CLD - LAB06 : Infrastructure-as-code and configuration management - Terraform, Ansible and Gitlab

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In this lab, we are going to deploy a website running in the cloud and using Terraform and Ansible, tools that use the principle of infrastructure as code. We'll be using NGINX and Google Cloud technologies.

In the first part of this lab, we're going to provision the cloud infrastructure. In other words, we'll create the necessary resources on the cloud.

In the second part, we'll configure the virtual machine by installing a web server and configuration files. To do this, we'll use Ansible.

In the third part, which is optional, we'll use Terraform as a team. The solution will be to store the state of Terraform in a version control system.

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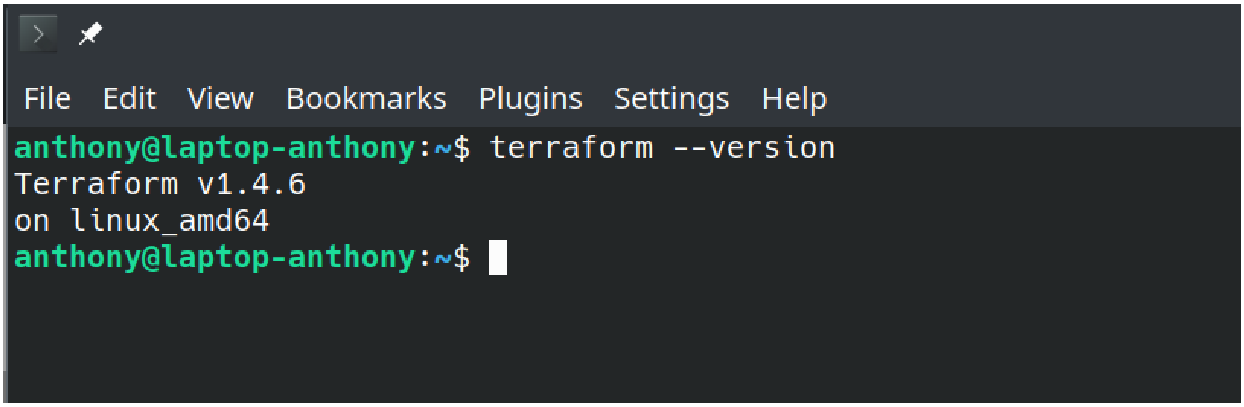
Task 1: Install Terraform

We installed Terraform on our laptop based on Ubuntu.

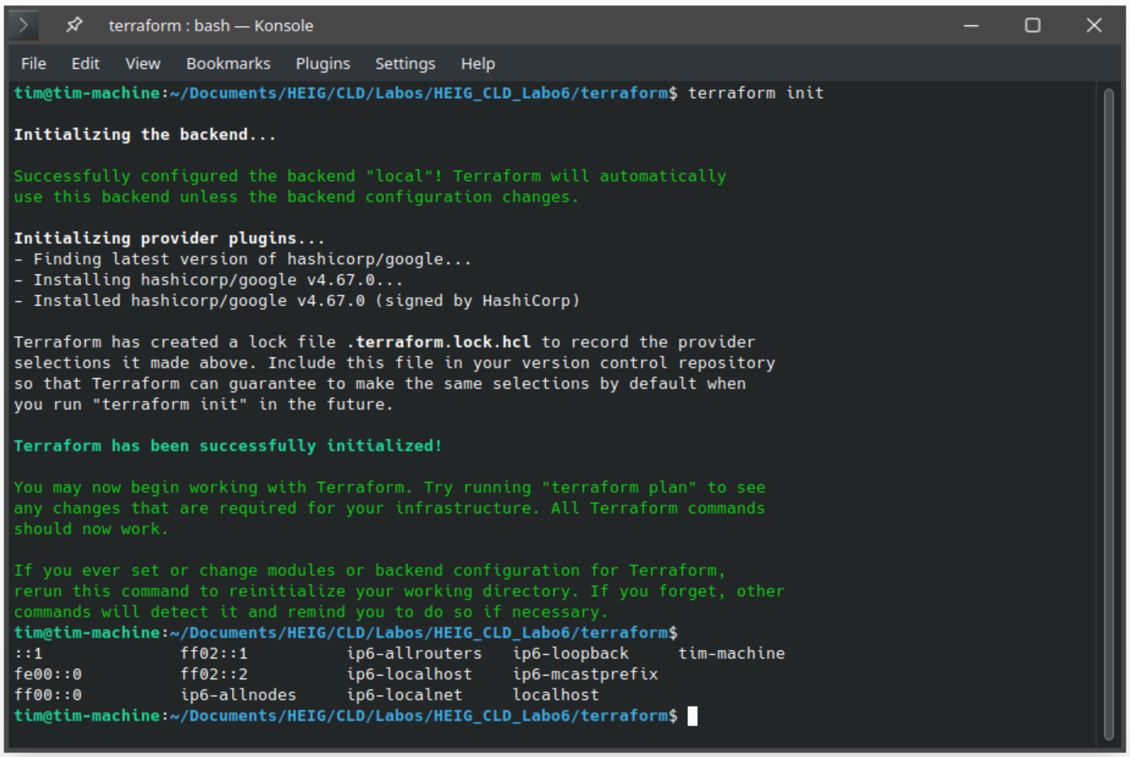


Task 2: Create a cloud infrastructure on Google Compute Engine with Terraform

The project-IDs :

- **labgce-388816** For Anthony account
- **labgce-388413** For Tim account

Firs, we added the variables values in the terraform.tfvar file. Then we initialized terraform:



