CASE STUDY

32524 LANs and Routing

(Autumn 2023)

Due Date:

IPv4 Addressing Milestone Submission (Tables A, B and C):
By the end of Week 5 (Emailed to your Lab Instructor by 9 am Monday 27 March 2023)

Video Demonstration Submission:
By the end of Week 10 (Emailed to your Lab Instructor by 9 am Monday 8 May 2023)

1. Preamble

This Case Study presents an opportunity for students to apply their network design, implementation, and troubleshooting skills acquired from studying LANs and Routing.

The Case Study is designed to aid groups in **progressively** completing the entire project, enhancing their learning experience. The Scenario outlines the project in general terms, including the reason for building the network. The Case Study comprises several tasks, each with detailed requirements that guide your group through multiple steps. It is crucial to read and comprehend each requirement and complete the tasks weekly to make progress in your studies.

2. Objectives and General Assessment Criteria

Objectives

- Design IPv4 addressing schemes that meet the addressing requirements.
- Configure OSPFv2, including simple route redistribution, for IPv4.
- Configure static, default static, summary static routing, and floating static routing for IPv4.
- Configure switching networks for management, VLANs, 802.1q trunking, and inter-VLAN routing.
- Configure static NAT and dynamic NAT with overloading.
- Verify the network's functionality and troubleshoot it as needed.

General Assessment Criteria

- Requirements met.
- Correctness of the design.
- Functionality of implementation.
- Justification of design and implementation.
- Verification of functionality.

3. Assessment

The case study is intended to be completed as a group activity, and its assessment consists of two parts:

1.1 Part A: IPv4 Addressing Milestone Submission (25%; due by the end of Week 5)

Each team is required to submit their IPv4 subnetting and addressing scheme, including Tables A, B, and C on Page 10 of the book, to the lab instructor via Email by the end of Week 5. Feedback on this milestone will be provided during the following week's lab class.

1.2 Part B: Packet Tracer Video Demonstration Submission (75%; due by Week 10):

By the end of Week 10, students as groups must submit a recorded video demonstrating each member's oral presentation of their Packet Tracer (PT) network, explaining how each part of their network was designed and implemented to meet the specified requirements. Additionally, the group must submit a copy of the completed PT file for reference.

For further information about the demonstration, please refer to Section 7 on Page 9 of this Case Study book.

4. Suggestions and General Requirements for Case Study Completion

It is anticipated that each student will need approximately 6 hours to complete this Case Study.

Groups are advised to plan and complete the Case Study on a weekly basis, aligning with the relevant topics covered in class, as suggested below. This approach ensures that all tasks are completed thoroughly and students receive maximum benefit.

Week 5: **complete Task One – IPv4 Subnetting (IPv4 Addressing due by Week 5)**
Week 7: **complete Task Two – Static and OSPF Routing**
Week 8: **complete Task Three – Switching**
Week 10: **PT Video Demonstration (Part B submission due by Week 10)**

Delaying the Case Study until the final week or day(s) may result in a poorly designed network and limited benefit to your final assessments. Therefore, we strongly recommend following the suggested weekly plan to ensure a successful outcome.

5. Scenario

The purpose of this Case Study is to present a scenario where the Arcadia Institute of Technology (AIT), a training organisation, has acquired and relocated to a new training centre in the heart of the city, prompting the need for a complete network redesign and implementation. Your group has been hired as AIT's ICT consultants to undertake this task, with the objective of developing and implementing a new network that will be evaluated by a prototype network demonstration using Packet Tracer.

AIT's campus network is composed of various networks, as depicted in the partial logical Topology Diagram provided in Figure 1. You are required to design and implement these networks, including a simulated ISP, using the interfaces/ports of your choice. AIT expects to see a prototype of the network prior to its full implementation, to ensure that it meets their requirements.

To help your group organise the Case Study, it has been broken down into four tasks, with specific requirements provided for each task. Upon completion of all tasks, a prototype of the network is expected to be implemented using Packet Tracer, and its functionality will be demonstrated.

As shown in Fig. 1, AIT for which you are to design a network, has networks distributed on the City Campus in four buildings, i.e., *West*, North, East, and *South Towers*, where the South Tower connects to the East Tower using an additional leased line serial connection.

