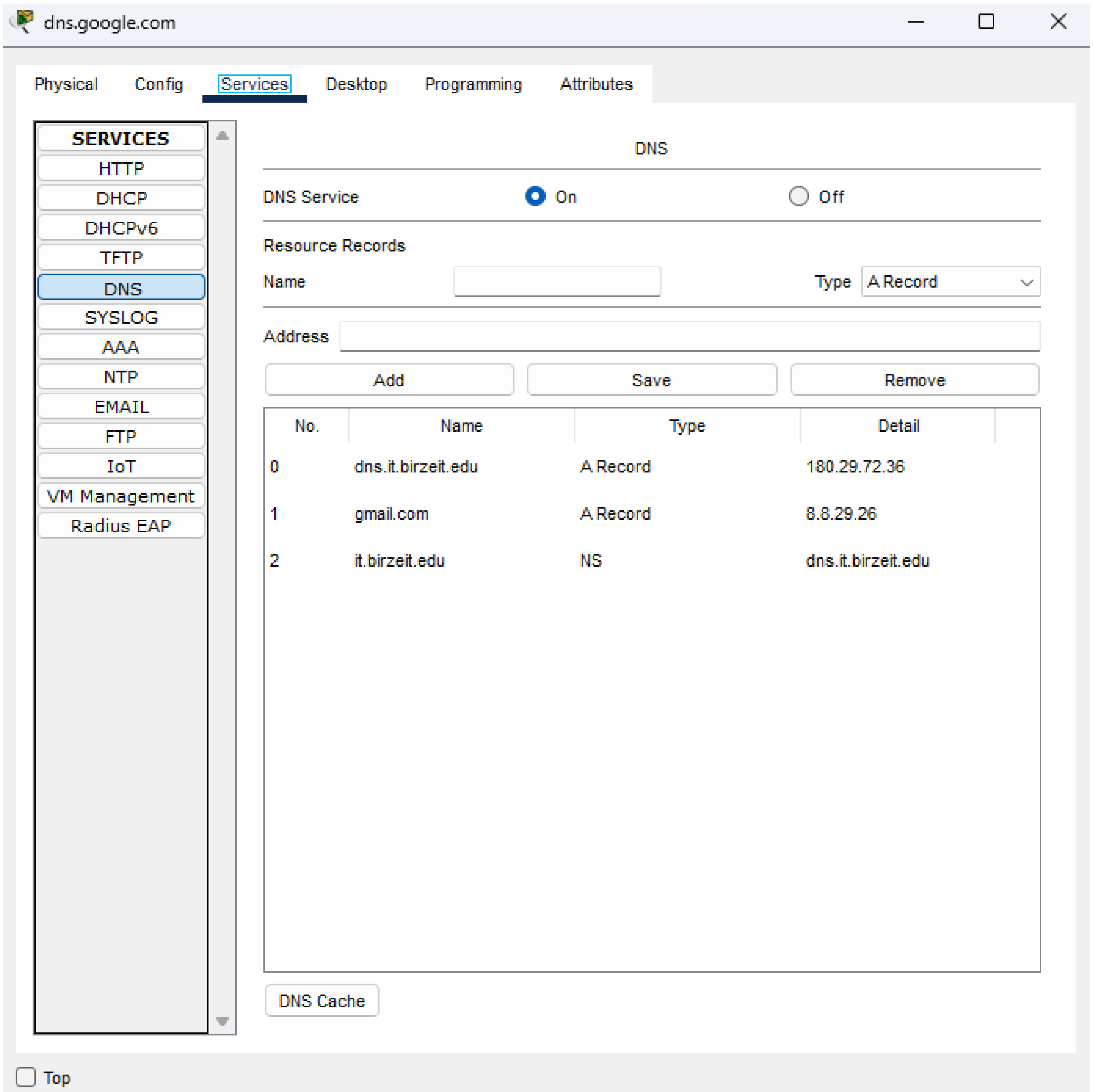


Figure 15: Adding RRs record

- In this figure we enable the SMTP (for sending emails) and POP3 (for receiving emails) protocols.

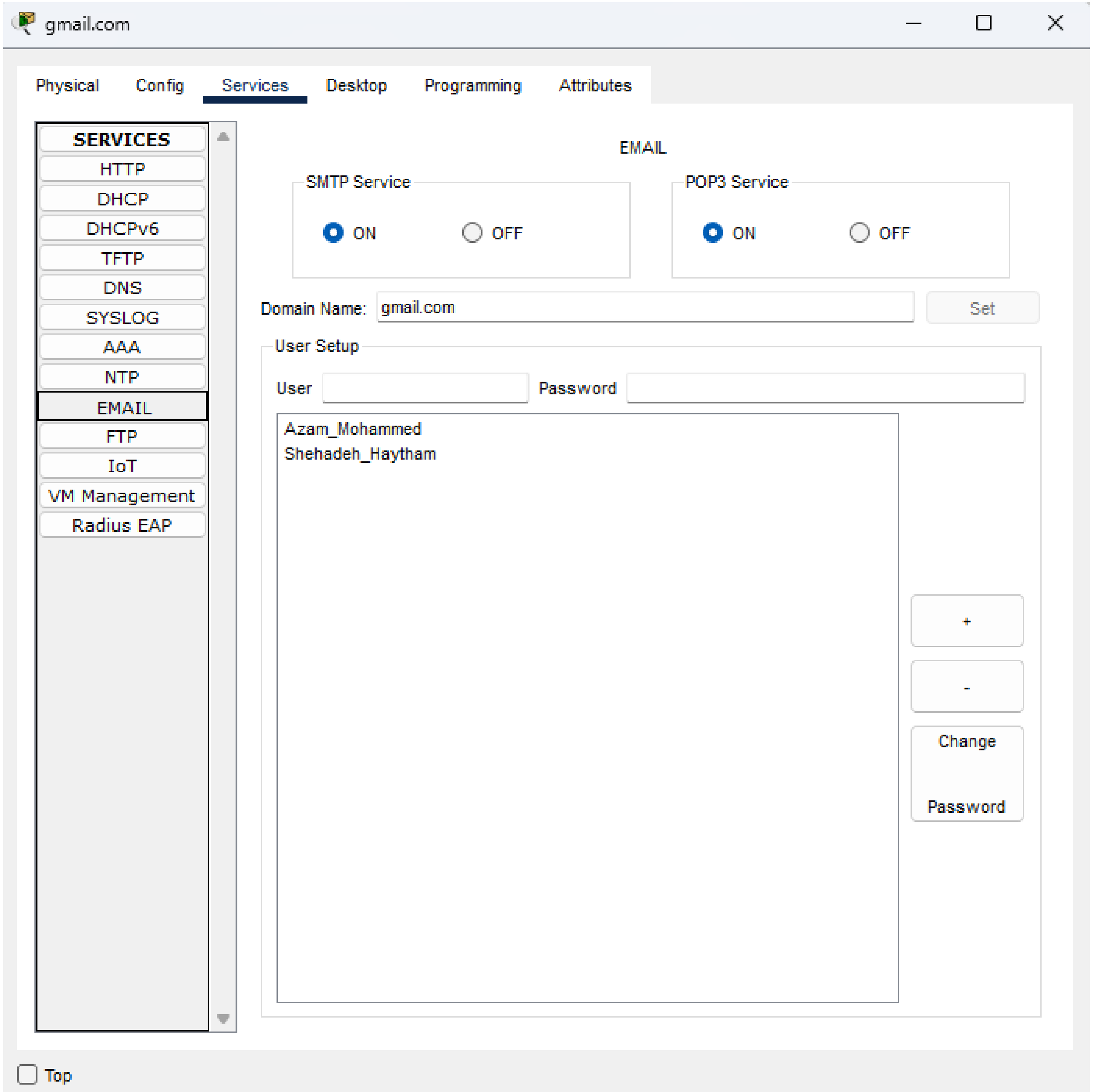


Figure 16: Enable SMTP AND POP3 protocols

- In this figure we assign a static IP configuration.

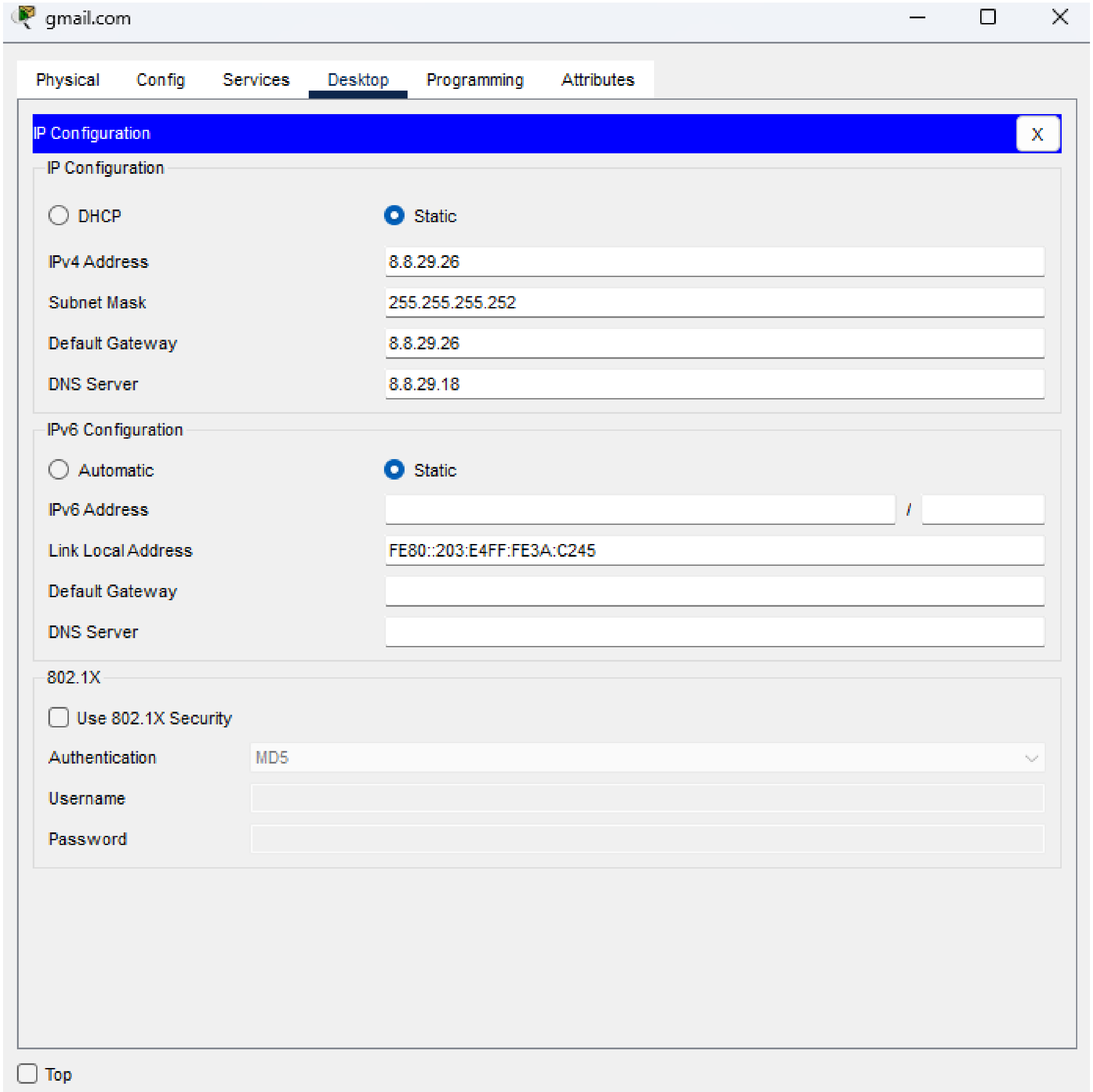


Figure 17: assign a static IP configuration for the Gmail server

In this figure we set the domain name (gmail.com).

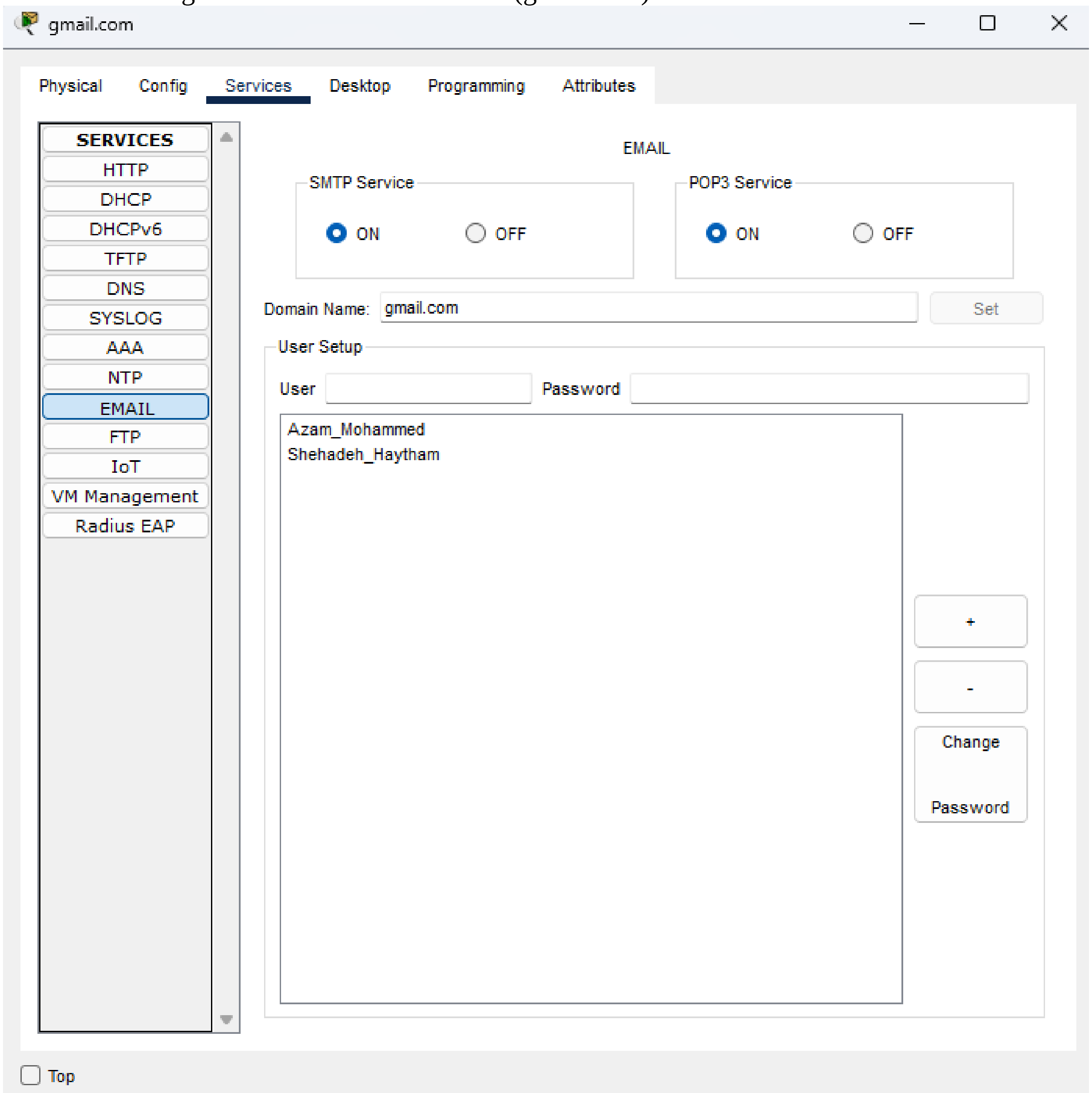


Figure 18: set the domain name

- In this figure we create first user account as required in project.

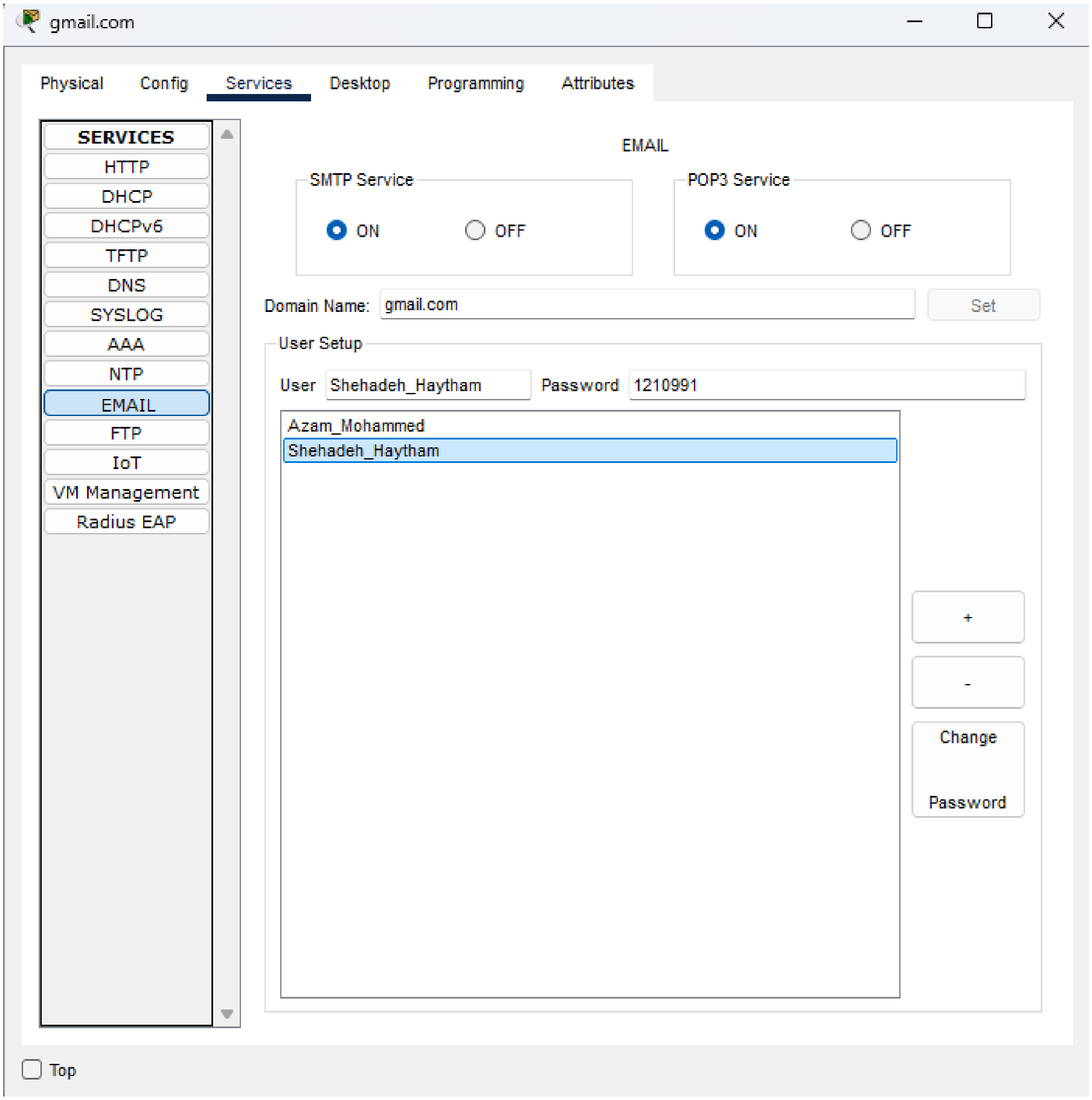


Figure 19: create first user account

- In this figure we create second user account as required in project.

