Birzeit University
Faculty of Engineering and Technology
Department of Electrical and Computer Engineering
ENCS3320 – Computer Networks (Term 1241)
Project #2 (*Cisco Packet Tracer*) – Due Thursday, January 16, 2025

A) Objectives

This project aims to enhance your knowledge and practical skills in computer network design, including subnetting, static and dynamic routing, wireless security, and essential network services such as Web, Email, Domain Name System (DNS), and Dynamic Host Configuration Protocol (DHCP). The specific objectives are:

- Design an IP addressing scheme using subnetting.
- Learn to use Cisco Packet Tracer to design and simulate network topologies.
- Develop skills in configuring and managing essential network services such as Web, Email, DNS, and DHCP servers.
- Understand and implement dynamic Network Address Translation (NAT) with Port Address Translation (PAT), and configure a router for Internet connectivity.
- Learn the fundamentals of wireless Local Area Network (LAN) configuration, including essential wireless security measures.
- Achieve expertise in configuring IP addressing for network devices, including both static and DHCP setups, while ensuring accurate connectivity verification.
- Gain proficiency in using fundamental network commands.
- Develop professional technical report writing skills to effectively document and communicate project results and analyses.
- Strengthen teamwork skills through collaboration on project tasks.

B) Requirements and Deliverables

As a team of ***three students*** *(from any section)*, your task is to design a network of networks using Cisco Packet Tracer and submit both your .pkt project file and a project report. Please adhere to the following guidelines:

- **Cisco Packet Tracer Installation:** Download the latest version of Cisco Packet Tracer from https://www.netacad.com/cisco-packet-tracer.
- **Implementation Guidelines:** Ensure that the implementation reflects *your work*. Refer to *Section D (Helpful Tutorials)* for resources to assist with creating the topology.
- **Team Coordination:** Active participation from each team member is essential at every stage of the project, including research, design, implementation, testing, and report preparation. To enhance collaboration, use **GitHub** for version control and coding, and **Overleaf** for real-time document editing. Clearly define responsibilities, maintain communication with regular feedback, and monitor progress closely to ensure a cohesive and successful project outcome.
- **Submission Requirements:** Submit the following **files** in a *single compressed folder* named ***Project2_TeamName.zip*** through **Moodle**:
  1) **Project Report (*report.pdf*)**
     A comprehensive technical report in **PDF** format that documents your solutions. The report should include:

a. **Cover Page**
   - Include the university logo, department, course name and number, project title, team members' names and IDs (with their sections), and submission date.

b. **Theory and Procedure**
   - Explain the theoretical concepts relevant to each project requirement, organized under appropriate section titles.
   - List the components or methods used for each part of the project, with a brief justification for each.
   - Use diagrams or flowcharts to illustrate your solutions. Provide detailed descriptions and captions for all figures, ensuring they are referenced in the text.
   - Cite all theoretical concepts and sources, and include a references section at the end of the report.

c. **Results and Discussions**
   - Provide a detailed discussion of your approach and the results for each task outlined in *Section C (Topology)*.
   - Include clear screenshots that demonstrate the functionality of all required tasks. Each screenshot must display the system's date and time. Accompany each screenshot with an explanation, detailing the results and their significance.

d. **Issues and Limitations**
   - Highlight challenges, limitations, or issues encountered during the project, whether individual or team-related.
   - Note any tasks or components that did not function as expected, if applicable.

e. **Teamwork**
   - Use a chart to document each team member's contributions, detailing specific tasks completed by each individual.

Ensure the report includes proper numbering, a table of contents, a list of figures, a list of tables, and appendices as necessary.

