Computer Network Project

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

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

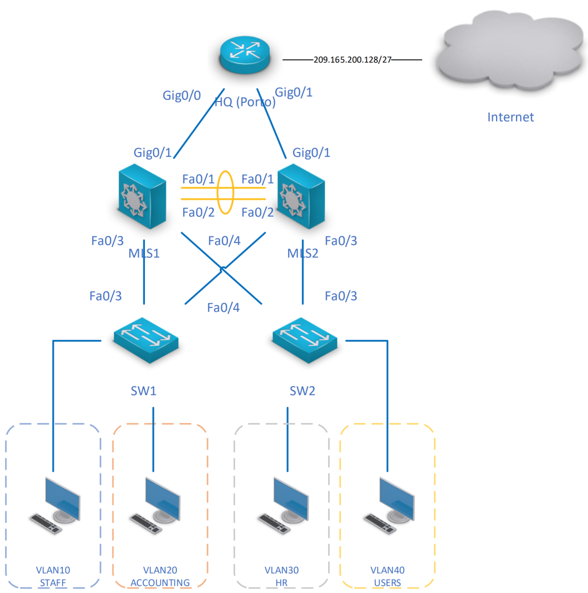

Figure 2.1: Oporto WAN Topology[1]

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.

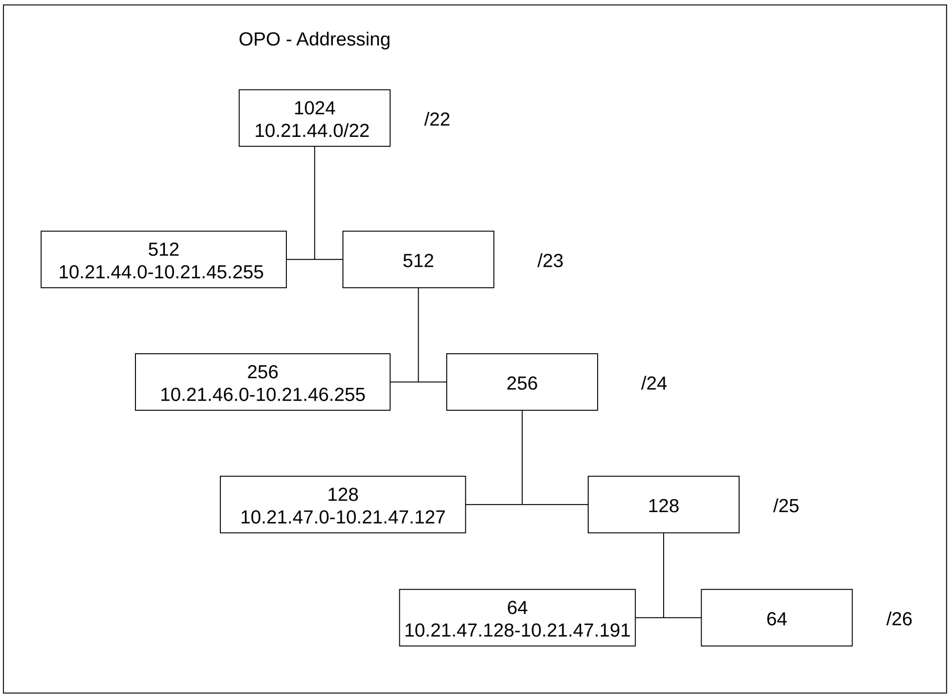

Figure 2.2: Oporto WAN Addressing Diagram[2]

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
HQ Router (2911)	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
MLS1 (3560-24PS)	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
MLS2 (3560-24PS)	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
HSRP Virtual IPs	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)
SW1, SW2 (2960-24TT)	Trunk links	N/A	Access layer switches, VTP clients
End Device (PC1)	VLAN10	DHCP assigned	STAFF network client
End Device (PC2)	VLAN20	DHCP assigned	ACCOUNTING network client
End Device (PC3)	VLAN30	DHCP assigned	HR network client
End Device (PC4)	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.

```
enable
configure terminal

! Internal connection to MLS1
interface GigabitEthernet0/0
 description HQ-MLS1 Connection
 ip address 10.21.47.193 255.255.255.252
 no shutdown
exit

! Internal connection to MLS2
interface GigabitEthernet0/1
 description HQ-MLS2 Connection
 ip address 10.21.47.197 255.255.255.252
 no shutdown
exit

! External connection to Service Provider (WAN)
interface GigabitEthernet0/0/0
 description Service Provider Connection
 ip address dhcp
 no shutdown
exit

! Default route to the Internet (through SP)
ip route 0.0.0.0 0.0.0.0 GigabitEthernet0/0/0
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.