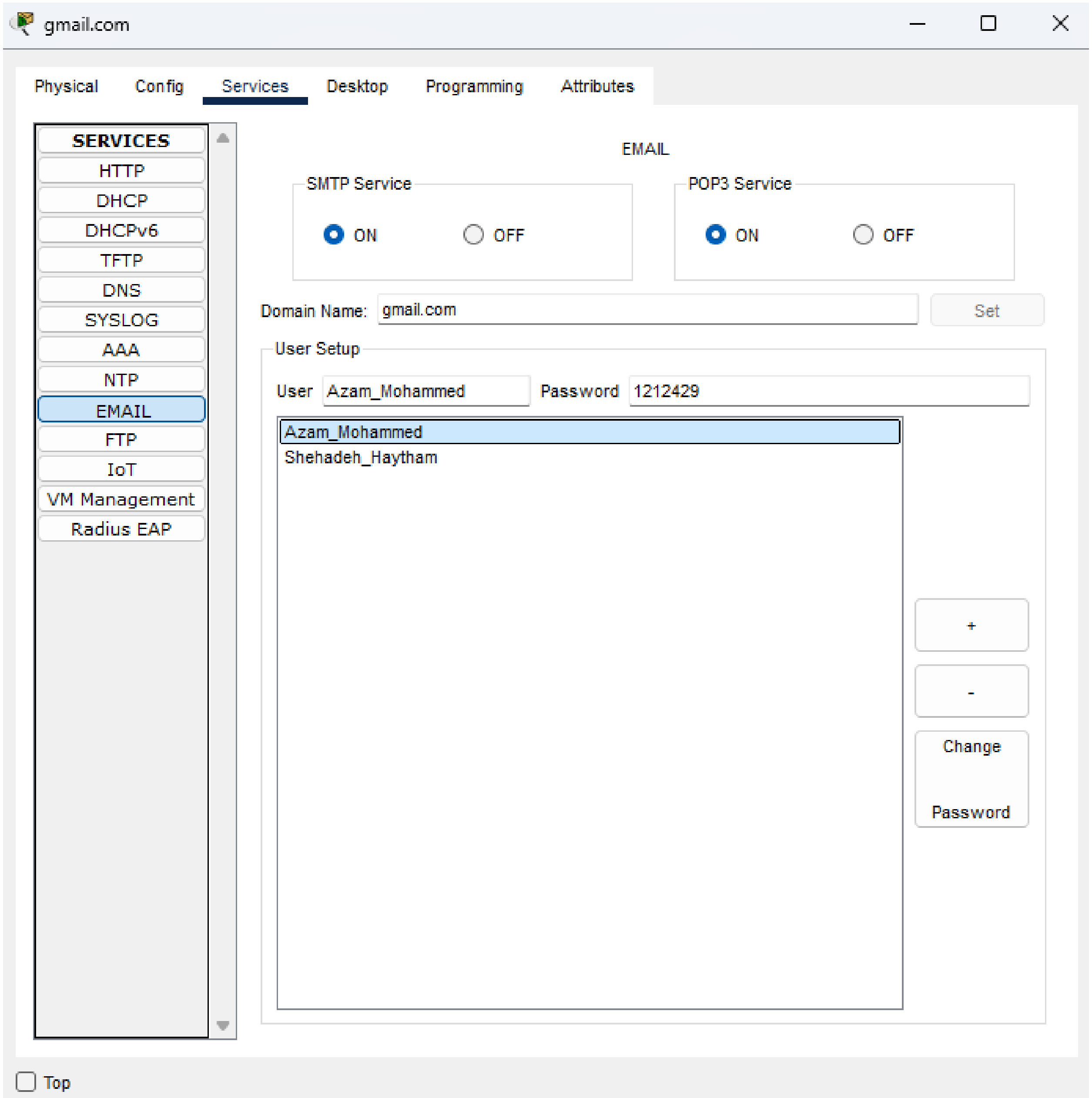


Figure 20: create second user account

2.3) AS 200

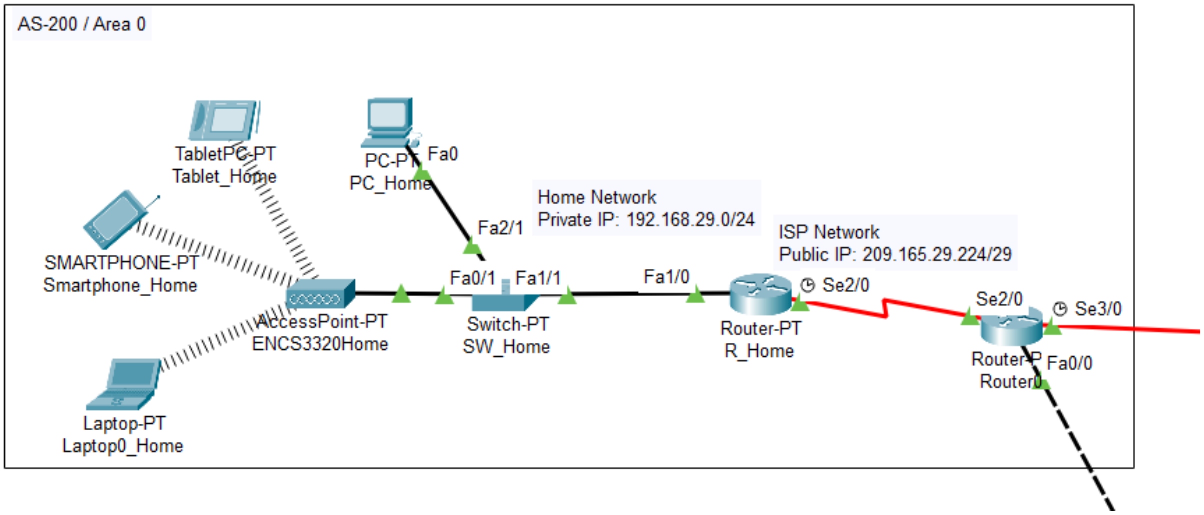


Figure 21: AS 200 / Area 0

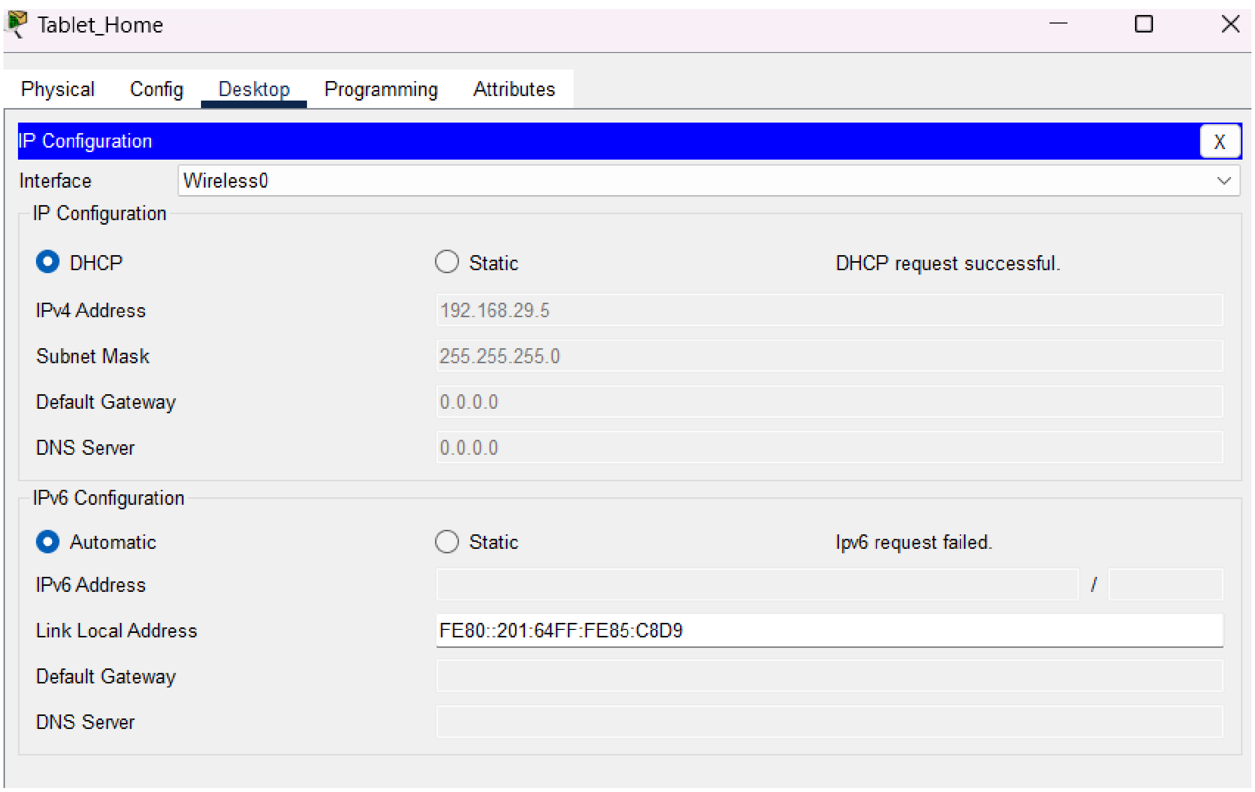


Figure 22: IP configuration of tablet

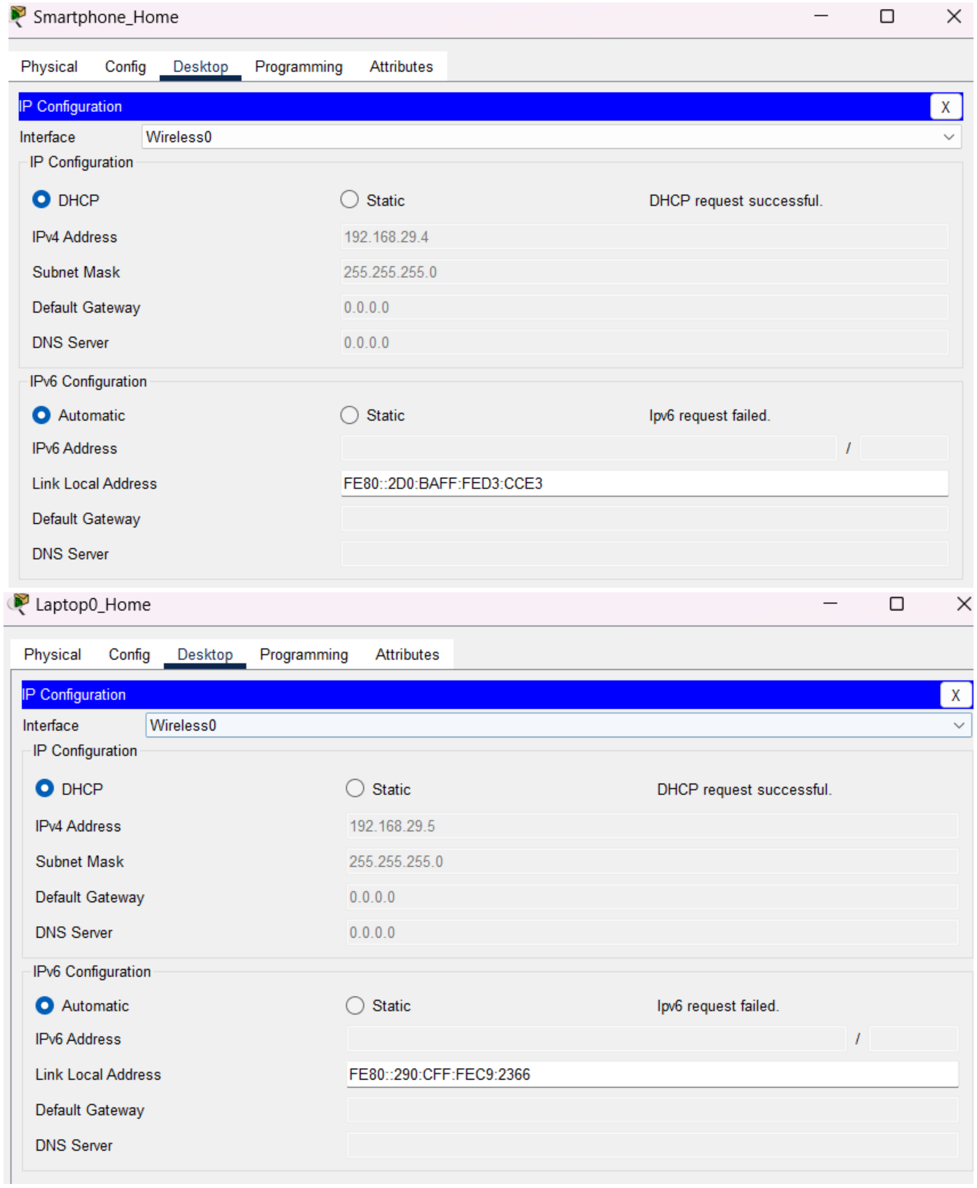
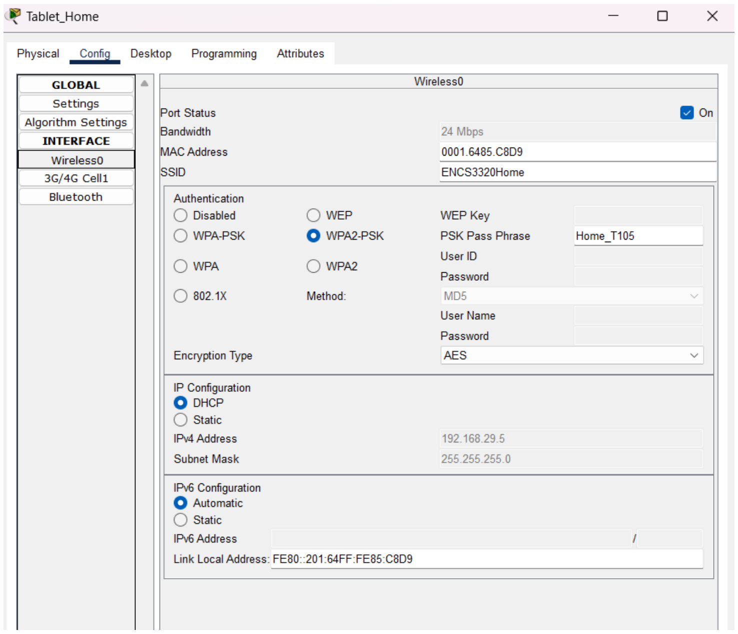


Figure 23: IP configuration of laptop and smart phone

Connect wireless end devices to the ENCS3320Home network and cabled end devices through the switch.

- **For end user configuration**



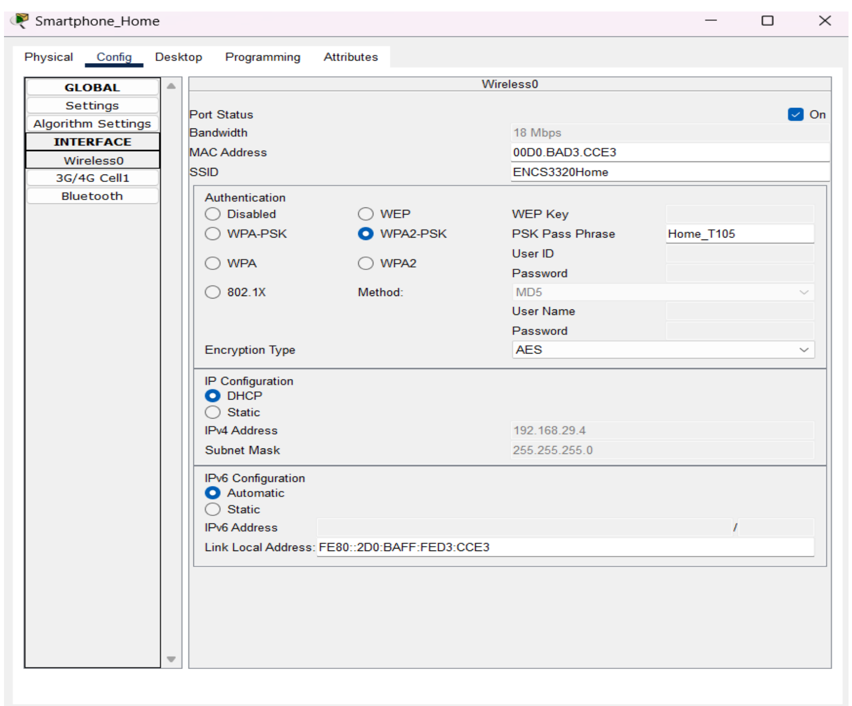


Figure 24: Tablet connection and smart phone AES 200

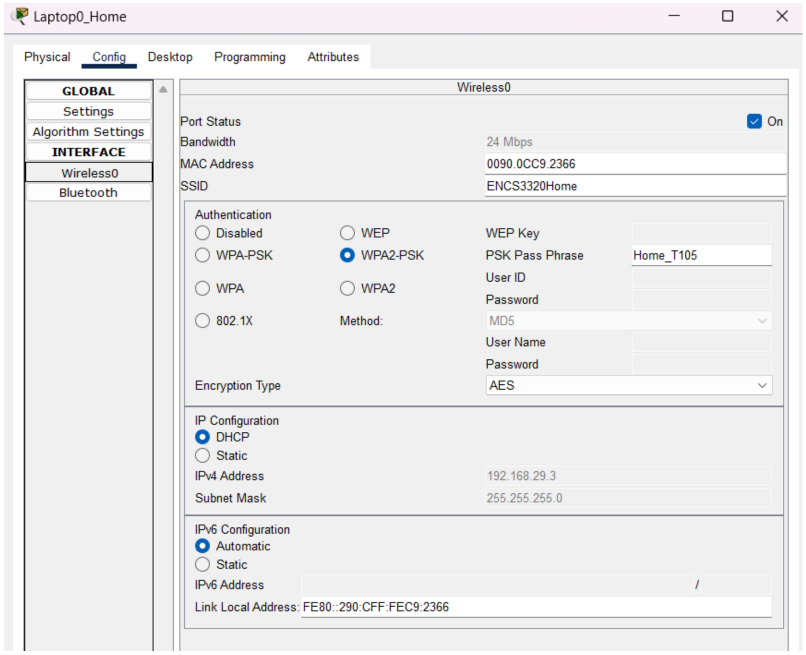


Figure 25: Laptop AES 200

Note:

- **we add an extra Wi-Fi adaptor to the laptop to connect via switch**
- **End user in aes 200 can get a dynamic Ip address from without routing**

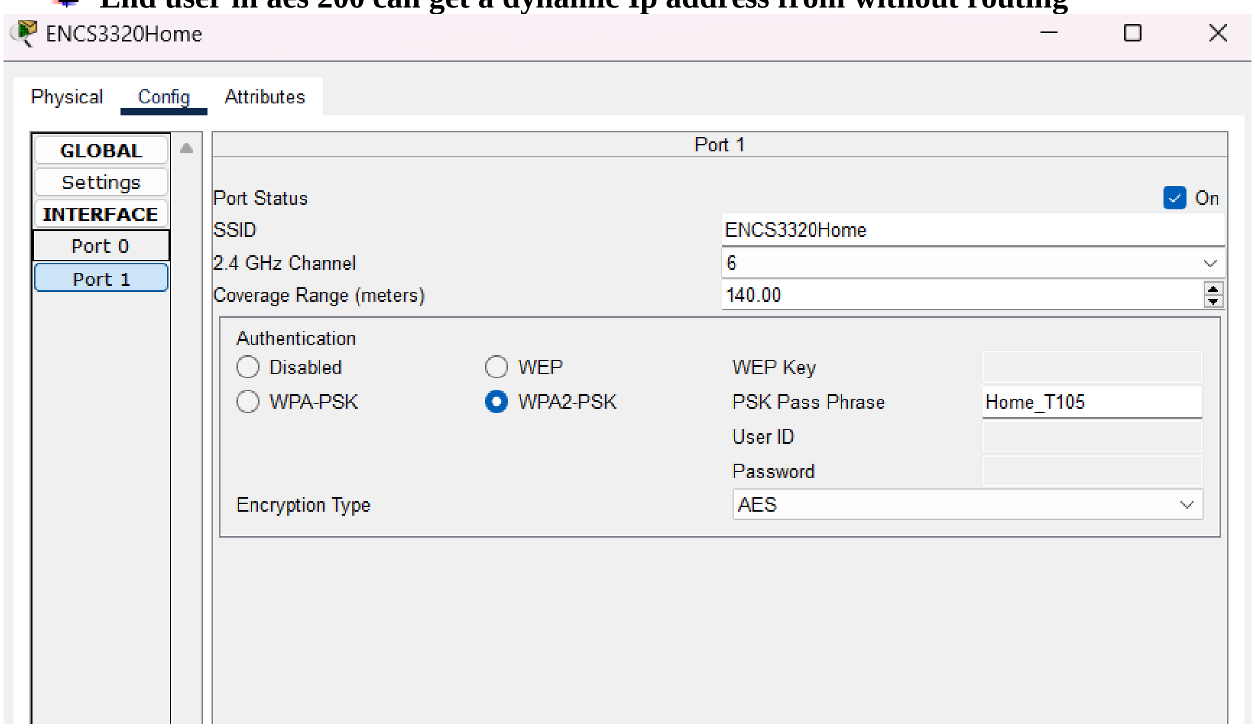


Figure 26: access point AES 200

- **Name: ENCS3320Home The password of the user is: Home_T05 with WPA2-PSK encryption scheme using the block cipher AES**

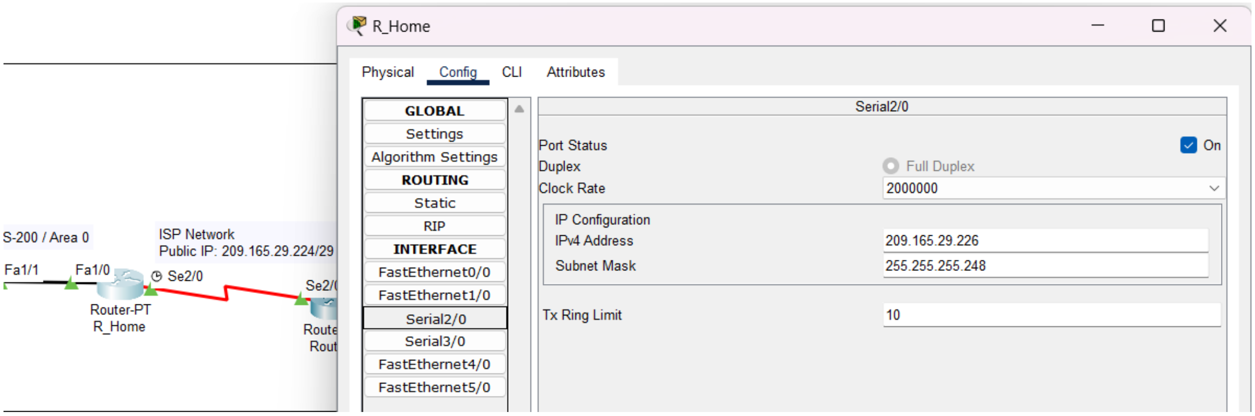


Figure 27: R_Home router with public IP AES 200

- **Assign a static IP address for the R_home router**

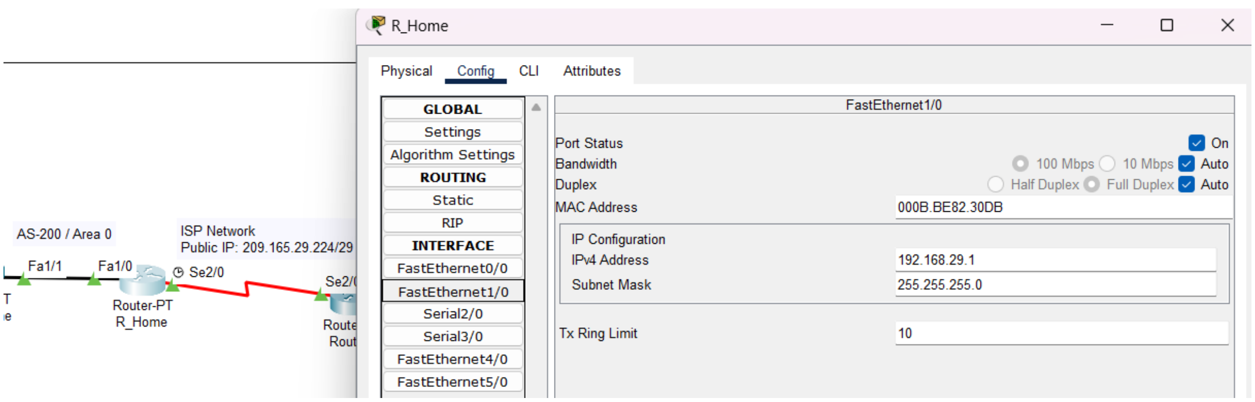


Figure 28: R_Home router with private IP AES 200

```
Router(config-if)#end
Router#
%SYS-5-CONFIG_I: Configured from console by console
enable
Router#show ip nat translations
Router#show running-config | include ip nat
 ip nat inside
 ip nat outside
ip nat pool p4 209.165.29.227 209.165.29.227 netmask 255.255.255.248
ip nat pool p8 209.165.29.227 209.165.29.227 netmask 255.255.255.248
ip nat inside source list 3 pool p3 overload
ip nat inside source list 6 pool p9 overload
Router#show ip nat statistics
Total translations: 0 (0 static, 0 dynamic, 0 extended)
Outside Interfaces: Serial2/0
Inside Interfaces: FastEthernet1/0
Hits: 0  Misses: 3
Expired translations: 0
Dynamic mappings:
-- Inside Source
access-list 3 pool p3 refCount 0
-- Inside Source
access-list 6 pool p9 refCount 0
Router#show ip nat translations
```

