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Cloud Computing Architecture

Google Cloud Platform (GCP) and Project Overview

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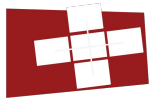
Agenda



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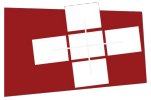
1. Project Logistics
2. Intro to Cloud Providers and GCP
3. Cluster setup: Kops
4. Running applications in a cluster: Kubernetes

Project Overview



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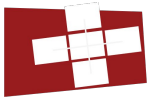
Goal: Schedule applications of different requirements (latency-sensitive, batch applications) in the cloud efficiently.

- **Part 1:** Measure the effect of resource **interference** (using **iBench**) in **memcached** application
- **Part 2:** Measure the effect of resource **interference** (using **iBench**) and **scalability** of **PARSEC** benchmarks.
- **Part 3:** Use insights from Part 1 & 2 to schedule memcached and PARSEC in **a cluster of heterogeneous VMs**.
- **Part 4:** Schedule memcached and PARSEC together (collocated) on **a single machine**.

Project Logistics



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- Deadline to submit group preferences for the project: **Thursday, March 9th, 2023**.
- Groups will be assigned on **Monday, March 13th, 2023**. You may then start working on the project.
- Project deadline for Part 1 and 2: **Thursday, April 6th, 2023 at 13:00**
- Project deadline for Part 3 and 4: **Thursday, May 25th, 2023 at 13:00**

- **You MUST signup on Moodle for the project (otherwise you cannot do the project):**
  - Sign up for a **specific** group

    or
  - Sign up for **general** group (and we will place you in a group)

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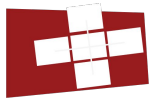
Cloud Providers and GCP

The Major Cloud Providers



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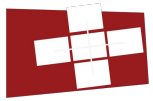
- Many public cloud providers:
  - Google Cloud Platform (GCP)
  - Amazon Web Services (AWS)
  - Microsoft Azure
  - etc.

- They provide services such as:
  - **Platform as a Service (PaaS):** app deployment, querying, …
  - **Infrastructure as a Service (IaaS):** VMs, storage, …
  - **Function as a Service (FaaS):** serverless computing
  - **Software as a Service (SaaS):** cloud gaming, e-mail, …
  - etc.

Google Cloud Platform (GCP)



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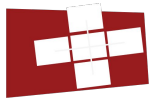
- Offers a set of cloud computing services:
  - Compute Engine
  - Cloud Storage/Filestore
  - BigQuery/DataFlow
  - Cloud Functions
  - AI Platform
  - etc.

- Same infrastructure that Google uses internally for its products (Gmail, Google Drive, etc.)

GCP - Agenda



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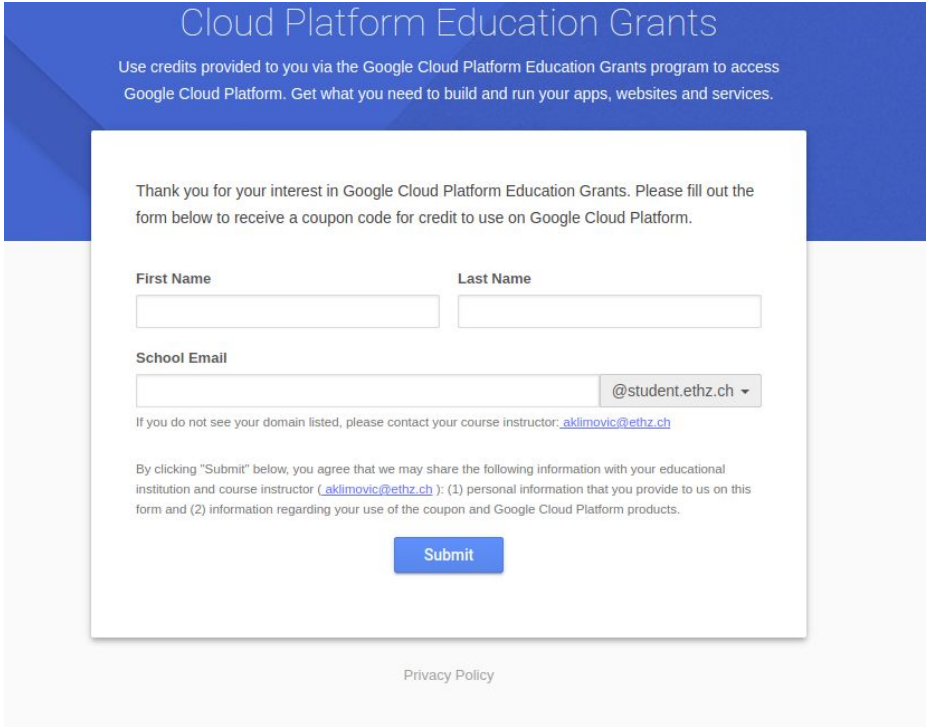
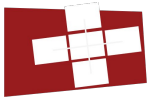
- Create a Project in GCP
- Configure GCP CLI
- Credits, Billing & Budget
- Create VMs
- Inspect/Access VMs
- Terminate VMs