```
enable
configure terminal
interface GigabitEthernet0/1
 description Link to HQ Router
 no switchport
 ip address 10.21.47.194 255.255.255.252
 no shutdown
end
```

Code 2.2: MLS1 link to HQ Router

```
enable
configure terminal
interface GigabitEthernet0/1
 description Link to HQ Router
 no switchport
 ip address 10.21.47.198 255.255.255.252
 no shutdown
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.

```
interface range fa0/5 - 8
 switchport mode access
 switchport access vlan 10
!
interface range fa0/9 - 12
 switchport mode access
 switchport access vlan 20
!
interface range fa0/13 - 16
 switchport mode access
 switchport access vlan 30
!
interface range fa0/17 - 20
 switchport mode access
 switchport access vlan 40
!
interface range fa0/1 - 4, fa0/21 - 24
 switchport access vlan 99
 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.

```
vtp domain RECOMP2526TTTGG
vtp password 6252pmocer
vtp mode server
```

Code 2.5: VTP configuration on MLS1 and MLS2

```
vtp domain RECOMP2526TTTGG
vtp password 6252pmocer
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.

```
vlan 10 name STAFF
vlan 20 name ACCOUNTING
vlan 30 name HR
vlan 40 name USERS
vlan 50 name NATIVE
vlan 99 name BLACKHOLE
```

Code 2.7: VLAN creation on MLS1 and MLS2[3]

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.

```
interface range fa0/1 - 2
 channel-group 1 mode active
!
interface port-channel 1
 switchport trunk encapsulation dot1q
 switchport mode trunk
 switchport trunk allowed vlan all
 switchport trunk native vlan 50
!
interface range fa0/3 - 4
 switchport mode trunk
 switchport trunk allowed vlan all
 switchport trunk native vlan 50
 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.

```
spanning-tree mode rapid-pvst
spanning-tree vlan 10,20 root primary
spanning-tree vlan 30,40 root secondary
```

Code 2.9: RSTP configuration on MLS1

```
spanning-tree mode rapid-pvst
spanning-tree vlan 30,40 root primary
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.

```
ip routing
!
interface vlan10
 ip address 10.21.47.130 255.255.255.192
 standby 10 ip 10.21.47.129
 standby 10 priority 110
 standby 10 preempt
!
interface vlan20
```

```
 ip address 10.21.46.2 255.255.255.0
 standby 20 ip 10.21.46.1
 standby 20 priority 110
 standby 20 preempt
```

Code 2.11: HSRP configuration on MLS1

```
ip routing
!
interface vlan30
 ip address 10.21.47.3 255.255.255.128
 standby 30 ip 10.21.47.1
 standby 30 priority 110
 standby 30 preempt
!
interface vlan40
 ip address 10.21.44.3 255.255.254.0
 standby 40 ip 10.21.44.1
 standby 40 priority 110
 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.