- The **West, North and South Tower** site is mainly for the AIT Teaching and Learning division. All user groups will each have users located in each of the three buildings, *i.e.*, **Thomas, Jones** and **Harry**. Because of the size and complexity of LANs, the company wants to create ***VLANs*** to control broadcasts, enhance security and logically organise user groups.
- To avoid single-point failure and allow certain levels of redundancy, users in the switching network have three exit points, i.e., via West (Primary), North and South Tower, respectively.
- Furthermore, AIT's internal network has **two exit links** for accessing the Internet and external services: one via **West** and the other via **East**. The link from West is the **primary** path and the backup path through the East will only become used when the primary West-ISP link becomes unavailable.

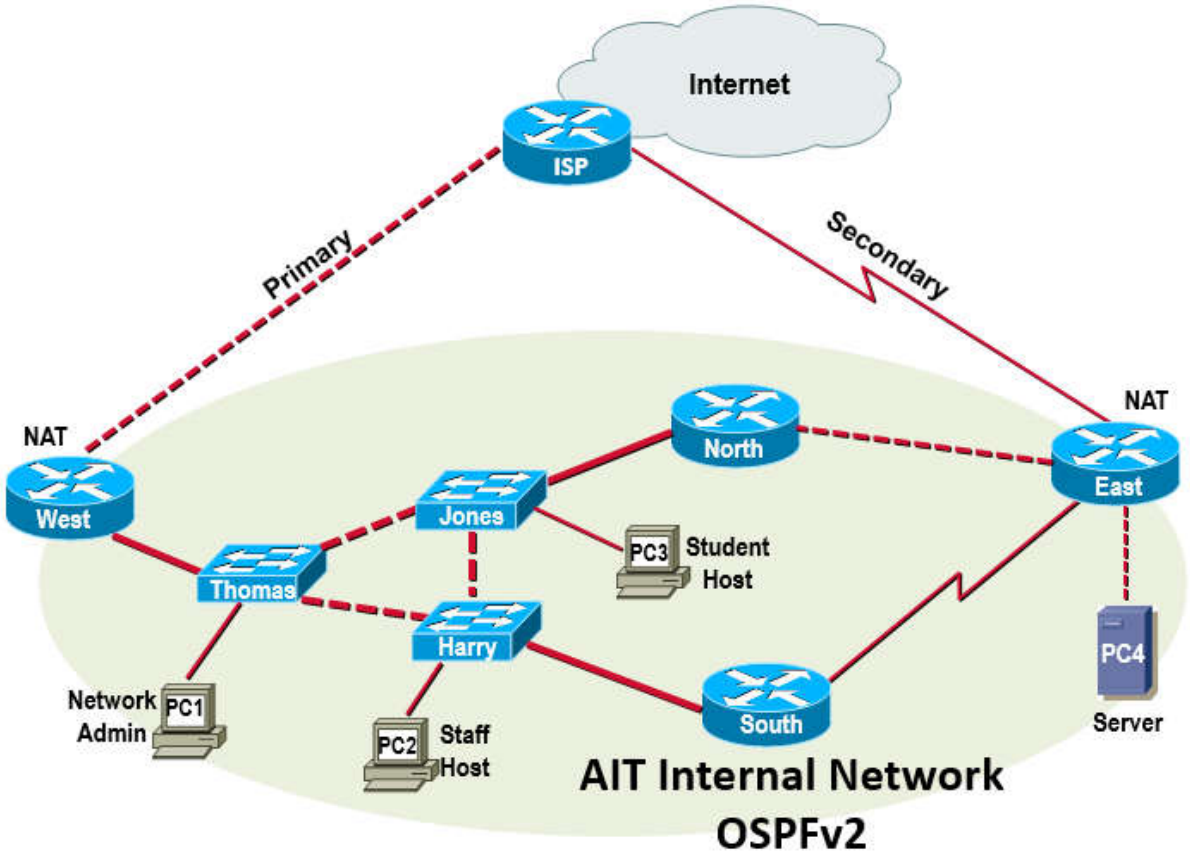

Fig. 1. Basic network topology

AIT has agreed to use **OSPF** for its internal networks. At this stage, only IPv4 is considered. AIT also wants to use private IPv4 addresses for the entire internal network and appreciates efficiency and address conservation in their design. NAT for IPv4 will also be implemented on both border routers.

