

# Lab Assignment: Infrastructure as Code

## Large Systems Course

**Date:** 11-11-2024

**Author:** Diogo Marques

### Version Control

The repository for this lab assignment can be accessed [here](#). It contains all source files used for configuring the virtual machines and services.

The screenshot shows a GitLab project interface for 'large-systems'. The project was created on November 11, 2024, and has 1 commit, 1 branch, and 0 tags. The README file contains the following content:

```
LS Lab Assignment: Infrastructure as Code

author: Diogo Marques
date: 11-11-2024
supervisor: Paul Daniëlse
```

The 'Getting started' section provides instructions for cloning the repository:

```
cd existing_repo
git remote add origin https://gitlab.os3.nl/dmarques/large-systems.git
git branch -M main
git push -uf origin main
```

### Source Files

## Environment

This lab assignment was completed using two KVM virtual machines with Ubuntu Linux, configured during Lab 2.

Virtual Machine	Role
<b>Guest-01</b>	DNS, DHCP, and Mail Server
<b>Guest-02</b>	Web Server

```
[root@tallinn:/home/dmarques# virsh list --all
 Id   Name      State
 -----
 97   Guest-01  running
 98   Guest-02  running
```

### Virtual Machines

## Ansible Configuration

Ansible was used to automate the setup and configuration of services across the virtual machines. This approach ensures repeatability, reduces human error, and simplifies infrastructure management.

#### Students Database A database of student user accounts was defined and referenced for the configuration of home pages, mailboxes, and other services.

```

1 Student_ID,Full_Name,Age,Major,Username
2 S001,Alice Johnson,19,Data Science,ajohnson
3 S002,Ethan Walker,20,Cybersecurity,ewalker
4 S003,Mia Thompson,21,Information Technology,mthompson
5 S004,Lucas Martinez,22,Computer Science,lmartinez
6 S005,Ella Robinson,20,Software Engineering,erobinson
7 S006,Alexander Lee,21,Artificial Intelligence,alee
8 S007,Aria Lewis,22,Web Development,alewis
9 S008,Benjamin Scott,23,Game Design,bscott
10 S009,Chloe Hill,19,Network Security,chill
11 S010,Daniel Adams,20,Cloud Computing,dadams

```

#### Students Servers Database A CSV file was used to configure IP addresses, MAC addresses, and DNS entries for the student servers and their DRAC interfaces.

```

1 ServiceTag,MainMACAddress,DRACMACAddress
2 A00001,16:ab:ee:00:01:01,17:ab:ff:00:01:01
3 B00002,16:ab:ee:00:02:02,17:ab:ff:00:02:02
4 C00003,16:ab:ee:00:03:03,17:ab:ff:00:03:03
5 D00004,16:ab:ee:00:04:04,17:ab:ff:00:04:04
6 E00005,16:ab:ee:00:05:05,17:ab:ff:00:05:05
7 F00006,16:ab:ee:00:06:06,17:ab:ff:00:06:06
8 G00007,16:ab:ee:00:07:07,17:ab:ff:00:07:07
9 H00008,16:ab:ee:00:08:08,17:ab:ff:00:08:08
10 I00009,16:ab:ee:00:09:09,17:ab:ff:00:09:09
11 J00010,16:ab:ee:00:0a:0a,17:ab:ff:00:0a:0a
12 K00011,16:ab:ee:00:0b:0b,17:ab:ff:00:0b:0b
13 L00012,16:ab:ee:00:0c:0c,17:ab:ff:00:0c:0c
14 M00013,16:ab:ee:00:0d:0d,17:ab:ff:00:0d:0d
15 N00014,16:ab:ee:00:0e:0e,17:ab:ff:00:0e:0e
16 O00015,16:ab:ee:00:0f:0f,17:ab:ff:00:0f:0f
17 P00016,16:ab:ee:00:10:10,17:ab:ff:00:10:10
18 Q00017,16:ab:ee:00:11:11,17:ab:ff:00:11:11
19 R00018,16:ab:ee:00:12:12,17:ab:ff:00:12:12
20 S00019,16:ab:ee:00:13:13,17:ab:ff:00:13:13
21 T00020,16:ab:ee:00:14:14,17:ab:ff:00:14:14
22 U00021,16:ab:ee:00:15:15,17:ab:ff:00:15:15
23 V00022,16:ab:ee:00:16:16,17:ab:ff:00:16:16
24 W00023,16:ab:ee:00:17:17,17:ab:ff:00:17:17
25 X00024,16:ab:ee:00:18:18,17:ab:ff:00:18:18
26 Y00025,16:ab:ee:00:19:19,17:ab:ff:00:19:19

```

#### Ansible Inventory The inventory includes the IPs for the virtual machines and groups for DNS, DHCP, and other services.

```

1 all:
2   hosts:
3     guest01:
4       ansible_host: 145.100.106.194
5       ansible_user: marques
6       ansible_python_interpreter: /usr/bin/python3
7     guest02:
8       ansible_host: 145.100.106.195
9       ansible_user: marques
10    children:
11      dns_server:
12        hosts:
13          guest01:
14      dhcp_server:
15        hosts:
16          guest01:
17      mail_server:
18        hosts:
19          guest01:
20      web_server:
21        hosts:
22          guest02:
23      students:
24        hosts:
25          student1:
26            username: student1
27          student2:
28            username: student2
29          student3:
30            username: student3

```

#### Ansible Playbook The playbook was modularized to include tasks for each service, ensuring reusability and clarity.

```

1 - name: Configure CSR infrastructure
2   hosts: "all:!students"
3   become: yes
4   roles:
5     - role: ntp
6     - role: dns_server
7       when: "'dns_server' in group_names"
8     - role: mail_server
9       when: "'mail_server' in group_names"
10    - role: web_server
11      when: "'web_server' in group_names"
12    - role: dhcp_server
13      when: "'dhcp_server' in group_names"
14

```

## Deployment of Infrastructure

Web Server and DNS Verification Web Server:

Hosted on Guest-02, running Apache. The server hosts the main page for the master's program at [www.csr4.nl](http://www.csr4.nl), accessible via DNS resolution. Individual student pages are auto-generated and accessible under [www.csr4.nl/students/](http://www.csr4.nl/students/). Verification:

```

root@Guest-02:/home/marques# ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
        inet 127.0.0.1/8 scope host lo
            valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp1s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 52:54:00:08:e4:1a brd ff:ff:ff:ff:ff:ff
        inet 145.100.106.194/28 brd 145.100.106.207 scope global enp1s0
            valid_lft forever preferred_lft forever
        inet6 fe80::5054:ff:fe:21:13e6/64 scope link
            valid_lft forever preferred_lft forever
root@Guest-02:/home/marques# curl http://www.cs4.nl/
apache2.service - The Apache HTTP Server
   Loaded: loaded (/lib/systemd/system/apache2.service; enabled; vendor preset: enabled)
     Active: active (running) since Sat 2024-11-30 00:01:18 UTC; 32min ago
       Docs: http://httpd.apache.org/docs/2.4/
    Process: 238515 ExecStart=/usr/sbin/apache2 start (code=exited, status=0/SUCCESS)
   Main PID: 238519 (apache2)
      Tasks: 55 (limit: 2384)
     Memory: 5.808MiB
        CPU: 0ms
      CGroup: /system.slice/apache2.service
              ├─238519 /usr/sbin/apache2 -k start
              ├─238520 /usr/sbin/apache2 -k start
              ├─238521 /usr/sbin/apache2 -k start
              └─238522 /usr/sbin/apache2 -k start

Nov 30 00:01:07 Guest-02 systemd[1]: Starting The Apache HTTP Server...
Nov 30 00:01:10 Guest-02 apache2[238518]: AH00558: apache2: Could not reliably determine the server's fully qualified domain name, using 145.100.106.195. Set the 'ServerName' directive globally to suppress this warning
Nov 30 00:01:10 Guest-02 systemd[1]: Started The Apache HTTP Server.

<html>
<head>
<title>Welcome to www.cs4.nl</title>
</head>
<body>
<h1>Welcome to www.cs4.nl</h1>
</body>
</html>

```

The homepage loads correctly with a curl command, demonstrating the Apache and DNS configuration.

## Student Pages:

The student listing page and individual profiles were verified.

```

root@Guest-02:/home/marques# curl http://www.cs4.nl/students/
<!DOCTYPE HTML PUBLIC "-//IETF//DTD HTML 3.2 Final//EN">
<html>
<head>
<title>Index of /students</title>
</head>
<body>
<h1>Index of /students</h1>
<table border="0" style="width:100%; border-collapse: collapse; margin-top: 10px;">
|  |  |  |  |
| --- | --- | --- | --- |
|  | Name | Last modified | Size |
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```

## images/dns.png

### Mail Server Postfix + Dovecot Configuration:

Postfix: Handles SMTP for email delivery. Dovecot: Provides IMAP/POP3 for mailbox access. User accounts, mailboxes, and aliases were created dynamically using Ansible and Jinja2 templates.

```
TASK [mail_server : Install Postfix and Dovecot] ****
skipping: [guest02]
ok: [guest01]

TASK [mail_server : Set default session to XFCE4 for new users] ****
skipping: [guest02]
ok: [guest01]

TASK [mail_server : Deploy Postfix main.cf] ****
skipping: [guest02]
changed: [guest01]

TASK [mail_server : Deploy transport map] ****
skipping: [guest02]
ok: [guest01]

TASK [mail_server : Generate transport map database] ****
skipping: [guest02]
ok: [guest01]

TASK [mail_server : Generate a self-signed SSL certificate] ****
skipping: [guest02]
ok: [guest01]

TASK [mail_server : Set secure permissions on the private key] ****
skipping: [guest02]
ok: [guest01]

TASK [mail_server : Verify the SSL files are created] ****
skipping: [guest02]
ok: [guest01]

TASK [mail_server : Debug certificate creation status] ****
ok: [guest01] => {
  "msg": "SSL certificate exists: True"
}
skipping: [guest02]

TASK [mail_server : Ensure Dovecot is enabled and started] ****
skipping: [guest02]
ok: [guest01]

TASK [mail_server : Configure Dovecot main configuration file] ****
skipping: [guest02]
ok: [guest01]

TASK [mail_server : Configure Dovecot IMAP and POP3 protocols] ****
skipping: [guest02]
changed: [guest01]

TASK [mail_server : Configure Dovecot authentication] ****
skipping: [guest02]
ok: [guest01]

TASK [mail_server : Configure SSL for Dovecot] ****
skipping: [guest02]
ok: [guest01]
```

```

TASK [mail_server : Create student accounts] *****
skipping: [guest02]
ok: [guest01] => (item={'student_id': 'S001', 'full_name': 'Alice Johnson', 'age': '19', 'major': 'Data Science', 'username': 'ajohnson'})
ok: [guest01] => (item={'student_id': 'S002', 'full_name': 'Ethan Walker', 'age': '20', 'major': 'Cybersecurity', 'username': 'ewalker'})
ok: [guest01] => (item={'student_id': 'S003', 'full_name': 'Mia Thompson', 'age': '20', 'major': 'Information Technology', 'username': 'mthompson'})
ok: [guest01] => (item={'student_id': 'S004', 'full_name': 'Lucas Martinez', 'age': '22', 'major': 'Computer Science', 'username': 'lmartinez'})
ok: [guest01] => (item={'student_id': 'S005', 'full_name': 'Ella Robinson', 'age': '20', 'major': 'Software Engineering', 'username': 'erobinson'})
ok: [guest01] => (item={'student_id': 'S006', 'full_name': 'Alexander Lee', 'age': '21', 'major': 'Artificial Intelligence', 'username': 'alee'})
ok: [guest01] => (item={'student_id': 'S007', 'full_name': 'Aria Lewis', 'age': '22', 'major': 'Web Development', 'username': 'alewis'})
ok: [guest01] => (item={'student_id': 'S008', 'full_name': 'Benjamin Scott', 'age': '23', 'major': 'Game Design', 'username': 'bscott'})
ok: [guest01] => (item={'student_id': 'S009', 'full_name': 'Chloe Hill', 'age': '19', 'major': 'Network Security', 'username': 'chill'})
ok: [guest01] => (item={'student_id': 'S010', 'full_name': 'Daniel Adams', 'age': '20', 'major': 'Cloud Computing', 'username': 'dadams'})