```
interface range fa0/5 - 8
 switchport mode access
 switchport access vlan 10
!
interface range fa0/9 - 12
 switchport mode access
 switchport access vlan 20
!
interface range fa0/13 - 16
 switchport mode access
 switchport access vlan 30
!
interface range fa0/17 - 20
 switchport mode access
 switchport access vlan 40
!
interface range fa0/1 - 4, fa0/21 - 24
 switchport access vlan 99
 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.

```
ip dhcp excluded-address 10.21.47.129 10.21.47.131
ip dhcp excluded-address 10.21.46.1 10.21.46.3
ip dhcp excluded-address 10.21.47.1 10.21.47.3
ip dhcp excluded-address 10.21.44.1 10.21.44.3
!
ip dhcp pool STAFF
 network 10.21.47.128 255.255.255.192
 default-router 10.21.47.129
 dns-server 8.8.8.8
 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.

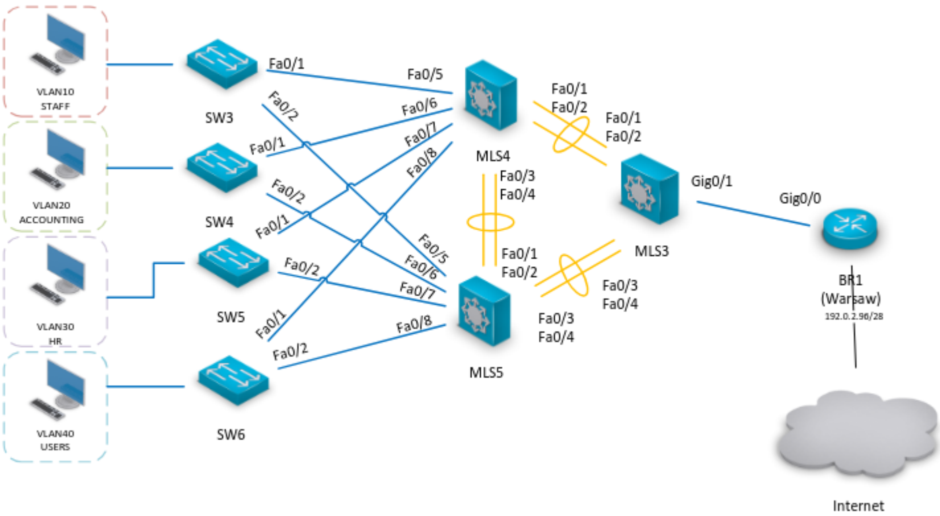

Figure 3.1: Warsaw Site Topology

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.

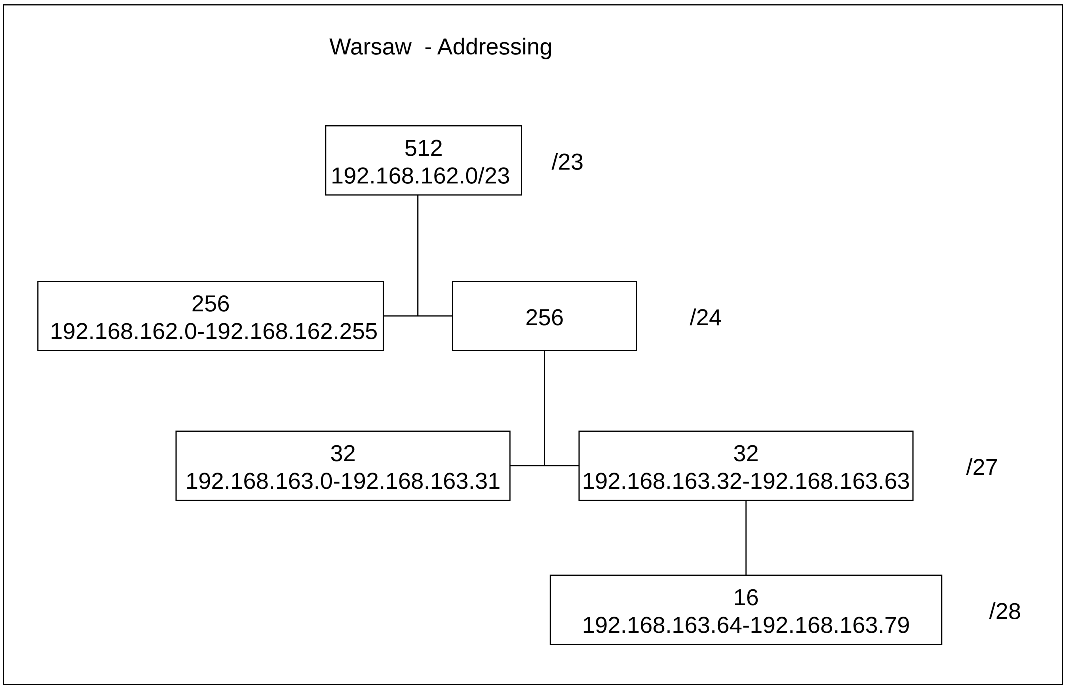

Figure 3.2: Warsaw IP Addressing Scheme

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.