Then, we created a terraform plan:

terraform : bash — Konsole

File Edit View Bookmarks Plugins Settings Help

```
tim@tim-machine:~/Documents/HEIG/CLD/Labos/HEIG_CLD_Labo6/terraform$ terraform plan -input=false -out=.terraform/plan.cache

Terraform used the selected providers to generate the following execution plan. Resource actions are
indicated with the following symbols:
  + create

Terraform will perform the following actions:

  # google_compute_firewall.http will be created
  + resource "google_compute_firewall" "http" {
      + creation_timestamp = (known after apply)
      + destination_ranges = (known after apply)
      + direction          = (known after apply)
      + enable_logging     = (known after apply)
      + id                 = (known after apply)
      + name               = "allow-http"
      + network            = "default"
      + priority           = 1000
      + project            = (known after apply)
      + self_link          = (known after apply)
      + source_ranges      = [
          + "0.0.0.0/0",
        ]

      + allow {
          + ports    = [
              + "80",
            ]
          + protocol = "tcp"
        }
    }

  # google_compute_firewall.ssh will be created
  + resource "google_compute_firewall" "ssh" {
      + creation_timestamp = (known after apply)
      + destination_ranges = (known after apply)
      + direction          = (known after apply)
      + enable_logging     = (known after apply)
      + id                 = (known after apply)
      + name               = "allow-ssh"
      + network            = "default"
      + priority           = 1000
      + project            = (known after apply)
      + self_link          = (known after apply)
      + source_ranges      = [
          + "0.0.0.0/0",
        ]

      + allow {
          + ports    = [
              + "22",
            ]
          + protocol = "tcp"
        }
    }

  # google_compute_instance.default will be created
  + resource "google_compute_instance" "default" {
      + can_ip_forward       = false
      + cpu_platform         = (known after apply)
      + current_status       = (known after apply)
      + deletion_protection  = false
      + guest_accelerator    = (known after apply)
      + id                   = (known after apply)
      + instance_id          = (known after apply)
      + label_fingerprint    = (known after apply)
      + machine_type         = "f1-micro"
      + metadata             = {
          + "ssh-keys" = <<-EOT
                cookie:ssh-ed25519 AAAAC3NzaC1lZDI1NTE5AAAAICY6AoT9fPtqaI6JiXf36Ntiz2BTT+Ibk/IcSq9UG+3/
            EOT
        }
      + metadata_fingerprint = (known after apply)
      + min_cpu_platform     = (known after apply)
      + name                 = "QuantumGigaByte"
      + project              = (known after apply)
      + self_link            = (known after apply)
      + tags_fingerprint     = (known after apply)
      + zone                 = "europe-west6-a"

      + boot_disk {
          + auto_delete                = true
          + device_name                = (known after apply)
          + disk_encryption_key_sha256 = (known after apply)
          + kms_key_self_link          = (known after apply)
          + mode                       = "READ_WRITE"
          + source                     = (known after apply)

          + initialize_params {
```

```
              + image  = "debian-cloud/debian-11"
              + labels = (known after apply)
              + size   = (known after apply)
              + type   = (known after apply)
            }
        }

      + network_interface {
          + ipv6_access_type   = (known after apply)
          + name               = (known after apply)
          + network            = "default"
          + network_ip         = (known after apply)
          + stack_type         = (known after apply)
          + subnetwork         = (known after apply)
          + subnetwork_project = (known after apply)

          + access_config {
              + nat_ip       = (known after apply)
              + network_tier = (known after apply)
            }
        }
    }

Plan: 3 to add, 0 to change, 0 to destroy.

Changes to Outputs:
  + gce_instance_ip = (known after apply)

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Saved the plan to: .terraform/plan.cache

To perform exactly these actions, run the following command to apply:
    terraform apply ".terraform/plan.cache"
```

Finally, we validated the plan:

```
tim@tim-machine:~/Documents/HEIG/CLD/Labos/HEIG_CLD_Labo6/terraform$ terraform apply -input=false .terraform/plan.cache
google_compute_instance.default: Creating...
google_compute_instance.default: Still creating... [10s elapsed]
google_compute_instance.default: Still creating... [20s elapsed]
google_compute_instance.default: Creation complete after 23s [id=projects/labgce-388413/zones/europe-west6-a/instances/cld-best-instance]

Apply complete! Resources: 1 added, 0 changed, 0 destroyed.

Outputs:

gce_instance_ip = "34.65.243.137"
```

> Explain the usage of each provided file and its contents by directly adding comments in the file as needed (we must ensure that you understood what you have done). In the file `variables.tf` fill the missing documentation parts and link to the online documentation. Copy the modified files to the report.

backend.tf:

```
terraform {
  backend "local" {
    # Local backend stores state files on the local filesystem
    # Adjust the backend configuration as needed (e.g., for remote state storage)
  }
}
```