TASK [mail_server : Set passwords for student accounts] *****
skipping: [guest02]
changed: [guest01] => (item={'student_id': 'S001', 'full_name': 'Alice Johnson', 'age': '19', 'major': 'Data Science', 'username': 'ajohnson'})
changed: [guest01] => (item={'student_id': 'S002', 'full_name': 'Ethan Walker', 'age': '20', 'major': 'Cybersecurity', 'username': 'ewalker'})
changed: [guest01] => (item={'student_id': 'S003', 'full_name': 'Mia Thompson', 'age': '21', 'major': 'Information Technology', 'username': 'mthompson'})
changed: [guest01] => (item={'student_id': 'S004', 'full_name': 'Lucas Martinez', 'age': '22', 'major': 'Computer Science', 'username': 'lmartinez'})
changed: [guest01] => (item={'student_id': 'S005', 'full_name': 'Ella Robinson', 'age': '20', 'major': 'Software Engineering', 'username': 'erobinson'})
changed: [guest01] => (item={'student_id': 'S006', 'full_name': 'Alexander Lee', 'age': '21', 'major': 'Artificial Intelligence', 'username': 'alee'})
changed: [guest01] => (item={'student_id': 'S007', 'full_name': 'Aria Lewis', 'age': '22', 'major': 'Web Development', 'username': 'alewis'})
changed: [guest01] => (item={'student_id': 'S008', 'full_name': 'Benjamin Scott', 'age': '23', 'major': 'Game Design', 'username': 'bscott'})
changed: [guest01] => (item={'student_id': 'S009', 'full_name': 'Chloe Hill', 'age': '19', 'major': 'Network Security', 'username': 'chill'})
changed: [guest01] => (item={'student_id': 'S010', 'full_name': 'Daniel Adams', 'age': '20', 'major': 'Cloud Computing', 'username': 'dadams'})

TASK [mail_server : Ensure Maildir exists] *****
skipping: [guest02]
ok: [guest01] => (item={'student_id': 'S001', 'full_name': 'Alice Johnson', 'age': '19', 'major': 'Data Science', 'username': 'ajohnson'})
ok: [guest01] => (item={'student_id': 'S002', 'full_name': 'Ethan Walker', 'age': '20', 'major': 'Cybersecurity', 'username': 'ewalker'})
ok: [guest01] => (item={'student_id': 'S003', 'full_name': 'Mia Thompson', 'age': '21', 'major': 'Information Technology', 'username': 'mthompson'})
ok: [guest01] => (item={'student_id': 'S004', 'full_name': 'Lucas Martinez', 'age': '22', 'major': 'Computer Science', 'username': 'lmartinez'})
ok: [guest01] => (item={'student_id': 'S005', 'full_name': 'Ella Robinson', 'age': '20', 'major': 'Software Engineering', 'username': 'erobinson'})
ok: [guest01] => (item={'student_id': 'S006', 'full_name': 'Alexander Lee', 'age': '21', 'major': 'Artificial Intelligence', 'username': 'alee'})
ok: [guest01] => (item={'student_id': 'S007', 'full_name': 'Aria Lewis', 'age': '22', 'major': 'Web Development', 'username': 'alewis'})
ok: [guest01] => (item={'student_id': 'S008', 'full_name': 'Benjamin Scott', 'age': '23', 'major': 'Game Design', 'username': 'bscott'})
ok: [guest01] => (item={'student_id': 'S009', 'full_name': 'Chloe Hill', 'age': '19', 'major': 'Network Security', 'username': 'chill'})
ok: [guest01] => (item={'student_id': 'S010', 'full_name': 'Daniel Adams', 'age': '20', 'major': 'Cloud Computing', 'username': 'dadams'})

TASK [mail_server : Generate aliases dynamically] *****
skipping: [guest02]
ok: [guest01] => (item={'student_id': 'S001', 'full_name': 'Alice Johnson', 'age': '19', 'major': 'Data Science', 'username': 'ajohnson'})
ok: [guest01] => (item={'student_id': 'S002', 'full_name': 'Ethan Walker', 'age': '20', 'major': 'Cybersecurity', 'username': 'ewalker'})
ok: [guest01] => (item={'student_id': 'S003', 'full_name': 'Mia Thompson', 'age': '21', 'major': 'Information Technology', 'username': 'mthompson'})
ok: [guest01] => (item={'student_id': 'S004', 'full_name': 'Lucas Martinez', 'age': '22', 'major': 'Computer Science', 'username': 'lmartinez'})
ok: [guest01] => (item={'student_id': 'S005', 'full_name': 'Ella Robinson', 'age': '20', 'major': 'Software Engineering', 'username': 'erobinson'})
ok: [guest01] => (item={'student_id': 'S006', 'full_name': 'Alexander Lee', 'age': '21', 'major': 'Artificial Intelligence', 'username': 'alee'})
ok: [guest01] => (item={'student_id': 'S007', 'full_name': 'Aria Lewis', 'age': '22', 'major': 'Web Development', 'username': 'alewis'})
ok: [guest01] => (item={'student_id': 'S008', 'full_name': 'Benjamin Scott', 'age': '23', 'major': 'Game Design', 'username': 'bscott'})
ok: [guest01] => (item={'student_id': 'S009', 'full_name': 'Chloe Hill', 'age': '19', 'major': 'Network Security', 'username': 'chill'})
ok: [guest01] => (item={'student_id': 'S010', 'full_name': 'Daniel Adams', 'age': '20', 'major': 'Cloud Computing', 'username': 'dadams'})

TASK [mail_server : Populate /etc/aliases] *****
skipping: [guest02]
ok: [guest01]

TASK [mail_server : Run new aliases] *****
skipping: [guest02]
changed: [guest01]

```

## Verification:

Emails were sent successfully using mailutils to student accounts. Logs were checked to confirm message delivery.

```

TASK [mail_server : Ensure Postfix is running] *****
skipping: [guest02]
ok: [guest01]

TASK [mail_server : Ensure Dovecot is running] *****
skipping: [guest02]
ok: [guest01]

TASK [mail_server : Install Mailutils] *****
skipping: [guest02]
ok: [guest01]

TASK [mail_server : Verify student user accounts are created] *****
skipping: [guest02]
ok: [guest01] => (item={'student_id': 'S001', 'full_name': 'Alice Johnson', 'age': '19', 'major': 'Data Science', 'username': 'ajohnson'})
ok: [guest01] => (item={'student_id': 'S002', 'full_name': 'Ethan Walker', 'age': '20', 'major': 'Cybersecurity', 'username': 'ewalker'})
ok: [guest01] => (item={'student_id': 'S003', 'full_name': 'Mia Thompson', 'age': '21', 'major': 'Information Technology', 'username': 'mthompson'})
ok: [guest01] => (item={'student_id': 'S004', 'full_name': 'Lucas Martinez', 'age': '22', 'major': 'Computer Science', 'username': 'lmartinez'})
ok: [guest01] => (item={'student_id': 'S005', 'full_name': 'Ella Robinson', 'age': '20', 'major': 'Software Engineering', 'username': 'erobinson'})
ok: [guest01] => (item={'student_id': 'S006', 'full_name': 'Alexander Lee', 'age': '21', 'major': 'Artificial Intelligence', 'username': 'alee'})
ok: [guest01] => (item={'student_id': 'S007', 'full_name': 'Aria Lewis', 'age': '22', 'major': 'Web Development', 'username': 'alewis'})
ok: [guest01] => (item={'student_id': 'S008', 'full_name': 'Benjamin Scott', 'age': '23', 'major': 'Game Design', 'username': 'bscott'})
ok: [guest01] => (item={'student_id': 'S009', 'full_name': 'Chloe Hill', 'age': '19', 'major': 'Network Security', 'username': 'chill'})
ok: [guest01] => (item={'student_id': 'S010', 'full_name': 'Daniel Adams', 'age': '20', 'major': 'Cloud Computing', 'username': 'dadams'})

