REDES DE INTERNET (RI) 2025-2026

LAB Project Nº 1 - VLAN/STP/OSPF MONO-AREA

CONTENTS

1. INTRODUCTION

This project familiarizes students with VLAN segmentation, L2 loop protection (STP/RSTP), inter-VLAN routing (router-on-a-stick), static routing, and single-area OSPF. The report must answer all questions and include configuration examples necessary to understand the adopted approach. A final discussion will be scheduled by the professor.

2. PROJECT REPORT STRUCTURE AND GRADING

Organize your report in sections according to the five main tasks of this lab, which are summarized next:

1. Enterprise A — L2 Foundations (VLAN/STP/RSTP)
2. Enterprise A — VLAN Segmentation & Addressing
3. Enterprise A — Router-on-a-Stick (RoS) & L3 Rules (no ACLs)
4. Enterprise B — Segmentation & ISP L2 Interconnection
5. Static Routing → OSPF Core & "Internet" Loopback → Public Addressing Test

Each section will have a relative weight in the final grading of **30%, 20%, 15%, 20%, 15%** respectively. In each section, follow the assigned tasks, answer the questions, and present results clearly and consistently.

Key report delivery requisites:

- Include an Introduction and Conclusions section
- Include an Index for the report sections
- Provide comprehensive answers to all practical questions
- Ensure clear justifications for each answer, with well-documented reasoning
- Include configuration snapshots, when relevant, to support your responses

The **maximum number of pages in the delivered report is 40**, which includes indexes, introduction, and conclusion. Ensure every group member participates in completing the required tasks and submit your group lab report on Moodle, check the deadlines!

Note: Plagiarism or copying configurations from other students will result in a zero grade for the project.

3. LAB ENVIRONMENT SETUP

This section presents the guidelines for the lab project execution, including the presentation of the lab software to be used and the experimental topology proposed.

3.1. SIMULATION SOFTWARE

This lab utilizes the following environment:

- Cisco Packet Tracer
- Devices: Cisco switches/routers
- Connections: Ethernet interfaces between switches/routers
- Host Machines: PCs connected to specific switches for connectivity testing

3.2. NETWORK TOPOLOGY OVERVIEW

Figure 1 presents the proposed lab topology, which includes two enterprises and an ISP. Students are expected to implement this topology step by step, with the complexity gradually increasing at each stage.