2) **Network Topology (***Project2_TeamName.pkt***)**

Create the network topology shown in **Figure 1**, adhering to the following requirements:

a. Use the following **devices** in your implementation:
   - Routers (**Router-PT**)
   - Access Point (**AccessPoint-PT**)
   - PCs/Laptops (**PC-PT/Laptop-PT**)
   - Smartphone (**SMARTPHONE-PT**)
   - Switches (**Switch-PT**)
   - Servers (**Server-PT**)
   - Printers (**Printer-PT**)
   - Tablet (**TabletPC-PT**)

b. Use **automatic connections** to link the devices. Start by connecting the **gateway routers** of the autonomous systems (**ASs**) — *R0_Google*, *R0_IT*, and *R_ISP* (as shown in **Figure 1**) — to enable *communication over the* ***serial interfaces***.

c. In the Home network, replace the laptop's wired LAN module with a **WPC300N** wireless adapter module to provide wireless connectivity with the access point.

Each team must submit **one** final version by January 16, 2025. **Late submissions *will not be accepted*** under any circumstances. Failure to submit your project solutions before the deadline will result in a score of zero.

C) Topology

The network topology comprises ***three*** ASs: (i) Google network, (ii) Faculty of Engineering and Technology network, and (iii) Home-ISP network. These ASs are interconnected through *three* links, as depicted in **Figure 1**. The IP addresses for each network are provided in the figure. Replace the variable ***X*** in the network IP addresses with the last two digits of the team leader's student ID (SID). For example, if the team leader's SID is 1212049, then ***X*** = **49**. Solutions that *fail to incorporate the SID* into the network IP addresses as specified will be deemed invalid and **rejected**.

1) **Google Network (AS-300)**

The topology and subnet IP addresses for this network are shown in **Figure 1**. Follow these steps to build and configure the Google network:

- Assign **static** IP configurations to all router ports.
- DNS Server (*dns.google.com*)
  a. Enable only the **DNS** service on this server.
  b. Assign a **static** IP configuration.
  c. Add the following **recourse records** (RRs):

Name	Value	Type
gmail.com	The IP address of the *gmail.com* server	A
dns.it.birzeit.edu	The IP address of the *dns.it.birzeit.edu* server	A
it.birzeit.edu	dns.it.birzeit.edu	NS

  These RRs map the authoritative name server *dns.it.birzeit.edu* and the email server *gmail.com* to their respective IP addresses. Additionally, they set the hostname of the authoritative name server *dns.it.birzeit.edu* for the domain *it.birzeit.edu*.
- Email Server (*gmail.com*)
  a. Enable only the **SMTP** (for sending emails) and **POP3** (for receiving emails) protocols.
  b. Assign a **static** IP configuration.
  c. Set the **domain name** (mail server alias hostname) as *gmail.com*.
  d. Create ***two*** user accounts for team members as follows:
    - Username: *LastName_FirstName*
    - Password: *Team member's SID*

  The email address will follow this format: *LastName_FirstName@gmail.com*

2) **Faculty of Engineering and Technology Network (AS-100)**

The Faculty of Engineering and Technology has been allocated the IP block *180.**X**.72.0/24* from the Information Technology Department. The network topology is shown in **Figure 1** and includes the following subnets:

- **Servers Subnet:** Requires **28** IP addresses.
- **Electrical and Computer Engineering (ECE) Subnet:** Requires **120** IP addresses.
- **Computer Science (CS) Subnet:** Requires **55** IP addresses.
- **Backbone Subnet:** Requires **4** IP addresses.

Assign IP addresses to these subnets, optimizing address space usage to minimize waste while maintaining the largest contiguous block of unused addresses for future expansion. In your report, provide the following details for each subnet:

- IP address (in CIDR notation).
- Subnet mask.
- Broadcast IP address.
- First usable host IP address.
- Last usable host IP address.

Below are the specific requirements for each subnet:

- Servers Subnet
  This subnet hosts the Web, Email, DNS, and DHCP servers.
  a. Web Server (*www.it.birzeit.edu*)
    - Enable only **HTTP** and HTTP Secure (**HTTPS**) protocols.
    - Assign a **static** IP configuration.

