

## ДОДАТОК А

Графічний матеріал кваліфікаційної роботи

Кафедра ЕОМ

Комп'ютерна інженерія та управління

Розгортання та управління Kubernetes-кластерами за допомогою Infrastructure as Code (IaC)

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## Мета та завдання роботи

### Мета :

Автоматизувати процес розгортання Kubernetes-кластера в хмарному середовищі OpenStack з використанням підходу Infrastructure as Code, забезпечити керованість, повторюваність та розширюваність розгортання.

### Завдання:

- Розробити шаблони Terraform для створення інфраструктури
- Інтегрувати Ansible для конфігурації кластеру
- Встановити Kubernetes-кластер через Kubespray
- Реалізувати GitOps-підхід із використанням FluxCD

## Що таке Terraform?

Terraform — це інструмент для опису інфраструктури у вигляді коду.

### Ключові особливості:



Декларативний підхід



Підтримка різних провайдерів (AWS, GCP, OpenStack)



Планування змін (terraform plan)



Управління станом (terraform.tfstate)

## Що таке Kubernetes?

Kubernetes — це система оркестрації контейнерів, яка автоматизує розгортання, масштабування та управління застосунками.

### Об'єкти:

- Pods — найменші одиниці розгортання
- Services — мережеві абстракції
- Deployments — управління реплікацією
- Ingress — маршрутизація трафіку