Figure 29: Nat and pool

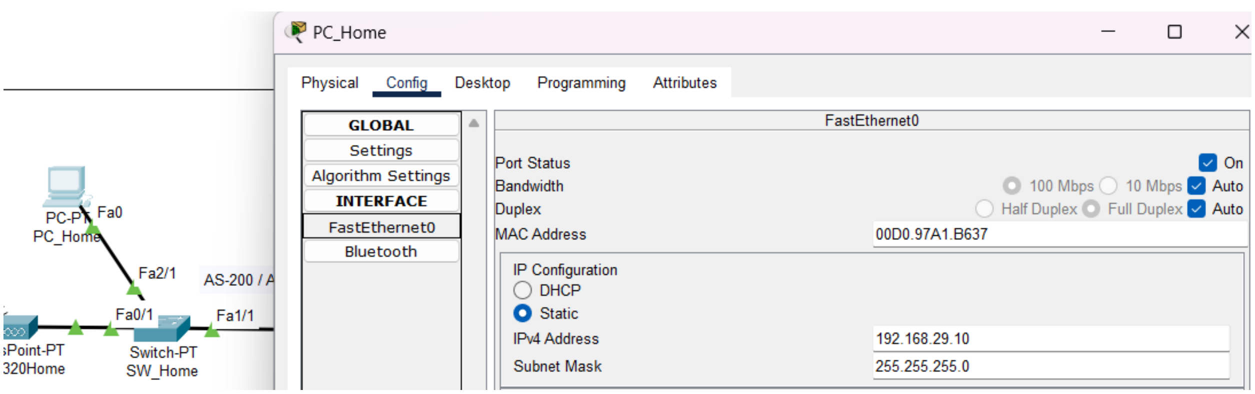
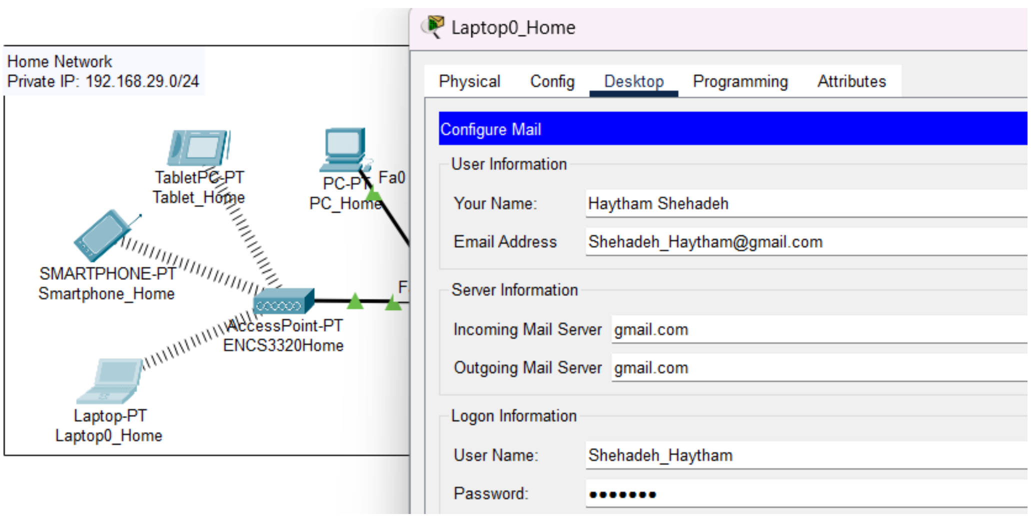


Figure 30: Apply a static IP address for the PC_Home

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num	Edit	Delete
	Successful	Tablet...	R_Home	ICMP		0.000	N	106	(edit)	(delete)
	Successful	Smart...	R_Home	ICMP		0.000	N	107	(edit)	(delete)
	Successful	PC_H...	R_Home	ICMP		0.000	N	108	(edit)	(delete)
	Successful	Lapto...	R_Home	ICMP		0.000	N	109	(edit)	(delete)
	Successful	PC_H...	R_Home	ICMP		0.000	N	110	(edit)	(delete)

Figure 31: successfully ping through the end device

- **Email client configuration for gmail.com and it.birzeit.edu accounts**



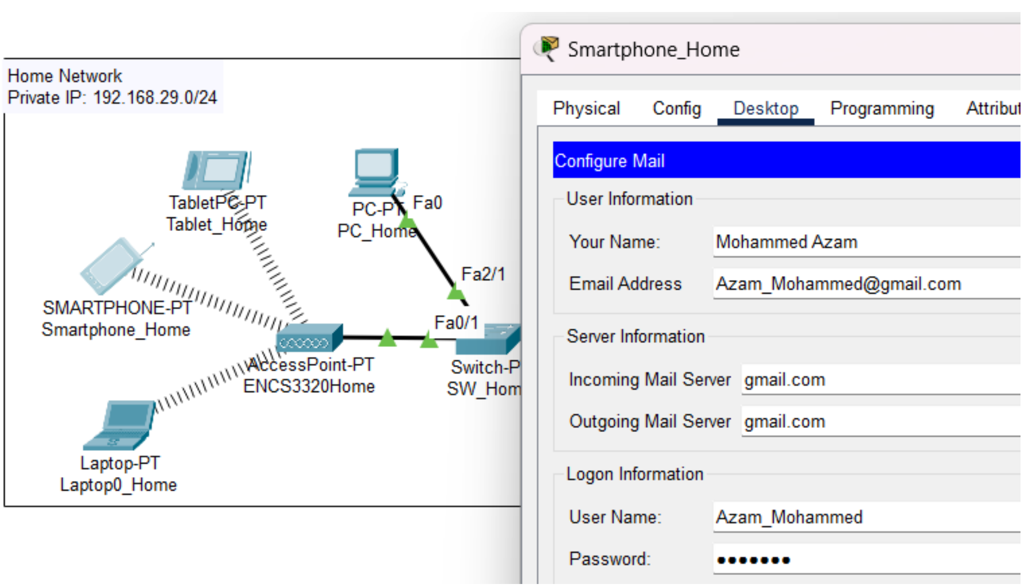
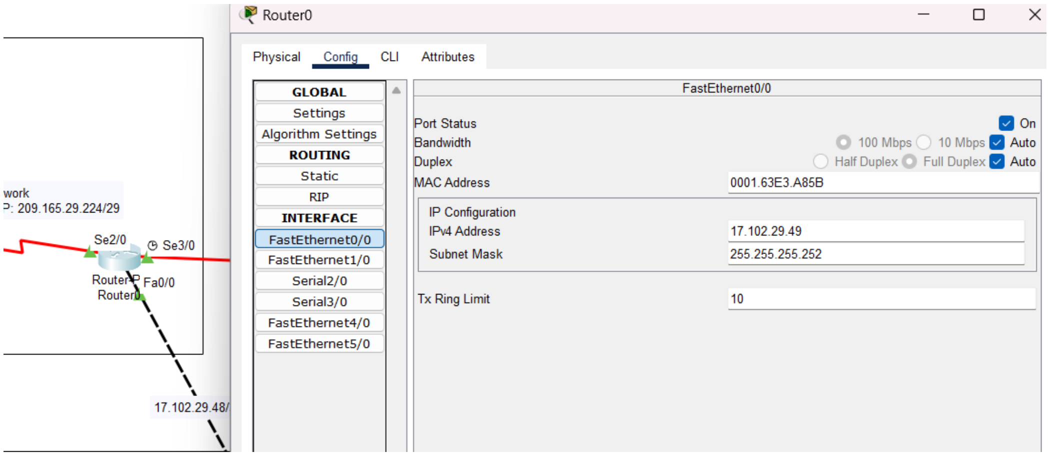
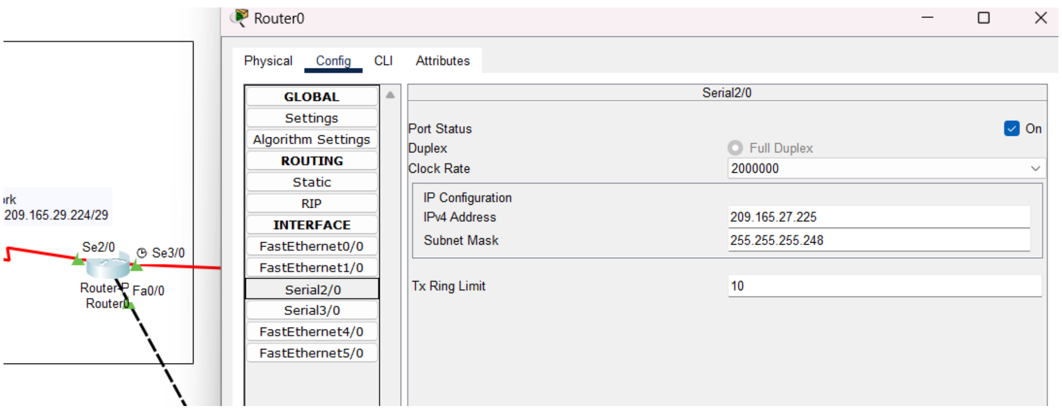


Figure 32: both Gmail account on tow devices in AES 200

- **IP for the global router r0**





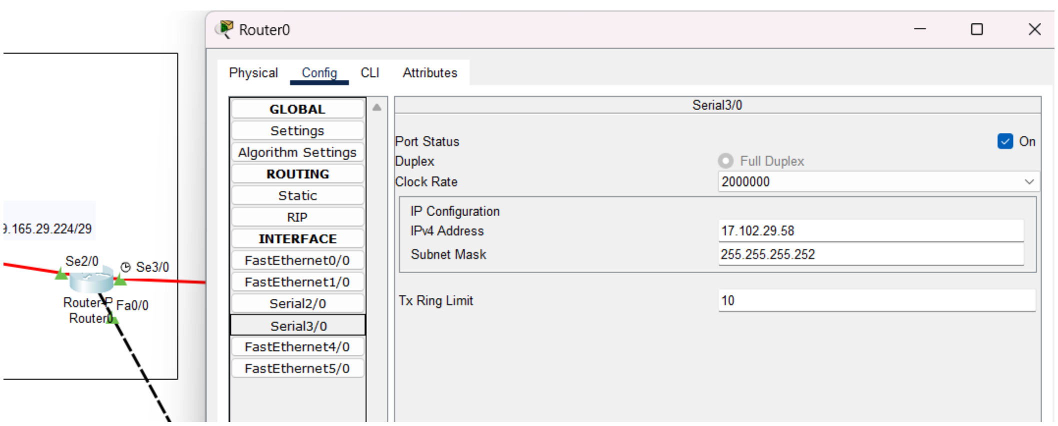


Figure 33: IP configuration of R_ISP

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

1. Servers Subnet

- **CIDR**: 180.29.72.0/27
- **Subnet Mask**: 255.255.255.224
- **Broadcast IP**: 180.29.72.31
- **First Usable IP**: 180.29.72.1
- **Last Usable IP**: 180.29.72.30

2. ECE Subnet

- **CIDR**: 180.29.72.32/25
- **Subnet Mask**: 255.255.255.128
- **Broadcast IP**: 180.29.72.159
- **First Usable IP**: 180.29.72.33
- **Last Usable IP**: 180.29.72.158

3. CS Subnet

- **CIDR**: 180.29.72.160/26
- **Subnet Mask**: 255.255.255.192
- **Broadcast IP**: 180.29.72.223
- **First Usable IP**: 180.29.72.161
- **Last Usable IP**: 180.29.72.222

4. Backbone Subnet

- **CIDR**: 180.29.72.224/30
- **Subnet Mask**: 255.255.255.252
- **Broadcast IP**: 180.29.72.227
- **First Usable IP**: 180.29.72.225
- **Last Usable IP**: 180.29.72.226

- For Router 4 (R1_IT), the following IP address configurations have been applied:

- **FastEthernet0/0**: Assigned the IP address **180.29.72.129** with a subnet mask of **255.255.255.128**
- **FastEthernet1/0**: Assigned the IP address **180.29.72.65** with a subnet mask of **255.255.255.192**.
- **Serial2/0**: Assigned the IP address **180.27.72.9** with a subnet mask of **255.255.255.248**.

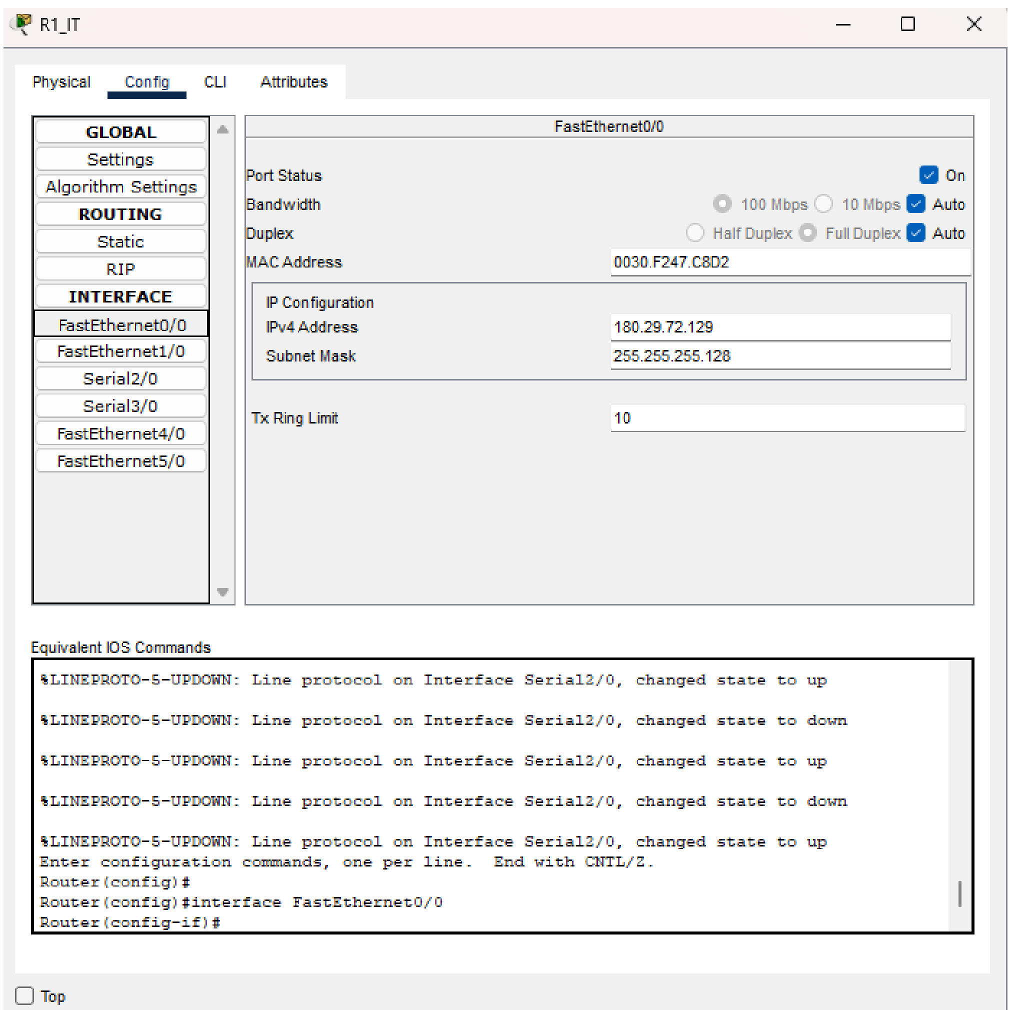


Figure 34: R1_IT Ethernet0/0 Configurations

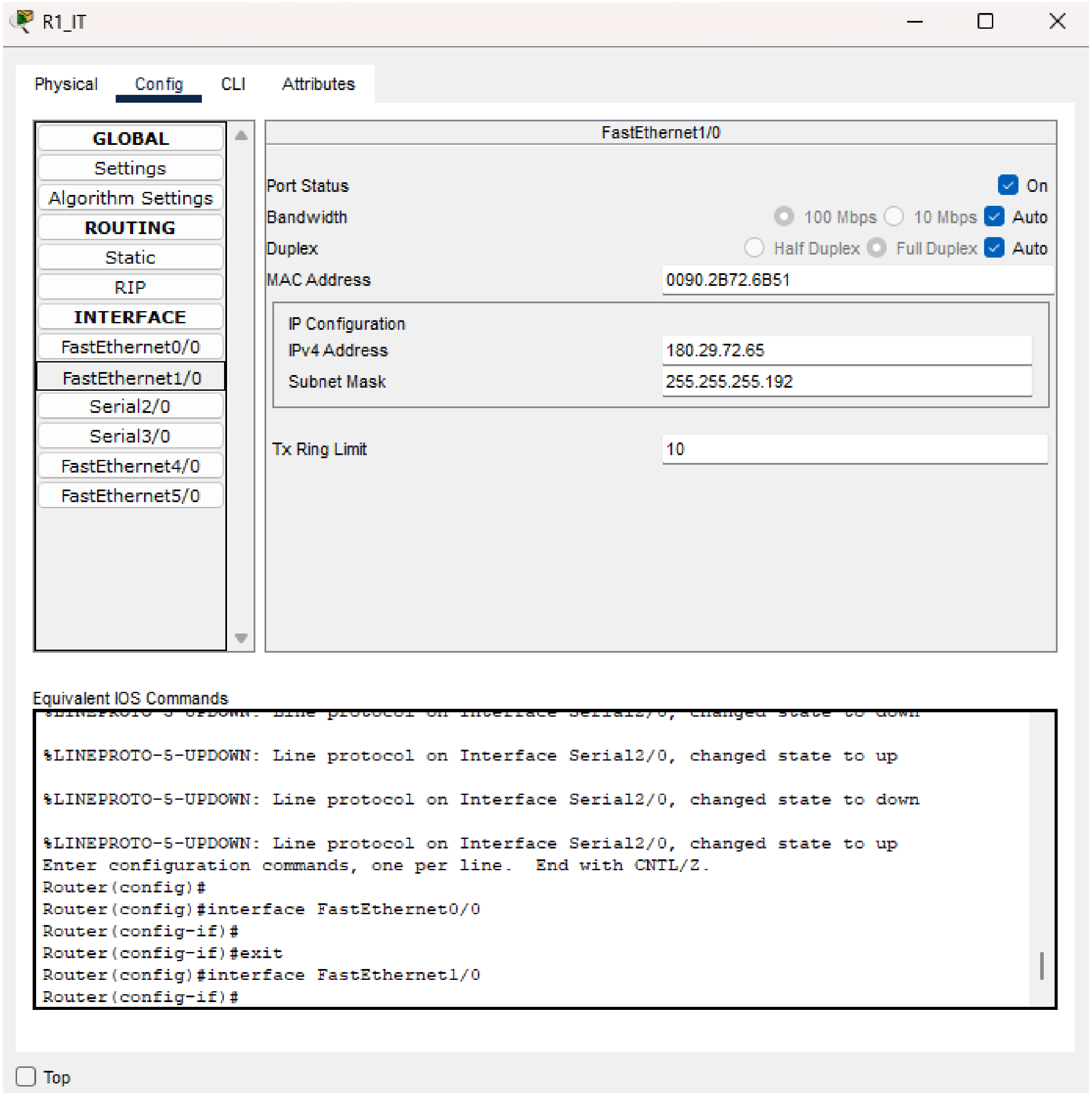


Figure 35: R1_IT Ethernet1/0 Configurations

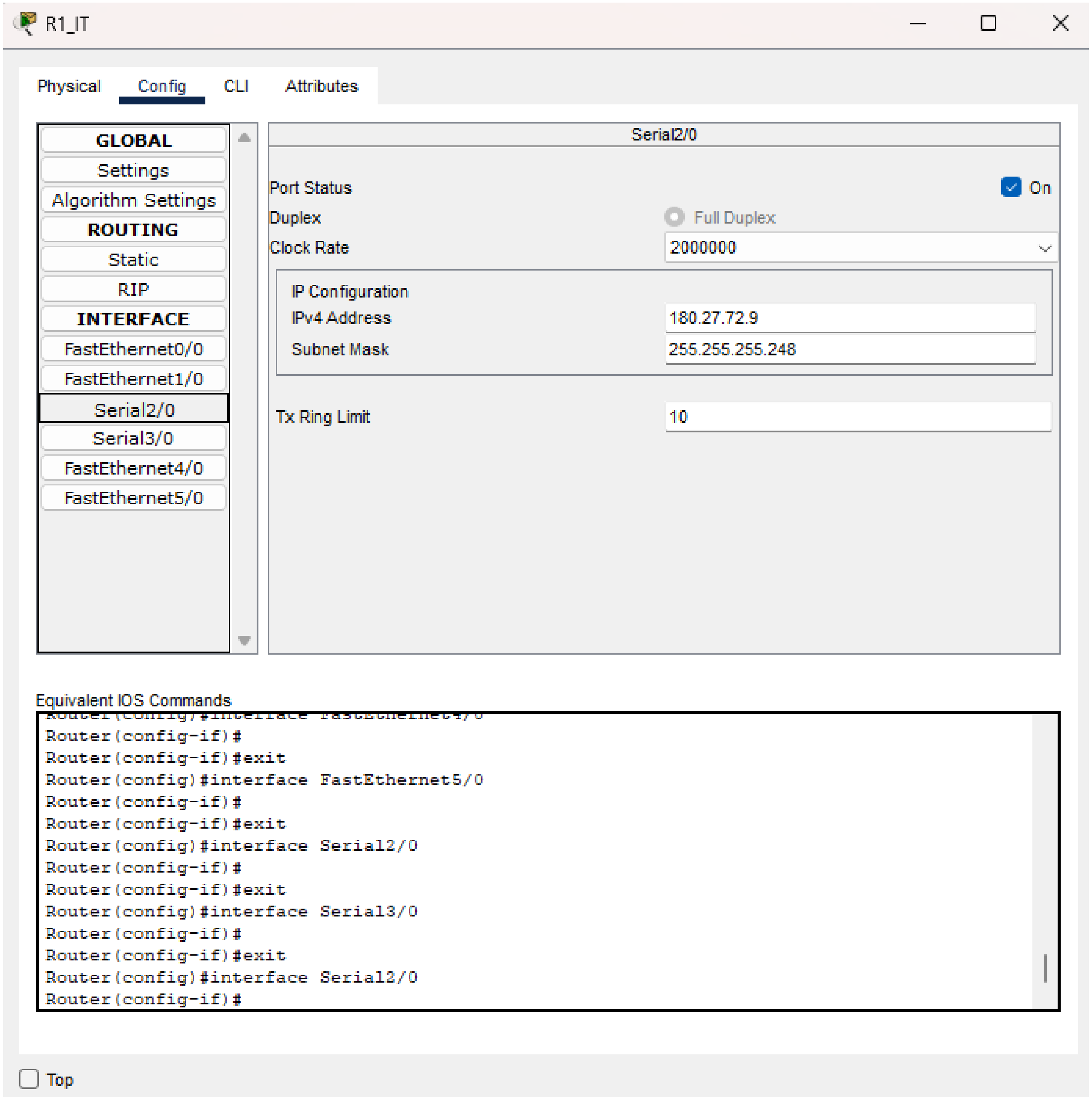


Figure 36: R1_IT Serial2/0 Configurations

- In this figure we enable HTTP and HTTP Secure (HTTPS) protocols.