- Customize the *index.html* page to include:
  - Tab Title: "IT-Birzeit"
  - Page Title: "Faculty of Engineering and Technology"
  - A description of the faculty, details about the ECE and CS departments, images, lists, and formatted text.

b. Mail Server (*mail.it.birzeit.edu*)

- Enable only the **SMTP** (for sending emails) and **POP3** (for receiving emails).
- Assign a **static** IP configuration.
- Set the **domain name** (mail server alias hostname) as *it.birzeit.edu*.
- Create ***two*** user accounts for team members as follows:
  - Username: *SID*
  - Password: *Team member's SID*

  The email address will follow this format: *SID@it.birzeit.edu*

c. DNS Server (*dns.it.birzeit.edu*)

- Enable only **DNS** service.
- Assign a **static** IP configuration.
- Add the following **RRs**:

Name	Value	Type
www.it.birzeit.edu	The IP address of the *www.it.birzeit.edu* server	A
mail.it.birzeit.edu	The IP address of the *mail.it.birzeit.edu* server	A
dns.google.com	The IP address of the *dns.google.com* server	A
gmail.com	dns.google.com	NS
it.birzeit.edu	mail.it.birzeit.edu	CNAME

These RRs map the Web server *www.it.birzeit.edu*, the email server *gmail.com*, and the authoritative name server *dns.google.edu* to their respective IP addresses. Additionally, they set the hostname of the authoritative name server *dns.google.com* for the domain *gmail.com* and set the DNS server to resolve the alias hostname *it.birzeit.edu* to its corresponding canonical name *mail.it.birzeit.edu*.

d. DHCP Server (*dhcp.it.birzeit.edu*)

- Enable only **DHCP** service.
- Assign a **static** IP configuration.
- Create *separate* **pools** for the ECE subnet (***ECE_Pool***) and CS subnet (***CS_Pool***). Example for the ***ECE_Pool***:
  - Default Gateway: *IP address of R1_IT router port in ECE network.*
  - DNS Server: *IP address of the dns.it.birzeit.edu server.*
  - Start IP Address: *First usable host IP address in ECE network after excluding the first 10 (reserved for the gateway, Printer_ECE, and future expansion).*
  - Subnet Mask: *ECE network mask.*
  - Maximum Number of Users: *Total number of remaining usable host IP addresses after accounting for exclusions.*
- 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:
  - `R1_IT(config)# interface <TYPE> <SLOT>/<PORT>`
  - `R1_IT(config-if)# ip helper-address <DHCP-Server-Address>`

- ECE Subnet

  This subnet includes a PC, laptop, and printer connected via a switch.

a. ECE computers need to know the printer's IP address to send information to it. Thus, assign a **static** IP configuration to the printer.
b. Use **dynamic** IP configurations for the PC and laptop (via DHCP).
c. Configure the PC's email client for the ***first*** Gmail account using the following settings:
   - Your Name: *FirstName LastName*
   - Email Address: *LastName_FirstName@gmail.com*
   - Incoming Mail Server: *gmail.com*
   - Outgoing Mail Server: *gmail.com*
   - User Name: *LastName_FirstName*
   - Password: *SID*
d. Configure the laptop's email client for the ***first*** Birzeit account.

- CS Subnet

  This subnet includes a PC, laptop, and printer connected via a switch.

  a. Assign a **static** IP configuration to the printer.
  b. Use **dynamic** IP configurations for the PC and laptop (via DHCP).
  c. Configure the PC's email client for the ***second*** Gmail account.
  d. Configure the laptop's email client for the ***second*** Birzeit account.