GCP - Create Project (Get Credits)

- You must have a Google Cloud account under your **ETH email address**
- **One group member** redeems the cloud credits (instructions in the project handout)
- **You should NOT redeem credits until the official start date of the project!**



GCP - Create Project



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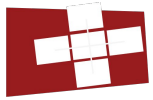
- Login and create the project via gcloud

```
$ gcloud init

[...]

You must log in to continue. Would you like to log in (Y/n)? Y

Go to the following link in your browser:

…

Enter verification code:

…
```

GCP - Create Project



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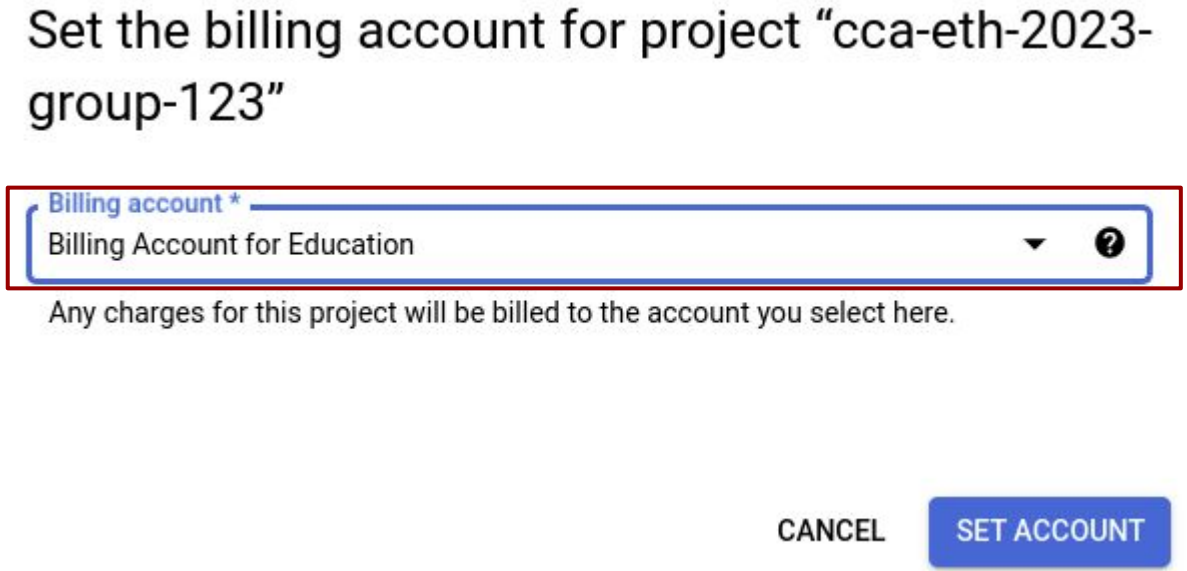
- Login and create the project via gcloud

```
$ gcloud init

[...]
You are logged in as: [ethzid@ethz.ch].

Pick cloud project to use:
 [1] …
 …
 [6] Enter a project ID
 [7] Create a new project
Please enter numeric choice or text value (must exactly match list item):  7

Enter a Project ID. Note that a Project ID CANNOT be changed later.
Project IDs must be 6-30 characters (lowercase ASCII, digits, or
hyphens) in length and start with a lowercase letter. cca-eth-2023-group-123
…
Your current project has been set to: [cca-eth-2023-group-123].
```