main.tf:

```
# Defines the provider for Google Cloud Platform
provider "google" {
  project     = var.gcp_project_id  # The GCP project ID
  region      = "europe-west6-a"    # The desired region for resources
  credentials = file("${var.gcp_service_account_key_file_path}")  # Path to GCP
service account key file
}

# Resource: Google Compute Engine instance
resource "google_compute_instance" "default" {
  name         = var.gce_instance_name  # Name of the GCE instance
  machine_type = "f1-micro"             # Machine type for the instance
  zone         = "europe-west6-a"       # Zone for the instance

  metadata = {
    # Set the SSH key for the instance
    ssh-keys =
"${var.gce_instance_user}:${file("${var.gce_ssh_pub_key_file_path}")}"
  }

  # Boot disk image for the instance
  boot_disk {
    initialize_params {
      image = "debian-cloud/debian-11"
    }
  }

  # Network for the instance
  network_interface {
    network = "default"

    access_config {
      # Include this section to give the VM an external IP address
    }
  }
}

# Resource: Google Compute Engine firewall for SSH
resource "google_compute_firewall" "ssh" {
  name          = "allow-ssh"   # Name of the firewall rule
  network       = "default"     # Network for the firewall rule
  source_ranges = ["0.0.0.0/0"] # Source IP ranges allowed to access

  allow {
    ports    = ["22"]   # Allowed SSH port
    protocol = "tcp"   # Protocol for the firewall rule
  }
}

# Resource: Google Compute Engine firewall for HTTP
resource "google_compute_firewall" "http" {
  name          = "allow-http"   # Name of the firewall rule
```

```
  network       = "default"      # Network for the firewall rule
  source_ranges = ["0.0.0.0/0"]  # Source IP ranges allowed to access

  allow {
    ports    = ["80"]   # Allowed HTTP port
    protocol = "tcp"   # Protocol for the firewall rule
  }
}
```

outputs.ft:

```
# Output: GCE instance IP address
output "gce_instance_ip" {
  value = google_compute_instance.default.network_interface.0.access_config.0.nat_ip
}
```

variables.tf:

```
variable "gcp_project_id" {
  description = "The ID of the Google Cloud Platform project"
  type        = string
  nullable    = false
  # Documentation:
https://developer.hashicorp.com/terraform/language/values/variables
}

variable "gcp_service_account_key_file_path" {
  description = "The file path to the GCP service account key file"
  type        = string
  nullable    = false
  # Documentation:
https://developer.hashicorp.com/terraform/language/values/variables
}

variable "gce_instance_name" {
  description = "The name of the Google Compute Engine instance"
  type        = string
  nullable    = false
  # Documentation:
https://developer.hashicorp.com/terraform/language/values/variables
}

variable "gce_instance_user" {
  description = "The username for SSH access to the GCE instance"
  type        = string
  nullable    = false
  # Documentation:
https://developer.hashicorp.com/terraform/language/values/variables
```

```
}

variable "gce_ssh_pub_key_file_path" {
  description = "The file path to the SSH public key file"
  type        = string
  nullable    = false
  # Documentation:
https://developer.hashicorp.com/terraform/language/values/variables
}
```

terraform.tfvars:

```
gcp_project_id = "labgce-388413"
gcp_service_account_key_file_path = "../credentials/labgce-388413-0359dba88e1b.json"
gce_instance_name = "cld-best-instance"
gce_instance_user = "cookie"
gce_ssh_pub_key_file_path = "../credentials/labgce-ssh-key.pub"
```

> Explain what the files created by Terraform are used for.

When we do a `terraform init`, it will create 1 directory and 4 files:

1. `.terraform/`: This directory is created at the root of the Terraform working directory and contains all the necessary files for the Terraform backend and provider plugins.
2. `.terraform.lock.hcl`: This file records the exact versions of the provider plugins used for the configuration. It ensures reproducibility and consistency when working with Terraform.
3. `terraform.tfstate` : If we are using a local backend, Terraform may create this file to store the state of our infrastructure. However, if we are using a remote backend, the state file is typically stored remotely and not created locally.
4. `terraform.tfstate.backup` : If a previous state file exists, Terraform may create a backup of it with this filename. The backup file helps protect against accidental loss or corruption of the state file.

> Where is the Terraform state saved?

By default, the Terraform state is stored in locally a file name `terraform.state`.

> Imagine you are working in a team and the other team members want to use Terraform, too, to manage the cloud infrastructure. Do you see any problems with this? Explain.

1. When multiple people simultaneously modify the infrastructure, conflicts can appear when committing and merging changes to the Git repository. Since the state file is binary and changes frequently, it can cause conflicts and difficulties in resolving them.
2. Storing the state file in Git requires continuous synchronization between team members. Each team member needs to ensure they have the latest state file before running Terraform commands.

3. The Terraform state file may contain sensitive information, such as resource IDs, credentials, and private IP addresses. Storing it in a Git repository potentially exposes this sensitive information to unauthorized access.

To solve these problems, we could use a remote backend for storing the Terraform state, such as Terraform Cloud, AWS S3, or Azure Blob Storage. This can provide a centralized and secure storage solution for the state file. It enables better collaboration, concurrency control, and automatic versioning. Each team member can access the state file without relying on Git synchronization, and sensitive information is protected in a more secure manner.

> What happens if you reapply the configuration (1) without changing `main.tf` (2) with a change in `main.tf`? Do you see any changes in Terraform's output? Why?

(1) If we reapply the configuration whitout making any changes to the `main.tf` file on our Terraform project, it will detect that there are no changes to apply and will simply refresh the state of our infrastructure. This means that it will query the current state of our ressources and update the Terraform status file accordingly, but itl will not make any changes to out infrastructure.

(2) If we make a change to the `maint.tf` file, Terraform will detect the change in the configuration file and compare it to the current state of the infrastructure. Depending on the nature of the change, Terraform may need to modify or recreate resources to align with the updated configuration. The Terraform output will display the changes it plans to make, such as creating new resources, modifying existing resources, or destroying and recreating resources as needed.

> Can you think of examples where Terraform needs to delete parts of the infrastructure to be able to reconfigure it?

Sometimes, Terraform determines that the existing resources do not match the desired configuration, and must takes the necessary steps to reconcile the infrastructure with the new state. For example:

1. If we change the type of a resource in the configuration (e.g., from an EC2 instance to an RDS database), Terraform needs to delete the existing resource and create a new one to run the change.
2. When we modify certain attributes of a resource, such as changing the size or configuration of an instance, Terraform may need to destroy and recreate the resource to apply the changes.
3. If we remove a resource from the configuration, Terraform will plan to delete the corresponding resource from the infrastructure to ensure it aligns with the desired state.
4. If we modify the dependencies between resources, Terraform may need to update the order in which it creates or modifies resources. This can result in deleting and recreating resources to reflect the new dependencies.