Include the following screenshots in your project report:

- Static IP configuration for *Printer_ECE* and *Printer_CS*.
- Dynamic IP configuration for an ECE network end device and a CS network end device.
- Static IP configuration for an *R0_IT* router port and an *R1_IT* router port.
- Successful Ping results within the Faculty of Engineering and Technology network.
- IP configuration of Web, Email, DNS, and DHCP servers.
- Email service with the user setup on the *mail.it.birzeit.edu*.
- DNS service with the RRs on the *dns.it.birzeit.edu*.
- DHCP service with the pools on the *dhcp.it.birzeit.edu*.
- Successful access to *www.it.birzeit.edu* from a Faculty of Engineering and Technology network end device.
- Email client configuration for *gmail.com* and *it.birzeit.edu* accounts.
- Successful sending and receiving of emails:
  - Between Gmail accounts within the Faculty of Engineering and Technology network.
  - Between Birzeit accounts within the Faculty of Engineering and Technology network.

3) **Home-ISP Network (AS-200)**

This network uses the following addressing scheme: **(**i) private IP addressing (*192.168.**X**.0/24*) for devices within the home subnet, and (ii) public address allocation (*209.165.**X**.224/29*) for routing through the Internet. The topology of the Home-ISP network is depicted in **Figure 1**. Follow these guidelines for building and configuring the network:

- Configure the wireless network by setting up the access point with the following parameters:
  - Name: *ENCS3320Home*
  - Security Model: *WPA2 Personal*
  - Encryption Type: *AES*
  - Key: *Home_TeamName* (e.g., *Home_001*)
- Connect wireless end devices to the *ENCS3320Home* network and cabled end devices through the switch.
- Assign **static** IP configuration on the *R_Home* router interface to serve as a gateway for the home subnet.

- Set up the *R_Home* router as a **DHCP server** for the *192.168.X.0/24* network. Specifically, set up the **DHCP pool** with the default gateway and DNS server (Google's DNS server discussed in *Section C-1 (Google Network)*) using the following commands:
  - `R_Home(config)# ip dhcp pool <DHCP-Pool-Name>`
  - `R_Home(dhcp-config)# network <ID-Address> <Mask>`
  - `R_Home(dhcp-config)# default-router <Gateway-Address>`
  - `R_Home(dhcp-config)# dns-server <DNS-Server-Address>`
- Assign **dynamic** IP configurations to end devices.
- Configure the *R_Home* router for **dynamic NAT** with **PAT** to translate private IP addresses to a single outside address.
  a. Assign **static** IP configuration from the *public address space* to the ports connecting the *R_Home* and *R_ISP* routers.
  b. Configure a **default route** from the *R_Home* router to the *R_ISP* router:
     - `R_Home(config)# ip route 0.0.0.0 0.0.0.0 <Next-Hop_Address>`

     Note: The `Next-Hop_Address` is the IP address of the *R_ISP* port on the link between *R_ISP* and *R_Home* routers.
  c. Create a **standard** Access Control List (**ACL**) to permit addresses from the home network to be translated:
     - `R_Home(config)# access-list <STD-ACL-NUMBER> permit <ID-Address> <WildCard-Mask>`
  d. Create a **NAT pool** with a single unused public IP address from the *209.165.X.224/29* range:
     - `R_Home(config)# ip nat pool <NAT-Pool-Name> <Start-IP-Address> <End-IP-Address> netmask <Mask>`

     Note: The `Start-IP-Address` and `End-IP-Address` are identical, corresponding to the selected public IP address.
  e. Configure **NAT** on the router:
     - `R_Home(config)# ip nat inside source list <STD-ACL-NUMBER> pool <NAT-Pool-Name> overload`
  f. Configure **inside** and **outside** NAT interfaces:
     - `R_Home(config)# interface <TYPE> <SLOT>/<PORT>`
     - `R_Home(config-if)# ip nat inside`
     - `R_Home(config)# interface <TYPE> <SLOT>/<PORT>`
     - `R_Home(config-if)# ip nat outside`
- Configure the email client on two end devices for accounts on *gmail.com*.
- Configure the email client on the other two end devices for accounts on *mail.it.birzeit.edu*.