6. Requirements in Tasks

In order to help your group organise this Case Study, the scenario has been broken into **four tasks** and detailed requirements are listed for each task. A prototype of the network is expected to be implemented using Packet Tracer to demonstrate its functionality when all tasks are completed.

Task One: Addressing the Network

The ISP links:

The ISP has allocated **one of the following public IPv4 address spaces for your group**, which will need to be broken into two /30 address spaces for each of the two ISP links:

- Group A/1: **209.165.200.200/29**
- Group B/2: **209.165.200.208/29**
- Group C/3: **209.165. 200.216/29**
- Group D/4: **209.165. 200.224/29**
- Group E/5: **209.165. 200.232/29**
- Group F/6: **209.165. 200.240/29**

The Internal Network:

As part of the network redesign, the AIT has allocated **one of the following private address spaces for your group** for addressing the internal network:

- Group A/1: **10.0.16.0/21**
- Group B/2: **10.0.24.0/21**
- Group C/3: **10.0.32.0/21**
- Group D/4: **10.0.40.0/21**
- Group E/5: **10.0.48.0/21**
- Group F/6: **10.0.56.0/21**

The expected numbers of users for each of the user groups are:

For the switching network (implemented using *VLANs*; see Task 3):

- 500 hosts for Students
- 80 hosts for Staff
- 200 hosts for Visitors

The AIT requires that:

- ☐ The use of **VLSM** design to maximise the use of IPv4 addresses.
- ☐ **All networking devices (including switch SVIs) must have IPv4 addresses** and the PC hosts' **gateways** will use the **first** usable address(es) in each subnet.
- ☐ Each of the ISP links will be allocated a **subnet mask of /30** for IPv4**.**
- ☐ The **Management VLAN** for the switching network will have **three extra hosts** (one of which is referred to as the "Network Admin Host" as shown in the Topology Diagram) for network administration usage.

At this stage, AIT agrees that it is sufficient to assign all hosts with an IPv4 address statically.

Milestone Submission: Tables A, B and C

1) IPv4 Network subnetting **Table A**, which shows possible subnets that meet the design requirements; Subnets that are not used are to be clearly identified in each table ('not in use').
2) Detailed IPv4 addressing tables (**Tables B and C**) showing all networking devices' names and their interface details. Note that, the gateways of the VLANS on West will be implemented as *sub-interfaces*, e.g., Fa0/0.10 as the gateway of VLAN10.

Discussion Questions: Consider how you do subnetting so as to meet each of the requirements.

Task Two: Routing the Network

Routing to and from ISP

The AIT network has purchased **two ISP links** to access the Internet and external services, *i.e.*, via the **West** and **East** respectively. AIT's policy requires that the backup ISP link via East is only used when the primary West-ISP link becomes unavailable.

Since the ISP also serves many other customers, routing to and from ISP will use static routing only, and a standard static route should be used on ISP to forward traffic to the AIT internal network only when needed.

When correctly implemented, all hosts within the AIT network must be able to reach *all* external addresses, via the West-ISP link, or the East-ISP link when the West-ISP link is unavailable, in both directions.

Note that, for the demonstration purpose, use the loopback address, i.e., **1.1.1.1/32**, on ISP to simulate the Internet. Also, NAT at both border routers will be considered at a later stage.

Routing the Internal Network

- AIT's policy is that OSPFv2 routing will be used internally for its IPv4 networks.

Your design and implementation of static routing should be in a most efficient manner.

