

# Computer Network Project

Master's in Computer Engineering - Cybersecurity and Systems  
Administration  
Computer Networks (RECOMP)

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DE ENGENHARIA DO PORTO

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# Acronyms

**WAN** Wide Area Network

**HQ** Headquarters

**VLAN** Virtual Local Area Network

**HSRP** Hot Standby Router Protocol

**STP** Spanning Tree Protocol

**RSTP** Rapid Spanning Tree Protocol

**DHCP** Dynamic Host Configuration Protocol

**RECOMP** Redes de Computadores

**VTP** VLAN Trunking Protocol

**IP** Internet Protocol

**SVI** Switched Virtual Interface

# Chapter 1

## Introduction

This report documents the work completed during Sprint 1 of the Redes de Computadores (RECOMP) Project, which focuses on the initial configuration and verification of the RECOMP Corporation WAN. The network spans four geographically distributed sites: Oporto (Headquarters (HQ)), Warsaw, Munich, and a secure location known as The Vault, all interconnected via the Internet. The initial project state was provided through the packet trace file `Proj1-start.pkt`.

During Sprint 1, the team carried out the following key activities:

- Completed the startup configuration of all routers and switches, ensuring connectivity to the Service Provider network and testing access to external sites such as `www.google.com`.
- Designed and implemented IP addressing schemes for each site based on the allocated address blocks:
  - Oporto: 10.21.44.0/22
  - Warsaw: 192.168.162.0/23
  - Munich: 172.18.78.0/23
  - The Vault: 10.31.81.0/24
- Configured VLANs, including link aggregation, trunking, and the VTP domain across all multilayer and Layer 2 switches.
- Implemented RSTP and configured HSRP for redundancy and high availability.
- Configured Dynamic Host Configuration Protocol (DHCP) servers for all VLANs, ensuring that host devices could obtain IP addresses automatically.
- Verified internal connectivity at each site to confirm that all PCs and network devices were correctly configured.

The hardware and network topology at each location were as follows:

- **Oporto (HQ):** 1 × 2911 router, 2 × 3560-24PS multilayer switches, 2 × 2960-24TT Layer 2 switches, and 4 PCs for STAFF, ACCOUNTING, HR, and USERS networks.

- **Warsaw (BR1):**  $1 \times$  2901 router,  $3 \times$  3560-24PS multilayer switches,  $4 \times$  2960-24TT Layer 2 switches, and 4 PCs per VLAN.
- **Munich (BR2):**  $2 \times$  2911 routers,  $4 \times$  2960-24TT Layer 2 switches, and 4 PCs for various networks.
- **The Vault:**  $1 \times$  2911 router and  $1 \times$  2960-24TT Layer 2 switch.

The work was distributed among the team as follows:

- João Paulo Araujo (1250525@isep.ipp.pt) — Munich WAN
- João Silva (1200813@isep.ipp.pt) — Warsaw WAN
- Manuela Leite (1200720@isep.ipp.pt) — Oporto WAN

This report details the implementation steps, configuration settings, and verification results achieved during Sprint 1, providing the foundation for subsequent sprints in the RECOMP Project.



# Chapter 2

## Oporto WAN

### 2.1 Site Overview

Oporto is the location of the headquarters of the RECOMP Corporation and represents the most complex part of the WAN. The site consists of the following devices:

- One Router HQ (2911 model)
- Two Multilayer Switches MLS1 and MLS2 (3560-24PS model)
- Two Layer 2 switches (2960-24TT model)
- Four PCs representing each of the HQ networks: STAFF, ACCOUNTING, HR and USERS

The topology of the Oporto WAN is illustrated in Figure 2.1, showing the connection between the router, multilayer switches, Layer 2 switches, and VLANs for each network.

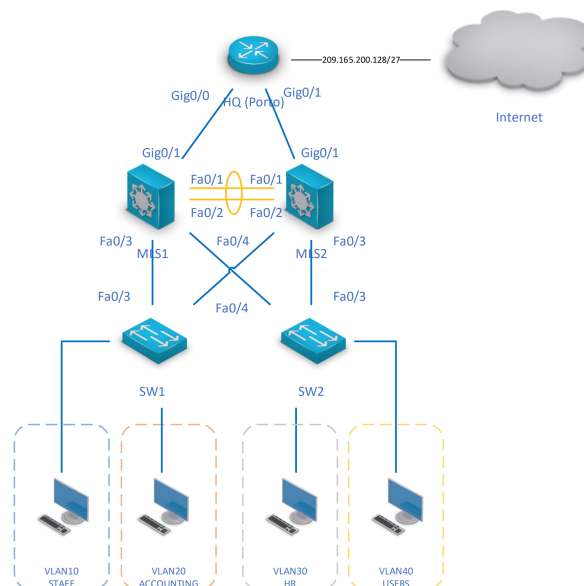


Figure 2.1: Oporto WAN Topology<sup>1</sup>

The VLANs assigned to the HQ networks are:

- VLAN 10: STAFF
- VLAN 20: ACCOUNTING
- VLAN 30: HR
- VLAN 40: USERS

The Oporto WAN is connected to the Internet using the address block 209.165.200.128/27.

## 2.2 Oporto WAN Addressing

The IP addressing scheme for the Oporto site was designed to accommodate the four internal networks while optimizing the available address space. The networks and their corresponding addresses are summarized in Table 2.1.

| Network          | Number of Nodes | Network Address | Broadcast Address | Mask | First-Last Valid Address    |
|------------------|-----------------|-----------------|-------------------|------|-----------------------------|
| USERS            | 500             | 10.21.44.0      | 10.21.45.255      | /23  | 10.21.44.1 – 10.21.45.254   |
| ACCOUNTING       | 200             | 10.21.46.0      | 10.21.46.255      | /24  | 10.21.46.1 – 10.21.46.254   |
| HR               | 100             | 10.21.47.0      | 10.21.47.127      | /25  | 10.21.47.1 – 10.21.47.126   |
| STAFF            | 50              | 10.21.47.128    | 10.21.47.191      | /26  | 10.21.47.129 – 10.21.47.190 |
| HQ-ROUTER ↔ MLS1 | 4               | 10.21.47.192    | 10.21.47.195      | /30  | 10.21.47.193-10.21.47.194   |
| HQ-ROUTER ↔ MLS2 | 4               | 10.21.47.196    | 10.21.47.199      | /30  | 10.21.47.197-10.21.47.198   |

Table 2.1: Oporto WAN IP addressing scheme.