Include the following screenshots in your project report:

- Static IP configuration for *PC_Home*.
- Dynamic IP configuration for a home network end device.
- Static IP configuration of the *R_Home* router port.
- NAT table of *R_Home* router from the command:
  - `R_Home# show ip nat translations`
- Successful Ping results between home network devices.
- Wireless network configuration for *ENCS3320Home*.
- Successful access to *www.it.birzeit.edu* from a home network end device.
- Email client configuration for *gmail.com* and *it.birzeit.edu* accounts.
- Successful sending and receiving of emails:
  - Between *gmail.com* accounts within the Home-ISP network.

- Between *it.birzeit.edu* accounts within the Home-ISP network.
- Between *gmail.com* and *it.birzeit.edu* accounts within the Home-ISP network.
- Between Gmail accounts within the Home-ISP network and the Faculty of Engineering and Technology network.
- Between Birzeit accounts within the Home-ISP network and the Faculty of Engineering and Technology network.

- Using **Simulation Mode**, analyze the sequence of DNS, SMTP, and POP3 messages when sending an email from a *gmail.com* account to an *it.birzeit.edu* account. Ensure the DNS caches are cleared before initiating the process to observe the complete message flow.
- Send an email to a chosen username and attempt to retrieve it using both email clients: one configured on the Home-ISP network and the other on the Faculty of Engineering and Technology network. Were you able to successfully retrieve the email on both devices? Explain your findings and observations.

Assign appropriate **static** IP configurations to all router interfaces on the links between the ASs. Ensure each interface and end device is correctly configured with the ***subnet mask***, ***default gateway***, and ***DNS server*** settings. Additionally, **include labels** on the topology in the .pkt file for clarity.

Routing Configuration

- Use open shortest path first (**OSPF**) for *intra-AS routing*. For **AS-200** and **AS-300**, configure the OSPF with a ***single*** area (**Area 0**). On the other hand, configure the OSPF with ***three*** areas (**Area 0**, **Area 1**, and **Area 2**) for **AS-100**.
  a. Configuring OSPF on a router:
     - `Router(config)# router ospf <Process-ID>`

     This command starts the OSPF routing process with the process number ***Process-ID***. It is recommended to use the value **1** for the process number on all routers.
  b. Adding networks to the OSPF protocol:
     - `Router(config-router)# network <ID-Address> <WildCard-Mask> area <Area-ID>`

     This command defines an interface on which OSPF runs and defines the area ID for that interface.
- Use border gateway protocol (**BGP**) for *inter-AS routing*.
  a. Configuring BGP on a router:
     - `Router(config)# router bgp <AS-Number>`

     Note: The ***AS-Number*** is the autonomous system number where the router is.
  b. Configure a neighbor relationship with a router in a separate AS (eBGP Peer):
     - `Router(config-router)# neighbor <IP-Address-Next-Interface> remote-as <AS-Of-Remote-Neighbor>`

     Note: The ***IP-Address-Next-Interface*** is the IP address of the interface on the other peer, and the ***AS-Of-Remote-Neighbor*** is the autonomous system number of the next AS.
- Perform the necessary **redistribution** between OSPF and BGP to ensure seamless connectivity across the topology.
  a. Allow OSPF to communicate with BGP:
     - `Router(config)# router ospf <Process-ID>`
     - `Router(config-router)# redistribute bgp <AS-Number> subnets`
  b. Allow BGP to communicate with OSPF:
     - `Router(config)# router bgp <AS-Number>`
     - `Router(config-router)# redistribute ospf <Process-ID>`

  Note: The ***Process-ID*** is the ID of the OSPF process running on the router, and the ***AS-***

Number is the autonomous number for the BGP configured on the same router.