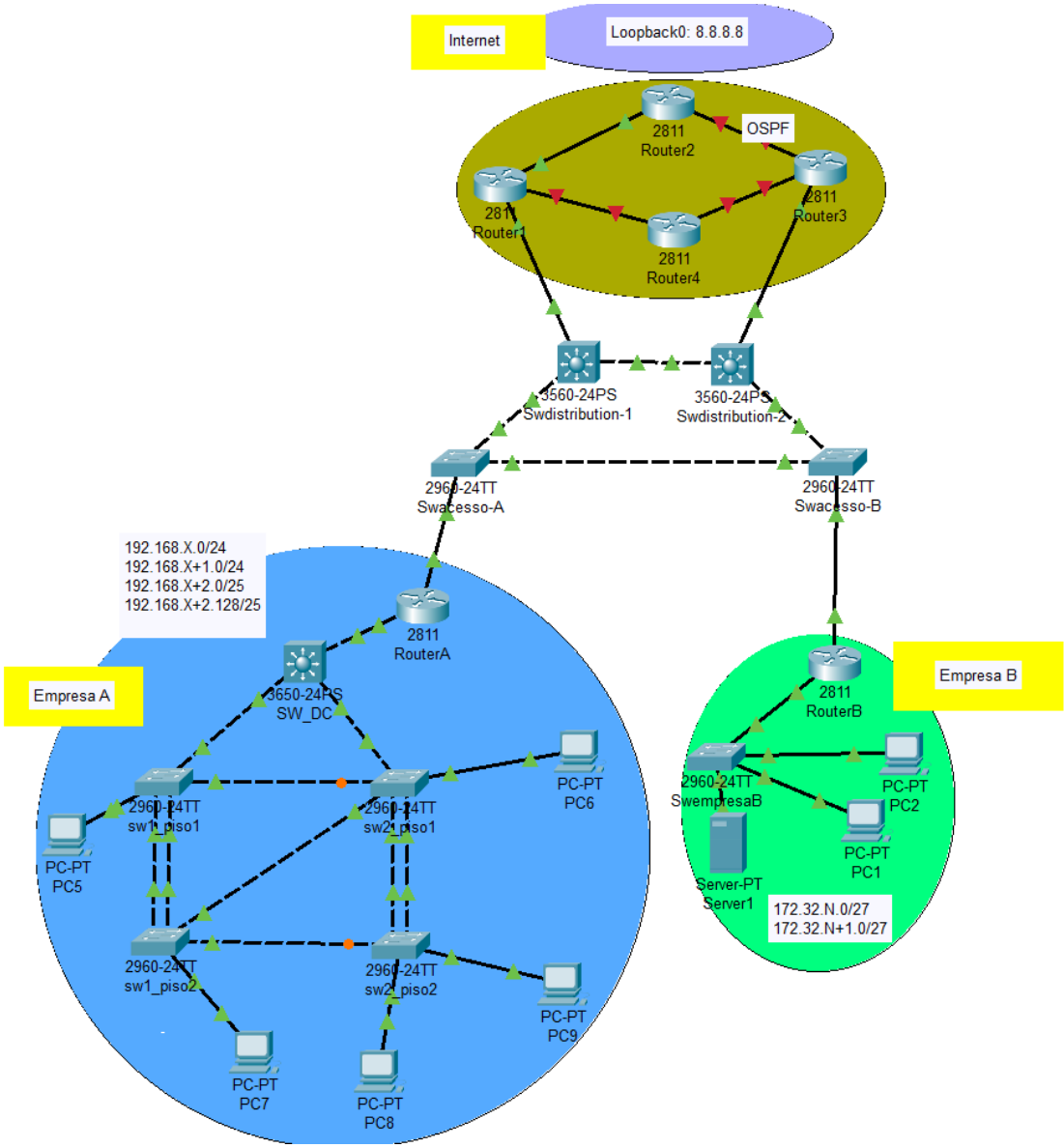

FIGURE 1 - NETWORK TOPOLOGY DIAGRAM

Note: The state of the *links* in the figure is just an example. Its implementation may be different depending on the configuration made and the characteristics of the equipment involved.

ISP context:

- ISP provides **NDD** (demarcation) at each company.
- Distinct IPv4 blocks per company; **/30** P2P links toward each customer router.
- ISP core uses **single-area OSPF**; **R2/Loopback0** simulates Internet.
- Aim for **maximum redundancy** without adding devices or harming efficiency.

3.3. LAB CONFIGURATION GUIDELINES

Next, the main guidelines for the project implementation will be provided, starting with general principles and then transitioning to specific instructions that should be observed while configuring the Interior Gateway Protocol (IGP) and the Exterior Gateway Protocol (EGP).

General

- Save often: write memory; VPCS: save
- Use hostname, interface description, and a **login banner**
- Validate with show ip interface brief, show arp, show mac-address-table, ping, traceroute
- Disable **DTP** on all access/trunk ports you configure

IP & L2/L3

- Company A starts with L2 (VLANs + STP/RSTP), then inter-VLAN and L3
- Company B uses VLANs and addressing as specified
- ISP uses VLAN 90/95 and /30 P2P to customers; prune trunks to required VLANs
- Static routing first (forwarding section), then OSPF in ISP core (single area)

4. EXPERIMENTAL WORK

This section includes five subsections; each associated to an experimental work phase, each including practical questions that must be thoroughly addressed in the project report.

4.1. PHASE 1 - ENTERPRISE A: L2 FOUNDATIONS (VLAN + STP/RSTP)

4.1.1. OBJECTIVES

- Implement Company A's L2 topology.
- Configure static VLANs (access ports explicitly assigned).
- Run STP, identify RB and port roles; enable Rapid PVST (Per-VLAN RSTP).

4.1.2. IMPLEMENTATION

1. Build the Company A's L2 topology using the provided PT file (assume "add" → **active**).
2. Create required VLANs; assign **access** ports to VLANs; configure **trunks** where needed; **disable DTP** on non-dynamic ports.
3. Enable STP (default) and record RB/roles/costs.
4. Convert to **Rapid PVST**; verify per-VLAN instances and changes in roles/timers.

4.1.3. TEST AND VALIDATION

1. Determine the root bridge (RB), designated/blocked ports, and **path costs** (check PT's cost model)
2. Force **SW_DC** as the RB (lower priority) and reassess blocked links
3. With dual links between sw1_piso1 and sw1_piso2, modify settings so the previously blocked link forwards and the other blocks (justify)

4. Confirm stability and loop-free forwarding
5. SAVE YOUR PROGRESS
    - Save all router configurations: `write memory` on each router
    - Save this project phase as TP1_RI_25_26_GROUP<ID>_phase1