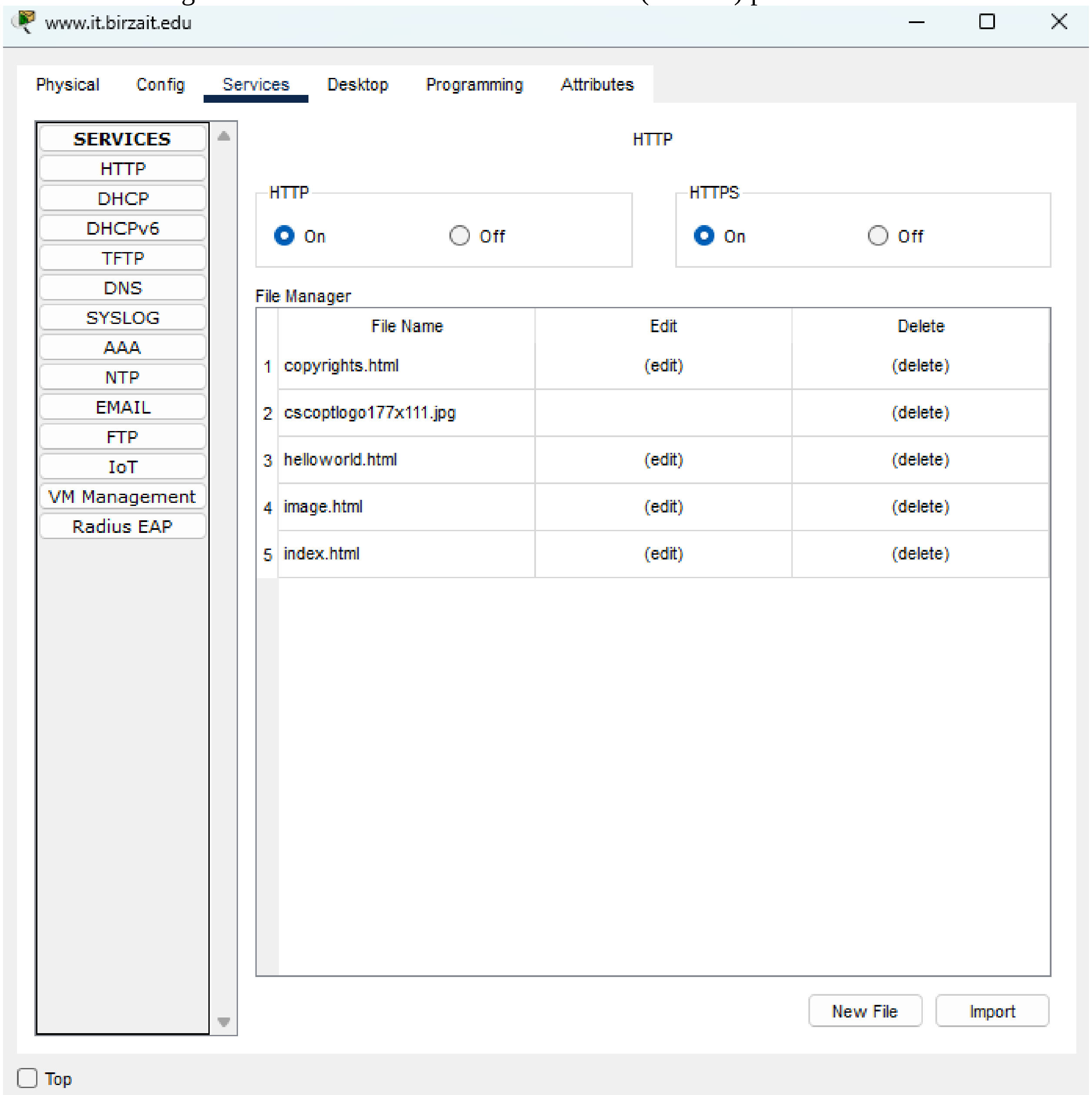


Figure 37: enable HTTP and HTTP

- In this figure we assign a static IP configuration.

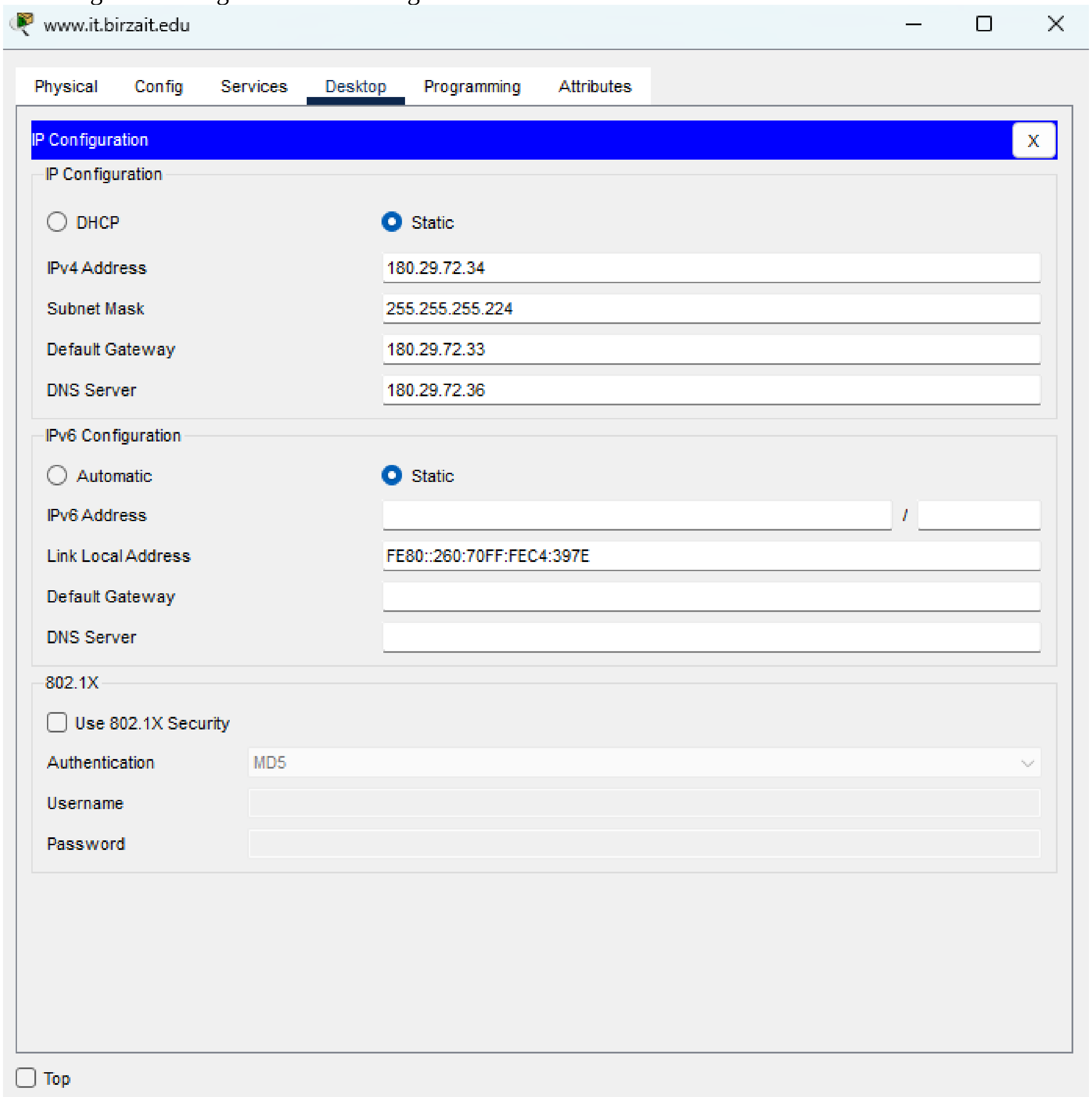


Figure 38: assign a static IP configuration for it.birazit.edu

- In this figure we customize the index.html page include as required.

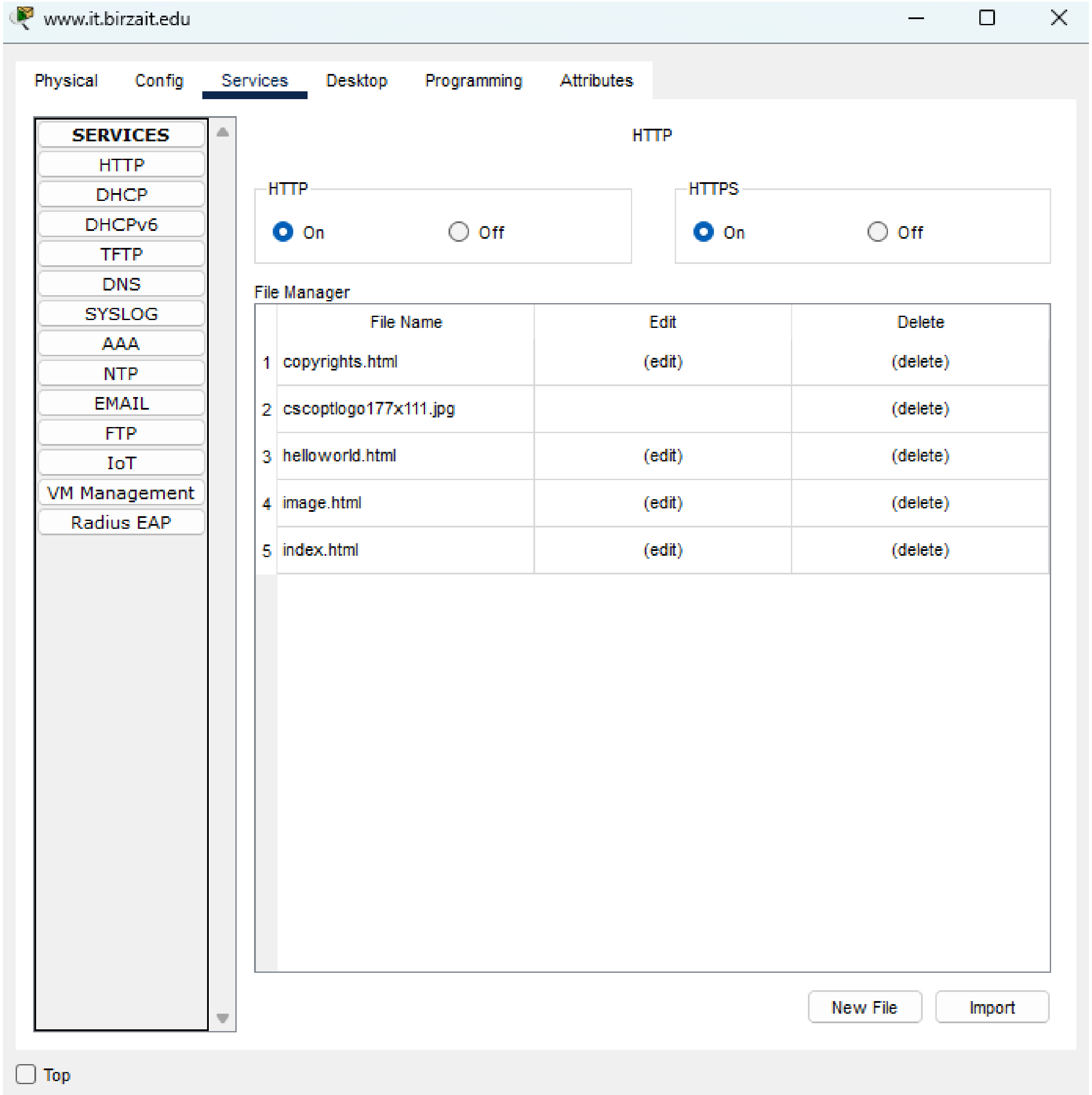


Figure 39: customize the index.html page

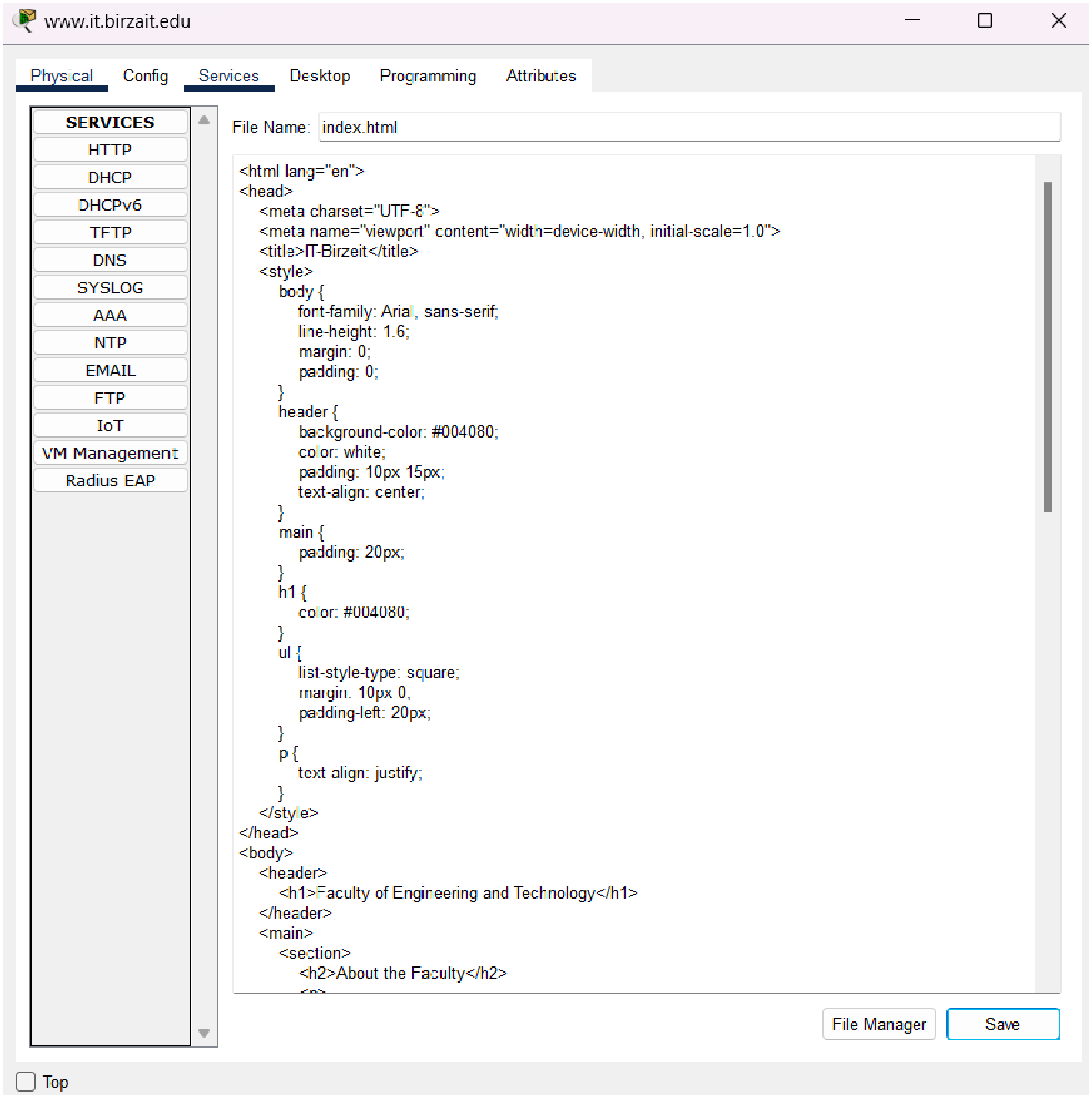


Figure 40: a snapshot of the html code

- In this figure we enable the SMTP (for sending emails) and POP3 (for receiving emails) protocols.

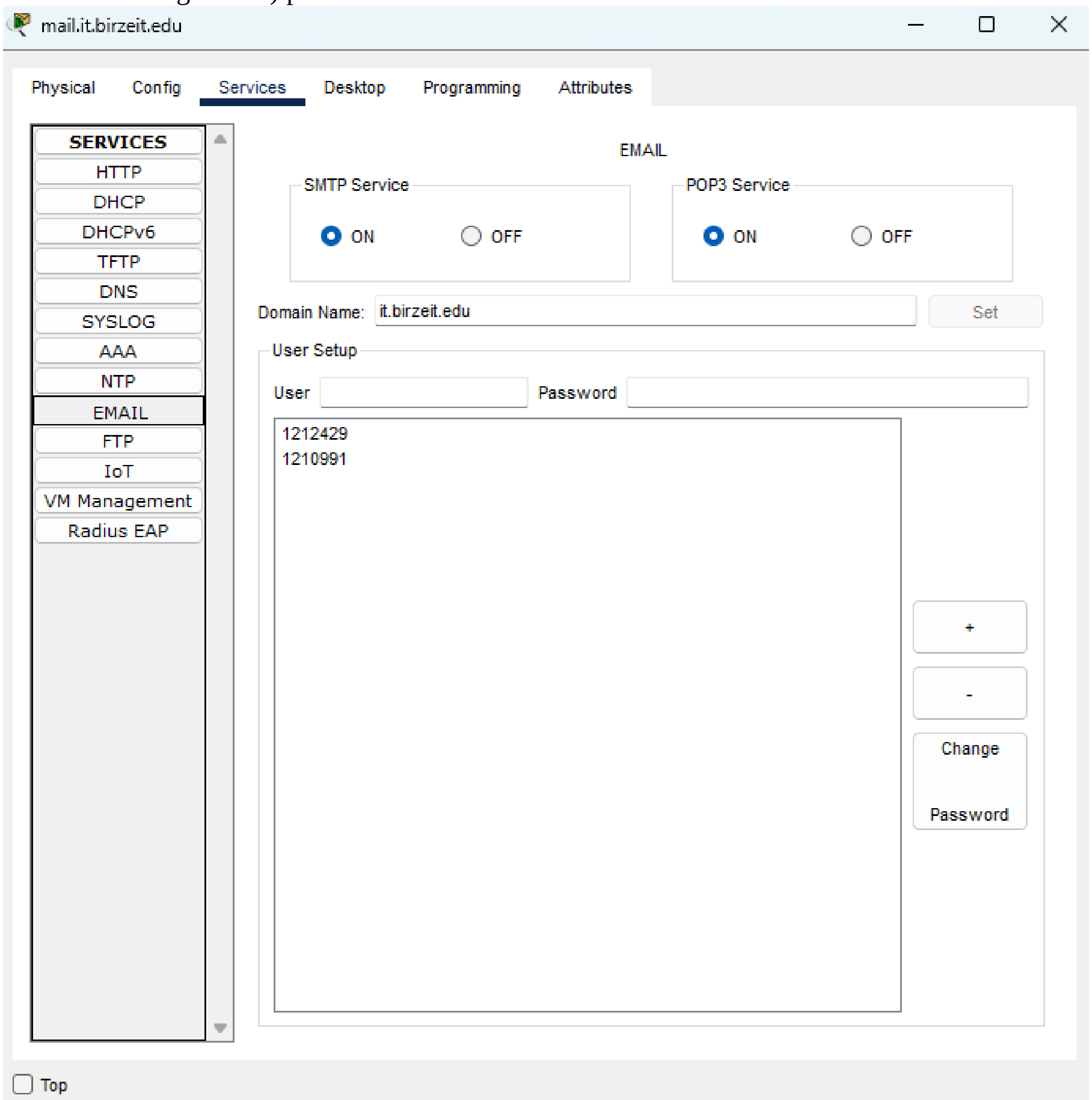


Figure 41: enable POP3 and SMTP protocols

- In this figure we assign a static IP configuration.