### Основні компоненти:

#### Control Plane

API Server, etcd, scheduler

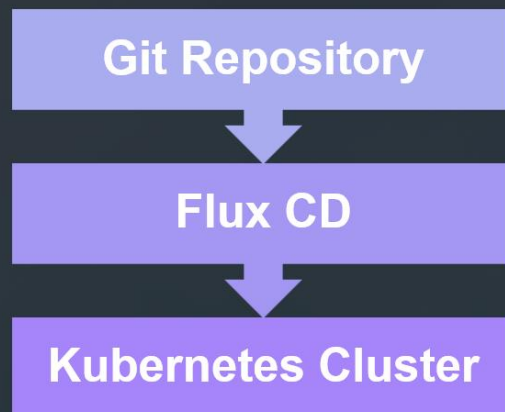
#### Worker Nodes

kubelet, container runtime

## Архітектура рішення



## Flux CD та GitOps



```

initializing modules...
- ipsec in modules/ipsec
- k8s in modules/k8s
- loadbalancer in modules/loadbalancer
- network in modules/network
Initializing provider plugins...
- terraform.io/built-in/terraform is built in to Terraform
- Reusing previous version of fluxcd/flux from the dependency lock file
- Reusing previous version of ansible/ansible from the dependency lock file
- Reusing previous version of hashicorp/tls from the dependency lock file
- Reusing previous version of hashicorp/local from the dependency lock file
- Reusing previous version of hashicorp/kubernetes from the dependency lock file
- Reusing previous version of hashicorp/cloudinit from the dependency lock file
- Reusing previous version of terraform-provider-openstack/openstack from the dependency lock file
- Reusing previous version of hashicorp/helm from the dependency lock file
- Installing ansible/ansible v1.3.0...
- Installing ansible/ansible v1.3.0 (signed by a HashiCorp partner, key ID 41F01D0480007165)
- Installing hashicorp/tls v4.0.5...
- Installing hashicorp/tls v4.0.5 (signed by HashiCorp)
- Installing hashicorp/local v2.5.1...
- Installing hashicorp/local v2.5.1 (signed by HashiCorp)
- Installing hashicorp/kubernetes v2.33.0...
- Installing hashicorp/kubernetes v2.33.0 (signed by HashiCorp)
- Installing hashicorp/cloudinit v2.3.5...
- Installing hashicorp/cloudinit v2.3.5 (signed by HashiCorp)
- Installing terraform-provider-openstack/openstack v3.0.0...
- Installing terraform-provider-openstack/openstack v3.0.0 (self-signed, key ID 4F8527A3918EF02)
- Installing hashicorp/helm v2.16.1...
- Installing hashicorp/helm v2.16.1 (signed by HashiCorp)
- Installing fluxcd/flux v1.4.0...
- Installing fluxcd/flux v1.4.0 (self-signed, key ID D5D316A8808B589)
Partner and community providers are signed by their developers.
If you'd like to know more about provider signing, you can read about it here:
https://www.terraform.io/docs/cli/plugins/signing.html
Terraform has been successfully initialized!

# terraform plan
data.openstack_compute_flavor_v2.bastion: Reading...
data.openstack_compute_flavor_v2.worker: Reading...
module.network_data.openstack_networking_network_v2.external: Reading...
data.openstack_compute_flavor_v2.master: Reading...
module.network_data.openstack_networking_network_v2.internal: Read complete after 3s [id=c3799996-dc8e-4477-a399-9e4ed7]
data.openstack_compute_flavor_v2.worker: Read complete after 3s [id=3d8f96a-d74e-4c4f-9112-79d7f09127d]
data.openstack_compute_flavor_v2.master: Read complete after 3s [id=3d8f96a-d74e-4c4f-9112-79d7f09127d]
data.openstack_compute_flavor_v2.bastion: Read complete after 4s [id=2712d36d-a012-411c-9f48-68cc65d1189]

Terraform used the selected providers to generate the following execution plan. Resource actions are indicated with the following symbols:
+ create
== read (data resources)

Terraform will perform the following actions:

# data.local_sensitive_file.kubeconfig will be read during apply
# (depends on a resource of a module with changes pending)
+ data.local_sensitive_file.kubeconfig {
  + content = (sensitive value)
  + content_base64 = (sensitive value)
  + content_base64sha256 = (known after apply)
  + content_base64sha512 = (known after apply)
  + content_md5 = (known after apply)
  + content_sha1 = (known after apply)
  + content_sha256 = (known after apply)
  + content_sha512 = (known after apply)
  + filename = "/.ansible/artifacts-test/admin.conf"
  + id = (known after apply)
}

# ansible_group.all will be created
+ resource.ansible_group.all {
  + id = (known after apply)
  + name = "all"
  + variables = {
    "ansible_python_interpreter" = "/usr/bin/python3"
    "ansible_ssh_host_key_checking" = "false"
    "ansible_ssh_private_key_file" = "/Users/jamroz/airship/terraform/ansible/.ssh/test_id_rsa"
    "ansible_user" = "ansible"
  }
}