To gain a clearer understanding of the network design and its operations, a recorded video will soon be available at: https://drive.google.com/drive/folders/1c1Qc_okQdNop_UHKHli83CLtnHoJv3D5. This video will detail the project tasks, guide effective design strategies, and demonstrate interactions between the various devices

D) Helpful Tutorials

- Cisco Packet Tracer download and installation:
  - https://www.youtube.com/watch?v=5dqZ623N7U4
- Access Point and DHCP configuration:
  - https://www.youtube.com/watch?v=-E4yivI26SY
- NAT configuration:
  - https://www.youtube.com/watch?v=TOJ-oksqR-M
- DHCP, DNS, and Web servers configuration:
  - https://www.youtube.com/watch?v=ZTNwwevT7S8
- DNS hierarchy:
  - https://www.youtube.com/watch?v=wpO6ftVNGHo
- Email server configuration:
  - https://www.youtube.com/watch?v=RWGw7hcNyNA
  - https://www.youtube.com/watch?v=rH01HbeWw4o
- OSPF routing configuration:
  - https://www.youtube.com/watch?v=1iJ882Xqqm0
- BGP routing configuration:
  - https://www.youtube.com/watch?v=vldkMhMrI8M

E) Grading Criteria

This project constitutes **8%** *of the total course grade*. **Table 1** outlines the detailed grading criteria. Performance on this project will be evaluated competitively, with additional points awarded for the following exceptional achievements:

- A professional and visually appealing design for the web server's index page, incorporating advanced HTML/CSS features.
- Precise calculation and documentation of IP address usage, including reserved space and provisions for future expansion.
- Accurate and efficient configuration of routing protocols (OSPF and BGP), demonstrating clear evidence of seamless connectivity across all networks.
- Detailed analysis of DNS, SMTP, and POP3 message flows, supported by packet captures or logs that explain the processes comprehensively.
- Comprehensive screenshots paired with clear, detailed explanations for each configuration step.
- Inclusion of troubleshooting procedures and resolutions for any issues encountered throughout the project.
- Thorough and insightful explanations for email retrieval success or failure across devices, backed by evidence.
- Submission of a structured, professional project report with well-organized sections, detailed diagrams, and proper labels.
- Demonstrated collaborative teamwork with clear evidence of each member's unique contributions.

To further encourage skill development and maximize effort, ***short-answer questions related to this project will be included in the final exam***. These questions will carry a weight of **4 grades** and will be considered ***bonus points*** *toward the total course grade.*

Table 1: Grading Criteria.

Use ***X*** in IP configuration: A) True B) False

Subject	Sub-Subject	Points	Remarks
Report	File name and extension	**2**	
	Cover page, numbering, table of contents, list of figures, list of tables, references, and appendices		
	Theory (NAT, DHCP, Web, Email, DNS, OSPF, BGP)		
	Subnetting		
	Results and discussion		
	Issues and limitations		
	Teamwork (Ratios and details)		
Google AS	Connect devices	**1.25**	
	Static IP configuration		
	DNS server configuration (IP, service, and RRs)		
	Email server configuration (IP, service, domain, and accounts)		
	OSPF and BGP routing		
Faculty of Engineering and Technology AS	Connect devices	**3**	
	Static and dynamic IP configuration		
	Web server configuration		
	Email server configuration (IP, service, domain, and accounts)		
	DNS server configuration (IP, service, and RRs)		
	DHCP server configuration (IP, service, pools, and IP helper command)		
	Email client configuration		
	OSPF and BGP routing		
	Testing: • Ping between Faculty network devices • Access to the website *www.it.birzeit.edu* • Sending and receiving emails between Gmail accounts, Birzeit accounts, and between Gmail and Birzeit accounts		
Home-ISP AS	Connect devices	**1.75**	
	Wireless network configuration		
	Static and dynamic IP configuration		
	DHCP server configuration		
	Dynamic NAT configuration		
	Email client configuration		
	OSPF and BGP routing		
	Testing: • NAT table • Ping between Home network devices • Access to the website *www.it.birzeit.edu* • Sending and receiving emails between Gmail accounts, Birzeit accounts, and between Gmail and Birzeit accounts		
Total Points		**8**	