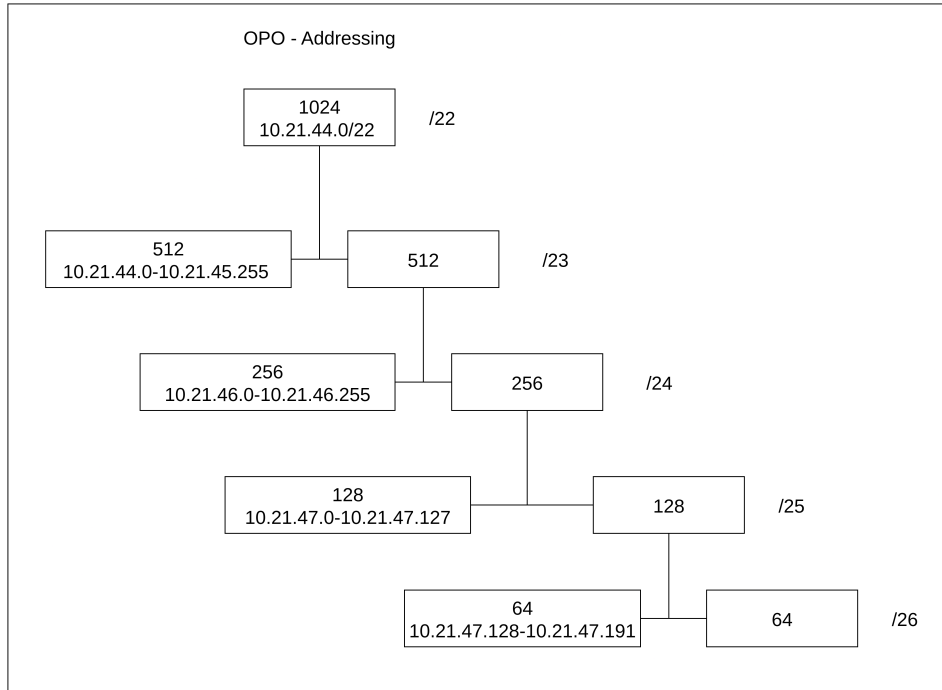


Figure 2.2: Oporto WAN Addressing Diagram<sup>2</sup>

This addressing plan ensures that each network has sufficient IP addresses to accommodate all devices, while also allowing room for potential future expansion. The subnet sizes were calculated based on the number of hosts in each network, following standard subnetting rules.

## 2.2.1 Equipment Addressing

The IP addresses listed in Table 2.2 correspond to statically assigned management and gateway interfaces within the Oporto headquarters network. These addresses are **excluded from DHCP** to prevent dynamic clients from receiving them.

Each VLAN has three reserved addresses:

- The **HSRP virtual gateway**, used by hosts as their default gateway.
- The **Switched Virtual Interface (SVI) address on MLS1**.
- The **SVI address on MLS2**.

These static IPs ensure stable Layer 3 routing and redundancy between MLS1 and MLS2. All other addresses within the VLAN subnet ranges are assigned dynamically by the DHCP server.

Table 2.2: Network Equipment and Assigned IP Addresses Oporto WAN

| Device                      | Interface / VLAN | IP Address       | Description / Function             |
|-----------------------------|------------------|------------------|------------------------------------|
| <b>HQ Router (2911)</b>     | G0/0             | 10.21.47.193 /30 | Link to MLS1                       |
|                             | G0/1             | 10.21.47.197 /30 | Link to MLS2                       |
|                             | G0/0/0           | DHCP (Public)    | WAN connection to ISP              |
| <b>MLS1 (3560-24PS)</b>     | VLAN10           | 10.21.47.130 /26 | STAFF SVI (HSRP Active)            |
|                             | VLAN20           | 10.21.46.2 /24   | ACCOUNTING SVI (HSRP Active)       |
|                             | VLAN30           | 10.21.47.2 /25   | HR SVI (HSRP Standby)              |
|                             | VLAN40           | 10.21.44.2 /23   | USERS SVI (HSRP Standby)           |
|                             | G0/1             | 10.21.47.194 /30 | Link to HQ Router                  |
| <b>MLS2 (3560-24PS)</b>     | VLAN10           | 10.21.47.131 /26 | STAFF SVI (HSRP Standby)           |
|                             | VLAN20           | 10.21.46.3 /24   | ACCOUNTING SVI (HSRP Standby)      |
|                             | VLAN30           | 10.21.47.3 /25   | HR SVI (HSRP Active)               |
|                             | VLAN40           | 10.21.44.3 /23   | USERS SVI (HSRP Active)            |
|                             | G0/1             | 10.21.47.198 /30 | Link to HQ Router                  |
| <b>HSRP Virtual IPs</b>     | VLAN10           | 10.21.47.129 /26 | STAFF Gateway (Virtual)            |
|                             | VLAN20           | 10.21.46.1 /24   | ACCOUNTING Gateway (Virtual)       |
|                             | VLAN30           | 10.21.47.1 /25   | HR Gateway (Virtual)               |
|                             | VLAN40           | 10.21.44.1 /23   | USERS Gateway (Virtual)            |
| <b>SW1, SW2 (2960-24TT)</b> | Trunk links      | N/A              | Access layer switches, VTP clients |
| <b>End Device (PC1)</b>     | VLAN10           | DHCP assigned    | STAFF network client               |
| <b>End Device (PC2)</b>     | VLAN20           | DHCP assigned    | ACCOUNTING network client          |
| <b>End Device (PC3)</b>     | VLAN30           | DHCP assigned    | HR network client                  |
| <b>End Device (PC4)</b>     | VLAN40           | DHCP assigned    | USERS network client               |