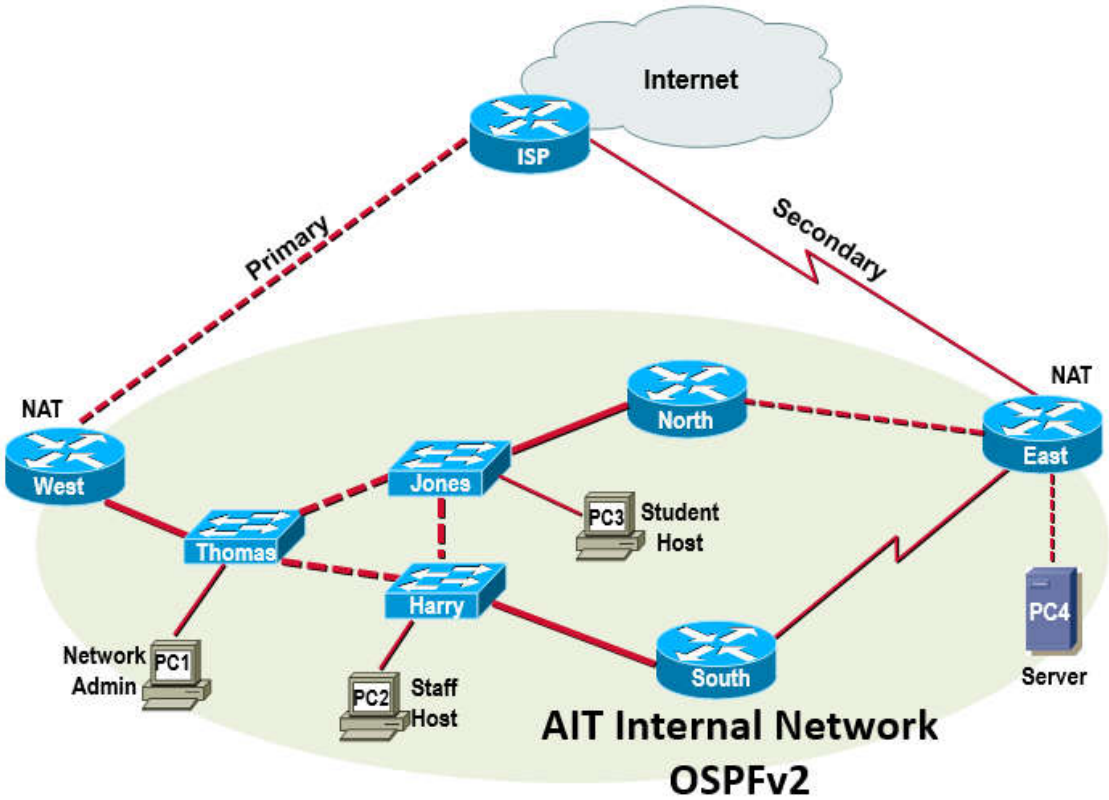

Fig. 2. Routing the network dynamically and statically

Discussion Questions:

Consider how you **implement** and **verify** the following functions:

1) OSPF routing for the internal networks.
2) Static routing and failover routing via the two ISP links.

Task Three: Switching Network at the City Campus

Because of the size and complexity of LANs at the **City Campus**, AIT wants to use **VLAN** technologies to control broadcasts, enhance security and logically organise its user groups. 802.1Q trunk-based Inter-VLAN routing is to be implemented to advertise all VLAN networks.

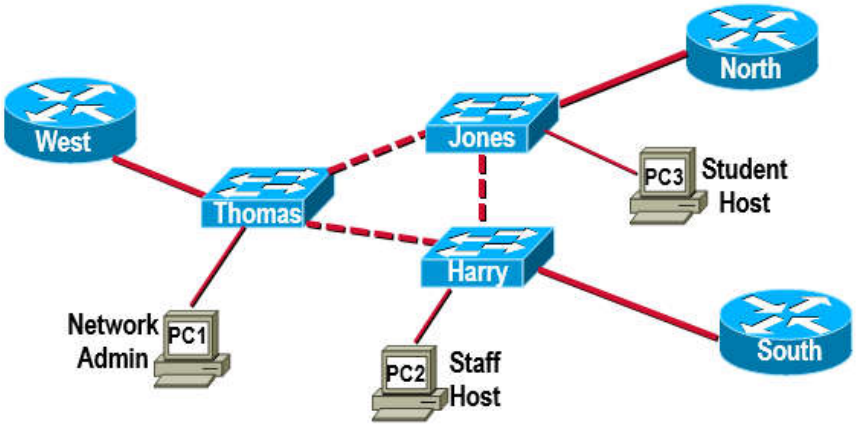

Fig. 3. The switching networks.