TASK [mail_server : Display user creation test results] *****
skipping: [guest02]
ok: [guest01] => (item{'changed': False, 'stdout': 'walker@x1086:~$ /home/ajohnson/bin/bash', 'stderr': '', 'rc': 0, 'cmd': 'grep "ajohnson" /etc/passwd', 'start': '2024-11-30 00:51:28.748836', 'end': '2024-11-30 00:51:28.748835', 'delta': '0:00:00.000105', 'msg': '', 'invocation': {'module_args': {'raw_params': 'true', 'raw_username': 'ajohnson', 'uses_shell': True, 'expand_argument_vars': True}, 'stdin': 'stidn_lines: []', 'stdout': 'stidn_lines: ["ajohnson:x:1086:1087:/home/ajohnson:/bin/bash"]', 'stderr': 'stidn_lines: []', 'failed': False, 'failed_when_result': False, 'item': {'student_id': 'S001', 'full_name': 'Alice Johnson', 'age': '19', 'major': 'Data Science', 'username': 'ajohnson'}, 'ansible_loop_var': 'item'}) => (
    msg: "User ('student_id': 'S001', 'full_name': 'Alice Johnson', 'age': '19', 'major': 'Data Science', 'username': 'ajohnson') exists: True"
)
ok: [guest01] => (item{'changed': False, 'stdout': 'walker@x1086:~$ /home/ewalker/bin/bash', 'stderr': '', 'rc': 0, 'cmd': 'grep "ewalker" /etc/passwd', 'start': '2024-11-30 00:51:28.938918', 'end': '2024-11-30 00:51:28.938843', 'delta': '0:00:00.002935', 'msg': '', 'invocation': {'module_args': {'raw_params': 'true', 'raw_username': 'ewalker', 'uses_shell': True, 'expand_argument_vars': True}, 'stdin': 'stidn_lines: []', 'stdout': 'stidn_lines: ["ewalker:x:1086:1087:/home/ewalker:/bin/bash"]', 'stderr': 'stidn_lines: []', 'failed': False, 'failed_when_result': False, 'item': {'student_id': 'S002', 'full_name': 'Ethan Walker', 'age': '20', 'major': 'Cybersecurity', 'username': 'ewalker'}, 'ansible_loop_var': 'item'}) => (
    msg: "User ('student_id': 'S002', 'full_name': 'Ethan Walker', 'age': '20', 'major': 'Cybersecurity', 'username': 'ewalker') exists: True"
)
ok: [guest01] => (item{'changed': False, 'stdout': 'thompson@x1086:~$ /home/mthompson/bin/bash', 'stderr': '', 'rc': 0, 'cmd': 'grep "mthompson" /etc/passwd', 'start': '2024-11-30 00:51:29.122888', 'end': '2024-11-30 00:51:29.122887', 'delta': '0:00:00.000101', 'msg': '', 'invocation': {'module_args': {'raw_params': 'true', 'raw_username': 'mthompson', 'uses_shell': True, 'expand_argument_vars': True}, 'stdin': 'stidn_lines: []', 'stdout': 'stidn_lines: ["mthompson:x:1086:1087:/home/mthompson:/bin/bash"]', 'stderr': 'stidn_lines: []', 'failed': False, 'failed_when_result': False, 'item': {'student_id': 'S003', 'full_name': 'Mia Thompson', 'age': '21', 'major': 'Information Technology', 'username': 'mthompson'}, 'ansible_loop_var': 'item'}) => (
    msg: "User ('student_id': 'S003', 'full_name': 'Mia Thompson', 'age': '21', 'major': 'Information Technology', 'username': 'mthompson') exists: True"
)
ok: [guest01] => (item{'changed': False, 'stdout': 'martinez@x1086:~$ /home/lmartinez/bin/bash', 'stderr': '', 'rc': 0, 'cmd': 'grep "lmartinez" /etc/passwd', 'start': '2024-11-30 00:51:29.319594', 'end': '2024-11-30 00:51:29.319593', 'delta': '0:00:00.000209', 'msg': '', 'invocation': {'module_args': {'raw_params': 'true', 'raw_username': 'lmartinez', 'uses_shell': True, 'expand_argument_vars': True}, 'stdin': 'stidn_lines: []', 'stdout': 'stidn_lines: ["lmartinez:x:1086:1087:/home/lmartinez:/bin/bash"]', 'stderr': 'stidn_lines: []', 'failed': False, 'failed_when_result': False, 'item': {'student_id': 'S004', 'full_name': 'Lucas Martinez', 'age': '22', 'major': 'Computer Science', 'username': 'lmartinez'}, 'ansible_loop_var': 'item'}) => (
    msg: "User ('student_id': 'S004', 'full_name': 'Lucas Martinez', 'age': '22', 'major': 'Computer Science', 'username': 'lmartinez') exists: True"
)
ok: [guest01] => (item{'changed': False, 'stdout': 'erobinson@x1086:~$ /home/erobinson/bin/bash', 'stderr': '', 'rc': 0, 'cmd': 'grep "erobinson" /etc/passwd', 'start': '2024-11-30 00:51:29.510788', 'end': '2024-11-30 00:51:29.510787', 'delta': '0:00:00.000101', 'msg': '', 'invocation': {'module_args': {'raw_params': 'true', 'raw_username': 'erobinson', 'uses_shell': True, 'expand_argument_vars': True}, 'stdin': 'stidn_lines: []', 'stdout': 'stidn_lines: ["erobinson:x:1086:1087:/home/erobinson:/bin/bash"]', 'stderr': 'stidn_lines: []', 'failed': False, 'failed_when_result': False, 'item': {'student_id': 'S005', 'full_name': 'Ella Robinson', 'age': '20', 'major': 'Software Engineering', 'username': 'erobinson'}, 'ansible_loop_var': 'item'}) => (
    msg: "User ('student_id': 'S005', 'full_name': 'Ella Robinson', 'age': '20', 'major': 'Software Engineering', 'username': 'erobinson') exists: True"
)