> Explain what you would need to do to manage multiple instances.

In our `main.tf` file, we can define multiple resource blocks for each VM instance we want to create. Each resource block represents an individual VM configuration, for example:

```
resource "google_compute_instance" "instance1" {
  # Configuration for instance 1
}

resource "google_compute_instance" "instance2" {
  # Configuration for instance 2
}
```

To create multiple instances more dynamically, we can leverage loops or dynamic expressions. We can use the `count` parameter in resource blocks or the `for_each` parameter to iterate over a list or map of instance configurations. Example with `count`:

```
resource "google_compute_instance" "instance" {
  count = 3

  # Configuration for each instance
}
```

Example with `for_each`:

```
variable "instances" {
  description = "Map of instance configurations"
  type        = map(object({
    # Define instance configuration attributes
  }))
  default = {
    "instance1" = { ... },
    "instance2" = { ... },
  }
}

resource "google_compute_instance" "instance" {
  for_each = var.instances

  # Configuration for each instance
}
```

If we have multiple instances with different configurations, we can manage variables for each instance by defining them in a separate file or data structure. This allows to specify instance-specific values and easily update the configurations.

As we responded in the previous question, we can set up a remote state backend for improved collaboration and shared state management.

Now, to manage the instances, we can make changes to the configuration (e.g. instance type, security groups, etc.) and apply these changes using `terraform apply`. Terraform will update existing instances in line with the configuration changes.

Finally, if we want to delete specific instances, we have 2 options:

Option 1: Remove Resource Block by simply deleting the the resource block in our `main.tf` file that corresponds to the instance we want to delete, then run `terraform plan` and `terraform apply`. Terraform will identify that the instance needs to be deleted and handle the removal accordingly.

Option 2: Run `terraform destroy -target=<resource_address>` . This allows us to specifically target and delete a specific resource without modifying the configuration file. This approach is useful when we want to delete a resource without removing its resource block from the configuration permanently.

> Take a screenshot of the Google Cloud Console showing your Google Compute instance and put it in the report.

Basic information

Name	cld-best-instance
Instance ID	3979514716935664
Description	None
Type	Instance
Status	Running
Creation time	Jun 5, 2023, 3:39:26 pm UTC+02:00
Zone	europe-west6-a
Instance template	None
In use by	None
Reservations	Automatically choose (default)
Labels	None
Tags	–
Deletion protection	Disabled
Confidential VM service	Disabled
Preserved state size	0 GB

Machine configuration

Machine type	f1-micro
CPU platform	Intel Skylake
Architecture	x86/64
vCPUs to core ratio	–
Custom visible cores	–
Display device	Disabled Enable to use screen capturing and recording tools
GPUs	None

Networking

Public DNS PTR record	None
Total egress bandwidth tier	–
NIC type	–

→ VIEW IN NETWORK TOPOLOGY

Firewalls

HTTP traffic	Off
HTTPS traffic	Off

Network tags

None

Network interfaces

Name ↑	Network	Subnetwork	Primary internal IP address	IP stack type	External IP address
nic0	default	default	10.172.0.2	IPv4	34.65.3.209 (Ephemeral)

Storage

Boot disk

Name	Image	Interface type	Size (GB)	Device name	Type	Architecture	Encryption	Mode
cld-best-instance	debian-11-bullseye-v20230509	SCSI	10	persistent-disk-0	Standard persistent disk	x86/64	Google-managed	Boot, read/write

Local disks

None

Additional disks

None

Security and access

Shielded VM

Secure Boot	Off
vTPM	On
Integrity Monitoring	On

SSH keys

SSH keys

Username	Key
cookie	[redacted]

Block project-wide SSH keys	Off

API and identity management

Service account	None

Management

Availability policies

VM provisioning model	Standard
Max duration	None
Preemptibility	Off (Recommended)
On VM termination	—
On host maintenance	Migrate VM instance (Recommended)
Automatic restart	On (Recommended)
Customer-managed encryption key (CMEK) revocation policy	Do nothing

Sole tenancy

Affinity labels	None
CPU overcommit	Disabled

Custom metadata

None

Task 3: Install Ansible

We followed the instructions for installing Ansible and everything went smoothly.

Note that we had to set up a virtual Python environment that we named `ansible-env`.

Procedure to create and activate a python virtual environment

Creation of an environment called `ansible-env` :

```
python -m venv ansible-env
```

Activation of the environment called `ansible-env` :

```
# On linux
source ansible-env/bin/activate

# On Windows
ansible-env\Scripts\activate
```