```
vtp mode server
vtp domain RECOMP2526M1A06
vtp password 6252pmocer

vlan 10
 name STAFF
vlan 20
 name ACCOUNTING
vlan 30
 name HR
vlan 40
 name USERS
vlan 50
 name NATIVE
vlan 99
 name BLACKHOLE
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.

```
spanning-tree mode rapid-pvst
spanning-tree vlan 10,20 root primary
spanning-tree vlan 30,40 root secondary
```

Code 3.2: RSTP configuration on MLS4

```
spanning-tree mode rapid-pvst
spanning-tree vlan 30,40 root primary
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.

```

interface vlan 10
 ip address 192.168.163.2 255.255.255.224
 standby 10 ip 192.168.163.1
 standby 10 priority 110
 standby 10 preempt
 no shutdown
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.

```
ip dhcp pool VLAN10_STAFF
 network 192.168.163.0 255.255.255.224
 default-router 192.168.163.1
 dns-server 8.8.8.8
 domain-name RECOMP2526M1A06.recomp.com
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.

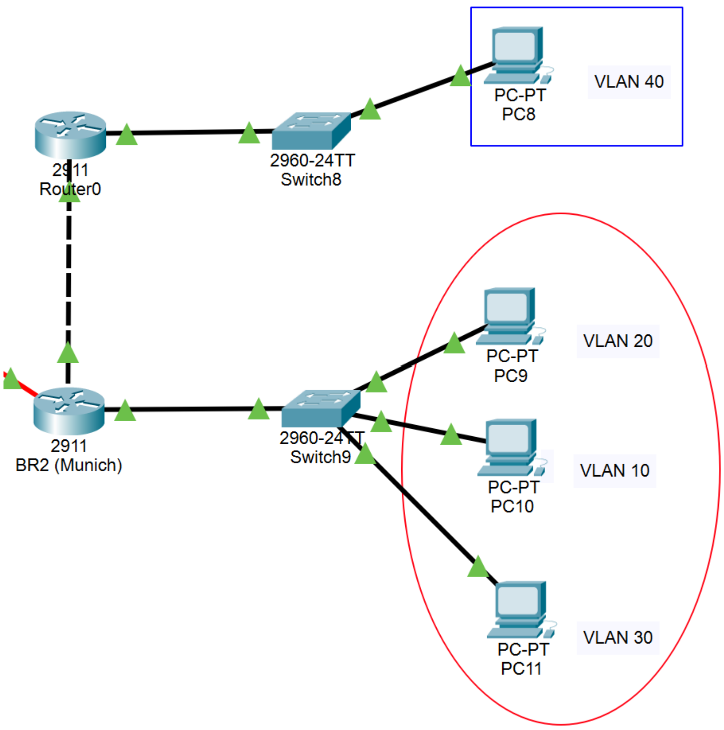

Figure 4.1: Munich WAN Topology

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.

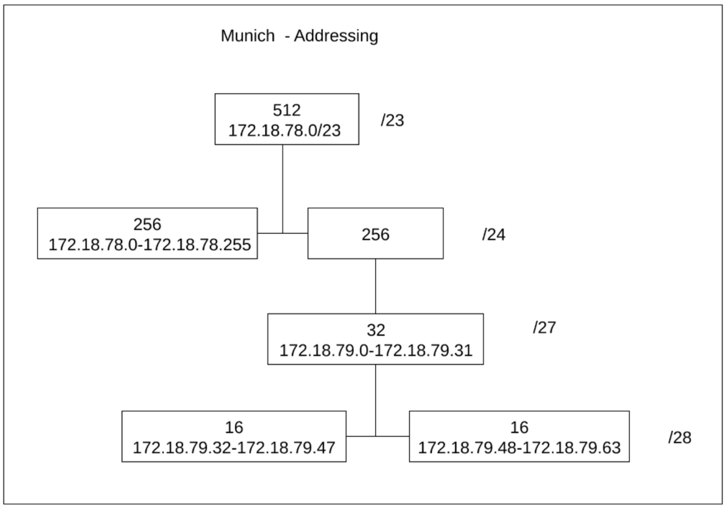

Figure 4.2: Munich IP Addressing

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:

```
vlan 10
  name STAFF
vlan 20
  name ACCOUNTING
vlan 30
  name HR
vlan 50
```

```
  name NATIVE
vlan 99
  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:

```
interface gigabitEthernet0/1
    switchport mode trunk
    switchport trunk native vlan 50
    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.