TASK [mail_server : Send test email to each student] *****
skipping: [guest02]
ok: [guest01] => (item={'student_id': 'S001', 'full_name': 'Alice Johnson', 'age': '19', 'major': 'Data Science', 'username': 'ajohnson'})
ok: [guest01] => (item={'student_id': 'S002', 'full_name': 'Ethan Walker', 'age': '20', 'major': 'Cybersecurity', 'username': 'ewalker'})
ok: [guest01] => (item={'student_id': 'S003', 'full_name': 'Mia Thompson', 'age': '21', 'major': 'Information Technology', 'username': 'mthompson'})
ok: [guest01] => (item={'student_id': 'S004', 'full_name': 'Lucas Martinez', 'age': '22', 'major': 'Computer Science', 'username': 'lmartinez'})
ok: [guest01] => (item={'student_id': 'S005', 'full_name': 'Ella Robinson', 'age': '20', 'major': 'Software Engineering', 'username': 'erobinson'})
ok: [guest01] => (item={'student_id': 'S006', 'full_name': 'Alexander Lee', 'age': '21', 'major': 'Artificial Intelligence', 'username': 'alee'})
ok: [guest01] => (item={'student_id': 'S007', 'full_name': 'Aria Lewis', 'age': '22', 'major': 'Web Development', 'username': 'alewis'})
ok: [guest01] => (item={'student_id': 'S008', 'full_name': 'Benjamin Scott', 'age': '23', 'major': 'Game Design', 'username': 'bscott'})
ok: [guest01] => (item={'student_id': 'S009', 'full_name': 'Chloe Hill', 'age': '19', 'major': 'Network Security', 'username': 'chill'})
ok: [guest01] => (item={'student_id': 'S010', 'full_name': 'Daniel Adams', 'age': '20', 'major': 'Cloud Computing', 'username': 'dadams'})

```

## Configuration files for each service:

### Users

A complete list of student accounts was generated. Home directories were created for each student.

```
root@csr4:/home/marques# cut -d: -f1 /etc/passwd
root
daemon
bin
sys
sync
games
man
lp
mail
news
uucp
proxy
www-data
backup
list
irc
gnats
nobody
systemd-network
systemd-resolve
messagebus
systemd-timesync
syslog
_apt
tss
uuid
tcpdump
sshd
pollinate
landscape
fwupd-refresh
marques
lxd
ntp
bind
postfix
student1
student2
student3
dovecot
dovenull
student4
courier
rtkit
usbmux
avahi
saned
colord
pulse
dhcpcd
dnsmasq
cups-pk-helper
lightdm
whoopsie
geoclue
ajohnson
ewalker
mthompson
lmartinez
erobinson
alee
alewis
bscott
chill
```

### NTP

Time synchronization was configured to ensure accurate timestamps across the services.

```
[root@csr4:/home/marques# cat /etc/ntp.conf
# NTP configuration template (ntp.conf.j2)
driftfile /var/lib/ntp/ntp.drift

server 0.pool.ntp.org iburst
server 1.pool.ntp.org iburst
server 2.pool.ntp.org iburst

restrict -4 default kod notrap nomodify nopeer noquery
restrict -6 default kod notrap nomodify nopeer noquery
root@csr4:/home/marques#
```

## DNS

Zone files were extended to include entries for all students' machines and DRAC

```
[root@csr4:/home/marques# cat /etc/bind/named.conf.local
zone "csr4.nl" {
    type master;
    file "/etc/bind/zones/csr4.nl.zone";
};

[root@csr4:/home/marques# cat /etc/bind/zones
zones/      zones.rfc1918
[root@csr4:/home/marques# cat /etc/bind/zones/csr4.nl.zone
$TTL 86400
@ IN SOA ns1.csr4.nl. root.csr4.nl. (
                2024111801 ; Serial
                3600        ; Refresh
                1800        ; Retry
                1209600     ; Expire
                86400       ; Minimum TTL

@ IN NS ns1.csr4.nl.
ns1 IN A 145.100.106.194
mail IN A 145.100.106.194
www IN A 145.100.106.195
@ IN MX 10 mail.csr4.nl.

A00001.csr4.nl.    IN   A   10.0.127.101
drac.A00001.csr4.nl.    IN   A   10.0.42.101
B00002.csr4.nl.    IN   A   10.0.127.102
drac.B00002.csr4.nl.    IN   A   10.0.42.102
C00003.csr4.nl.    IN   A   10.0.127.103
drac.C00003.csr4.nl.    IN   A   10.0.42.103
D00004.csr4.nl.    IN   A   10.0.127.104
drac.D00004.csr4.nl.    IN   A   10.0.42.104
E00005.csr4.nl.    IN   A   10.0.127.105
drac.E00005.csr4.nl.    IN   A   10.0.42.105
F00006.csr4.nl.    IN   A   10.0.127.106
drac.F00006.csr4.nl.    IN   A   10.0.42.106
G00007.csr4.nl.    IN   A   10.0.127.107
drac.G00007.csr4.nl.    IN   A   10.0.42.107
H00008.csr4.nl.    IN   A   10.0.127.108
drac.H00008.csr4.nl.    IN   A   10.0.42.108
I00009.csr4.nl.    IN   A   10.0.127.109
drac.I00009.csr4.nl.    IN   A   10.0.42.109
J00010.csr4.nl.    IN   A   10.0.127.110
drac.J00010.csr4.nl.    IN   A   10.0.42.110
K00011.csr4.nl.    IN   A   10.0.127.111
drac.K00011.csr4.nl.    IN   A   10.0.42.111
L00012.csr4.nl.    IN   A   10.0.127.112
drac.L00012.csr4.nl.    IN   A   10.0.42.112
M00013.csr4.nl.    IN   A   10.0.127.113
drac.M00013.csr4.nl.    IN   A   10.0.42.113
N00014.csr4.nl.    IN   A   10.0.127.114
drac.N00014.csr4.nl.    IN   A   10.0.42.114
O00015.csr4.nl.    IN   A   10.0.127.115
drac.O00015.csr4.nl.    IN   A   10.0.42.115
P00016.csr4.nl.    IN   A   10.0.127.116
drac.P00016.csr4.nl.    IN   A   10.0.42.116
```

interfaces.

## Mail Server

### Postfix: Configured for SMTP.