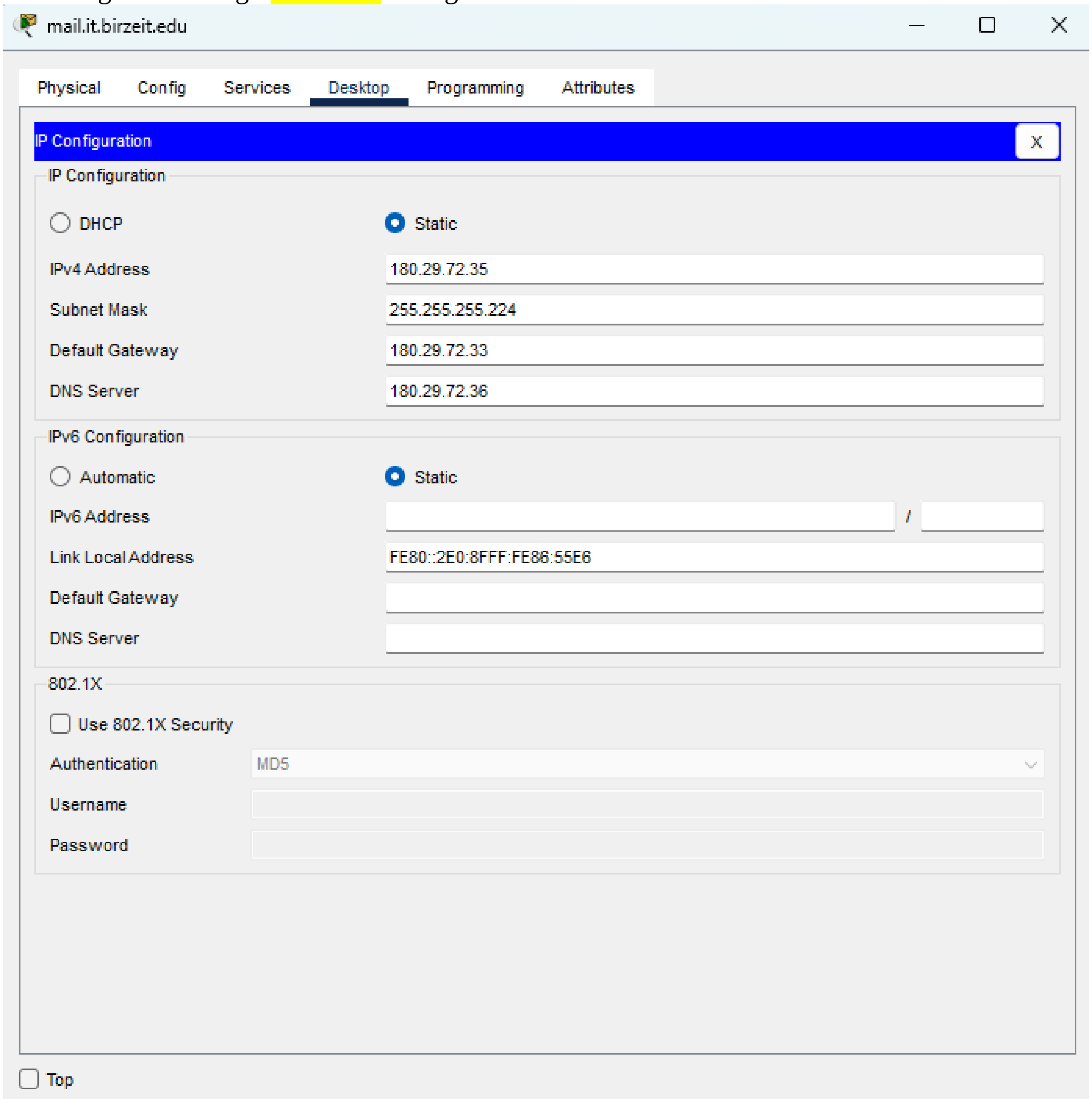


Figure 42: assign a static IP configuration for mail.it

- In this figure we set the domain name (it.birzeit.edu).

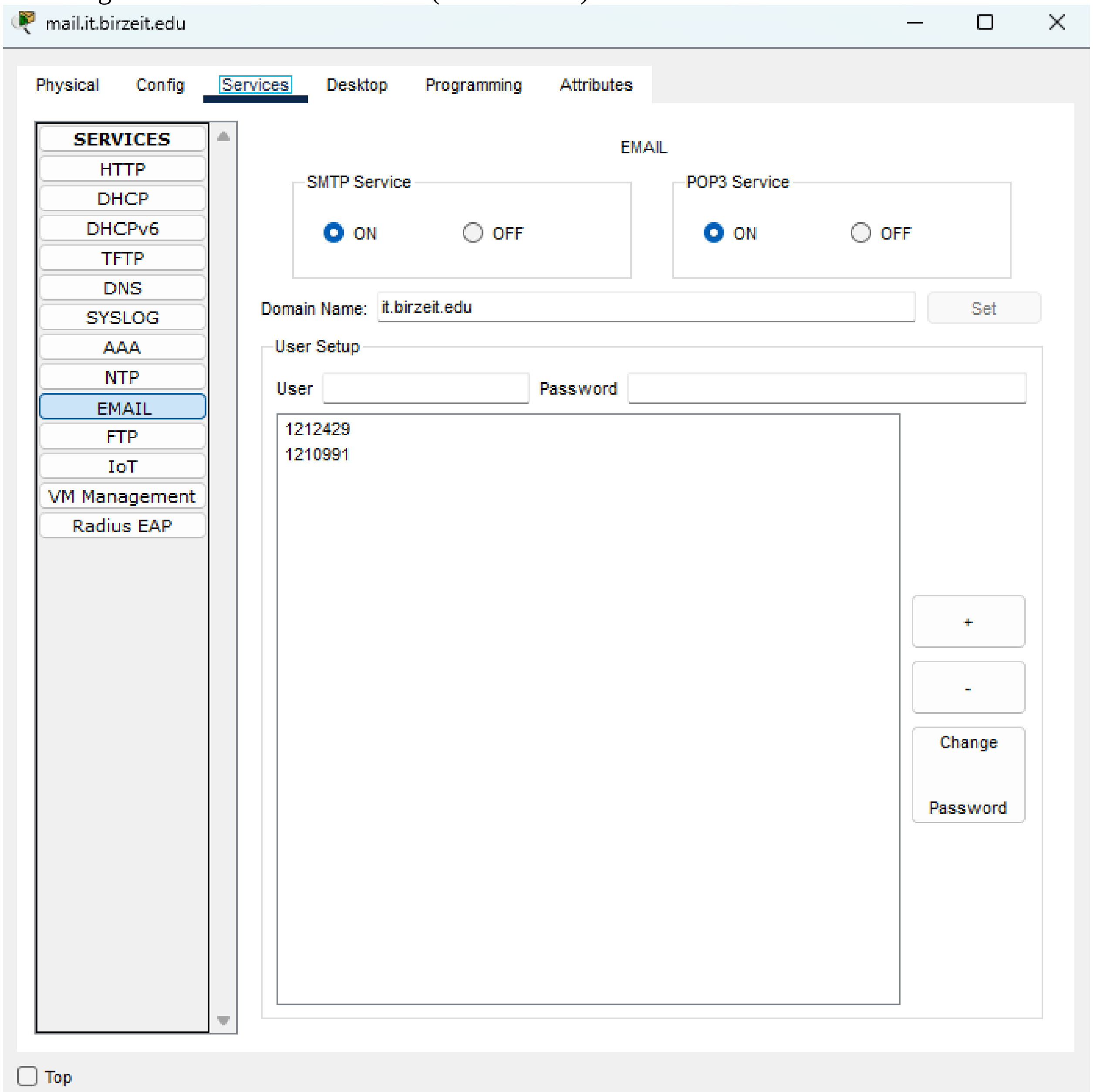


Figure 43: set the domain name

- In this figure we create first user account as required in project.

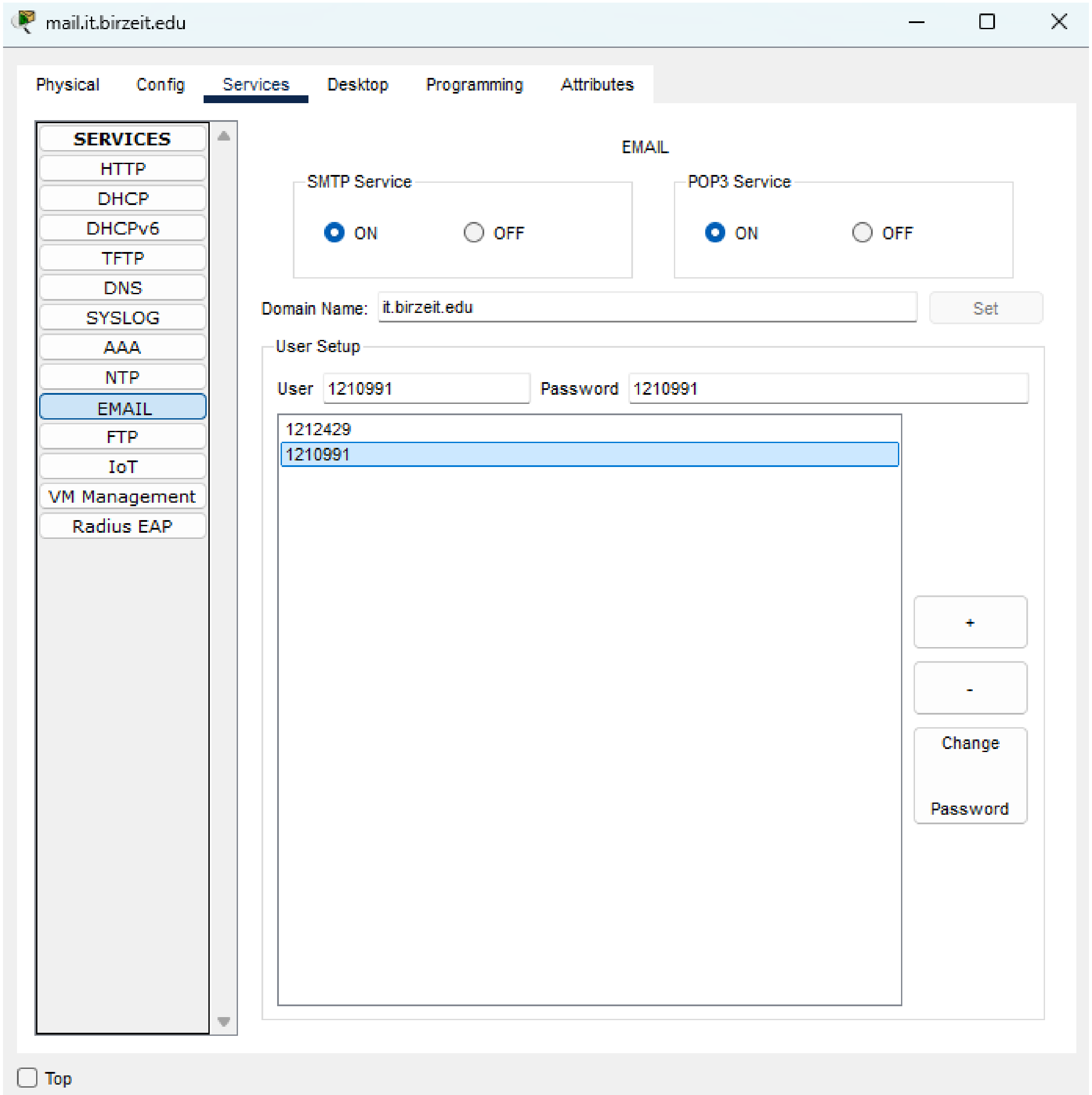


Figure 44: create first user account

- In this figure we create second user account as required in project.

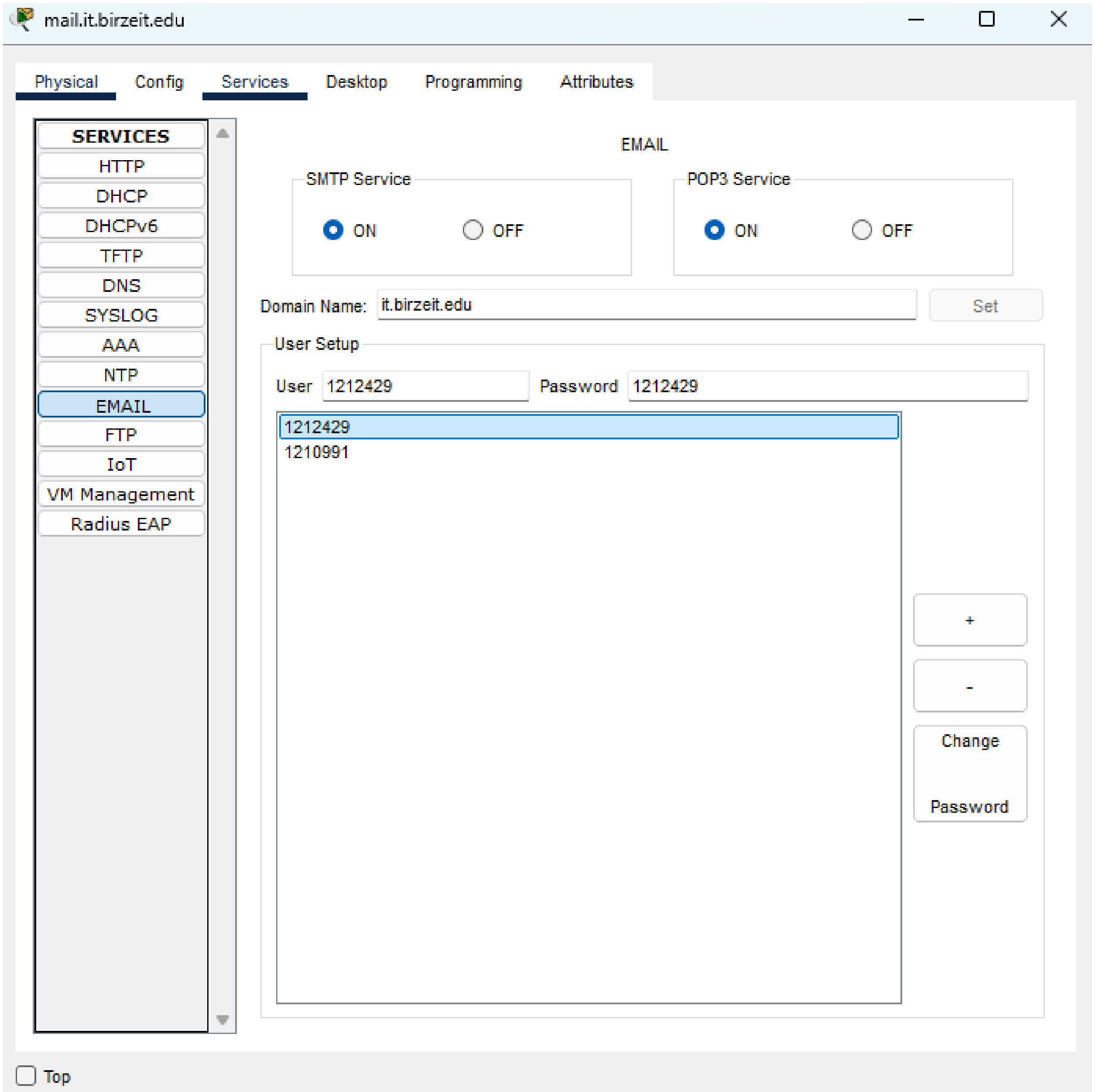


Figure 45: create second user account

- In this figure we Enable only the DNS service on this server.

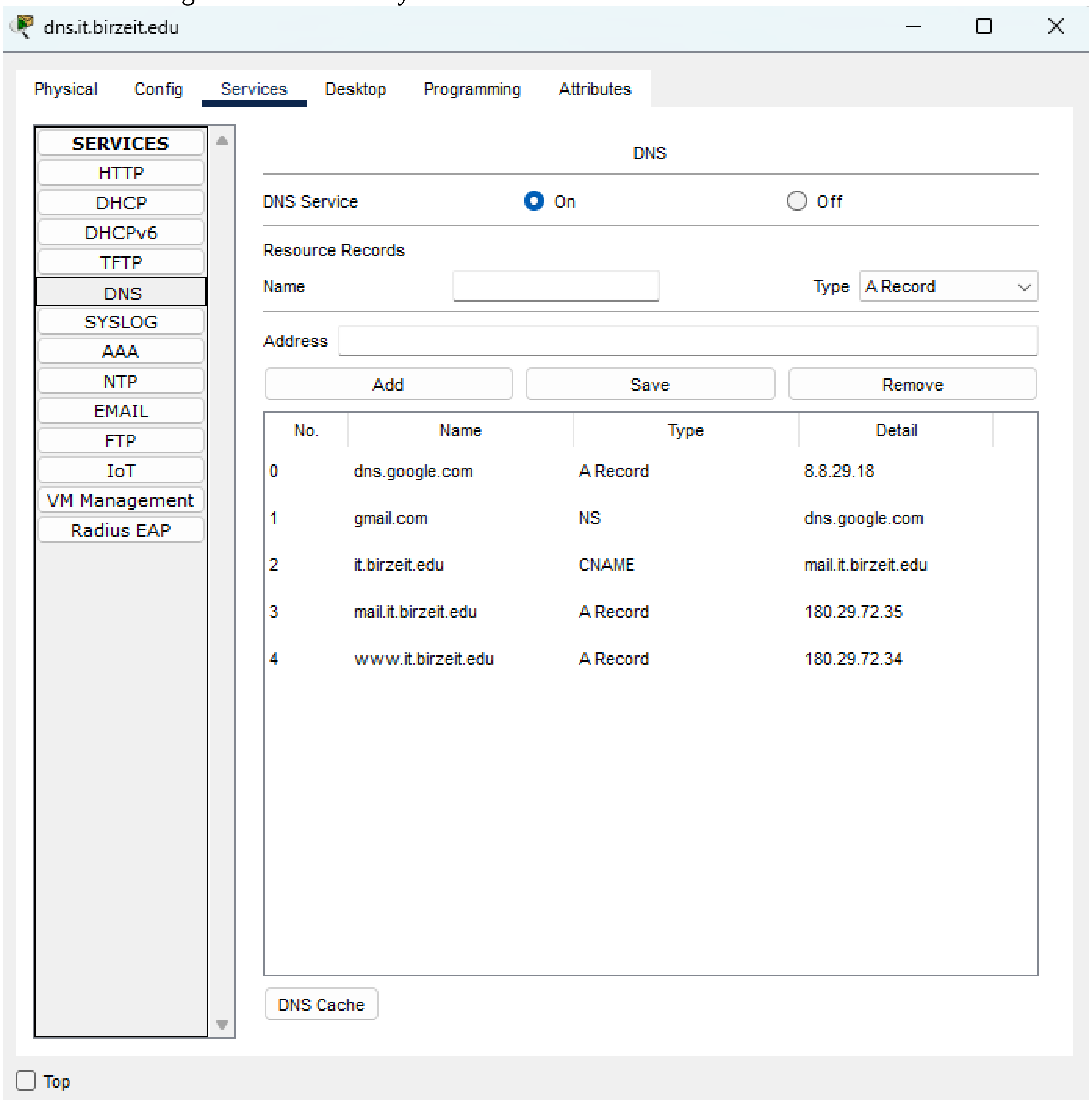


Figure 46: Enable only the DNS

- In this figure we assign a static IP configuration.

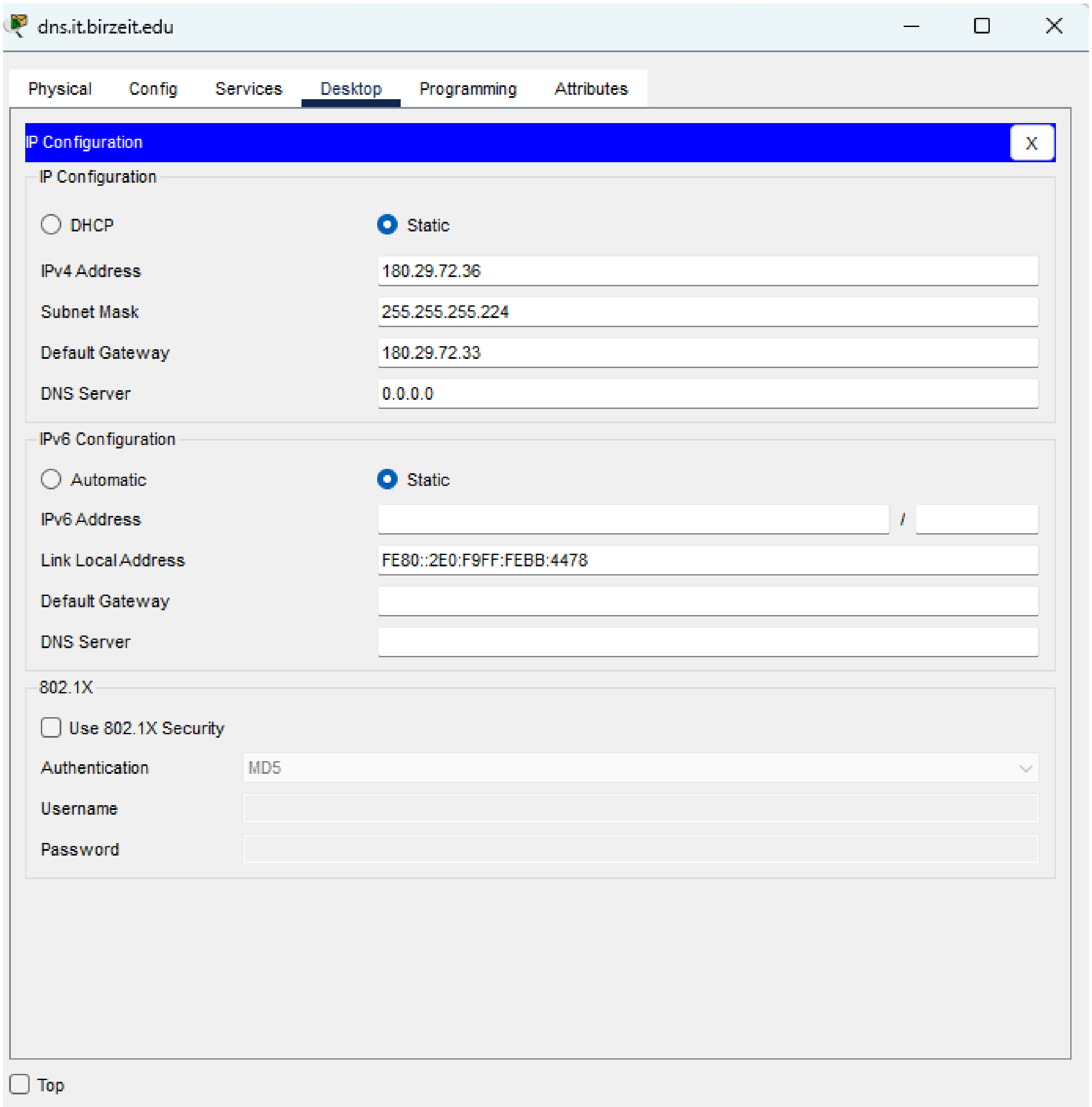


Figure 47: assign a static IP configuration for the DNS server

- In this figure we add the RRs as required in project.