GOOD LUCK

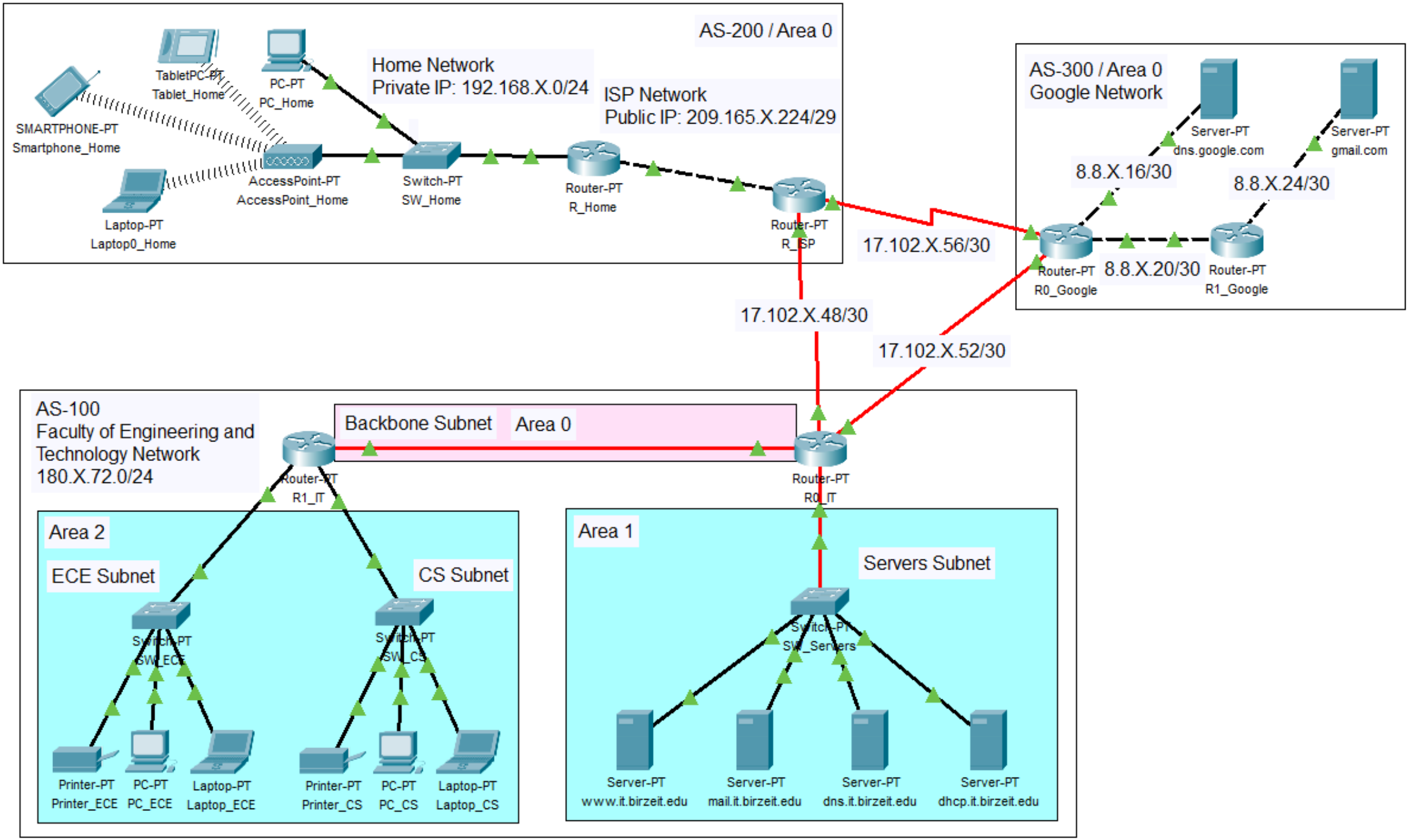

Figure 1: Network Topology.