Task 4: Configure Ansible to connect to the managed VM

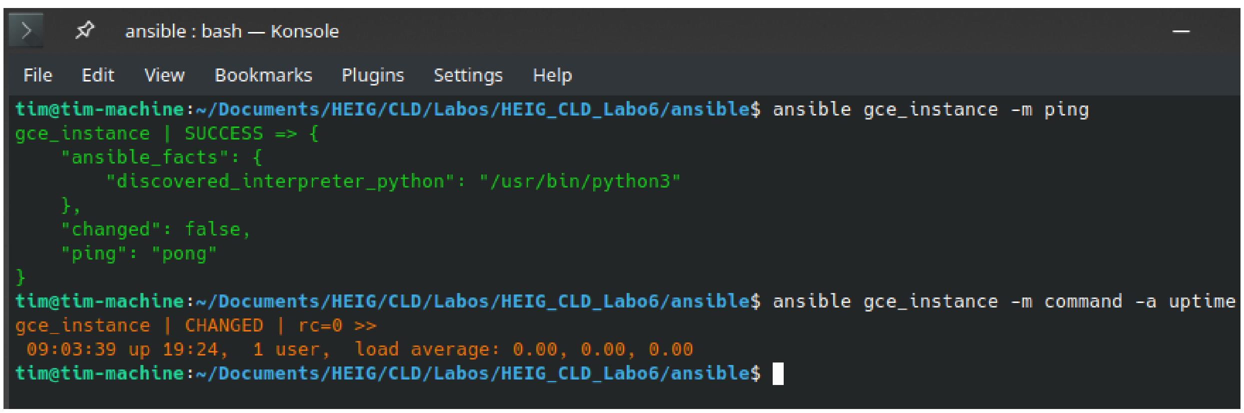
Here is the ansible.cfg file content:

```
[defaults]
inventory = hosts
remote_user = cookie
private_key_file = ../credentials/labgce-ssh-key
host_key_checking = false
deprecation_warnings = false
```

Here is the hosts file content:

```
gce_instance ansible_ssh_host=34.65.3.209
```

Here is a screenshot of the ping and uptime commands:



> What happens if the infrastructure is deleted and then recreated with Terraform? What needs to be updated to access the infrastructure again?

When the infrastructure is recreated, the public IP address of the managed VM might change. We would need to update the `hosts` file with the new public IP address.

Task 5: Install a web server and configure a web site

We didn't encounter any difficulty doing this part. After copying the files in the directory, we launched succesfully the playbook:

```
ansible : bash — Konsole
File  Edit  View  Bookmarks  Plugins  Settings  Help
tim@tim-machine:~/Documents/HEIG/CLD/Labos/HEIG_CLD_Labo6/ansible$ ansible webservers -m ping
gce_instance | SUCCESS => {
    "ansible_facts": {
        "discovered_interpreter_python": "/usr/bin/python3"
    },
    "changed": false,
    "ping": "pong"
}
tim@tim-machine:~/Documents/HEIG/CLD/Labos/HEIG_CLD_Labo6/ansible$ ansible-playbook playbooks/web.yml

PLAY [Configure webserver with nginx] ***************************************************************************

TASK [Gathering Facts] ******************************************************************************************
ok: [gce_instance]

TASK [install nginx] ********************************************************************************************
changed: [gce_instance]

TASK [copy nginx config file] ***********************************************************************************
changed: [gce_instance]

TASK [enable configuration] *************************************************************************************
ok: [gce_instance]

TASK [copy index.html] ******************************************************************************************
changed: [gce_instance]

TASK [restart nginx] ********************************************************************************************
changed: [gce_instance]

PLAY RECAP ******************************************************************************************************
gce_instance               : ok=6    changed=4    unreachable=0    failed=0    skipped=0    rescued=0    ignored=0
```

> Explain the usage of each file and its contents, add comments to the different blocks if needed (we must ensure that you understood what you have done). Link to the online documentation.

`web.yml`:

Defines the tasks to configure the webserver with nginx. It specifies that the tasks should be executed on the hosts belonging to the `webservers` group. It uses the `apt` module to install nginx, copies configuration files, templates, and restarts the nginx service.

```yaml
- name: Configure webserver with nginx    # Name of the playbook
  hosts: webservers                       # Target hosts
  become: True                            # Use elevated privileges (sudo)
  tasks:                                  # List of tasks to perform

# Task 1: Install nginx
# Use the 'apt' module to install nginx
    - name: install nginx
      apt: name=nginx update_cache=yes

# Task 2: Copy nginx conf file to target host
```

```
# Use the 'copy' module to copy the nginx.conf file from the local 'files' directory
to the target host's location.
   - name: copy nginx config file
     copy: src=files/nginx.conf dest=/etc/nginx/sites-available/default

# Task 3: Create a symbolic link for the nginx configuration file in 'sites-enabled'
directory
# Use the 'file' module to ensure the symbolic link exists. This will enable the
nginx configuration.
    - name: enable configuration
      file: >
        dest=/etc/nginx/sites-enabled/default
        src=/etc/nginx/sites-available/default
        state=link

# Task 4: Copy the index.html file to the target host's nginx document root
# Use the 'template' module to render the 'index.html.j2' file from the local
'templates' directory and copy it to the target host's location.
    - name: copy index.html
      template: src=templates/index.html.j2 dest=/usr/share/nginx/html/index.html
mode=0644

# Task 5: Restart the nginx service
# Use the 'service' module to ensure the nginx service is restarted, thus activating
the new configuration.
    - name: restart nginx
      service: name=nginx state=restarted
```

Documentation:

- Apt: https://docs.ansible.com/ansible/latest/collections/ansible/builtin/apt_module.html
- Copy: https://docs.ansible.com/ansible/latest/collections/ansible/builtin/copy_module.html
- Files: https://docs.ansible.com/ansible/latest/collections/ansible/builtin/file_module.html
- Templates: https://docs.ansible.com/ansible/latest/collections/ansible/builtin/template_module.html
- Service: https://docs.ansible.com/ansible/latest/collections/ansible/builtin/service_module.html

`nginx.conf`:

Contains the configuration for the nginx web server. It defines the server block with the `listen` directive, `root` directory, and other settings.

```
server {
    # Listens on port 80. The 'default_server' option makes this server block the
default.
    listen 80 default_server;

    # Also listen on IPv6 addresses.
    listen [::]:80 default_server ipv6only=on;
```

```
    # Document root - where the web files are located.
    root /usr/share/nginx/html;

    # Default files to serve if a directory is requested.
    index index.html index.htm;

    # Server name. This is useful for serving different content for different
domains.
    server_name localhost;

    # For requests to the root directory or any subdirectory, try to serve the file
or      directory that was requested. If it doesn't exist, return a 404 error.
    location / {
        try_files $uri $uri/ =404;
    }
}
```