## 2.3 Configuration

### 2.3.1 HQ Router and MLS Configuration

The HQ Router obtains its external IP address from the Service Provider via DHCP, while the internal connections between the HQ Router and the multilayer switches (MLS1 and MLS2) are configured with static IP addresses. This ensures consistent routing and stable communication between the HQ and internal networks.

```

1 enable
2 configure terminal
3
4 ! Internal connection to MLS1
5 interface GigabitEthernet0/0
6   description HQ-MLS1 Connection
7   ip address 10.21.47.193 255.255.255.252
8   no shutdown
9 exit
10
11 ! Internal connection to MLS2
12 interface GigabitEthernet0/1
13   description HQ-MLS2 Connection
14   ip address 10.21.47.197 255.255.255.252
15   no shutdown
16 exit
17
18 ! External connection to Service Provider (WAN)
19 interface GigabitEthernet0/0/0
20   description Service Provider Connection
21   ip address dhcp
22   no shutdown
23 exit
24
25 ! Default route to the Internet (through SP)
26 ip route 0.0.0.0 0.0.0.0 GigabitEthernet0/0/0
27 end

```

Code 2.1: HQ Router configuration

The static IPs configured on the HQ Router correspond to the point-to-point subnets used for internal routing with MLS1 and MLS2.

```

1 enable
2 configure terminal
3 interface GigabitEthernet0/1
4   description Link to HQ Router
5   no switchport
6   ip address 10.21.47.194 255.255.255.252
7   no shutdown
8 end

```

Code 2.2: MLS1 link to HQ Router

```

1 enable
2 configure terminal
3 interface GigabitEthernet0/1
4   description Link to HQ Router
5   no switchport
6   ip address 10.21.47.198 255.255.255.252
7   no shutdown
8 end

```

Code 2.3: MLS2 link to HQ Router

This configuration guarantees reliable Layer 3 communication between the HQ Router and both MLS devices. By assigning static IP addresses internally and using DHCP externally, the HQ Router maintains dynamic Internet access while ensuring stable connectivity with the local switching infrastructure.

```

1 interface range fa0/5 - 8
2   switchport mode access
3   switchport access vlan 10
4   !
5 interface range fa0/9 - 12
6   switchport mode access
7   switchport access vlan 20
8   !
9 interface range fa0/13 - 16
10  switchport mode access
11  switchport access vlan 30
12  !
13 interface range fa0/17 - 20
14  switchport mode access
15  switchport access vlan 40
16  !
17 interface range fa0/1 - 4, fa0/21 - 24
18   switchport access vlan 99
19   shutdown

```

Code 2.4: Access port configuration on SW1 and SW2

### 2.3.2 VTP and VLAN Configuration

VTP was implemented on the HQ switches in order to automate VLAN propagation. MLS1 and MLS2 were configured as VTP servers and SW1 and SW2 as clients. This ensures that VLAN information is consistent across all switches.

```

1 vtp domain RECOMP2526TTTGG
2 vtp password 6252pmocer
3 vtp mode server

```

Code 2.5: VTP configuration on MLS1 and MLS2

```

1 vtp domain RECOMP2526TTTGG
2 vtp password 6252pmocer
3 vtp mode client

```

Code 2.6: VTP configuration on SW1 and SW2

VLANs were created on the MLS switches to segment traffic per department, improving security and broadcast efficiency.

```

1 vlan 10 name STAFF
2 vlan 20 name ACCOUNTING
3 vlan 30 name HR
4 vlan 40 name USERS
5 vlan 50 name NATIVE
6 vlan 99 name BLACKHOLE

```

Code 2.7: VLAN creation on MLS1 and MLS2<sup>3</sup>

### 2.3.3 Trunk and Port-Channel Configuration

To provide redundancy and increased bandwidth between MLS1 and MLS2, a Port-Channel was configured using interfaces Fa0/1-2. All inter-switch links were configured as trunks, using VLAN 50 as the native VLAN.

```

1 interface range fa0/1 - 2
2   channel-group 1 mode active
3   !
4 interface port-channel 1
5   switchport trunk encapsulation dot1q
6   switchport mode trunk
7   switchport trunk allowed vlan all
8   switchport trunk native vlan 50
9   !
10 interface range fa0/3 - 4
11   switchport mode trunk
12   switchport trunk allowed vlan all
13   switchport trunk native vlan 50
14   no shutdown

```

Code 2.8: Trunk and Port-Channel configuration on MLS1 and MLS2

This design allows all VLANs to traverse the trunks, ensuring communication between switches and minimizing single points of failure.

### 2.3.4 RSTP

Rapid-PVST was used to optimize convergence and redundancy. Root bridge roles were manually assigned to balance VLAN traffic: MLS1 for VLANs 10 and 20, and MLS2 for VLANs 30 and 40.

```

1 spanning-tree mode rapid-pvst
2 spanning-tree vlan 10,20 root primary
3 spanning-tree vlan 30,40 root secondary

```

Code 2.9: RSTP configuration on MLS1

```

1 spanning-tree mode rapid-pvst
2 spanning-tree vlan 30,40 root primary
3 spanning-tree vlan 10,20 root secondary

```

Code 2.10: RSTP configuration on MLS2

This configuration ensures load balancing and prevents loops, as each switch becomes the primary root for specific VLANs.