```

# terraform init i plan

```

module.network.openstack_networking_secgroup_rule_v2.cloud_controller_manager: Creation complete after 1s [id=e2418dd-9473-4668-8d35-51deb8b9fe0a]
module.network.openstack_networking_secgroup_rule_v2.kube_proxy_ipv6["master"]: Creating...
module.network.openstack_networking_secgroup_rule_v2.node-exporter["worker"]: Creation complete after 2s [id=d0d940c8-03b8-4d28-8bed-c7ff555b02d8]
module.network.openstack_networking_secgroup_rule_v2.cinder_csi["master"]: Creating...
module.network.openstack_networking_secgroup_rule_v2.etccd: Creation complete after 2s [id=041e0c5c-9d88-45ff-a4a4-96c49bce201]
module.network.openstack_networking_secgroup_rule_v2.kube_proxy_ipv4["worker"]: Creating...
module.network.openstack_networking_secgroup_rule_v2.kube_proxy_ipv6["worker"]: Creation complete after 2s [id=5c85a921-183b-4b93-a6b7-10d4412928e7]
module.network.openstack_networking_secgroup_rule_v2.kube_proxy_ipv4["master"]: Creating...
module.network.openstack_networking_secgroup_rule_v2.node-exporter["master"]: Creation complete after 3s [id=83a6eef-f1eb-4f2b-b226-45f1a281d2ed]
module.network.openstack_networking_secgroup_rule_v2.vxlan["master"]: Creating...
module.network.openstack_networking_secgroup_rule_v2.cinder_csi["worker"]: Creation complete after 3s [id=73265517-7029-49d3-91fb-c920d629c368]
module.network.openstack_networking_secgroup_rule_v2.kubelet_api_ipv4["master"]: Creating...
module.network.openstack_networking_secgroup_rule_v2.kubelet_api_ipv6["master"]: Creation complete after 4s [id=17896c1e-a3ad-438e-a125-b377527ae11]
module.network.openstack_networking_secgroup_rule_v2.vxlan["worker"]: Creating...
module.network.openstack_networking_secgroup_rule_v2.kubelet_api_ipv6["worker"]: Creation complete after 3s [id=6c0a63ff-d61e-4ee4-aa84-08b2d25d03d3]
module.network.openstack_networking_secgroup_rule_v2.kubelet_api_ipv4["worker"]: Creating...
module.network.openstack_networking_secgroup_rule_v2.kube_proxy_ipv6["master"]: Creation complete after 3s [id=6ad65aa9-05cb-49ce-b10f-f987ccb7f2a0]
module.network.openstack_networking_secgroup_rule_v2.ssh["master"]: Creating...
module.network.openstack_networking_secgroup_rule_v2.kube_proxy_ipv4["worker"]: Creation complete after 3s [id=394345bf-cd16-4413-94db-8262d2ea7b84]
module.network.openstack_networking_secgroup_rule_v2.ssh["worker"]: Creating...
module.network.openstack_networking_secgroup_rule_v2.cinder_csi["master"]: Creation complete after 3s [id=4d41ab74-9ca5-4b55-9b35-46c829edb851]
module.network.openstack_networking_secgroup_rule_v2.ssh["bastion"]: Creating...
module.network.openstack_networking_secgroup_rule_v2.vxlan["worker"]: Creation complete after 2s [id=d110fb87-d9a7-4127-9310-3fe39027f829]
module.network.openstack_networking_secgroup_rule_v2.dhcp["master"]: Creating...
module.network.openstack_networking_network_v2.internal: Creation complete after 9s [id=e8067bd-f74d-4284-828c-b2398f5beb50]
module.network.openstack_networking_secgroup_rule_v2.dhcp["bastion"]: Creating...
module.network.openstack_networking_secgroup_rule_v2.kube_proxy_ipv4["master"]: Creation complete after 4s [id=6a0d8ffe-84b7-4149-9692-b2elec87d8cd]
module.network.openstack_networking_secgroup_rule_v2.dhcp["worker"]: Creating...