Documentation : https://nginx.org/en/docs/beginners_guide.html

`index.html.j2`:

Jinja2 template for the `index.html` file. It will be rendered by Ansible's `template` module. Jinja2 is a templating language for Python, modeled after Django's templates. It's used to dynamically create configuration files for applications based on variables. It is useful with Ansible to generate different configuration files for different systems, with different settings based on the host, environment, or other factors.

```
<html>
    <head>
    <title>Welcome to ansible</title> </head>
    <body>
    <h1>nginx, configured by Ansible</h1>
    <p>If you can see this, Ansible successfully installed nginx.</p>
    <!-- Will be replaced with a string that tells how this file is managed by
Ansible -->
    <p>{{ ansible_managed }}</p>
    <p>Some facts Ansible gathered about this machine:
    <table>
        <!-- The OS family will be dynamically filled by Ansible -->
        <tr><td>OS family:</td><td>{{ ansible_os_family }}</td></tr>

        <!-- The OS distribution will be dynamically filled by Ansible -->
        <tr><td>Distribution:</td><td>{{ ansible_distribution }}</td></tr>

        <!-- The OS distribution version will be dynamically filled by Ansible. -->
        <tr><td>Distribution version:</td><td>{{ ansible_distribution_version }}
</td></tr>
```

```
    </table>
    </p>
    </body>
</html>
```

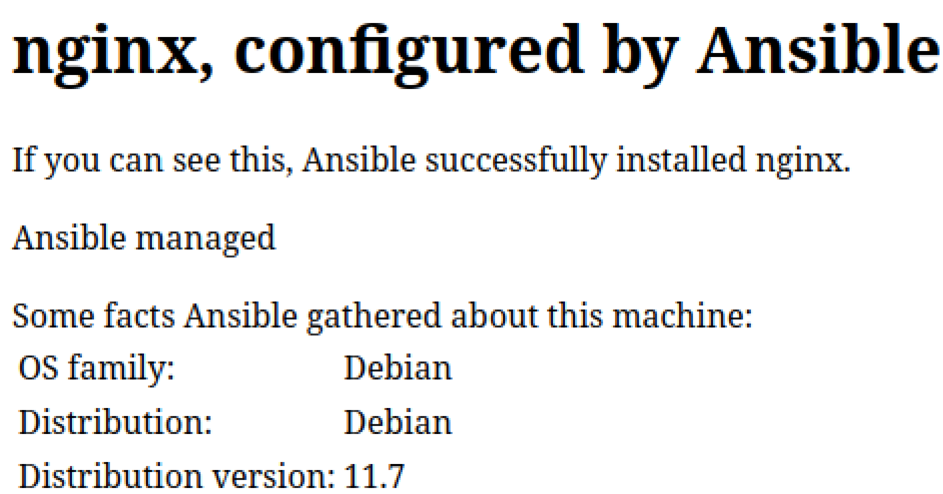
Documentation: https://docs.ansible.com/ansible/latest/playbook_guide/playbooks_templating.html

> Copy your hosts file into your report.

`hosts`:

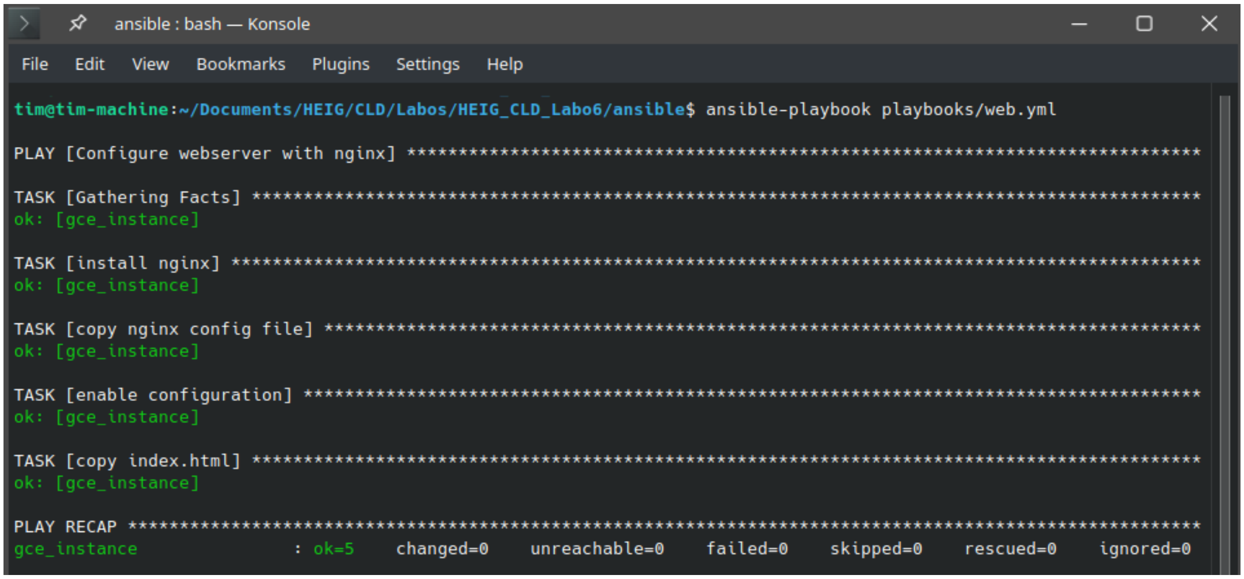
```
[webservers]
gce_instance ansible_ssh_host=34.65.3.209
```