### 2.3.5 HSRP Configuration

HSRP was configured on both MLS switches to provide default gateway redundancy. Each VLAN has a virtual gateway IP, and the active MLS for each VLAN matches its STP root, optimizing path efficiency.

```

1 ip routing
2   !
3 interface vlan10
4   ip address 10.21.47.130 255.255.255.192
5   standby 10 ip 10.21.47.129
6   standby 10 priority 110
7   standby 10 preempt
8   !
9 interface vlan20

```

```

10 ip address 10.21.46.2 255.255.255.0
11 standby 20 ip 10.21.46.1
12 standby 20 priority 110
13 standby 20 preempt

```

Code 2.11: HSRP configuration on MLS1

```

1 ip routing
2 !
3 interface vlan30
4 ip address 10.21.47.3 255.255.255.128
5 standby 30 ip 10.21.47.1
6 standby 30 priority 110
7 standby 30 preempt
8 !
9 interface vlan40
10 ip address 10.21.44.3 255.255.254.0
11 standby 40 ip 10.21.44.1
12 standby 40 priority 110
13 standby 40 preempt

```

Code 2.12: HSRP configuration on MLS2

This setup guarantees seamless failover for gateway services in the event one switch fails.

### 2.3.6 Layer 2 Switch Configuration

SW1 and SW2 were configured to connect end devices to the correct VLANs and isolate unused ports.

```

1 interface range fa0/5 - 8
2 switchport mode access
3 switchport access vlan 10
4 !
5 interface range fa0/9 - 12
6 switchport mode access
7 switchport access vlan 20
8 !
9 interface range fa0/13 - 16
10 switchport mode access
11 switchport access vlan 30
12 !
13 interface range fa0/17 - 20
14 switchport mode access
15 switchport access vlan 40
16 !
17 interface range fa0/1 - 4, fa0/21 - 24
18 switchport access vlan 99
19 shutdown

```

Code 2.13: Access port configuration on SW1 and SW2

Unused ports were placed in VLAN 99 and shut down to enhance security and prevent unauthorized connections.

### 2.3.7 DHCP Configuration

Redundant DHCP services were configured on both MLS switches. Each VLAN has its own pool, while addresses used by HSRP and SVIs were excluded to avoid conflicts.

```
1 ip dhcp excluded-address 10.21.47.129 10.21.47.131
2 ip dhcp excluded-address 10.21.46.1 10.21.46.3
3 ip dhcp excluded-address 10.21.47.1 10.21.47.3
4 ip dhcp excluded-address 10.21.44.1 10.21.44.3
5 !
6 ip dhcp pool STAFF
7   network 10.21.47.128 255.255.255.192
8   default-router 10.21.47.129
9   dns-server 8.8.8.8
10  domain-name recomp2526.com
```

Code 2.14: DHCP configuration on MLS1 and MLS2

This ensures reliable address distribution and gateway redundancy across all VLANs.



# Chapter 3

## Warsaw WAN

### 3.1 Site Overview

The Warsaw site is one of the three main locations in the RECOMP Corporation architecture. His structure includes the following key components:

- Tree core multilayer switches (3560-24PS model).
- One router (2901 model).
- Four layer 2 switches (2960-24TT model).
- Four PCs representing each of the networks (STAFF, ACCOUNTING, HR, USERS).

The topology of the warsaw site is illustrated in Figure 3.1, showcasing the interconnections between the core switches, router, layer 2 switches, and PCs.

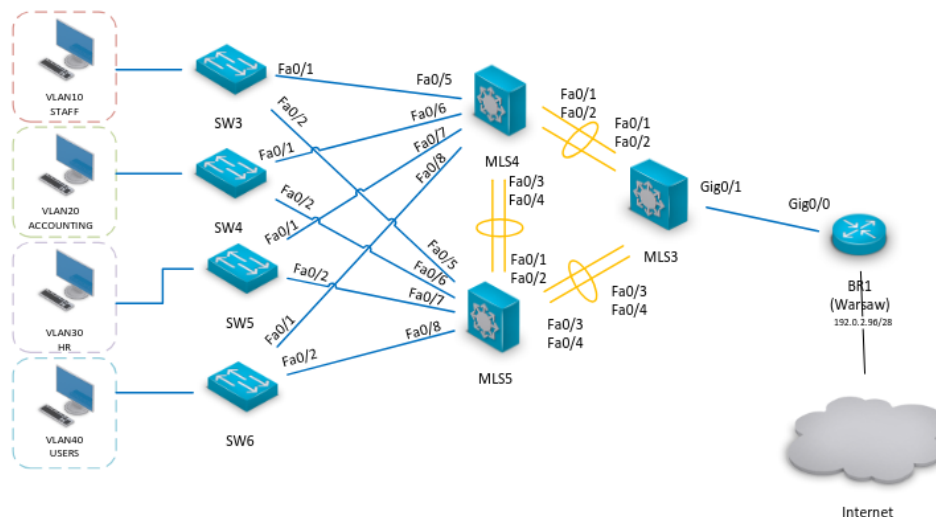


Figure 3.1: Warsaw Site Topology

### 3.2 IP Addressing Scheme

The Warsaw network architecture is built upon a structured IP plan. The following tables detail the VLAN subnets and the specific IP addresses assigned to core network devices.

### 3.3 VLAN Subnet Allocation

Table 3.1: VLAN Subnet Allocation

| VLAN Name  | VLAN ID | Network ID     | Mask | Usable IP Range                 | Broadcast       |
|------------|---------|----------------|------|---------------------------------|-----------------|
| USERS      | 40      | 192.168.162.0  | /24  | 192.168.162.1 – 192.168.162.254 | 192.168.162.255 |
| STAFF      | 10      | 192.168.163.0  | /27  | 192.168.163.1 – 192.168.163.30  | 192.168.163.31  |
| ACCOUNTING | 20      | 192.168.163.32 | /27  | 192.168.163.33 – 192.168.163.62 | 192.168.163.63  |
| HR         | 30      | 192.168.163.64 | /27  | 192.168.163.65 – 192.168.163.94 | 192.168.163.95  |

As the figure 3.2 shows, the VLANs were designed to accommodate the minimum number of hosts required, also with additional capacity for future growth.