```

# terraform apply

## ■ Ansible + Kubespray

```

terraform_data.kubespray (local-exec): TASK [kubernetes_sigs.kubespray.kubernetes/preinstall : Remove kubespray specific config from dhclient config] ***
terraform_data.kubespray (local-exec): skipping: [test-master-0] => {"changed": false, "false_condition": "resolvconf_mode != 'host_resolvconf'", "skip_reason": "Conditional result was False"}
terraform_data.kubespray (local-exec): skipping: [test-master-1] => {"changed": false, "false_condition": "resolvconf_mode != 'host_resolvconf'", "skip_reason": "Conditional result was False"}
terraform_data.kubespray (local-exec): skipping: [test-master-2] => {"changed": false, "false_condition": "resolvconf_mode != 'host_resolvconf'", "skip_reason": "Conditional result was False"}
terraform_data.kubespray (local-exec): skipping: [test-worker-0] => {"changed": false, "false_condition": "resolvconf_mode != 'host_resolvconf'", "skip_reason": "Conditional result was False"}
terraform_data.kubespray (local-exec): skipping: [test-worker-1] => {"changed": false, "false_condition": "resolvconf_mode != 'host_resolvconf'", "skip_reason": "Conditional result was False"}

terraform_data.kubespray (local-exec): TASK [kubernetes_sigs.kubespray.kubernetes/preinstall : Remove kubespray specific dhclient hook] ***
terraform_data.kubespray (local-exec): skipping: [test-master-0] => {"changed": false, "false_condition": "resolvconf_mode != 'host_resolvconf'", "skip_reason": "Conditional result was False"}
terraform_data.kubespray (local-exec): skipping: [test-master-1] => {"changed": false, "false_condition": "resolvconf_mode != 'host_resolvconf'", "skip_reason": "Conditional result was False"}
terraform_data.kubespray (local-exec): skipping: [test-master-2] => {"changed": false, "false_condition": "resolvconf_mode != 'host_resolvconf'", "skip_reason": "Conditional result was False"}
terraform_data.kubespray (local-exec): skipping: [test-worker-0] => {"changed": false, "false_condition": "resolvconf_mode != 'host_resolvconf'", "skip_reason": "Conditional result was False"}
terraform_data.kubespray (local-exec): skipping: [test-worker-1] => {"changed": false, "false_condition": "resolvconf_mode != 'host_resolvconf'", "skip_reason": "Conditional result was False"}

terraform_data.kubespray (local-exec): TASK [kubernetes_sigs.kubespray.kubernetes/preinstall : Flush handlers] *****
terraform_data.kubespray (local-exec): TASK [kubernetes_sigs.kubespray.kubernetes/preinstall : Flush handlers] *****
terraform_data.kubespray (local-exec): TASK [kubernetes_sigs.kubespray.kubernetes/preinstall : Flush handlers] *****
terraform_data.kubespray (local-exec): TASK [kubernetes_sigs.kubespray.kubernetes/preinstall : Flush handlers] *****
terraform_data.kubespray (local-exec): TASK [kubernetes_sigs.kubespray.kubernetes/preinstall : Flush handlers] *****

terraform_data.kubespray (local-exec): RUNNING HANDLER [kubernetes_sigs.kubespray.kubernetes/preinstall : Preinstall | reload kubelet] ***
terraform_data.kubespray (local-exec): skipping: [test-master-0] => {"changed": false, "false_condition": "not dns_early | bool", "skip_reason": "Conditional result was False"}
terraform_data.kubespray (local-exec): skipping: [test-master-1] => {"changed": false, "false_condition": "not dns_early | bool", "skip_reason": "Conditional result was False"}
terraform_data.kubespray (local-exec): skipping: [test-master-2] => {"changed": false, "false_condition": "not dns_early | bool", "skip_reason": "Conditional result was False"}
terraform_data.kubespray (local-exec): skipping: [test-worker-0] => {"changed": false, "false_condition": "not dns_early | bool", "skip_reason": "Conditional result was False"}
terraform_data.kubespray (local-exec): skipping: [test-worker-1] => {"changed": false, "false_condition": "not dns_early | bool", "skip_reason": "Conditional result was False"}

terraform_data.kubespray (local-exec): RUNNING HANDLER [kubernetes_sigs.kubespray.kubernetes/preinstall : Preinstall | kube-apiserver configured] ***
terraform_data.kubespray (local-exec): skipping: [test-worker-0] => {"changed": false, "false_condition": "inventory_hostname in groups['kube_control_plane'] and dns_mode != 'none' and resolvconf_mode == 'host_resolvconf'", "skip_reason": "Conditional result was False"}
terraform_data.kubespray (local-exec): skipping: [test-worker-1] => {"changed": false, "false_condition": "inventory_hostname in groups['kube_control_plane'] and dns_mode != 'none' and resolvconf_mode == 'host_resolvconf'", "skip_reason": "Conditional result was False"}
terraform_data.kubespray (local-exec): ok: [test-master-2] => {"changed": false, "stat": {"exists": false}}
terraform_data.kubespray (local-exec): ok: [test-master-0] => {"changed": false, "stat": {"exists": false}}
terraform_data.kubespray (local-exec): ok: [test-master-1] => {"changed": false, "stat": {"exists": false}}

terraform_data.kubespray (local-exec): RUNNING HANDLER [kubernetes_sigs.kubespray.kubernetes/preinstall : Preinstall | kube-controller configured] ***