```
root@csr4:/home/marques# cat /etc/postfix/main.cf
# See http://www.postfix.org/COMPATIBILITY_README.html -- default to 3.6 on
# fresh installs.
compatibility_level = 3.6

# TLS parameters
smtpd_tls_cert_file=/etc/ssl/certs/ssl-cert-snakeoil.pem
smtpd_tls_key_file=/etc/ssl/private/ssl-cert-snakeoil.key
smtpd_tls_security_level=may

smtpd_tls_CApath=/etc/ssl/certs
smtpd_tls_session_cache_database = btree:/var/lib/postfix/smtp_scache

smtpd_relay_restrictions = permit_mynetworks permit_sasl_authenticated defer_unauth_destination
mydomain = csr4.nl
myorigin = csr4.nl
relay_domains = csr4.nl
myhostname = csr4.nl
alias_maps = hash:/etc/aliases
alias_database = hash:/etc/aliases
mydestination = mail.csr4.nl, localhost.mail.csr4.nl, localhost, csr4.nl
relayhost =
mynetworks = 145.100.106.192/28
mailbox_transport = local
mailbox_size_limit = 0
recipient_delimiter = +
inet_interfaces = all
inet_protocols = ipv4
home_mailbox = Maildir/

# Transport maps
transport_maps = hash:/etc/postfix/transport

debug_peer_level = 2
debug_peer_list = 127.0.0.1
[root@csr4:/home/marques# cat /etc/postfix/transport
csr4.nl smtp:[145.100.106.194]
```

### Dovecot: Configured for mailbox access.

```
root@csr4:/home/marques# cat /etc/dovecot/dovecot.conf
protocols = imap pop3
mail_location = maildir:~/Maildir
disable_plaintext_auth = yes
ssl = required
ssl_cert = /etc/ssl/certs/dovecot.pem
ssl_key = /etc/ssl/private/dovecot.key
[root@csr4:/home/marques# cat /etc/dovecot/conf.d/10-mail.conf
mail_location = maildir:~/Maildir
[root@csr4:/home/marques# cat /etc/dovecot/conf.d/10-auth.conf
disable_plaintext_auth = yes
auth_mechanisms = plain login
passdb {
    driver = pam
}
userdb {
    driver = passwd
}
[root@csr4:/home/marques# cat /etc/dovecot/conf.d/10-ssl.conf
ssl = required
ssl_cert = </etc/ssl/certs/dovecot.pem
ssl_key = </etc/ssl/private/dovecot.key
```

### Web Server

Apache was configured to host the main program page and student profiles.

```
[root@Guest-02:/home/marques# ls /etc/apache2/sites-available/
000-default.conf  default-ssl.conf  www.csr4.nl.conf
[root@Guest-02:/home/marques# cat /etc/apache2/sites-available/www.csr4.nl.conf
<VirtualHost *:80>
    ServerName www.csr4.nl
    DocumentRoot /var/www/www.csr4.nl

    <Directory /var/www/www.csr4.nl>
        Options Indexes FollowSymLinks
        AllowOverride None
        Require all granted
    </Directory>

    ErrorLog ${APACHE_LOG_DIR}/www.csr4.nl_error.log
    CustomLog ${APACHE_LOG_DIR}/www.csr4.nl_access.log combined
</VirtualHost>
[root@Guest-02:/home/marques# tree /var/www/www.csr4.nl
/var/www/www.csr4.nl
└── index.html
   └── students
      ├── ajohnson
      │   └── index.html
      ├── alee
      │   └── index.html
      ├── alewis
      │   └── index.html
      ├── bscott
      │   └── index.html
      ├── chill
      │   └── index.html
      ├── dadams
      │   └── index.html
      ├── erobinson
      │   └── index.html
      ├── ewalker
      │   └── index.html
      ├── lmartinez
      │   └── index.html
      ├── mthompson
      │   └── index.html
      ├── student1
      │   └── index.html
      ├── student2
      │   └── index.html
      └── student3
          └── index.html

14 directories, 14 files
[root@Guest-02:/home/marques# cat /var/www/www.csr4.nl/index.html
<html>
<head>
    <title>Welcome to www.csr4.nl</title>
</head>
<body>
    <h1>Welcome to www.csr4.nl!</h1>
</body>
</html>
[root@Guest-02:/home/marques# cat /var/www/www.csr4.nl/students/ewalker/index.html
<html>
    <head><title>ewalker's Home Page</title></head>
    <body>
        <h1>Welcome, ewalker!</h1>
        <p>This is the personal homepage for Closed Source Rules.</p>
    </body>
</html>
```

## DHCP

Subnets and static host configurations were included in dhcpcd.conf.

```
root@csr4:/# cat /etc/dhcp/dhcpcd.conf
# DHCP Configuration for CSR4 Network

default-lease-time 600;
max-lease-time 7200;
log-facility local7;

# Subnet for enp1s0 (145.100.106.192/28)
subnet 145.100.106.192 netmask 255.255.255.240 {
    # Dynamic range excludes 145.100.106.194, 145.100.106.195
    range 145.100.106.196 145.100.106.200;
    option routers 145.100.106.193;
    option domain-name-servers 145.100.106.194;
    option domain-name "csr4.nl";
}

# Subnet for desktops
subnet 10.0.0.0 netmask 255.255.255.0 {
    range 10.0.0.100 10.0.0.200;
    option routers 145.100.106.194;
    option domain-name-servers 145.100.106.194;
    option domain-name "csr4.nl";

    # Include host-specific configuration for desktops / servers / iDracs
    include "/etc/dhcp/dhcp_hosts.conf";
}

# Subnet for servers
subnet 10.0.127.0 netmask 255.255.255.0 {
    option routers 145.100.106.194;
    option domain-name-servers 145.100.106.194;
    option domain-name "csr4.nl";
}

# Subnet for DRAC interfaces
subnet 10.0.42.0 netmask 255.255.255.0 {
    option routers 145.100.106.194;
    option domain-name-servers 145.100.106.194;
    option domain-name "csr4.nl";
}

# Placeholder for future IPv6 configuration
# subnet6 2001:db8::/64 {
#     range6 2001:db8::1000 2001:db8::2000;
#     option dhcp6.name-servers 2001:db8::1;
#     option dhcp6.domain-search "csr4.nl";
# }
```

Interface configuration

```
root@csr4:/# cat /etc/default/isc-dhcp-server
# Defaults for isc-dhcp-server (sourced by /etc/init.d/isc-dhcp-server)

# Path to dhcpcd's config file (default: /etc/dhcp/dhcpcd.conf).
#DHCPDv4_CONF=/etc/dhcp/dhcpcd.conf
#DHCPDv6_CONF=/etc/dhcp/dhcpcd6.conf

# Path to dhcpcd's PID file (default: /var/run/dhcpcd.pid).
#DHCPDv4_PID=/var/run/dhcpcd.pid
#DHCPDv6_PID=/var/run/dhcpcd6.pid

# Additional options to start dhcpcd with.
#       Don't use options -cf or -pf here; use DHCPD_CONF/ DHCPD_PID instead
#OPTIONS=""