The switching networks at the West tower:

- Create VLANs with the following VLAN IDs and Names for the required networks:
  - VLAN 10 – Students
  - VLAN 20 – Visitors
  - VLAN 30 – Staff
- All user groups will each have employees located in the three adjoining buildings, i.e., connected via **Thomas**, **Jones and Harry** switches, respectively. For the purpose of demonstrating network functionality, allocate **five** ports to each user VLAN on each switch.
- Create **VLAN 99** as the Management VLAN and allocate **one** port to this VLAN on each switch. Use VLAN **555** as the native VLAN ID.
- Do NOT allow traffic of the default VLAN 1 and unknown VLANs onto the trunk link(s).

Discussion Questions:

Explain, in detail, how you **implement** (e.g., show the corresponding commands used from the device's running-configure outputs) and **use specific tools/commands to verify** the following functions:

1) Creating VLANs and assigning ports.
2) SVI configuration and verification.
3) Inter-VLAN routing configuration and verification.

Task Four: IP Addressing Services

The Company has been allocated one of the following small blocks of public IPv4 addresses for the IPv4 NAT pool. For the Internet connectivity, private IPv4 addresses with **overloaded NAT** are to be used for addressing the internal network.

- Group A/1: **209.165.202.88/29**
- Group B/2: **209.165.202.96/29**
- Group C/3: **209.165.202.104/29**
- Group D/4: **209.165.202.112/29**
- Group E/5: **209.165.202.120/29**
- Group F/6: **209.165.202.128/29**

Requirements on NAT for IPv4:

- ☐ All devices and only these devices in the internal network are expected to have Internet connectivity using the available addresses from the public address pool with overloading.
- ☐ For demonstration purposes, define a **static NAT** for the **Serve host** (PC4) using an available address from the pool(s).
- ☐ Adjust the static routing configuration on the ISP so that returning traffic from the Internet and external services can return to the internal network.