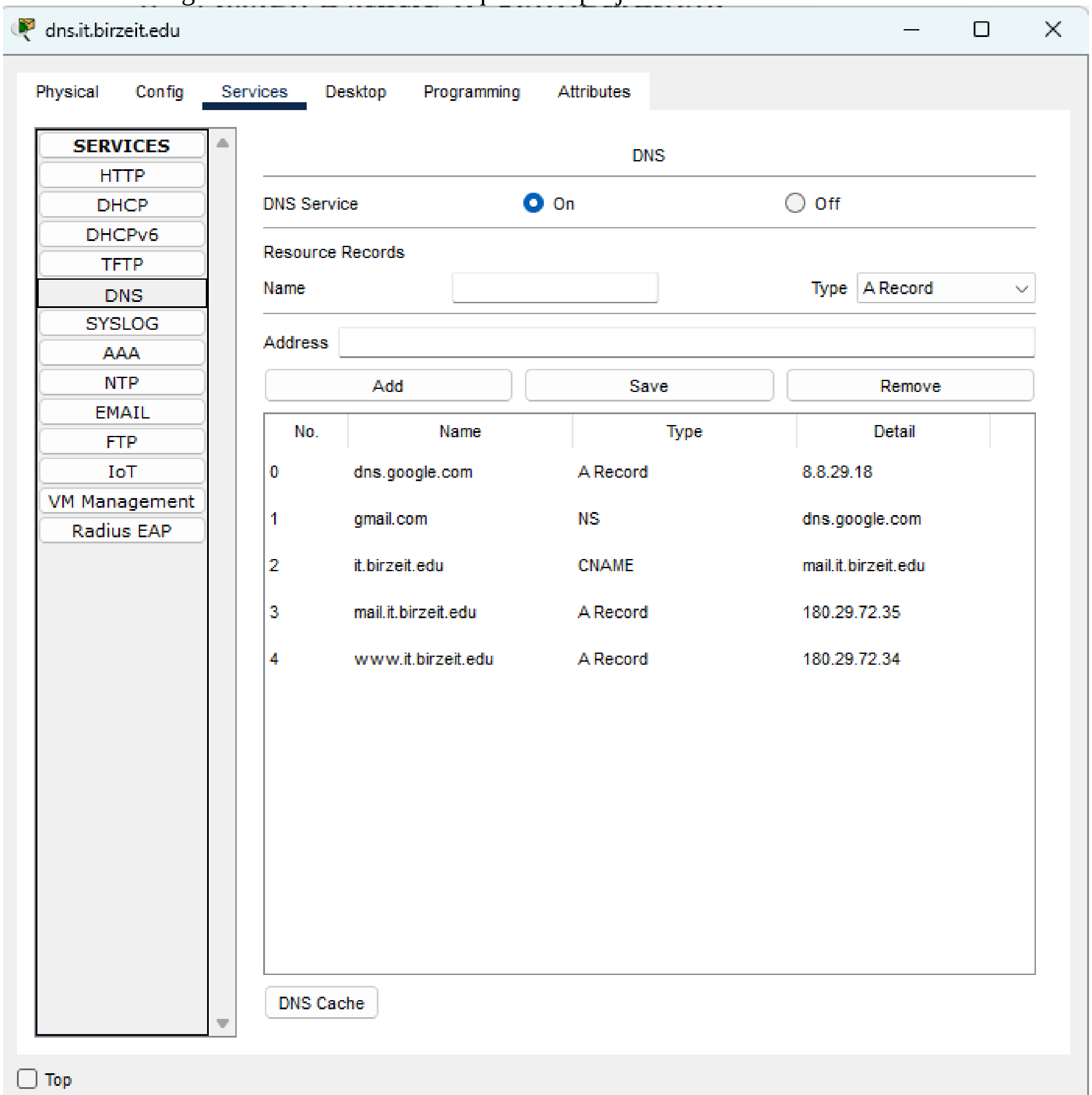


Figure 48: add the RRs record

- In this figure we enable only DHCP service.

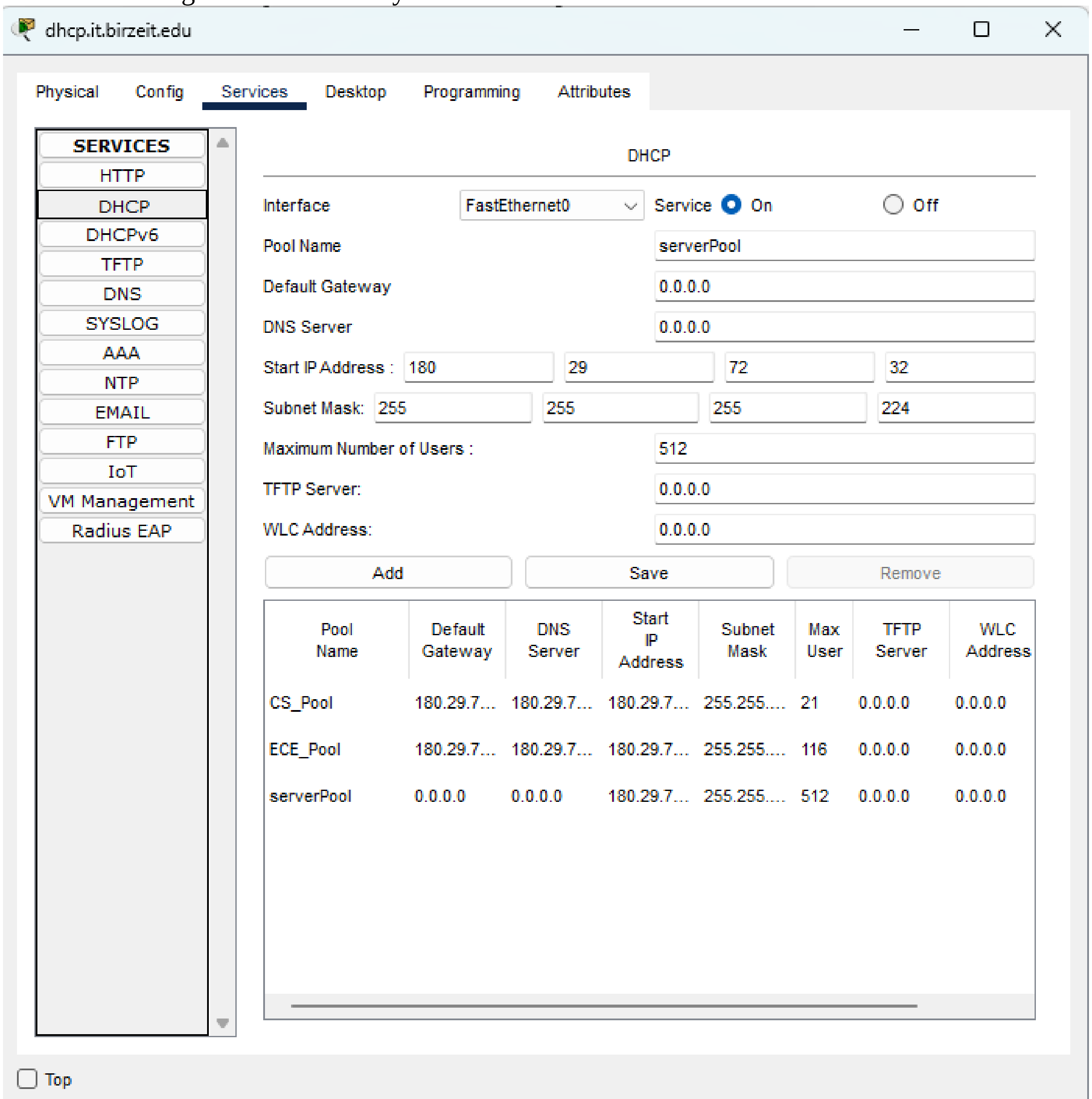


Figure 49: enable only DHCP

- In this figure we assign a static IP configuration.

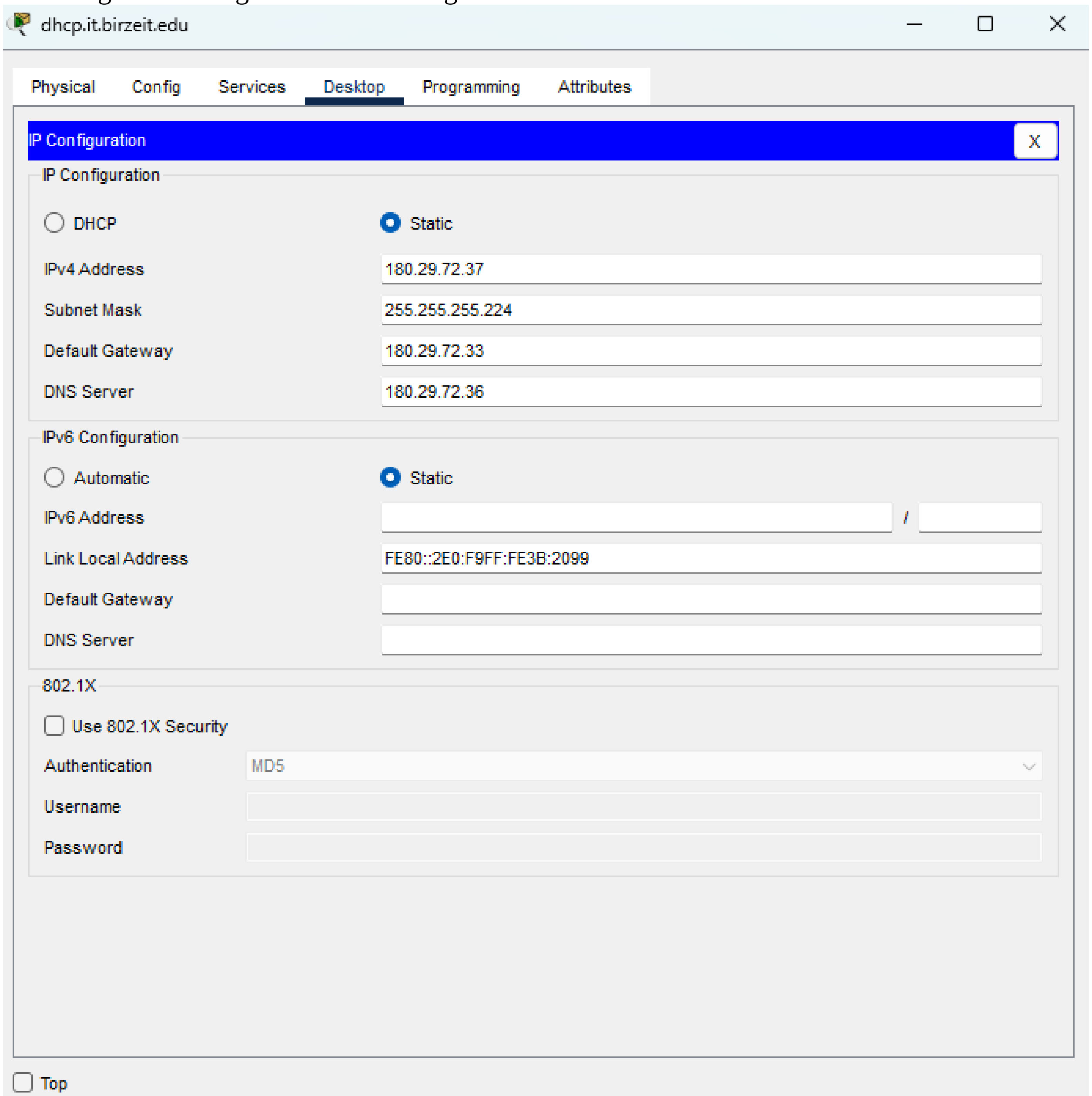


Figure 50: Assign a static IP configuration

- In this figure we create separate pools for the CS subnet (CS_Pool). In this

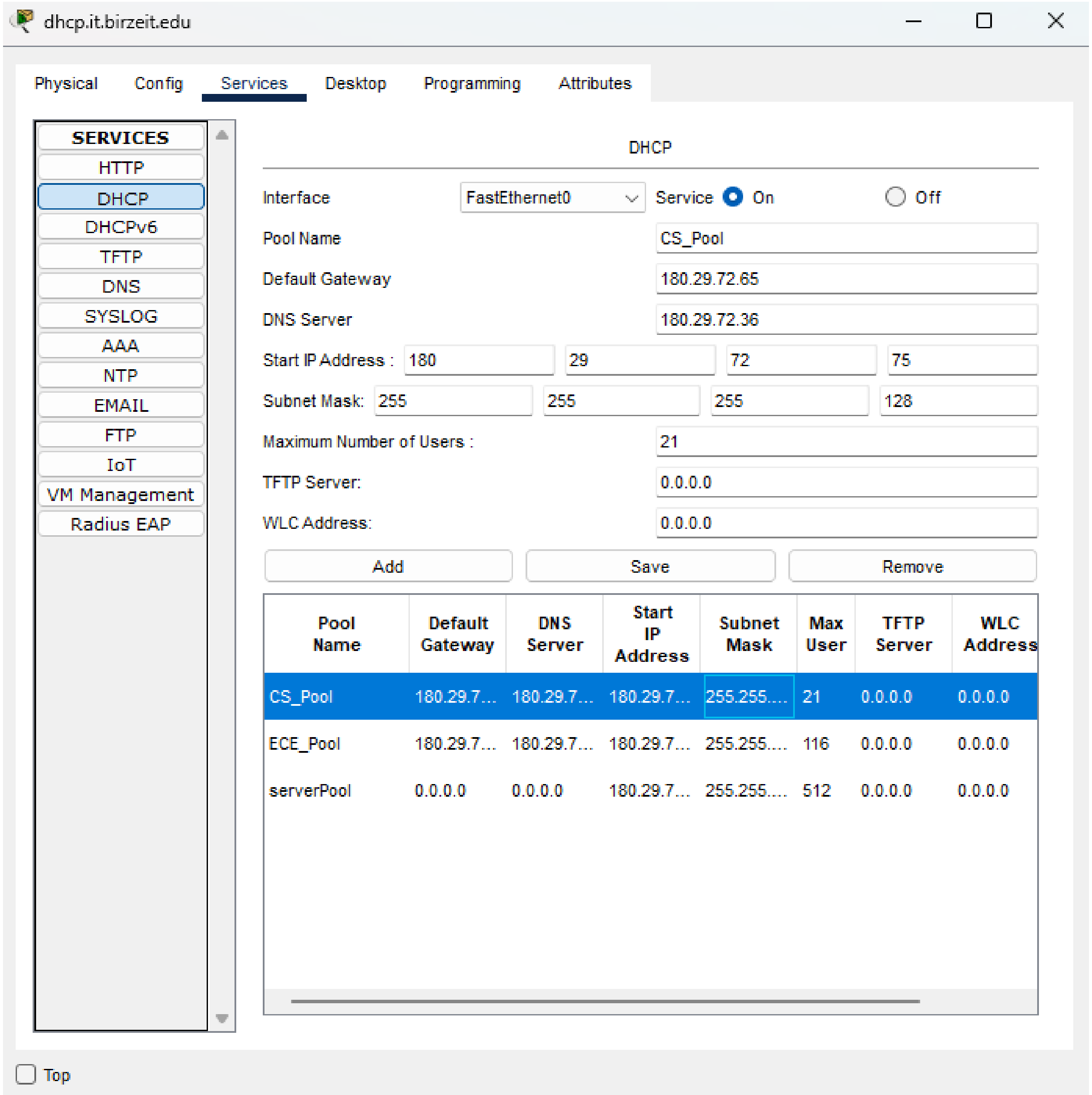


Figure 51: create separate pools (CS_Pool).

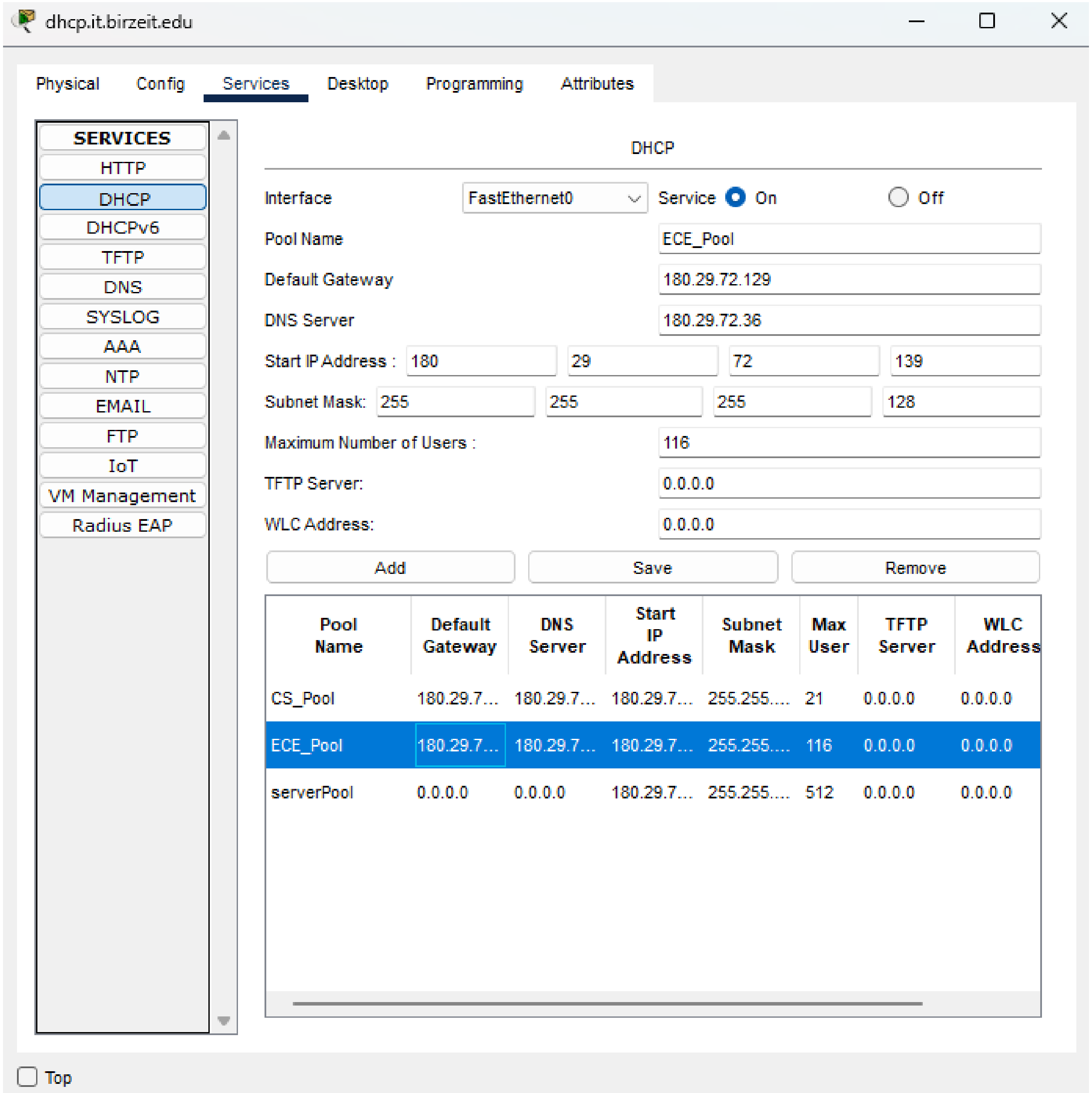


Figure 52: create separate pools (ECE_Pool).

- In this figure we configure the R1_IT router to forward DHCP broadcast messages received on the gateway interface for the ECE and CS networks using the ip helper command.