4.1.4. PRACTICAL QUESTIONS

1. What is the purpose of this command - "no ip domain-lookup"?
2. What default VLANs exist before any VLAN is configured on any equipment?
3. What is the format of the tags introduced in Ethernet frames in trunk connections?
4. Why is it that on a LAN that uses VLANs, on an Access-type connection the frames do not include tags?
5. What is the tag that the wefts belonging to VLAN 1 carry?
6. When a machine receives an Ethernet frame, how does it differ if it includes the Type/Length field after the source address field or if it includes the fields associated with a VLAN?
7. What are the possible consequences of passing the timers "Max Age"=20 sec and "Forward Delay"= 15 sec to half of these values?
8. What is the Root Bridge (RB)? Justify.
9. By default, what is the type of active Spanning-Tree (STP) [hint: use sh span]?
10. How many spanning trees are there in the implemented topology?
11. For company A, build the table for calculating the cost of the paths and determining which are the Root, Designated and Blocking ports and calculate the respective values (check in the PT which cost values are used in the calculations of the spanning trees). Are the final results you arrived at consistent with those that the PT simulator presents?
12. What is the cost of the shortest path to Router A since PC9?

4.2. PHASE 2 - ENTERPRISE A: VLAN SEGMENTATION & ADDRESSING

4.2.1. OBJECTIVES

Segment Company A using the information provided in the table below.

Vlan No.	Name	IP Gateway	Network	Pcs
N_Grupo*10+1	Accounting	*Last Helpful*	172.20.**X**.0/24	PC7,PC9
N_Grupo*10+2	Secretariat	*Last Helpful*	172. 20.**X**+1.0/24	PC5,PC8
N_Grupo*10+3	Computer science	*Last Helpful*	172. 20.**X**+2.0/25	PC6

- "**N_Grupo**" represents the number of your group and the **X** is the VLAN number taken from the first column of the table row.
- *n* is the number of students in the group in question.

4.2.2. IMPLEMENTATION

1. Configure the VLANs as per the previous table requirements.
2. Configure access and trunk ports (disable DTP on all configured ports).
3. Assign IPs to PCs per subnets.

4.2.3. TEST AND VALIDATION

1. Verify intra-VLAN and inter-VLAN connectivity.
2. Check if there is connectivity between the PCs on each VLAN. Use show vlan brief, show interfaces trunk, selected ping tests inside each VLAN.
3. Confirm gateway plan and document addressing decisions
4. SAVE YOUR PROGRESS
   - Save all router configurations: `write memory` on each router
   - Save this project phase as TP1_RI_25_26_GROUP<ID>_phase2

4.2.4. PRACTICAL QUESTIONS

1. Briefly justify the VLAN design choices (IDs, access vs trunk mapping).
2. Explain what actions were required to accommodate the topology requirements.
3. Did you achieve inter vlan connectivity in this phase? Explain the observed behavior.

4.3. PHASE 3 - ENTERPRISE A: ROUTER-ON-A-STICK (NO ACLs)

4.3.1. OBJECTIVES

- From the Accounting and Secretariat networks, they must not communicate with any other internal or external network/VLAN.
- From the IT network, it must be possible to communicate with the VLAN of the secretariat and outside Company A.
- The equipment in the VLAN Network Management of Company A must be able to communicate with each other (Note: All support equipment in the company network must be accessible from PC6 to be able to perform remote management).

4.3.2. IMPLEMENTATION

1. Create and configure sub interfaces to implement the L3 (rules without ACLs):
    - Accounting & Secretariat: no access to any other internal or external VLAN/network
    - IT: access to Secretariat and outside Company A
    - Net-Management: mutual access (all support equipment must be reachable from PC6 for remote management)
2. Create a trunk link between Router A and SW_DC
3. Create sub interfaces with encapsulation dot1Q and IPs (parent interface no IP)

```
interface Fa0/1
 description Link to SW_DC G1/0/5
 no shutdown
!
interface Fa0/1.10
 description VLAN <ID>
 encapsulation dot1Q <ID>
 ip address <ip> <mask>
! (repeat for each VLAN)
```

4. Name *routers/switches* with the `hostname command`:

```
Router(config)# hostname RouterN
RouterN(config)#
```

5. Set up an initial message for those who enter the machine:

```
RouterN (config)# banner login ^C
---                     Router N                      ---
---  ------------------------------------------------  ---
---       UNAUTHORISED ACCESS IS PROHIBITED           ---
--- Entries not authorized by lei ---
--- (Law 109/2009 of 15 September) ---
^C
```