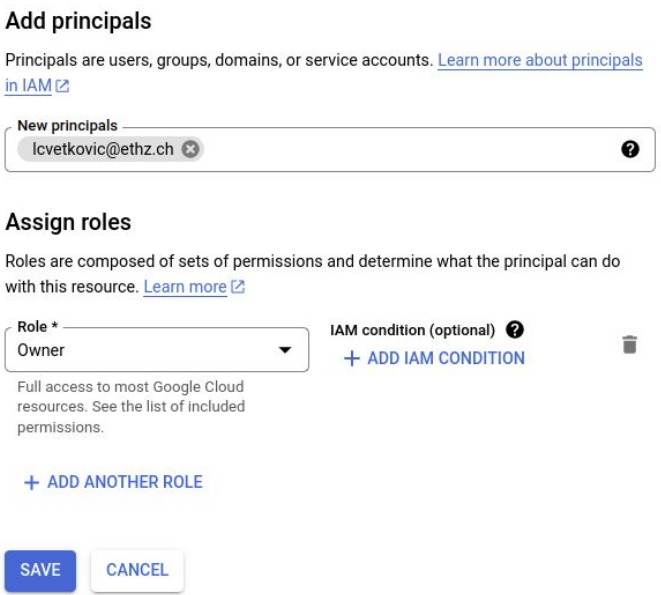
GCP - Create Project

- Link the project with the **Billing Account for Education**

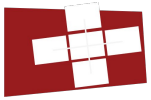


GCP - Create Project

- Add your teammates to the project



GCP - Create Project



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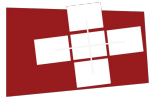
- View available zones (usually have all VMs in the same availability zone)

```
$ gcloud compute zones list

API [compute.googleapis.com] not enabled on project [...]. Would you like to enable and retry (this will take a few minutes)? (y/N)?  y

Enabling service [compute.googleapis.com] on project [...]...

NAME                REGION              STATUS
us-east1-b          us-east1            UP
us-east1-c          us-east1            UP
us-east1-d          us-east1            UP
us-east4-c          us-east4            UP
us-east4-b          us-east4            UP
us-east4-a          us-east4            UP
us-central1-c       us-central1         UP
....
```

Shown the first time

GCP - Configure CLI



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Get available/active accounts:

```
$ gcloud auth list

Credentialed Accounts
ACTIVE  ACCOUNT
*       username@ethz.ch

To set the active account, run:
   $ gcloud config set account `ACCOUNT`
```

Set account

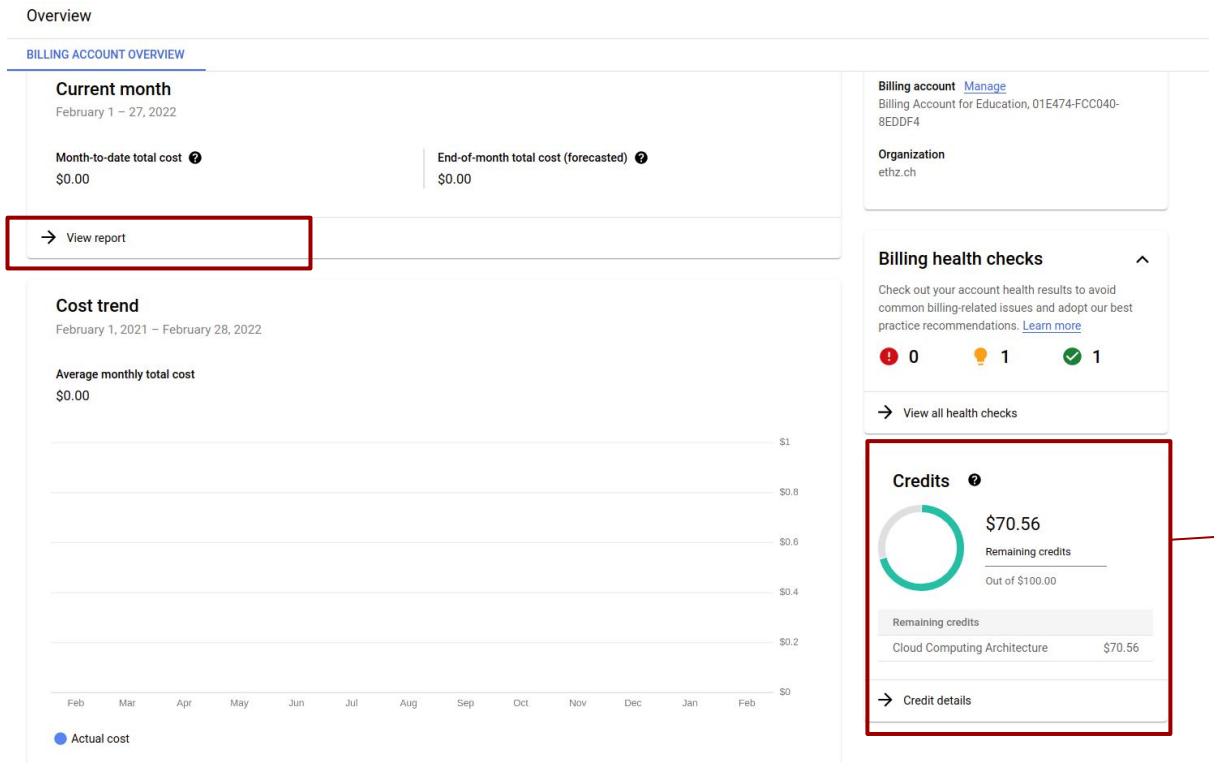
```
$ gcloud auth application-default login

Go to the following link in your browser:
....
```