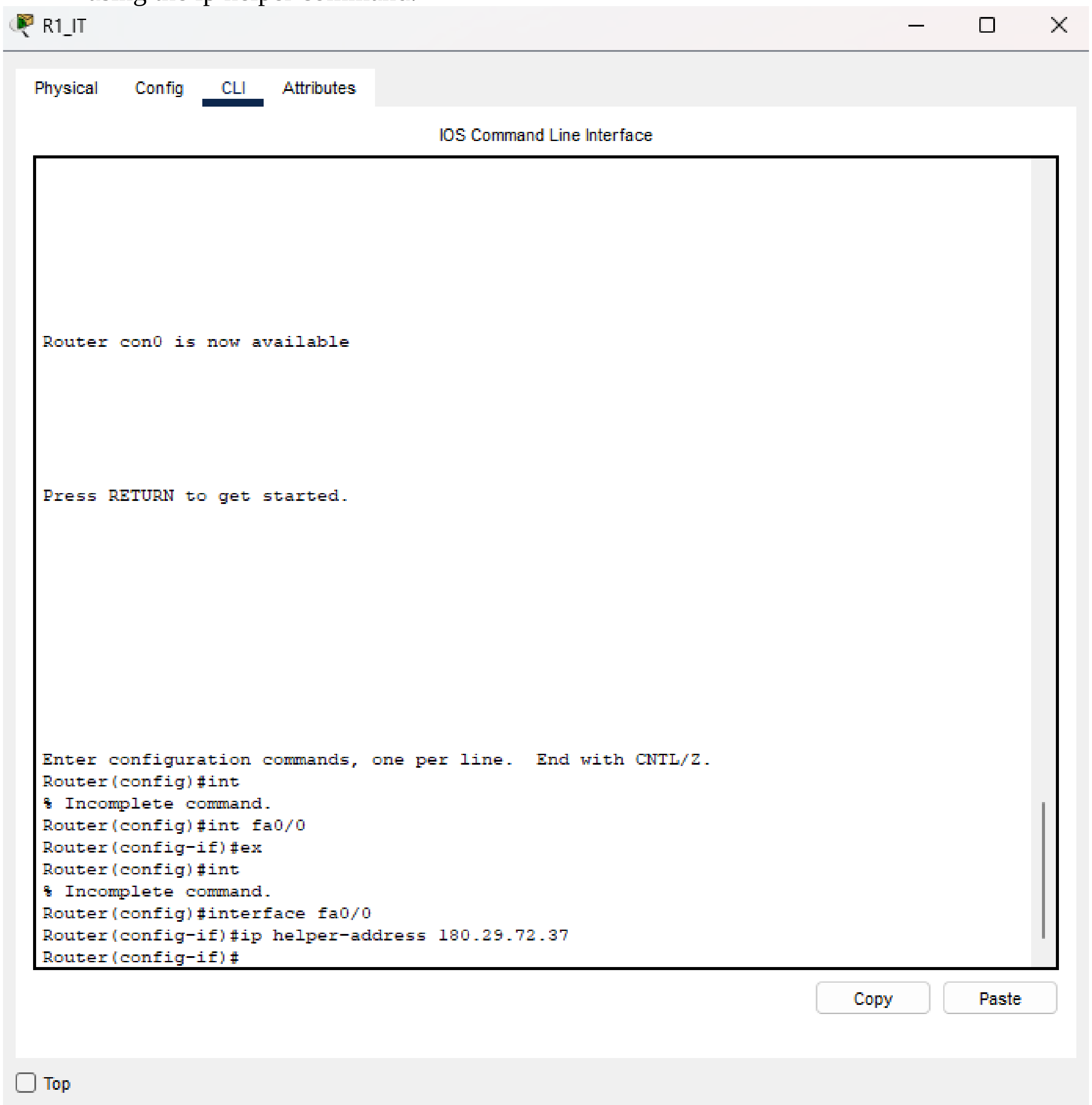


Figure 53: R1_IT router to forward DHCP broadcast messages

- In this figure we assign a static IP configuration to the printer

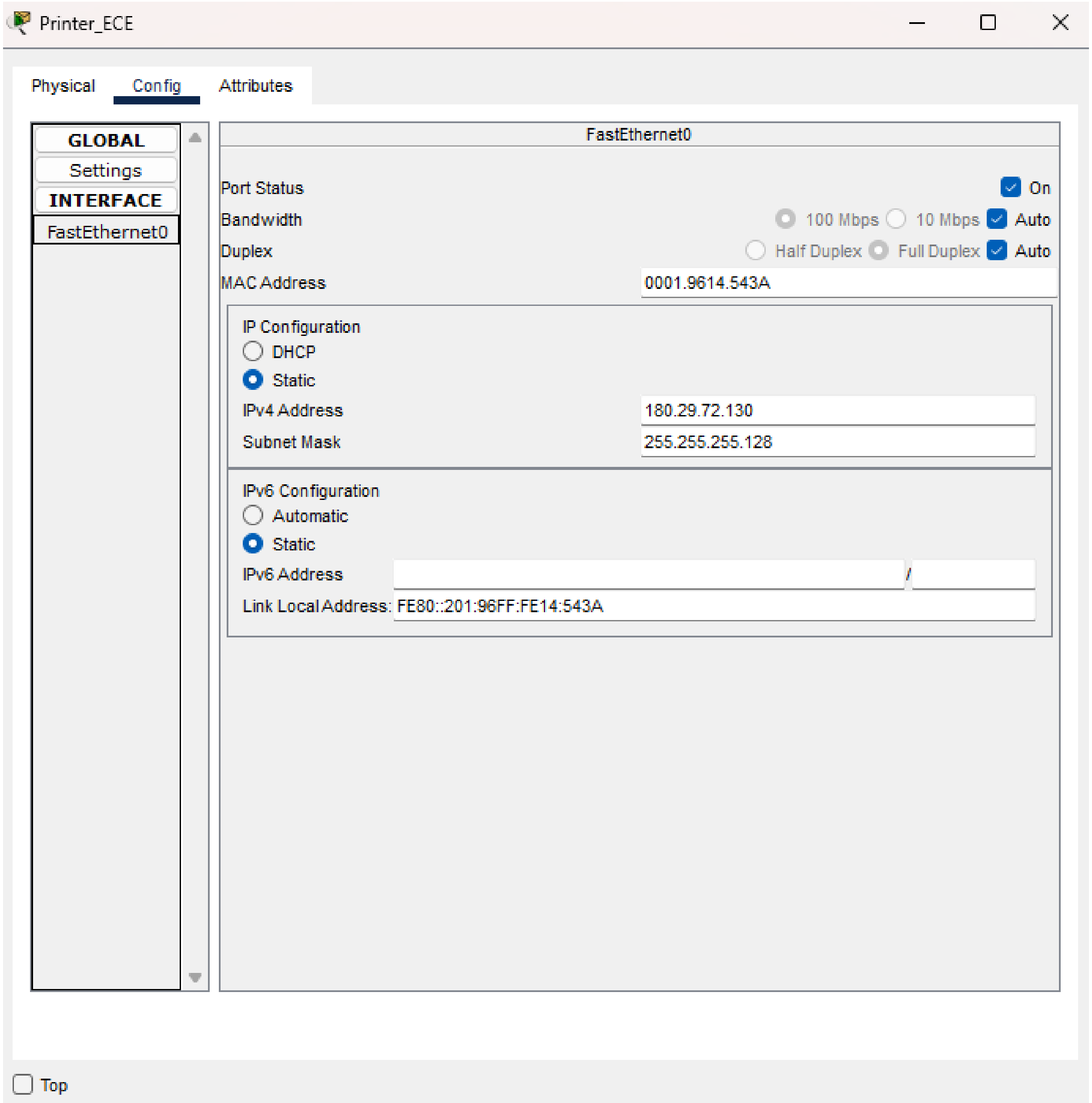


Figure 54: assign a static IP configuration to the printer

- In this figure we use dynamic IP configurations for the PC.

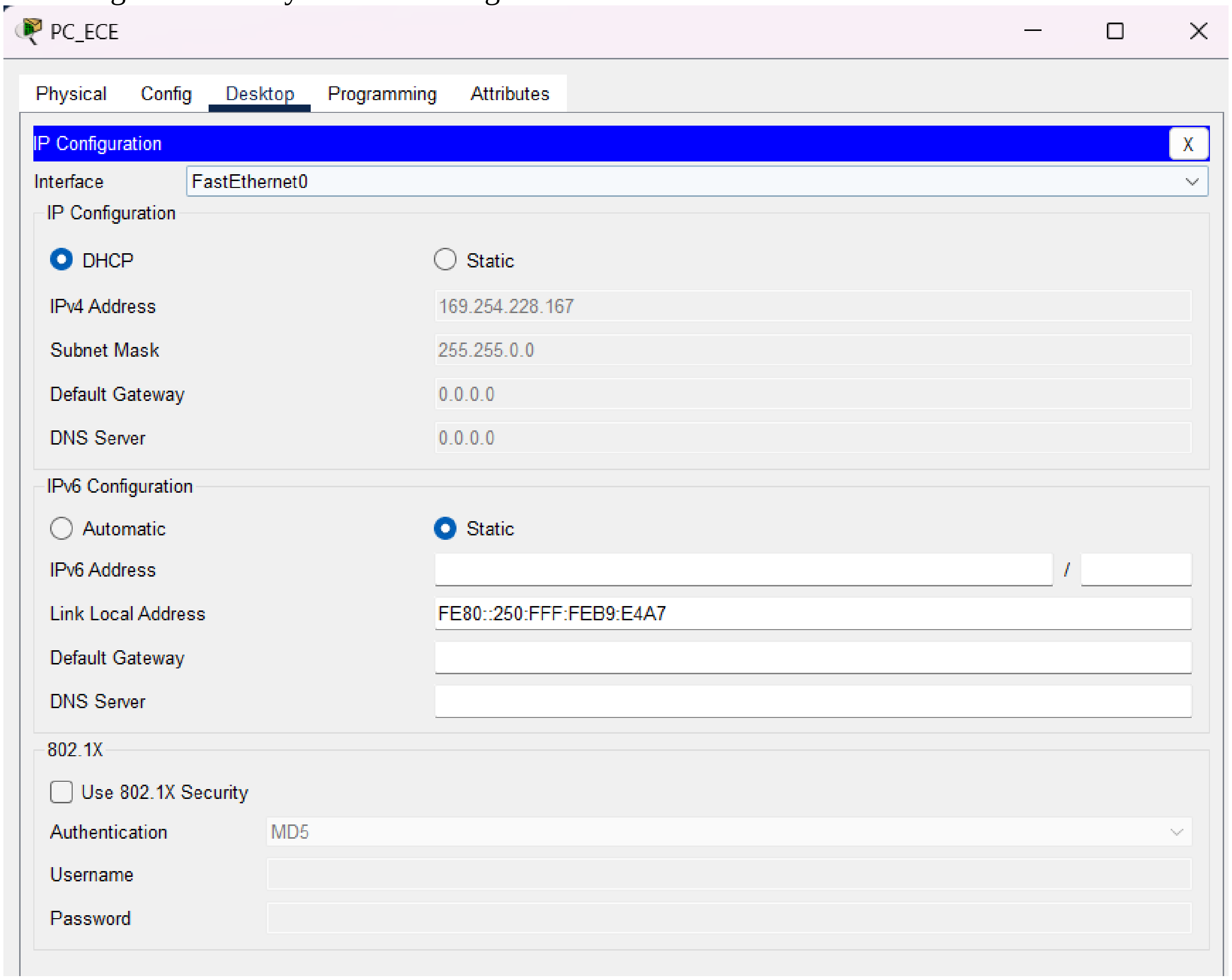


Figure 55: use dynamic IP configurations for the PC

- In this figure we use dynamic IP configurations for the laptop.

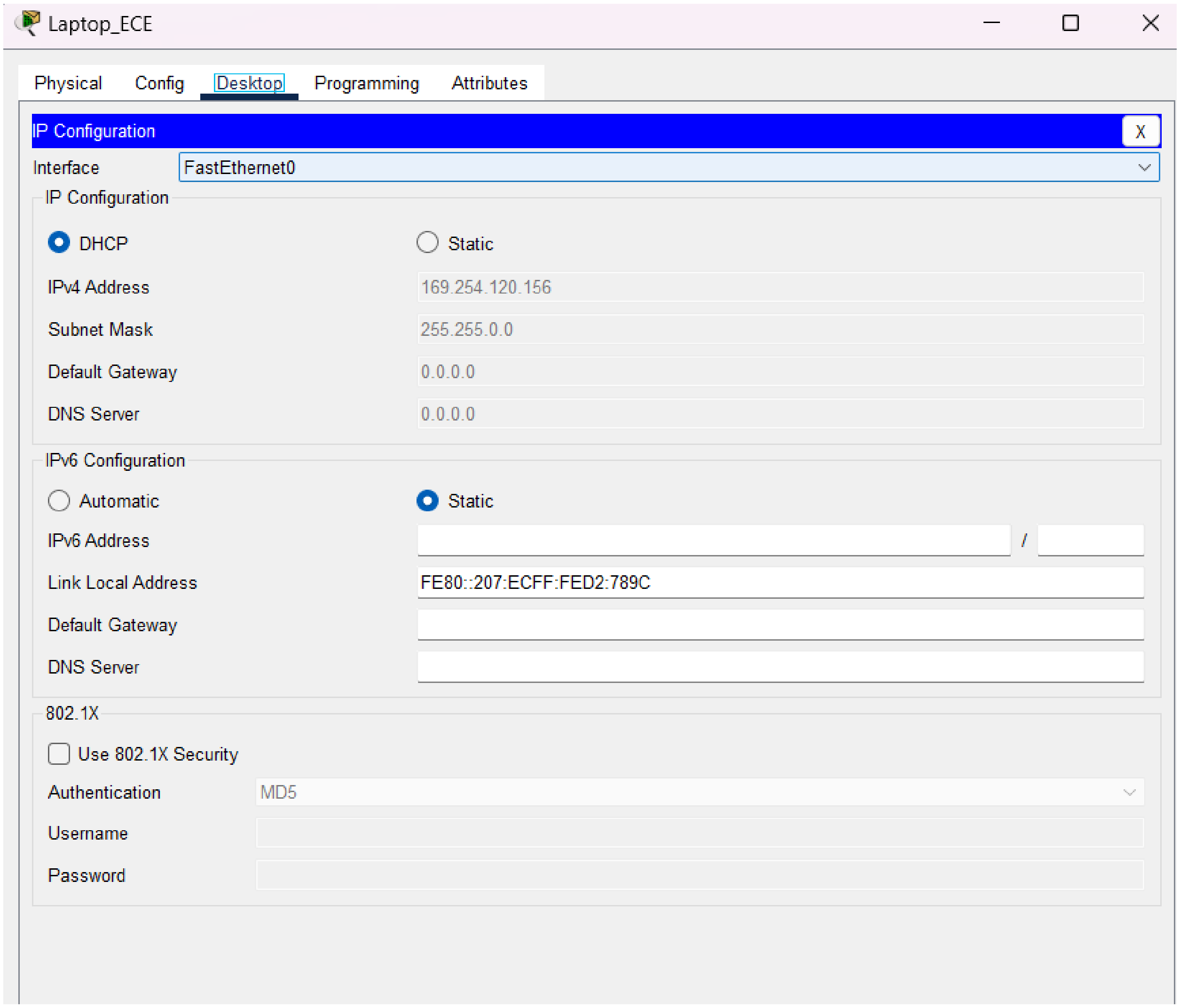


Figure 56: use dynamic IP configurations for the laptop

- In this figure we configure the PC email client for the first Gmail account using the settings as required in project.

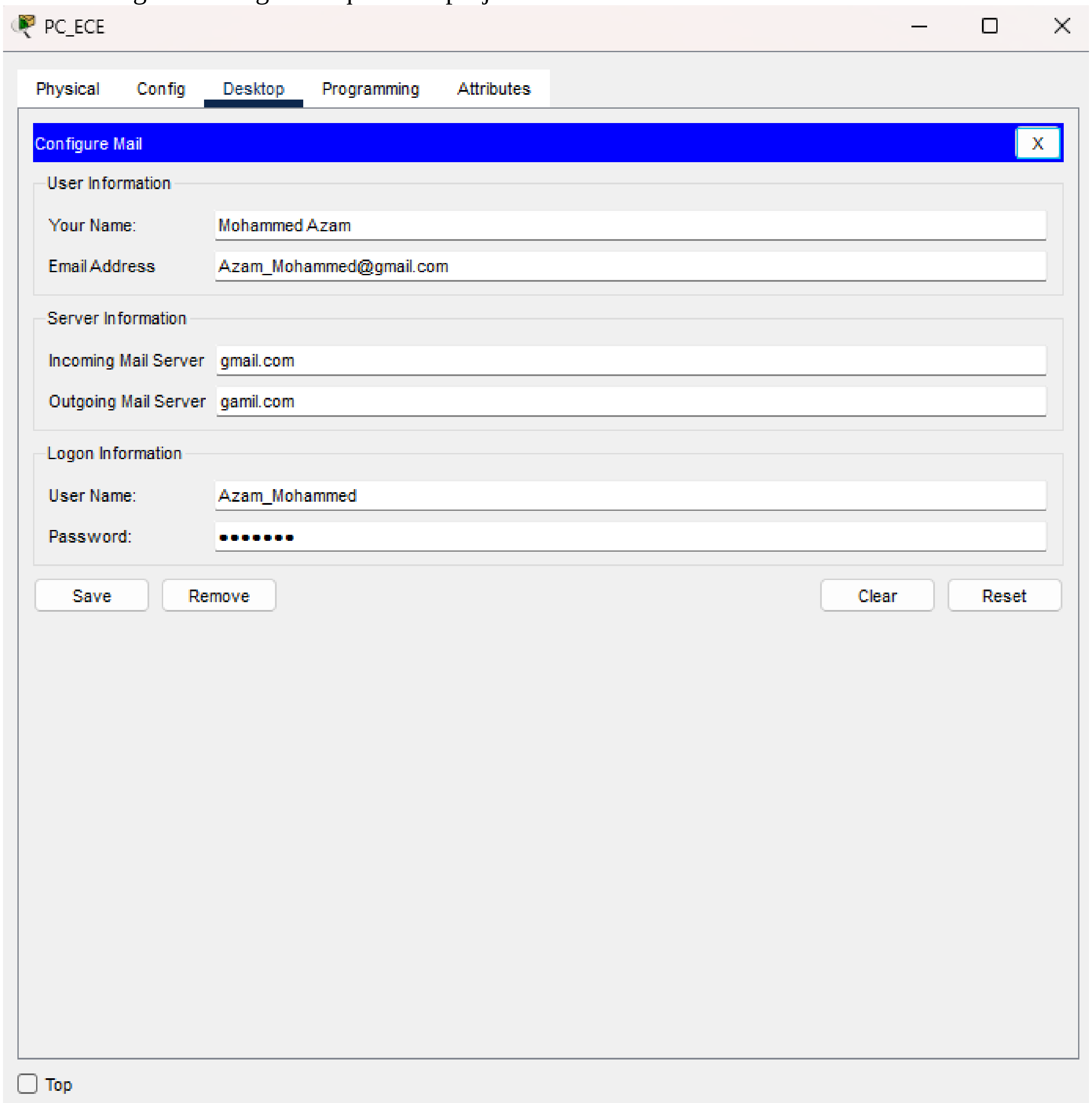


Figure 57: configure the PC email client for the first Gmail account

- In this figure we configure the laptop's email client for the first Birzeit account.

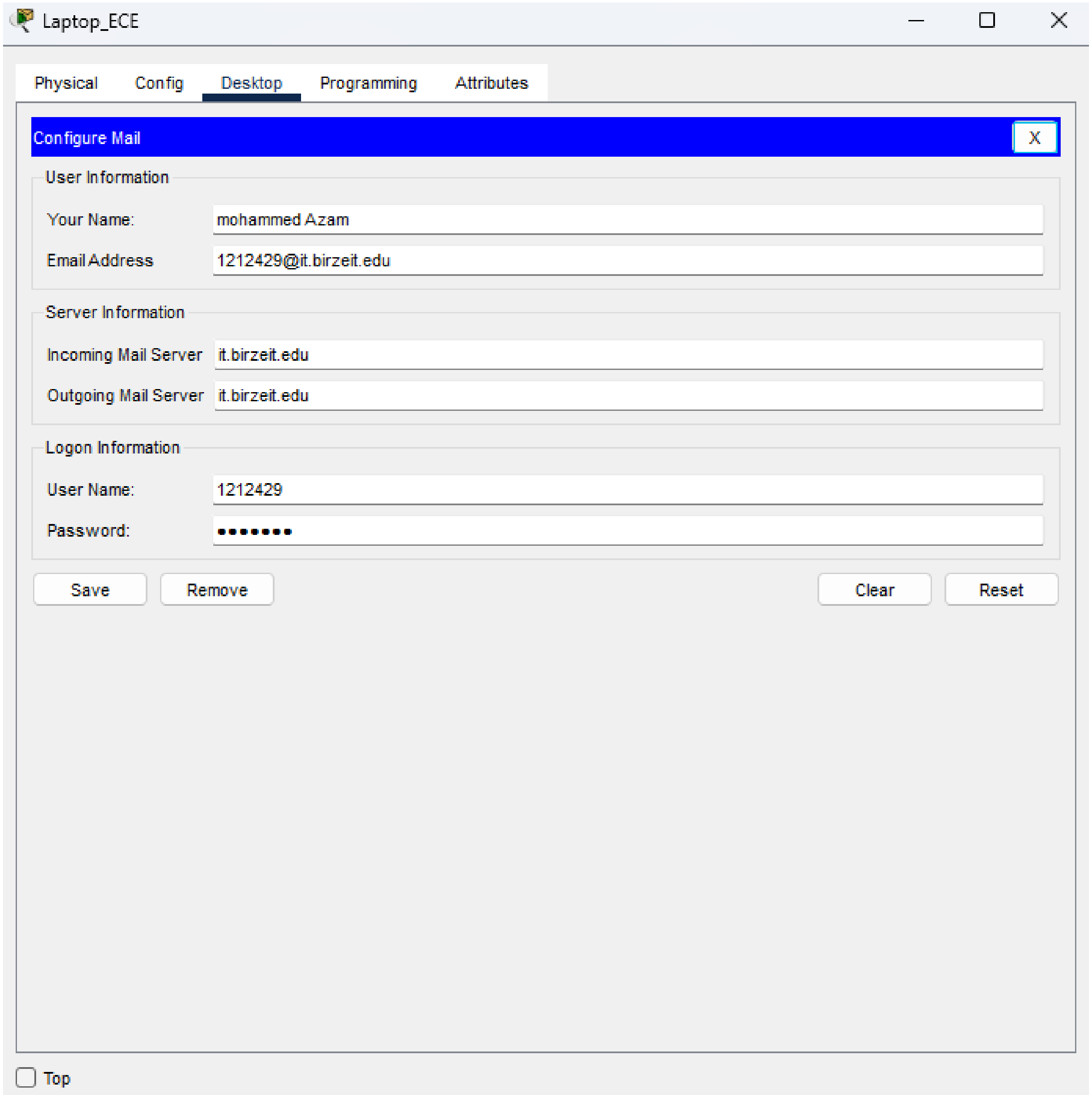


Figure 58: configure the laptop's email client for the first Birzeit account

- In this figure we assign a static IP configuration to the printer.