# On what interfaces should the DHCP server (dhcpcd) serve DHCP requests?
#       Separate multiple interfaces with spaces, e.g. "eth0 eth1".
INTERFACESv4="enp1s0"
INTERFACESv6=""
```

Hosts conf including student servers and idracs interfaces

```
root@csr4:/# cat /etc/dhcp/dhcp_hosts.conf
# Autogenerated DHCP host entries

host A00001 {
    hardware ethernet 16:ab:ee:00:01:01;
    fixed-address 10.0.0.100;
}

host A00001-drac {
    hardware ethernet 17:ab:ff:00:01:01;
    fixed-address 10.0.42.100;
}

host B00002 {
    hardware ethernet 16:ab:ee:00:02:02;
    fixed-address 10.0.0.101;
}

host B00002-drac {
    hardware ethernet 17:ab:ff:00:02:02;
    fixed-address 10.0.42.101;
}

host C00003 {
    hardware ethernet 16:ab:ee:00:03:03;
    fixed-address 10.0.0.102;
}

host C00003-drac {
    hardware ethernet 17:ab:ff:00:03:03;
    fixed-address 10.0.42.102;
}

host D00004 {
    hardware ethernet 16:ab:ee:00:04:04;
    fixed-address 10.0.0.103;
}

host D00004-drac {
    hardware ethernet 17:ab:ff:00:04:04;
    fixed-address 10.0.42.103;
}

host E00005 {
    hardware ethernet 16:ab:ee:00:05:05;
    fixed-address 10.0.0.104;
}

host E00005-drac {
    hardware ethernet 17:ab:ff:00:05:05;
    fixed-address 10.0.42.104;
}

host F00006 {
    hardware ethernet 16:ab:ee:00:06:06;
    fixed-address 10.0.0.105;
}

host F00006-drac {
```

## Reinstall after a fresh installation of new VMs.

After removing the virtual machines and reinitializing them, the Ansible playbooks were run again to validate the process. All services were installed and configured successfully.

Guest-01 Verification:

NTP, DNS, DHCP, Postfix, and Dovecot services were operational.

```
root@csr4:/home/marques# systemctl status ntp
● ntp.service - Network Time Service
   Loaded: loaded (/lib/systemd/system/ntp.service; enabled; vendor preset: enabled)
   Active: active (running) since Sat 2024-11-30 23:24:20 UTC; 1s ago
     Docs: man:ntpd(8)
   Process: 66124 ExecStart=/usr/lib/ntp/ntp-systemd-wrapper (code=exited, status=0/SUCCESS)
   Main PID: 66124 (ntpd)
      Tasks: 2 (l limit: 2384)
        Memory: 1.9M
       CPU: 18ms
      CGroup: /system.slice/ntp.service
           └─66130 /usr/sbin/ntpd -g -u 113:121

Nov 30 23:24:20 csr4.n1 ntpd[66130]: Listen and drop on 0 vwidard [:]:123
Nov 30 23:24:20 csr4.n1 ntpd[66130]: Listen and drop on 1 vwidard 0.0.0.1:123
Nov 30 23:24:20 csr4.n1 ntpd[66130]: Listen normally on 3 enp1s0 145.108.106.194:123
Nov 30 23:24:20 csr4.n1 ntpd[66130]: Listen normally on 4 lo [:]:123
Nov 30 23:24:20 csr4.n1 ntpd[66130]: Listen normally on 5 enp1s [fe80::5054:ff:fe08:41a%2]:123
Nov 30 23:24:20 csr4.n1 ntpd[66130]: Listening on routing socket on fd #22 for interface updates
Nov 30 23:24:20 csr4.n1 ntpd[66130]: Listening on socket /var/run/ntp/ntpctrl:2841: Client synchronized
Nov 30 23:24:20 csr4.n1 ntpd[66130]: kernel reports TIME_ERROR: 0x2841: Clock Unsynchonized
Nov 30 23:24:20 csr4.n1 systemd[1]: Started Network Time Service.

root@csr4:/home/marques# systemctl status bind9
● named.service - BIND Domain Name Server
   Loaded: loaded (/lib/systemd/system/named.service; enabled; vendor preset: enabled)
   Active: active (running) since Sat 2024-11-30 00:30:54 UTC; 22h ago
     Docs: man:named(8)
   Main PID: 44694 (named)
      Tasks: 8 (l limit: 2384)
        Memory: 8.1M
       CPU: 5.948s
      CGroup: /system.slice/named.service
           └─44694 /usr/sbin/named -u bind

Nov 30 23:11:37 csr4.n1 named[44694]: network unreachable resolving 'xyphen.it/DS/IN': 2a00:1620:c0:220:194:119:192:34#53
Nov 30 23:11:38 csr4.n1 named[44694]: success resolving 'hosted.by.xyphen.it/A' after disabling qname minimization due to 'cache nxdomain'
Nov 30 23:12:33 csr4.n1 named[44694]: listening on IPv4 interface enp1s0, 145.108.106.194#53
Nov 30 23:12:33 csr4.n1 named[44694]: no longer listening on 145.108.106.194#53
Nov 30 23:12:33 csr4.n1 named[44694]: listening on IPv4 interface enp1s0, 145.108.106.194#53
Nov 30 23:12:34 csr4.n1 named[44694]: no longer listening on 145.108.106.194#53
Nov 30 23:12:34 csr4.n1 named[44694]: listening on IPv4 interface enp1s0, 145.108.106.194#53
Nov 30 23:12:34 csr4.n1 named[44694]: no longer listening on 145.108.106.194#53
Nov 30 23:12:34 csr4.n1 named[44694]: listening on IPv4 interface enp1s0, 145.108.106.194#53

root@csr4:/home/marques# systemctl status isc-dhcp-server
● isc-dhcp-server.service - ISC DHCP IPv4 server
   Loaded: loaded (/lib/systemd/system/isc-dhcp-server.service; enabled; vendor preset: enabled)
   Active: active (running) since Fri 2024-11-29 10:00:51 UTC; 1 day 13h ago
     Docs: man:dhcpcd(8)
   Main PID: 526 (dhcpcd)
      Tasks: 4 (l limit: 2384)
        Memory: 6.3M
       CPU: 1.894s
      CGroup: /system.slice/isc-dhcp-server.service
           └─526 dhcpcd -user dhcpcd -group dhcpcd -f -4 -pf /run/dhcp-server/dhcpcd.pid -cf /etc/dhcp/dhcpcd.conf enp1s0