```

## ■ Helm-чарти

NGINX  
Ingress

Metrics  
Server

OpenStack  
CCM

```

test-worker-1 Ready <none> 19m v1.30.4 192.168.140.149 <none> ubuntu 22.04.4 LTS
> kubectl get pods -A
NAMESPACE NAME READY STATUS RESTARTS AGE
flux-system helm-controller-6f558f6c5d-r6sjr 1/1 Running 0 5m40s
flux-system kustomize-controller-74fb56995-7zd2g 1/1 Running 0 5m40s
flux-system notification-controller-5d794dd575-cw52j 1/1 Running 0 5m40s
flux-system source-controller-6d597849c8-cqgsm 1/1 Running 0 5m39s
ingress-nginx ingress-nginx-controller-test-6c5495dc6-xxqbb 1/1 Running 0 4m54s
kube-system calico-kube-controllers-b5f8f6849-2w6vx 1/1 Running 0 13m
kube-system calico-node-24q28 1/1 Running 0 15m
kube-system calico-node-77ghr 1/1 Running 0 15m
kube-system calico-node-n4qlr 1/1 Running 0 15m
kube-system calico-node-qj5rp 1/1 Running 0 15m
kube-system calico-node-v7mnv 1/1 Running 0 15m
kube-system coredns-776bb9bb5d-dfvqg 1/1 Running 0 5m50s
kube-system coredns-776bb9bb5d-rrn9p 1/1 Running 0 10m
kube-system dns-autoscaler-6ffb84bd6-xkq6d 1/1 Running 0 10m
kube-system etcd-test-master-0 1/1 Running 0 25m
kube-system etcd-test-master-1 1/1 Running 0 24m
kube-system etcd-test-master-2 1/1 Running 0 23m
kube-system kube-apiserver-test-master-0 1/1 Running 1 25m
kube-system kube-apiserver-test-master-1 1/1 Running 1 24m
kube-system kube-apiserver-test-master-2 1/1 Running 1 23m
kube-system kube-controller-manager-test-master-0 1/1 Running 2 25m
kube-system kube-controller-manager-test-master-1 1/1 Running 2 24m
kube-system kube-controller-manager-test-master-2 1/1 Running 2 23m
kube-system kube-proxy-7d79k 1/1 Running 0 19m
kube-system kube-proxy-tq8l5 1/1 Running 0 25m
kube-system kube-proxy-lswb9 1/1 Running 0 24m
kube-system kube-proxy-mc98w 1/1 Running 0 23m
kube-system kube-proxy-nh6t4 1/1 Running 0 19m
kube-system kube-scheduler-test-master-0 1/1 Running 1 25m
kube-system kube-scheduler-test-master-1 1/1 Running 1 24m
kube-system kube-scheduler-test-master-2 1/1 Running 1 23m
kube-system openstack-cinder-csi-controllerplugin-5cd96bb787-f4t8f 6/6 Running 0 5m47s
kube-system openstack-cinder-csi-nodeplugin-7zxmb 3/3 Running 0 5m48s
kube-system openstack-cinder-csi-nodeplugin-dfgp5 3/3 Running 0 5m48s
kube-system openstack-cinder-csi-nodeplugin-k4nj9 3/3 Running 0 5m48s
kube-system openstack-cinder-csi-nodeplugin-k5dxh 3/3 Running 0 5m48s
kube-system openstack-cinder-csi-nodeplugin-n97zd 3/3 Running 0 5m48s
kube-system openstack-cloud-controller-manager-9fgwd 1/1 Running 0 6m
kube-system openstack-cloud-controller-manager-rt2qw 1/1 Running 0 6m
kube-system openstack-cloud-controller-manager-z5c4l 1/1 Running 0 6m


```

**Готовый кластер k8s**

```

> kubectl get nodes -o wide
NAME STATUS ROLES
test-master-0 Ready control-plane
test-master-1 Ready control-plane
test-master-2 Ready control-plane
test-worker-0 Ready <none>
test-worker-1 Ready <none>

```



```

---
apiVersion: helm.toolkit.fluxcd.io/v2
kind: HelmRelease
metadata:
  name: prometheus-stack
  namespace: flux-system
spec:
  interval: 10m
  releaseName: prometheus-stack
  targetNamespace: monitoring
  chart:
    spec:
      chart: kube-prometheus-stack
      version: "66.x.x"
      sourceRef:
        kind: HelmRepository
        name: prometheus
        namespace: flux-system
        interval: 10m
  install:
    createNamespace: true
  crds: CreateReplace
  upgrade:
    crds: CreateReplace
  values:
    prometheusOperator:
      resources:

```

```

> flux get all -A
NAMESPACE NAME REVISION SUSPENDED READY MESSAGE
flux-system gitrepository/flux-system master@sha1:c82dc5d8 False True stored artifact for revision 'master@sha1:c82dc5d8'

NAMESPACE NAME REVISION SUSPENDED READY MESSAGE
flux-system kustomization/flux-system master@sha1:c82dc5d8 False True Applied revision: master@sha1:c82dc5d8

```