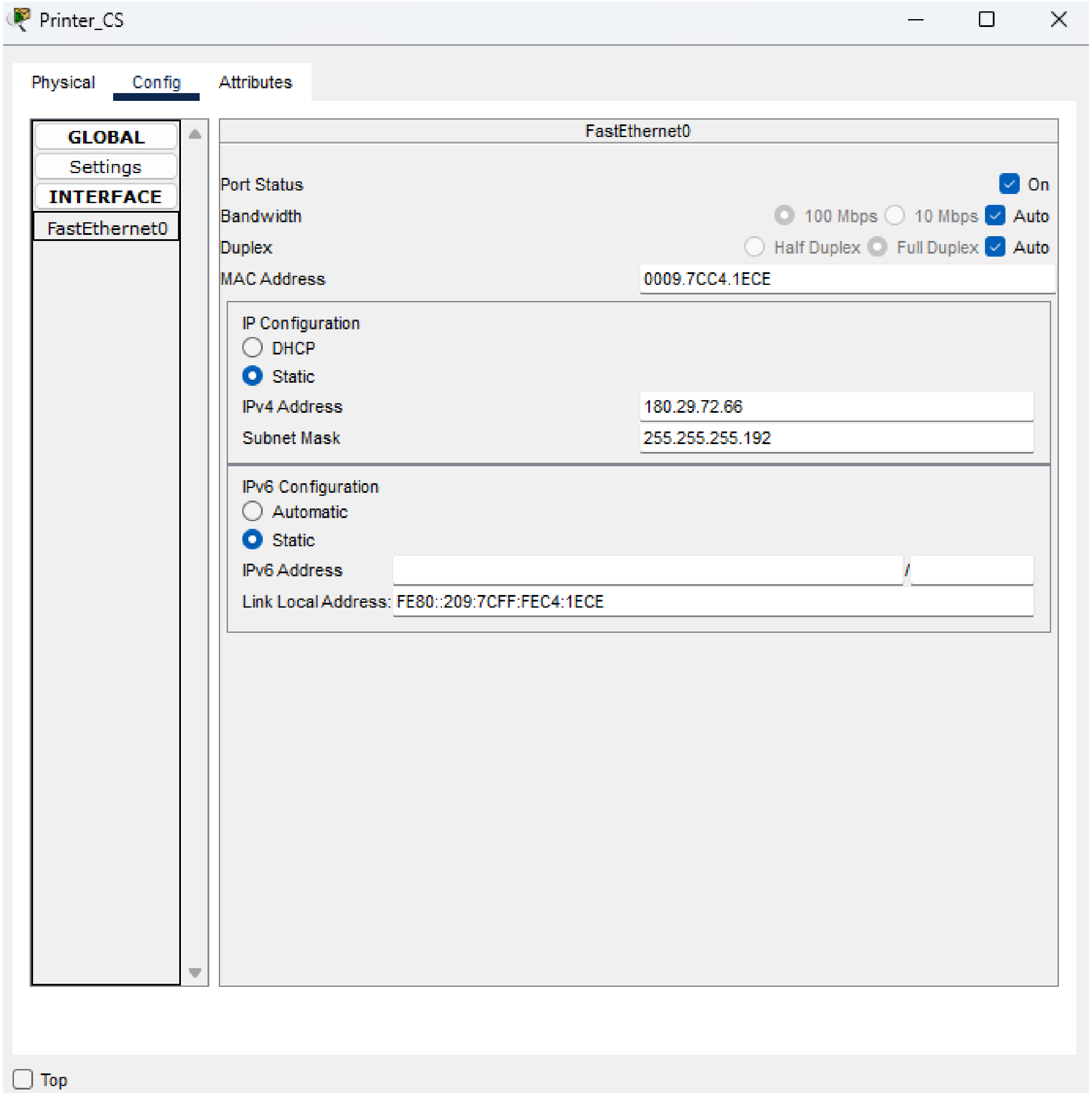


Figure 59: assign a static IP configuration to the printer

- In this figure we use dynamic IP configurations for the PC.

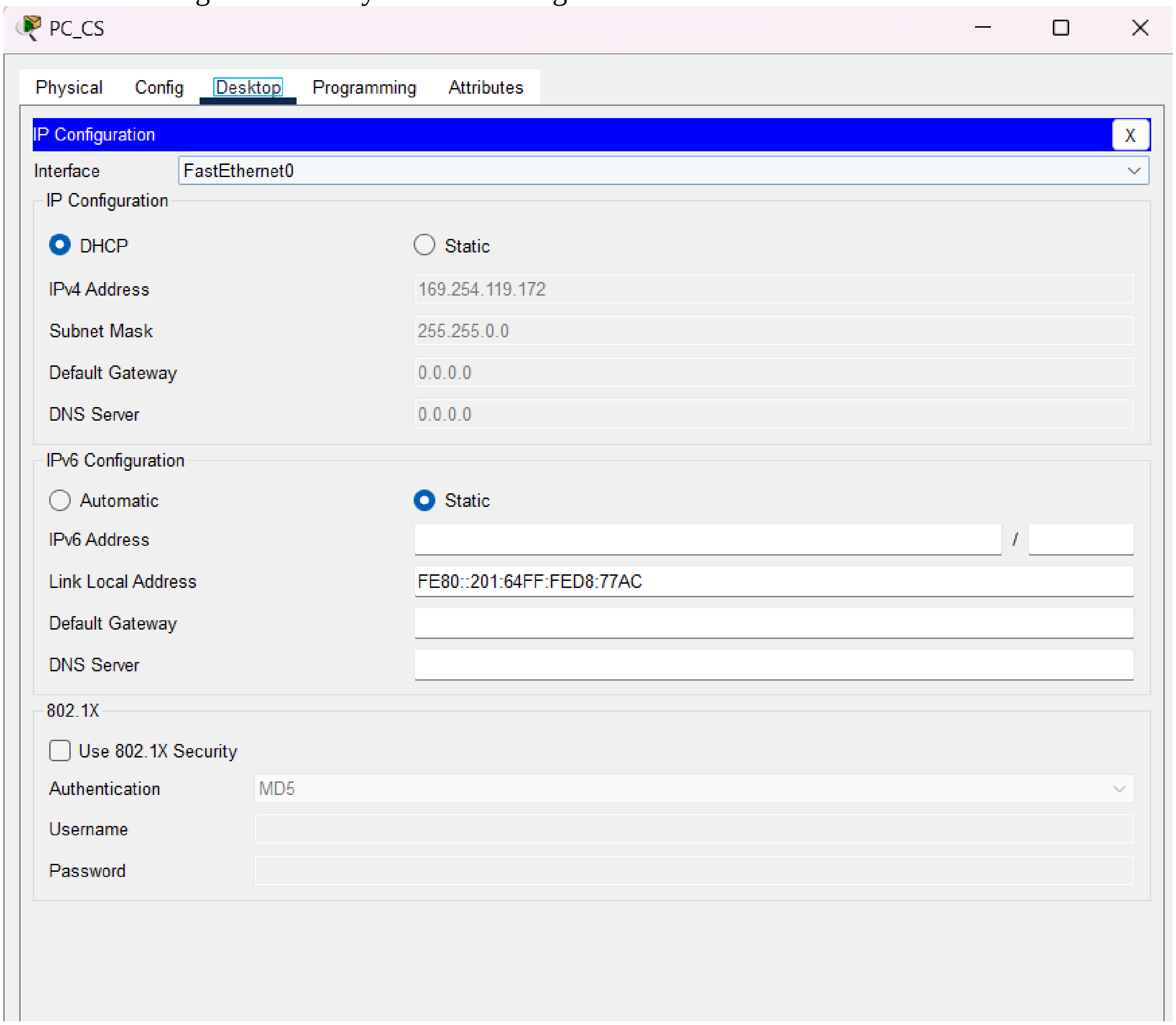


Figure 60: use dynamic IP configurations for the PC

- In this figure we use dynamic IP configurations for the Laptop.

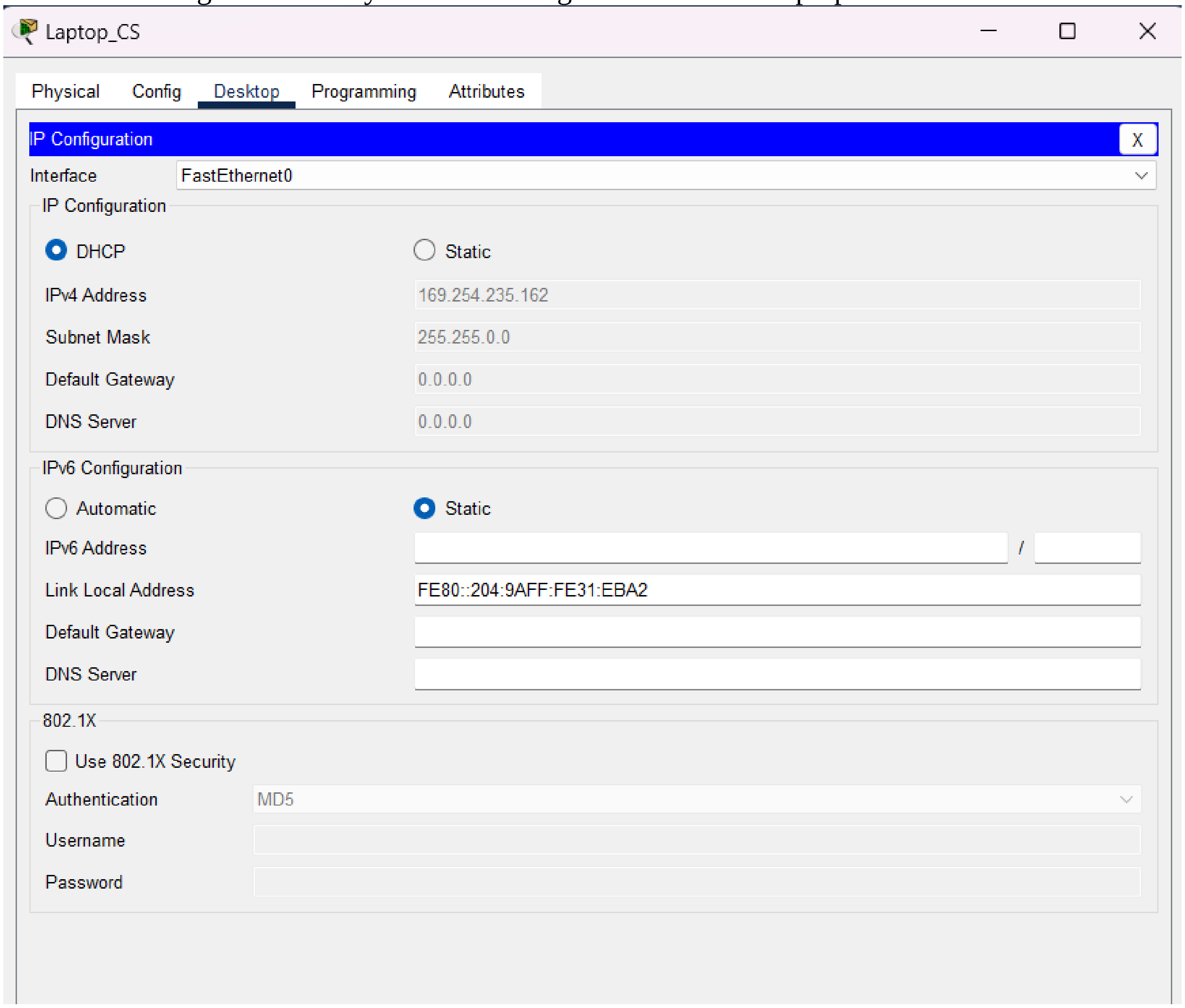


Figure 61: use dynamic IP configurations for the laptop

- In this figure we configure the PC email client for the second Gmail account.

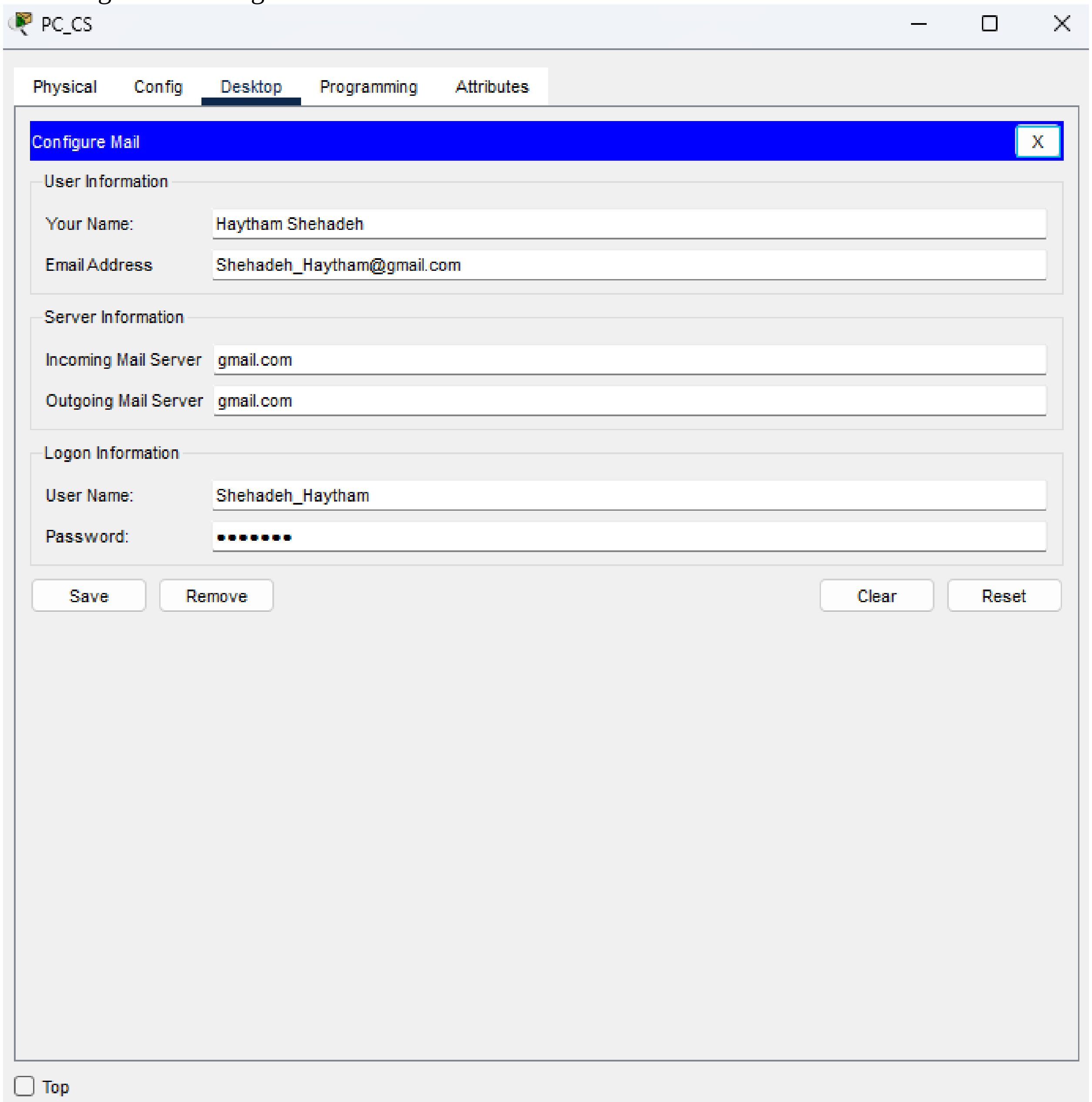


Figure 62: configure the PC email client

* In this figure we configure the laptop email client for the second Birzeit account.

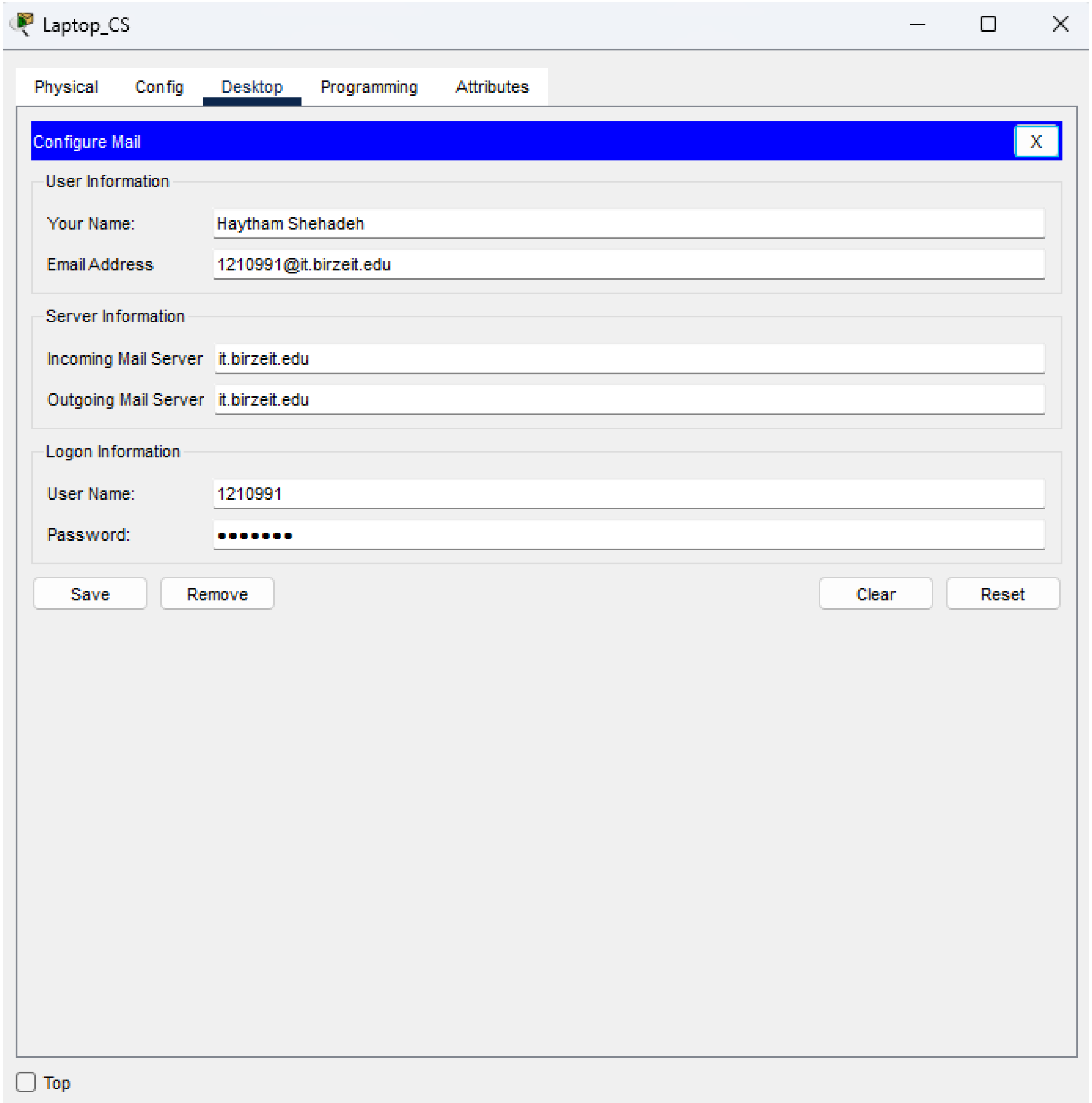


Figure 63: configure the laptop email client

Issues and limitations

I think there are problems in the program itself when choosing the subnet mask automatically, as this thing did not make us reach a correct result until after calculating it, and there is also something wrong with the automatic wires, as the entire network works correctly, but when sending an email, we face a problem that we did not recognize, and although we walked through all the details of the complete project, there are difficulties in finding the IP for the devices and how to connect them together, as it is a new program for us, but we worked with all honesty and care on it

Teamwork

We both did all the tasks equally, each of us took a part of the project, and each of us took a part of the report in a fair and equitable manner. In terms of numbers, it was 50% for both parties.

Conclusion

Completing this project significantly enhanced our practical understanding of network design. Using Cisco Packet Tracer, we built a robust network that included various servers, end devices, and switches. The theoretical concepts of subnetting learned in lectures became tangible as we implemented them, deepening our grasp of the subject. Although we encountered challenges with device configurations and routing, we overcame these obstacles through teamwork and careful troubleshooting.

References

1 : https://www.encyclopedia.com/computing/news-wires-white-papers-and-books/network-networks

2: https://www.geeksforgeeks.org/network-address-translation-nat/

3: https://en.wikipedia.org/wiki/Network_address_translation

4: https://www.techtarget.com/searchnetworking/definition/DHCP

5: https://www.geeksforgeeks.org/dynamic-host-configuration-protocol-dhcp/

6: https://www.cloudflare.com/learning/dns/what-is-dns/