```
interface range fa0/1-5
    switchport mode access
    switchport access vlan 10
    no shutdown
exit

interface range fa0/6-10
    switchport mode access
    switchport access vlan 20
    no shutdown
exit

interface range fa0/11-15
    switchport mode access
    switchport access vlan 30
    no shutdown
exit

interface range fa0/16-24
    switchport mode access
    switchport access vlan 99
    shutdown
```

Code 4.3: Access port configuration on SW7

The ports not used were assigned to Blackhole VLAN 99 and administratively shutdown to improve security.

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

```
vlan 40
  name USERS
vlan 50
  name NATIVE
vlan 99
  name BLACKHOLE
```

Code 4.4: VLAN creation on SW8

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

```
interface range fa0/1-24
```

```
    switchport mode access
    switchport access vlan 40
    no shutdown
exit

interface range gigabitEthernet0/2
    switchport mode access
    switchport access vlan 99
    shutdown
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:

```
interface gigabitEthernet0/0
  ip address 193.136.60.147 255.255.255.248
  no shutdown
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.

```
interface gigabitEthernet0/1.10
  encapsulation dot1q 10
  ip address 172.18.79.46 255.255.255.240

interface gigabitEthernet0/1.20
  encapsulation dot1q 20
  ip address 172.18.79.30 255.255.255.224

interface gigabitEthernet0/1.30
  encapsulation dot1q 30
  ip address 172.18.79.62 255.255.255.240

interface gigabitEthernet0/1.50
  encapsulation dot1q 50 native
  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.

```
interface gigabitEthernet0/1
  no shutdown
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.

```
interface gigabitEthernet0/0
  ip address 193.136.60.148 255.255.255.248
  no shutdown
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.

```
interface gigabitEthernet0/1
  ip address 172.18.78.254 255.255.255.0
  no shutdown
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.

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

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

```
ip dhcp pool STAFF
 network 172.18.79.32 255.255.255.240
 default-router 172.18.79.46
 dns-server 8.8.8.8
 domain-name RECOMP2526M1A06.recomp.com
exit
```

Code 4.12: Creation of a DHCP pool called STAFF

```
ip dhcp pool ACCOUNTING
 network 172.18.79.0 255.255.255.224
 default-router 172.18.79.30
 dns-server 8.8.8.8
 domain-name RECOMP2526M1A06.recomp.com
exit
```

Code 4.13: Creation of a DHCP pool called ACCOUNTING

```
ip dhcp pool HR
 network 172.18.79.48 255.255.255.240
 default-router 172.18.79.62
 dns-server 8.8.8.8
 domain-name RECOMP2526M1A06.recomp.com
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.

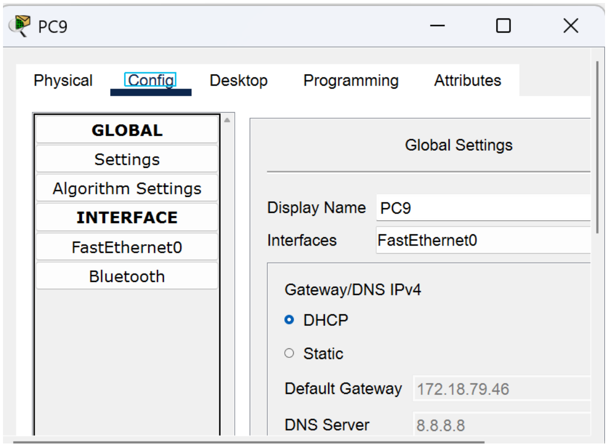

Figure 4.3: Demonstration of PC9 DNS and your Default-Gateway

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

```
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.

```
ip route 172.18.79.0 255.255.255.224 193.136.60.147
ip route 172.18.79.32 255.255.255.240 193.136.60.147
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.

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