Nov 29 10:00:51 csr4.n1 dhcpcd[526]: Wrote 0 deleted host decls to leases file.
Nov 29 10:00:51 csr4.n1 dhcpcd[526]: Wrote 0 new dynamic host decls to leases file.
Nov 29 10:00:51 csr4.n1 dhcpcd[526]: Listening on LPI/enp1s0/52:54:00:08:e4:1a/145.108.106.192/28
Nov 29 10:00:51 csr4.n1 sh[526]: Listening on LPI/enp1s0/52:54:00:08:e4:1a/145.108.106.192/28
Nov 29 10:00:51 csr4.n1 sh[526]: Sending on LPI/enp1s0/52:54:00:08:e4:1a/145.108.106.192/28
Nov 29 10:00:51 csr4.n1 sh[526]: Sending on Socket/fallback-net
Nov 29 10:00:51 csr4.n1 dhcpcd[526]: Listening on LPI/enp1s0/52:54:00:08:e4:1a/145.108.106.192/28
Nov 29 10:00:51 csr4.n1 dhcpcd[526]: Sending on Socket/fallback-net
Nov 29 10:00:51 csr4.n1 dhcpcd[526]: Server starting service.

root@csr4:/home/marques# systemctl status postfix
● postfix.service - Postfix Mail Transport Agent
   Loaded: loaded (/lib/systemd/system/postfix.service; enabled; vendor preset: enabled)
   Active: active (running) since Sat 2024-11-30 23:12:36 UTC; 7min ago
     Docs: man:postfix(1)
   Process: 44254 ExecStart=/bin/true (code=exited, status=0/SUCCESS)
   Main PID: 65584 (code=exited, status=0/SUCCESS)
      CPU: 980us

Nov 30 23:12:36 csr4.n1 systemd[1]: Starting Postfix Mail Transport Agent...
Nov 30 23:12:36 csr4.n1 systemd[1]: Finished Postfix Mail Transport Agent.

root@csr4:/home/marques# systemctl status dovecot
● dovecot.service - Dovecot IMAP/POP email server
   Loaded: loaded (/lib/systemd/system/dovecot.service; enabled; vendor preset: enabled)
   Active: active (running) since Sat 2024-11-30 00:11:25 UTC; 23h ago
     Docs: man:dovecot(1)
       https://doc.dovecot.org/
   Main PID: 44254 (dovecot)
   Status: "v2.16 (7e9e00c1a) running"
   Tasks: 4 (l limit: 2384)
     Memory: 6.1M
       CPU: 1.895s
      CGroup: /system.slice/dovecot.service
           ├─44255 dovecot -u 113
           ├─44256 dovecot -u 113
           ├─44256 dovecot/log
           └─44257 dovecot/config
           └─44728 dovecot/stats

Nov 30 23:12:36 csr4.n1 systemd[1]: Starting Postfix Mail Transport Agent...
Nov 30 23:12:36 csr4.n1 systemd[1]: Finished Postfix Mail Transport Agent.

root@csr4:/home/marques# systemctl status dovecot
● dovecot.service - Dovecot IMAP/POP email server
   Loaded: loaded (/lib/systemd/system/dovecot.service; enabled; vendor preset: enabled)
   Active: active (running) since Sat 2024-11-30 00:11:25 UTC; 23h ago
     Docs: man:dovecot(1)
       https://doc.dovecot.org/
   Main PID: 44254 (dovecot)
   Status: "v2.16 (7e9e00c1a) running"
   Tasks: 4 (l limit: 2384)
     Memory: 6.1M
       CPU: 1.895s
      CGroup: /system.slice/dovecot.service
           ├─44255 dovecot -u 113
           ├─44256 dovecot -u 113
           ├─44256 dovecot/log
           └─44257 dovecot/config
           └─44728 dovecot/stats
```

## Guest-02 Verification:

The web server was operational and serving content correctly.

```
root@Guest-02:/home/marques# systemctl status ntp
● ntp.service - Network Time Service
   Loaded: loaded (/lib/systemd/system/ntp.service; enabled; vendor preset: enabled)
   Active: active (running) since Thu 2024-11-14 23:44:31 UTC; 2 weeks 1 day ago
     Docs: man:ntpd(8)
   Main PID: 66124 (ntpd)
      Tasks: 2 (l limit: 2384)
        Memory: 1.6M
       CPU: 1m56.63307s
      CGroup: /system.slice/ntp.service
           └─66130 /usr/sbin/ntpd -g -u 113:121

Nov 24 11:20:11 Guest-02 ntpd[66130]: 185.224.146.6 local addr 145.108.106.195 -> <null>
Notice: journal has been rotated since unit was started, output may be incomplete.

root@Guest-02:/home/marques# systemctl status apache2
● apache2.service - The Apache HTTP Server
   Loaded: loaded (/lib/systemd/system/apache2.service; enabled; vendor preset: enabled)
   Active: active (running) since Thu 2024-11-14 23:12:07 UTC; 2 weeks 1 day ago
     Docs: https://httpd.apache.org/docs/2.4/
   Process: 247614 ExecStart=/usr/sbin/apache2 start (code=exited, status=0/SUCCESS)
   Main PID: 247619 (apache2)
      Tasks: 55 (l limit: 2384)
        Memory: 978s
      CGroup: /system.slice/apache2.service
           ├─247619 /usr/sbin/apache2 -k start
           ├─247620 /usr/sbin/apache2 -k start
           ├─247621 /usr/sbin/apache2 -k start
           └─247622 /usr/sbin/apache2 -k start

Nov 30 23:12:37 Guest-02 systemd[1]: Starting The Apache HTTP Server...
Nov 30 23:12:37 Guest-02 apache2[247618]: AH00557: apache2: apr_sockaddr_info_get() failed for Guest-02
Nov 30 23:12:37 Guest-02 apache2[247618]: AH00558: apache2: Could not reliably determine the server's fully qualified domain name, using 127.0.0.1. Set the 'ServerName' directive globally to suppress this
Nov 30 23:12:37 Guest-02 systemd[1]: Started The Apache HTTP Server.
lines 1-18/18 (END)
```

## Conclusion

This lab assignment successfully demonstrated the use of Infrastructure as Code (IaC) principles to configure and deploy critical services for a simulated multi-user environment. The process emphasized the importance of automation, modularity, and scalability in managing large systems.

Key achievements include:

- automated deployment of DNS,

- automated deployment of DHCP,
- automated deployment of Mail,
- and automated deployment of Web services using Ansible.
- dynamic configuration of IP addresses and DNS entries for student servers and DRAC interfaces.
- verification of services with concrete tests for functionality.

The modular approach ensures the infrastructure is easy to extend and modify, providing a robust foundation for future scalability.