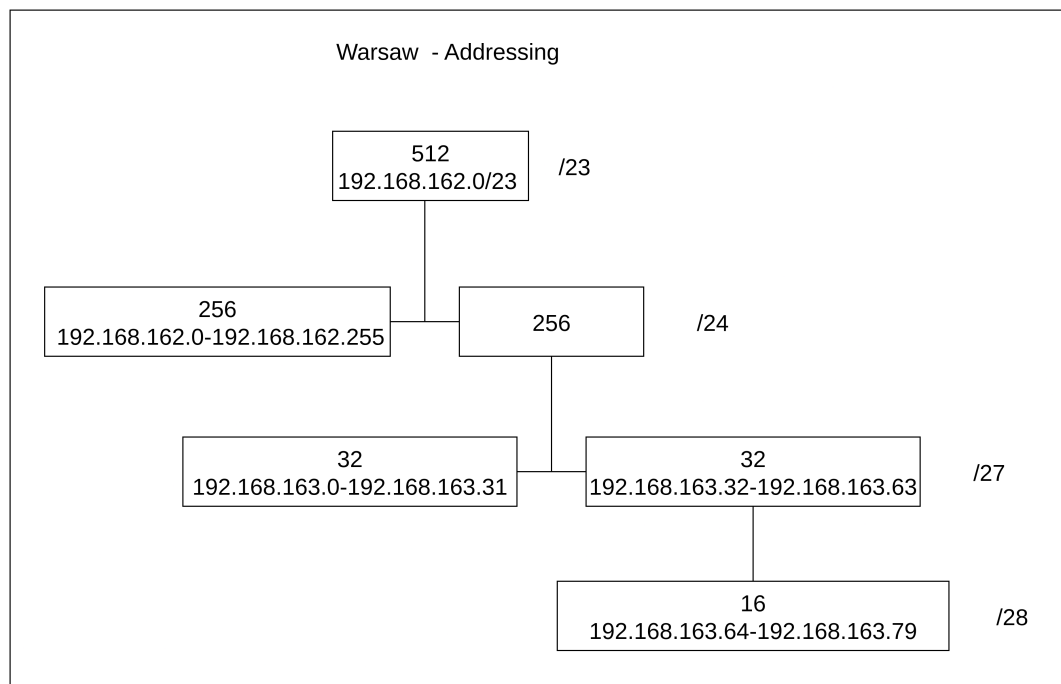


Figure 3.2: Warsaw IP Addressing Scheme

### 3.4 Core Device Interface Assignments

Static IP addresses were assigned to core multilayer switch (MLS) interfaces for routing.

### 3.5 Core Device Configuration

The following command sets were applied to the core multilayer switches to establish VLANs, routing, and redundancy.

Table 3.2: Core Device Interface Assignments

| Device | Interface | IP Address / Mask  |
|--------|-----------|--------------------|
| MLS4   | VLAN 10   | 192.168.163.2 /27  |
|        | VLAN 20   | 192.168.163.34 /27 |
|        | VLAN 30   | 192.168.163.66 /27 |
|        | VLAN 40   | 192.168.162.2 /24  |
| MLS5   | VLAN 10   | 192.168.163.3 /27  |
|        | VLAN 20   | 192.168.163.35 /27 |
|        | VLAN 30   | 192.168.163.67 /27 |
|        | VLAN 40   | 192.168.162.3 /24  |

### 3.5.1 VLAN and VTP Configuration

VLAN Trunking Protocol (VTP) was configured to synchronize VLAN databases across the Warsaw switching domain. All multilayer switches operate in **server** mode to ensure database consistency and integrity.

```

1 vtp mode server
2 vtp domain RECOMP2526M1A06
3 vtp password 6252pmocer
4
5 vlan 10
6   name STAFF
7 vlan 20
8   name ACCOUNTING
9 vlan 30
10  name HR
11 vlan 40
12  name USERS
13 vlan 50
14  name NATIVE
15 vlan 99
16  name BLACKHOLE
17 ip routing

```

Code 3.1: VLAN and VTP configuration

### 3.5.2 Spanning Tree Protocol STP Configuration

Rapid Per-VLAN Spanning Tree (Rapid-PVST) was enabled to maintain a loop-free topology and to provide load balancing between core switches.

```

1 spanning-tree mode rapid-pvst
2 spanning-tree vlan 10,20 root primary
3 spanning-tree vlan 30,40 root secondary

```

Code 3.2: RSTP configuration on MLS4

```

1 spanning-tree mode rapid-pvst
2 spanning-tree vlan 30,40 root primary
3 spanning-tree vlan 10,20 root secondary

```

Code 3.3: RSTP configuration on MLS5

### 3.5.3 HRSP! Configuration

HRSP was configured on both on MLS4 and MLS5 to provide gateway redundancy for endpoint devices. The following example shows the configuration for VLAN 10 (STAFF); similar configurations were applied for all other VLANs.

```
1 interface vlan 10
2 ip address 192.168.163.2 255.255.255.224
3 standby 10 ip 192.168.163.1
4 standby 10 priority 110
5 standby 10 preempt
6 no shutdown
7 exit
```

Code 3.4: HRSP configuration for VLAN10 on MLS4/MLS5

### 3.5.4 DHCP Service Configuration

DHCP services were configured on MLS4 and MLS5 to automate IP address assignment for endpoint devices. The following example shows the configuration for the VLAN 10 (STAFF) pool; similar pools were created for all other VLANs.

```
1 ip dhcp pool VLAN10_STAFF
2 network 192.168.163.0 255.255.255.224
3 default-router 192.168.163.1
4 dns-server 8.8.8.8
5 domain-name RECOMP2526M1A06.recomp.com
6 exit
```

Code 3.5: DHCP configuration for VLAN10 on MLS4/MLS5

# Chapter 4

## Munich WAN

### 4.1 Site Overview

Munich is the other branch of the RECOMP Corporation. The network has:

- Two Routers (2911 model);
- Four switch Layer 2 switches (2960-24TT model);
- Four PCs representing each of the networks present in each branch: Staff, Accounting, Human Resources and Users.