Here is a screenshot of the website we deployed on the instance:



Task 6: Adding a handler for NGINX restart

Handlers are just like regular tasks, but they run only if notified by another task. If a task returns 'changed', then all of the 'notify' directives (which are referenced by the handler's name) will be triggered. Appart from a problem in the indentation of the playbook, we didn't encounter any problems deploying it:



```
ansible : bash — Konsole
File  Edit  View  Bookmarks  Plugins  Settings  Help
tim@tim-machine:~/Documents/HEIG/CLD/Labos/HEIG_CLD_Labo6/ansible$ ansible-playbook playbooks/web.yml

PLAY [Configure webserver with nginx] **********************************************************************

TASK [Gathering Facts] *************************************************************************************
ok: [gce_instance]

TASK [install nginx] ***************************************************************************************
ok: [gce_instance]

TASK [copy nginx config file] ******************************************************************************
ok: [gce_instance]

TASK [enable configuration] ********************************************************************************
ok: [gce_instance]

TASK [copy index.html] *************************************************************************************
ok: [gce_instance]

PLAY RECAP *************************************************************************************************
gce_instance               : ok=5    changed=0    unreachable=0    failed=0    skipped=0    rescued=0    ignored=0
```

> Copy the modified playbook into your report.

```yaml
- name: Configure webserver with nginx
  hosts: webservers
  become: True
  tasks:
    - name: install nginx
      apt: name=nginx update_cache=yes

    - name: copy nginx config file
      copy:
        src: files/nginx.conf
        dest: /etc/nginx/sites-available/default
      notify: Restart nginx # Notify the handler whenever this task changes something

    - name: enable configuration
      file:
        dest: /etc/nginx/sites-enabled/default
        src: /etc/nginx/sites-available/default
        state: link
      notify: Restart nginx # Notify the handler whenever this task changes something

    - name: copy index.html
      template:
```

```
        src: templates/index.html.j2
        dest: /usr/share/nginx/html/index.html
        mode: 0644
      notify: Restart nginx # Notify the handler whenever this task changes
something

  handlers:
    - name: Restart nginx  # Define the handler
      service:
        name: nginx
        state: restarted
```

In this setup, the handler "Restart nginx" is notified whenever the nginx configuration file is copied, the configuration is enabled, or the index.html file is copied. If any of these tasks lead to a change, the handler will be triggered, and nginx will be restarted.

Documentation: https://docs.ansible.com/ansible/latest/playbook_guide/playbooks_handlers.html#handlers

Task 7: Test Desired State Configuration principles

> Return to the output of running the *web.yml* playbook the first time. There is one additional task that was not in the playbook. Which one? Among the tasks that are in the playbook there is one task that Ansible marked as *ok*. Which one? Do you have a possible explanation?

Here is the output:

```
ansible : bash — Konsole
File  Edit  View  Bookmarks  Plugins  Settings  Help
tim@tim-machine:~/Documents/HEIG/CLD/Labos/HEIG_CLD_Labo6/ansible$ ansible webservers -m ping
gce_instance | SUCCESS => {
    "ansible_facts": {
        "discovered_interpreter_python": "/usr/bin/python3"
    },
    "changed": false,
    "ping": "pong"
}
tim@tim-machine:~/Documents/HEIG/CLD/Labos/HEIG_CLD_Labo6/ansible$ ansible-playbook playbooks/web.yml

PLAY [Configure webserver with nginx] ****************************************************************************

TASK [Gathering Facts] *******************************************************************************************
ok: [gce_instance]

TASK [install nginx] *********************************************************************************************
changed: [gce_instance]

TASK [copy nginx config file] ************************************************************************************
changed: [gce_instance]

TASK [enable configuration] **************************************************************************************
ok: [gce_instance]

TASK [copy index.html] *******************************************************************************************
changed: [gce_instance]

TASK [restart nginx] *********************************************************************************************
changed: [gce_instance]

PLAY RECAP *******************************************************************************************************
gce_instance               : ok=6    changed=4    unreachable=0    failed=0    skipped=0    rescued=0    ignored=0
```

The additional task that was not in the playbook but is present in the output is "Gathering Facts". When Ansible runs, it will first gather facts about the systems it is managing before executing tasks. These facts are details about the system, such as network interfaces, operating system, IP addresses, etc. This information can then be used in our Ansible playbooks. This task is performed by default, unless explicitly skipped.

Reference: [Ansible facts]

The task marked as 'ok' is "enable configuration". When we run the playbook for the first time, the "enable configuration" task is marked as 'ok' because the `state` parameter of the `file` module in this task is set to `link`. In Ansible, the `file` module with `state: link` ensures a symbolic link exists. If the symbolic link at the specified `dest` path already exists in the system image provided by Google Cloud , then Ansible will report this task as 'ok' because the desired state is already present, hence no changes are needed.

Reference: [Ansible file module]

> Re-run the *web.yml* playbook a second time. In principle nothing should have changed. Compare Ansible's output with the first run. Which tasks are marked as changed?