4.3.3. TEST AND VALIDATION

1. Validate the L3 policy outcomes strictly match the rules defined above.
2. Use `show ip interface brief`, `show ip route`, `ping`, `traceroute`
3. Fault isolation: if each PC reaches its GW but inter-VLAN fails, inspect RouterA
3. SAVE YOUR PROGRESS
   - Save all router configurations: `write memory` on each router
   - Save this project phase as TP1_RI_25_26_GROUP<ID>_phase3

4.3.4. PRACTICAL QUESTIONS

1. Explain the advantages and disadvantages of the Router-on-a-stick functionality.
2. Explain how you enforced the three communication rules **without ACLs**
3. Provide short command outputs proving each rule is satisfied/blocked as required

4.4. PHASE 4 - ENTERPRISE B & ISP L2 INTERCONNECTION

4.4.1. OBJECTIVES

- Implement **Company B** VLANs and addressing.
- Build ISP L2 paths (VLANs **90** and **95**) and redundancy across the topology.
- Prune trunks to required VLANs; set per-VLAN STP roles

4.4.2. IMPLEMENTATION

1. Implement the **Company B** VLANs and addressing knowing that the ISP has provided it with two IPv4/24 address block networks, but that for the purposes of address rationing Company B internally uses only the first /27 of each block, where N represents the group number.

Vlan No.	Name	IP Gateway	Network	PCs
2	Servers	192.168.**N**.30	192.168.**N**.0/27	Server1
3	Engineering	192.168.**N+1**.30	192.168.**N+1**.0/27	PC1, PC2

2. Implement the ISP topology of interconnection with customers, where the ISP uses two /30 (P2P layer3) networks to interconnect its routers and that of each company. The networks and their VLANs are:
   - Vlan 90 (Company A) -> 10.20.**N**.0/30
   - Vlan 95 (Company B) -> 10.20.**N**.4/30
3. Build the VLAN paths in the switch fabric (configuring the trunk or access interfaces when necessary), knowing that for the purpose of layer 2 redundancy, the ISP has built a circuit between the two companies, so it is to be used if necessary.

Note: In the event of equipment failure, it should be possible to maintain the service even if there are sections that have greater traffic. In the IP address, "N" corresponds to the group number.

4. Assign the IP address to Router 1, Router 3, Router A, and Router B, knowing that *routers* on the ISP side always have the first available IP addresses on their networks.

4.4.3. TEST AND VALIDATION

1. Verify end-to-end L3 connectivity: R1 ↔ RA, R3 ↔ RB
2. SAVE YOUR PROGRESS:
   - Save all router configurations: `write memory` on each router
   - Save this project phase as TP1_RI_25_26_GROUP<ID>_phase4

4.4.4. PRACTICAL QUESTIONS

1. Count STP trees; list blocked ports in VLANs 90 and 95 and justify.
2. State the advantage/goal of trunk pruning in the ISP fabric.
3. Explain the chosen RB priorities and observed blocked ports.

4.5. PHASE 5 - FORWARDING: STATIC → OSPF CORE → PUBLIC ADDRESSING

4.5.1. OBJECTIVES

1. Establish **static routing** for initial forwarding
2. Migrate to **single-area OSPF** in the ISP core (global connectivity)
3. Simulate "Internet" as **R2/Loopback0 = 8.8.8.8/32**
4. Replace private simulations with **public addressing** test (end-to-end pings)

4.5.2. IMPLEMENTATION

Static routing (initial)

1. Default static routes on company routers toward the ISP; identify **next-hop** and purpose.
2. On **R1–R4**, add required static routes to reach company blocks.
3. Verify which pings succeed **before** OSPF and explain why.

OSPF (ISP core)

4. Configure **OSPF** on R1–R4 (single area) per design; withdraw static routes as directed once OSPF is stable
5. Configure **R2 Loopback0 = 8.8.8.8/32** (Internet simulation)
6. Demonstrate global connectivity with redundancy

Public addressing test

7. Change configs so each company and the operator use **public IPs** (internal private may remain). Test pings across networks.

4.5.3. TESTING AND VALIDATION

1. Use show ip route, show ip ospf neighbor, show ip ospf interface brief.
2. Check ping/traceroute from company PCs to ISP and to 8.8.8.8
3. Compare reachability before/after OSPF
4. SAVE YOUR PROGRESS:
   - Save all router configurations: `write memory` on each router
   - Save this project phase as TP1_RI_25_26_GROUP<ID>_phase5

4.5.4. PRACTICAL QUESTIONS

1. Can corporate PCs ping the ISP router **before** OSPF? Justify.
2. What is the **next-hop** of your default routes and why?
3. Describe the purpose of static routes on R1–R4 and what changes once OSPF runs.
4. After enabling OSPF, explain the path selection you observe towards **8.8.8.8**.