The topology of the Munich branch is shown in Figure 4.1. The Munich WAN is connected to the Internet using the address block 193.136.60.147/29.

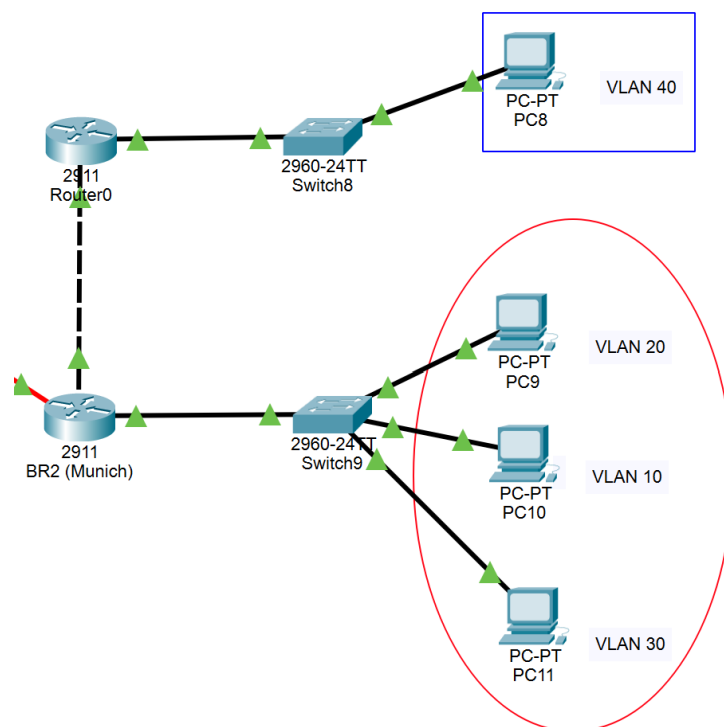


Figure 4.1: Munich WAN Topology

## 4.2 Munich Subnet Implementation

In this subchapter, you will find the addressing for this branch in Table 4.1. This branch, like the previous one, contains four VLANs, each with a number of nodes, a network address, a broadcast address, a mask, and a range of addresses that can be used for each machine on the network.

| Network    | Number of Nodes | Network Address | Broadcast Address | Mask | First–Last Valid Address    |
|------------|-----------------|-----------------|-------------------|------|-----------------------------|
| USERS      | 200             | 172.18.78.0     | 172.18.78.255     | /24  | 172.18.78.1 – 172.18.78.254 |
| ACCOUNTING | 20              | 172.18.79.0     | 172.18.79.31      | /27  | 172.18.79.1 – 172.18.79.30  |
| STAFF      | 10              | 172.18.79.32    | 172.18.79.47      | /28  | 172.18.79.33 – 172.18.79.46 |
| HR         | 10              | 172.18.79.48    | 172.18.79.63      | /28  | 172.18.79.49 – 172.18.79.62 |

Table 4.1: Munich WAN IP addressing scheme

As shown in Figure 4.2, the addressing for the Munich branch is presented.

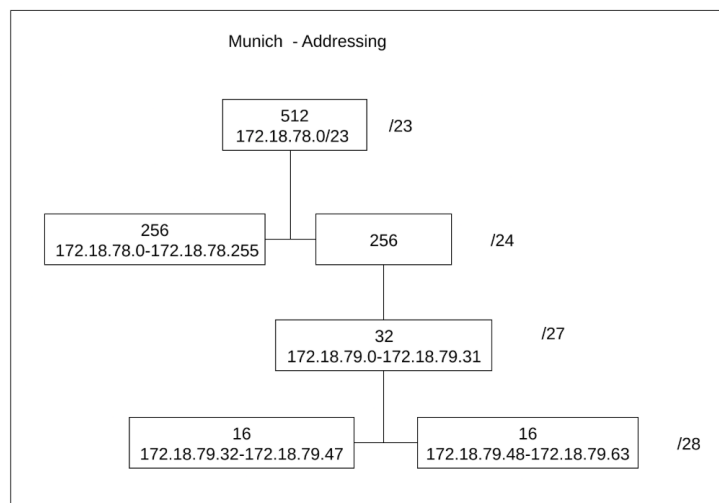


Figure 4.2: Munich IP Addressing

## 4.3 Implementation of Cisco Commands

In this Munich branch, the goal was to implement VLAN segmentation, inter-VLAN routing, DHCP address allocation and connectivity between remote sites through static routing.

### Switch Configuration

The Switch7 (SW7), was configured to handle three departments: Staff, Accounting, and Human Resources (HR). The following VLANs were created:

```
1 vlan 10
2   name STAFF
3 vlan 20
4   name ACCOUNTING
5 vlan 30
6   name HR
7 vlan 50
```

```

8   name NATIVE
9   vlan 99
10  name BLACKHOLE

```

Code 4.1: VLAN creation on SW7

The trunk link connecting SW7 to router BR2 was configured on the *gigabitEthernet0/1* interface, allowing VLANs 10, 20 and 30 and using VLAN 50 as the native VLAN:

```

1 interface gigabitEthernet0/1
2     switchport mode trunk
3     switchport trunk native vlan 50
4     switchport trunk allowed vlan 10,20,30

```

Code 4.2: Trunk configuration on SW7

The access ports for the end-user PCs were then assigned to their respective VLANs.

```

1 interface range fa0/1-5
2     switchport mode access
3     switchport access vlan 10
4     no shutdown
5 exit
6
7 interface range fa0/6-10
8     switchport mode access
9     switchport access vlan 20
10    no shutdown
11 exit
12
13 interface range fa0/11-15
14     switchport mode access
15     switchport access vlan 30
16     no shutdown
17 exit
18
19 interface range fa0/16-24
20     switchport mode access
21     switchport access vlan 99
22     shutdown

```

Code 4.3: Access port configuration on SW7

The ports not used were assigned to Blackhole VLAN 99 and administratively shut-down to improve security.