No tasks were marked as "changed" during the second run of the `web.yml` playbook. Here is the output:

```
ansible : bash — Konsole
File  Edit  View  Bookmarks  Plugins  Settings  Help
tim@tim-machine:~/Documents/HEIG/CLD/Labos/HEIG_CLD_Labo6/ansible$ ansible-playbook playbooks/web.yml

PLAY [Configure webserver with nginx] ****************************************************************************

TASK [Gathering Facts] *******************************************************************************************
ok: [gce_instance]

TASK [install nginx] *********************************************************************************************
ok: [gce_instance]

TASK [copy nginx config file] ************************************************************************************
ok: [gce_instance]

TASK [enable configuration] **************************************************************************************
ok: [gce_instance]

TASK [copy index.html] *******************************************************************************************
ok: [gce_instance]

PLAY RECAP *******************************************************************************************************
gce_instance               : ok=5    changed=0    unreachable=0    failed=0    skipped=0    rescued=0    ignored=0
```

> SSH into the managed server. Modify the NGINX configuration file */etc/nginx/sites-available/default*, for example by adding a line with a comment. Re-run the playbook. What does Ansible do to the file and what does it show in its output?

Here is the output:

```
ansible : bash — Konsole
File  Edit  View  Bookmarks  Plugins  Settings  Help
Connection to 34.65.3.209 closed.
tim@tim-machine:~/Documents/HEIG/CLD/Labos/HEIG_CLD_Labo6/credentials$ cd ..
tim@tim-machine:~/Documents/HEIG/CLD/Labos/HEIG_CLD_Labo6$ cd ansible/
tim@tim-machine:~/Documents/HEIG/CLD/Labos/HEIG_CLD_Labo6/ansible$ ansible-playbook playbooks/web.yml

PLAY [Configure webserver with nginx] ****************************************************************************

TASK [Gathering Facts] *******************************************************************************************
ok: [gce_instance]

TASK [install nginx] *********************************************************************************************
ok: [gce_instance]

TASK [copy nginx config file] ************************************************************************************
changed: [gce_instance]

TASK [enable configuration] **************************************************************************************
ok: [gce_instance]

TASK [copy index.html] *******************************************************************************************
ok: [gce_instance]

RUNNING HANDLER [Restart nginx] **********************************************************************************
changed: [gce_instance]

PLAY RECAP *******************************************************************************************************
gce_instance               : ok=6    changed=2    unreachable=0    failed=0    skipped=0    rescued=0    ignored=0
```

We can see that the "copy nginx config file" task is marked as "changed". When we manually added a comment line to the `/etc/nginx/sites-available/default` file, we modified the state of the file on the remote machine. During the next execution of the playbook, Ansible detected this difference between the desired state as defined in our playbook and the actual state on the remote machine. To achieve the desired state, Ansible replaced the file on the remote machine with the version from our control node.

Additionally, since we have configured a handler to restart nginx whenever the nginx configuration file is modified, the "Restart nginx" handler is also executed and marked as "changed".

> Do something more drastic like completely removing the homepage and repeat the previous question.

We deleted the default file. The result is exactly the same as before. The reason is the same as before, with the same explanation. We modified the state of the file, which was detected by Ansible and marked as modified.

> What is the differences between Terraform and Ansible? Can they both achieve the same goal?

Terraform and Ansible are used for different purposes and have distinct characteristics. Their functionalities may sometimes overlap, but they are used together to manage different stages of the infrastructure lifecycle.

Terraform is not a configuration management tool; it doesn't concern itself with the state of our machines but rather with the state of the infrastructure. It handles resources such as compute instances, storage, and networking in a declarative manner. It maintains an infrastructure state and enables reproducible deployments.

On the other hand, Ansible is primarily a configuration management tool that focuses on the state of the machines and how to bring them to the desired state. It can interact with cloud services, but its strength lies in managing applications and system configuration on existing servers.

> List the advantages and disadvantages of managing your infrastructure with Terraform/Ansible vs. manually managing your infrastructure. In which cases is one or the other solution more suitable?

Benefits	**Disadvantages**
Speed and efficiency: Automation enables rapid, reproducible deployments. This consistency reduces the risk of human error and ensures smooth, efficient deployments.	Learning curve: These tools have their own language and syntax, requiring time to learn.
Scalability: Manual management of a large number of servers can quickly become unmanageable. With automation tools, we can easily manage a large infrastructure with less effort.	Complexity: For smaller, simpler environments, using these tools can add unnecessary complexity.
Consistency and reproducibility: Since infrastructure is defined as code, it can be versioned and reviewed like any other code. This ensures that the infrastructure is consistent and reproducible.	Risk of over-dependence: There is a risk of becoming over-dependent on these tools, which can cause problems if manual intervention or troubleshooting is required.
Collaboration: The Infrastructure as Code approach facilitates team understanding and collaboration on infrastructure configuration.	

> Suppose you now have a web server in production that you have configured using Ansible. You are working in the IT department of a company and some of your system administrator colleagues who don't use Ansible have logged manually into some of the servers to fix certain things. You don't know what they did exactly. What do you need to do to bring all the server again to the initial state? We'll exclude drastic changes by your colleagues for this question.

Ansible is designed to be idempotent, which means that if we run our Ansible playbook again, it will restore the servers to the desired state as defined in the playbook.

So:

1. Let's check our Ansible playbook again to make sure it's up to date and contains all the configurations we need for our servers.
2. Let's run the playbook on all the servers that our colleagues have modified manually. This should return the servers to the state defined in the playbook.
3. Let's look at the results of running the Ansible playbook. All tasks with the result "changed" indicate that Ansible has performed an action on this server to bring it back to the desired state.

This assumes that our playbook covers all the configurations required to restore servers to their initial state. If this is not the case, we may need to enhance the playbook to cover more configurations.

Finally, if our colleagues have made corrections, this means that something wasn't working properly. So, after restoring the servers, we should add the fixes to the playbook and teach our colleagues how to use Ansible.

Task 8 (optionnal) : Configure your infrastructure using a CI/CD Pipeline

Since this part was optional and we were short of time, we deliberately decided not to do it.