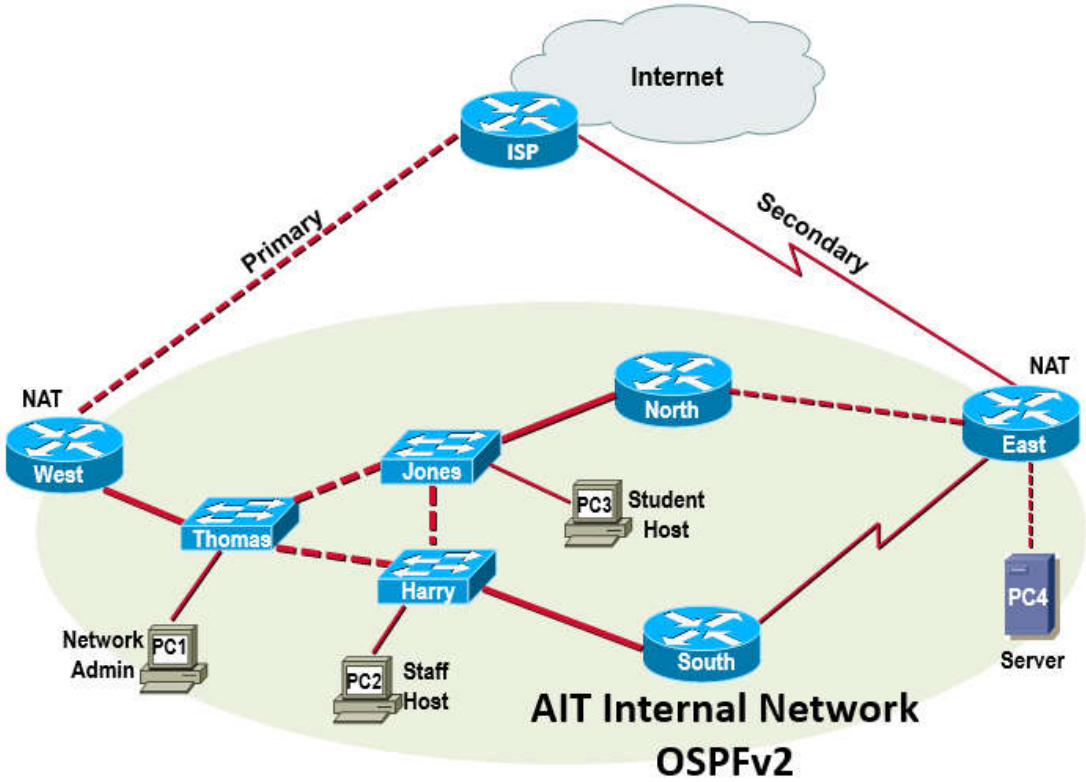

Fig. 4. IP Addressing Services

Discussion Questions:

1) **Show the details of your design**, such as NAT pools for IPv4, and **partial configuration scripts specific to this task** that help to justify your solution.
2) **Explain how the static routing over the two ISP links has changed with the implementation of NAT.**
3) **Discuss how you verify** that the functionality of your design meets all requirements.

7. Packet Tracer Video Demonstration

The Company now wants a demonstration of the prototype network. To do this, you need to set up the network that you have designed and configure devices in Packet Tracer to demonstrate all the required functions.

The demonstration requires **basic settings on all routers and switches** including hostname, passwords, MOTD banner, management address and **SSH** access, detailed as follows:

- ☐ Configure basic device settings for routers and switches:
  - Configure **hostnames** as per the partial Topology Diagram.
  - Configure password **`cisco`** for console connections.
  - Encrypt the privileged EXEC mode using the password **`class`**.
  - Disable Domain Name Server **(DNS) lookup**.
  - Enable **logging synchronous** for console connections and all virtual terminal lines.
- ☐ Configure the interfaces of routers and hosts as per the Topology Diagram and your Addressing Tables B&C.
- ☐ Configure static and OSPF routing on all routers according to the requirement and your design.
- ☐ Configure VLANs according to your Switch and VLAN tables.
- ☐ Configure the Management VLAN SVI interface on the switches.
- ☐ Configure the following host PCs based on your addressing:
  - **PC1** as the Network Admin Host on Management VLAN on the **Thomas** switch.
  - **PC2** as the Staff Host on the **Harry** switch.
  - **PC3** as the Visitor on the **Jones** switch.
  - **PC4** as the Server on the **East** router.

  PS. The Company has a plan to implement DHCPv4 service and use ACLs to control network traffic. At this stage, statically assigning IPv4 addresses is sufficient for the demonstration purpose.

The Company requires the following network verification to be assessed:

- Verification of the devices' basic configuration.
- Verification of the correctness and functionality of the interface configuration.
- Verification of dynamic routing for IPv4.
- Verification of static routing for IPv4.
- Verification of the VLANs and inter-VLAN routing.
- Verification of NAT (including Overloaded NAT and static NAT).
- Verifying end-to-end connectivity of all hosts to each other and the ISP's loopback addresses.
- Verification of the redundant links.

Discussion Questions:

1) **Discuss how to verify each of the above functions (the commands, expected outcomes, and explanation on the device outputs)**.

Sample Partial Tables:

Table A - IPv4 Subnetting Table

Subnet Number*	Subnet Address	Subnet Mask	Hosts Required	Maximum Hosts in Subnet	In Use (Yes or No)	Network Name

*"Subnet Number" is the index (starting from 0) of the subnet as the result of subnetting.

Table B Device Interface IP Addressing Table

Device	Interface	IPv4 address	Subnet Mask
ISP	Fa0/0		
	Se0/0/0		
West			
…			
Thomas	SVI		
…			

Table C Host Addressing Table

Host	IPv4 Address	Subnet Mask	Gateway
PC1			
PC2			
PC3			
PC4			

Table D Switch Table

Switch Name: Switch Management IP Address:

Interface type & Port Number	Description of Purpose	Port Bandwidth	Network Name	Subnet Address	Subnet Mask	VLAN ID & Name	Switch Port Mode	Layer 2 Encapsulation

Table E VLAN Table

Switch Name	Number of Ports	Location	IP Address	Gateway	VLAN ID & Name