Switch8 (SW8), used for local users in Users VLAN 40, was configured with VLAN 40, 50 and 99:

```

1 vlan 40
2     name USERS
3 vlan 50
4     name NATIVE
5 vlan 99
6     name BLACKHOLE

```

Code 4.4: VLAN creation on SW8

Secondly, we configured many different network interfaces for vlan 40 and vlan 99:

```

1 interface range fa0/1-24

```

```

2      switchport mode access
3      switchport access vlan 40
4      no shutdown
5  exit
6
7  interface range gigabitEthernet0/2
8      switchport mode access
9      switchport access vlan 99
10     shutdown
11 exit

```

Code 4.5: Access port configuration on SW8

### 4.3.1 Router Configuration

This subsection demonstrates the configuration of two routers: BR2 and Router0 (R0).

#### BR2

The BR2 router is connected to the internet with the IP address 193.136.60.147/29. The R0 router is connected to the BR2 router with a crossover cable.

First, the gigabitEthernet0/0 interface was configured, connecting the BR2 router to the internet. Therefore, we have the following code:

```

1 interface gigabitEthernet0/0
2     ip address 193.136.60.147 255.255.255.248
3     no shutdown
4 exit

```

Code 4.6: Interface GigabitEthernet0/0 Configuration

On the BR2 router, four subinterfaces were configured to handle traffic from different VLANs over a single physical interface. Each subinterface is identified by a . followed by the VLAN number, which allows the router to distinguish between the different VLANs. The command `encapsulation dot1q <VLAN>` specifies that 802.1Q trunking is being used, enabling the physical interface to carry traffic from multiple VLANs simultaneously.

The IP addresses assigned to each subinterface allow the router to act as the default gateway for the hosts in the corresponding VLANs:

- GigabitEthernet0/1.10: configured for VLAN 10 with IP address 172.18.79.46/28. This subinterface provides routing and inter-VLAN connectivity for devices in VLAN 10.
- GigabitEthernet0/1.20: configured for VLAN 20 with IP address 172.18.79.30/27, serving as the gateway for devices in VLAN 20.
- GigabitEthernet0/1.30: configured for VLAN 30 with IP address 172.18.79.62/28, providing routing services for VLAN 30 hosts.
- GigabitEthernet0/1.50: configured for VLAN 50 as the native VLAN. No IP address is assigned because this VLAN is likely used only for untagged traffic passing through the trunk, without requiring routing.



By assigning unique IP addresses to each subinterface, the router can perform inter-VLAN routing, allowing devices on different VLANs to communicate while still maintaining VLAN segmentation. This setup efficiently leverages a single physical interface to carry multiple networks, reducing hardware requirements and simplifying the network topology.

```
1 interface gigabitEthernet0/1.10
2     encapsulation dot1q 10
3     ip address 172.18.79.46 255.255.255.240
4
5 interface gigabitEthernet0/1.20
6     encapsulation dot1q 20
7     ip address 172.18.79.30 255.255.255.224
8
9 interface gigabitEthernet0/1.30
10    encapsulation dot1q 30
11    ip address 172.18.79.62 255.255.255.240
12
13 interface gigabitEthernet0/1.50
14     encapsulation dot1q 50 native
15     no ip address
```

Code 4.7: Subinterfaces configuration on BR2 router

Next, using the *no shutdown* command, the interface connecting BR2 to SW7 was enabled.

```
1 interface gigabitEthernet0/1
2     no shutdown
3 exit
```

Code 4.8: Turn on Interface GigabitEthernet0/1 between SW7 and BR2

## R0

Router R0 is connected to a switch, and that switch has only one associated VLAN, that's VLAN 40, which is USERS. First, the GigabitEthernet0/0 interface was configured to connect router BR2 to router R0 with the IP address 193.136.60.148/29 on R0 side.

```
1 interface gigabitEthernet0/0
2     ip address 193.136.60.148 255.255.255.248
3     no shutdown
4 exit
```

Code 4.9: Interface GigabitEthernet0/0 configuration on R0

Next, the interface connecting R0 to SW8 was configured. The IP address assigned in the configuration of this interface was 172.18.78.254/24.

```
1 interface gigabitEthernet0/1
2     ip address 172.18.78.254 255.255.255.0
3     no shutdown
4 exit
```

Code 4.10: Configuring the GigabitEthernet0/1 interface on R0

### 4.3.2 DHCP Configuration

In this subchapter, we will explain the DHCP configuration on the two Munich WAN routers for the VLANs of each of the two switches in this network. DHCP, basically, is a protocol that automatically assigns IP addresses and other network settings, (for example: gateway, DNS) to devices on a network.

#### BR2 Router

On the BR2 router, three DHCP pools were configured, corresponding to the VLANs connected to the SW7 switch: VLAN 20 (STAFF), VLAN 10 (ACCOUNTING), and VLAN 30 (HR). Each pool defines a specific IP range, the respective default gateway, DNS server, and same domain name to be distributed to the hosts within that VLAN. Additionally, several IP addresses were excluded to prevent them from being assigned dynamically—typically reserved for network devices such as routers and switches.

```
1 ip dhcp excluded-address 172.18.79.33 172.18.79.45
2 ip dhcp excluded-address 172.18.79.1 172.18.79.29
3 ip dhcp excluded-address 172.18.79.49 172.18.79.61
```

Code 4.11: Exclusion of static addresses already defined to avoid errors

```
1 ip dhcp pool STAFF
2   network 172.18.79.32 255.255.255.240
3   default-router 172.18.79.46
4   dns-server 8.8.8.8
5   domain-name RECOMP2526M1A06.recomp.com
6 exit
```

Code 4.12: Creation of a DHCP pool called STAFF

```
1 ip dhcp pool ACCOUNTING
2   network 172.18.79.0 255.255.255.224
3   default-router 172.18.79.30
4   dns-server 8.8.8.8
5   domain-name RECOMP2526M1A06.recomp.com
6 exit
```

Code 4.13: Creation of a DHCP pool called ACCOUNTING

```
1 ip dhcp pool HR
2   network 172.18.79.48 255.255.255.240
3   default-router 172.18.79.62
4   dns-server 8.8.8.8
5   domain-name RECOMP2526M1A06.recomp.com
6 exit
```

Code 4.14: Creation of a DHCP pool called HR

This configuration ensures that each VLAN has its own DHCP scope, allowing devices in each network to automatically obtain an IP address, gateway, and DNS information corresponding to their VLAN.

The use of excluded address ranges guarantees that static IPs assigned to infrastructure components will not conflict with dynamically assigned addresses. It should be noted that this DHCP configuration in Packet Tracer will have significant positive effects on PC9 (Vlan 20), PC10 (Vlan 10) and PC11 (Vlan 30).

For example, if you look at the DHCP settings on PC9 in the following figure 4.3, you will see that it corresponds to Code 4.12 and that it contains exactly the assigned DNS IP (Google) and the corresponding default-gateway from the Staff Pool.

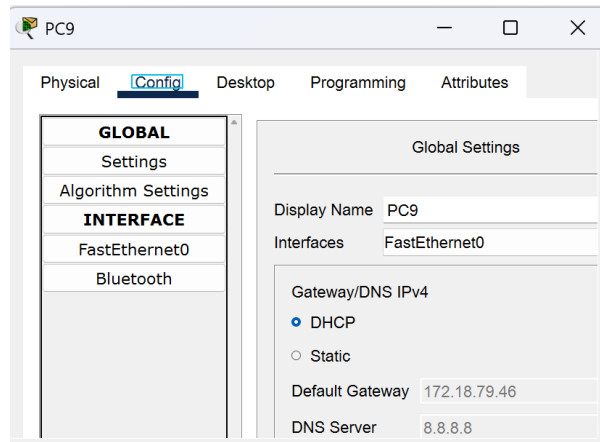


Figure 4.3: Demonstration of PC9 DNS and your Default-Gateway

### 4.3.3 IP Route Configuration

In this subsection, the configuration of IP routes in packet tracer on router BR2, as well as on router R0, is demonstrated.

#### BR2

```
1 ip route 172.18.78.0 255.255.255.0 193.136.60.148
```

Code 4.15: IP Route Demonstration of BR2 Router

In the Code 4.15, it can be seen that there is an IP designated by *172.18.78.0* which is the network address of router R0, followed by the network mask */24*, and finally there is the IP address *193.136.60.148* which is the IP of the next-hop or the IP of the neighboring router, i.e. is, the IP of Router0 where the traffic will be sent and reach the destination network.

#### R0

In this subsection, the configuration of static IP routes in Packet Tracer on Router0 is presented.

```
1 ip route 172.18.79.0 255.255.255.224 193.136.60.147
2 ip route 172.18.79.32 255.255.255.240 193.136.60.147
3 ip route 172.18.79.48 255.255.255.240 193.136.60.147
```

Code 4.16: IP Route Demonstration of Router0

In the Code 4.16, it can be observed that three static routes are configured on Router0. The first route defines the network *172.18.79.0/27*, the second route defines the network *172.18.79.32/28*, and the third route defines the network *172.18.79.48/28*. All these networks are reachable through the next-hop IP address *193.136.60.147*, which corresponds to the neighboring router BR2.

Therefore, these static routes allow Router0 to forward traffic destined for the mentioned networks through BR2, ensuring proper communication between the subnets and the rest of the topology.

# Chapter 5

## Conclusion

The development of RECOMP Corporation's WAN during Sprint 1 represented a crucial milestone in establishing a functional, scalable, and secure network infrastructure, interconnecting the company's three main facilities — Porto (headquarters), Warsaw, and Munich. Throughout this phase, key objectives were successfully achieved, including the design and implementation of IP addressing schemes, the configuration of VLANs and VTP domains, the deployment of redundancy protocols, and the validation of internal and external connectivity.

At the Porto headquarters, the configuration of multilayer switching, VLAN segmentation, and redundancy protocols such as HSRP ensured high availability and resilience against potential network failures. The use of VTP and DHCP services further simplified network management and automation.

In Warsaw, the implementation of a structured subnet plan and the correct configuration of redundancy mechanisms such as HSRP ensured seamless gateway failover and optimised routing performance. The implementation of DHCP pools for each VLAN confirmed proper network segmentation and automated address management.

Similarly, in Munich, routing between VLANs, trunking, and DHCP configuration were successfully implemented, ensuring connectivity between departments and between networks through static routing. The logical separation of VLANs and the configuration of subinterfaces on the routers enabled efficient communication between all networks on different VLANs.

This first sprint laid the foundation for RECOMP Corporation's enterprise network. Each site now operates with a consistent addressing scheme and stable connectivity to the Internet and between each machine (e.g., PCs) on each WAN.

Finally, all objectives set for Sprint 1 were fully achieved. RECOMP's WAN is now operational and ready for the next phases of development.

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