Set/get current project

```
$ gcloud config set project myproject

Updated property [core/project].


$ gcloud config get-value project

Your active configuration is [xyz]
myproject
```

GCP - Credits, Billing & Budget

- View remaining credits/cost overview

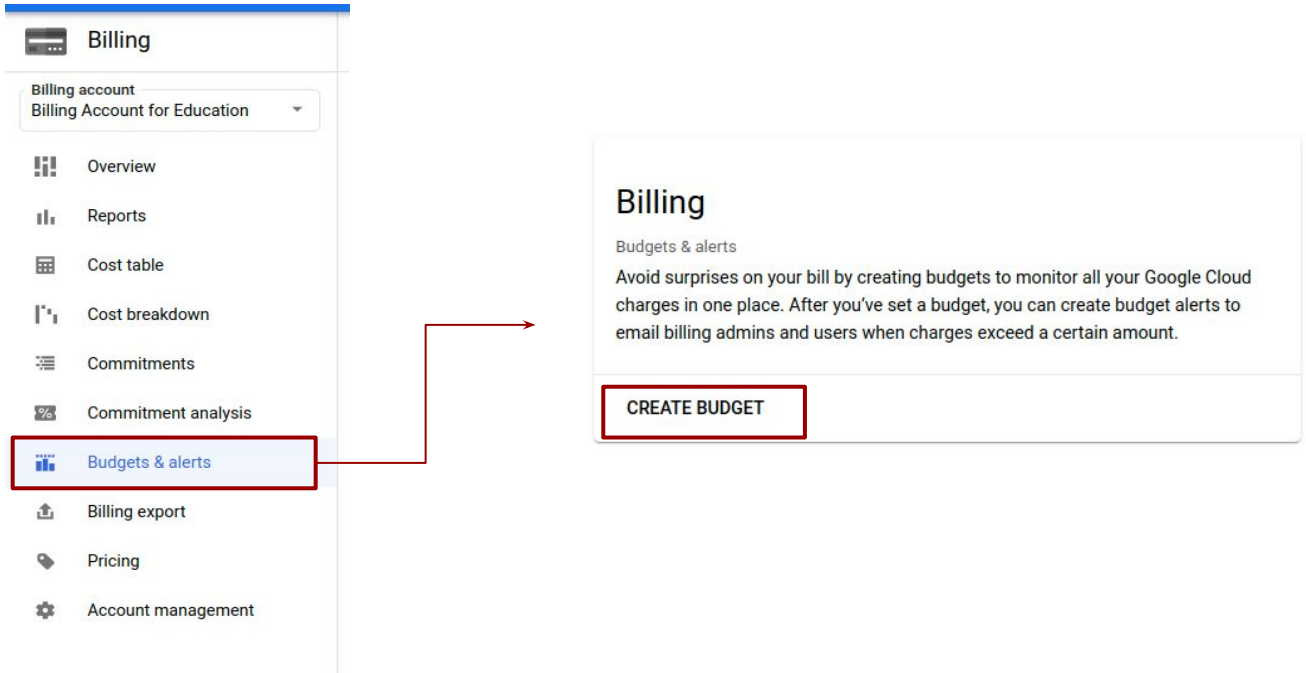


Cost breakdown

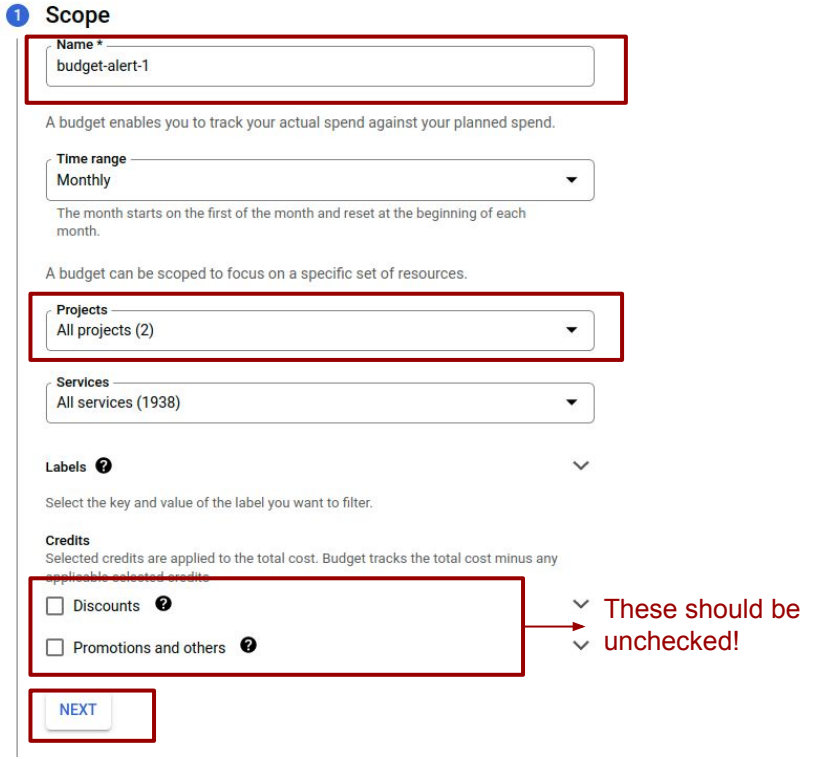
Remaining

GCP - Credits, Billing & Budget

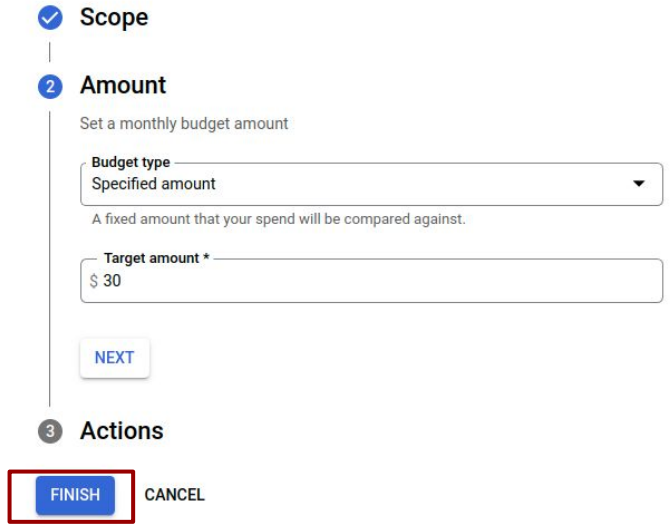
- Budget alerts



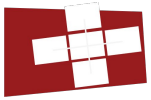
GCP - Credits, Billing & Budget



These should be unchecked!



GCP - Create VM - CLI



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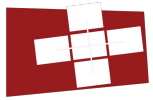
- Get a list of available images

```
$ gcloud compute images list

NAME                                  PROJECT          FAMILY                DEPRECATED  STATUS

centos-7-v20220126                    centos-cloud     centos-7                          READY
centos-stream-8-v20220128             centos-cloud     centos-stream-8                   READY
cos-85-13310-1416-5                   cos-cloud        cos-85-lts                        READY
cos-89-16108-604-11                   cos-cloud        cos-89-lts                        READY
cos-93-16623-102-12                   cos-cloud        cos-93-lts                        READY
cos-beta-93-16623-39-6                cos-cloud        cos-beta                          READY
debian-10-buster-v20220118            debian-cloud     debian-10                         READY
debian-11-bullseye-v20220120          debian-cloud     debian-11                         READY
debian-9-stretch-v20220118            debian-cloud     debian-9                          READY
fedora-cloud-base-gcp-33-1-2-x86-64   fedora-cloud     fedora-cloud-33                   READY
fedora-cloud-base-gcp-34-1-2-x86-64   fedora-cloud     fedora-cloud-34                   READY
fedora-cloud-base-gcp-35-1-2-x86-64   fedora-cloud     fedora-cloud-35                   READY
....
```

GCP - Create VM - CLI



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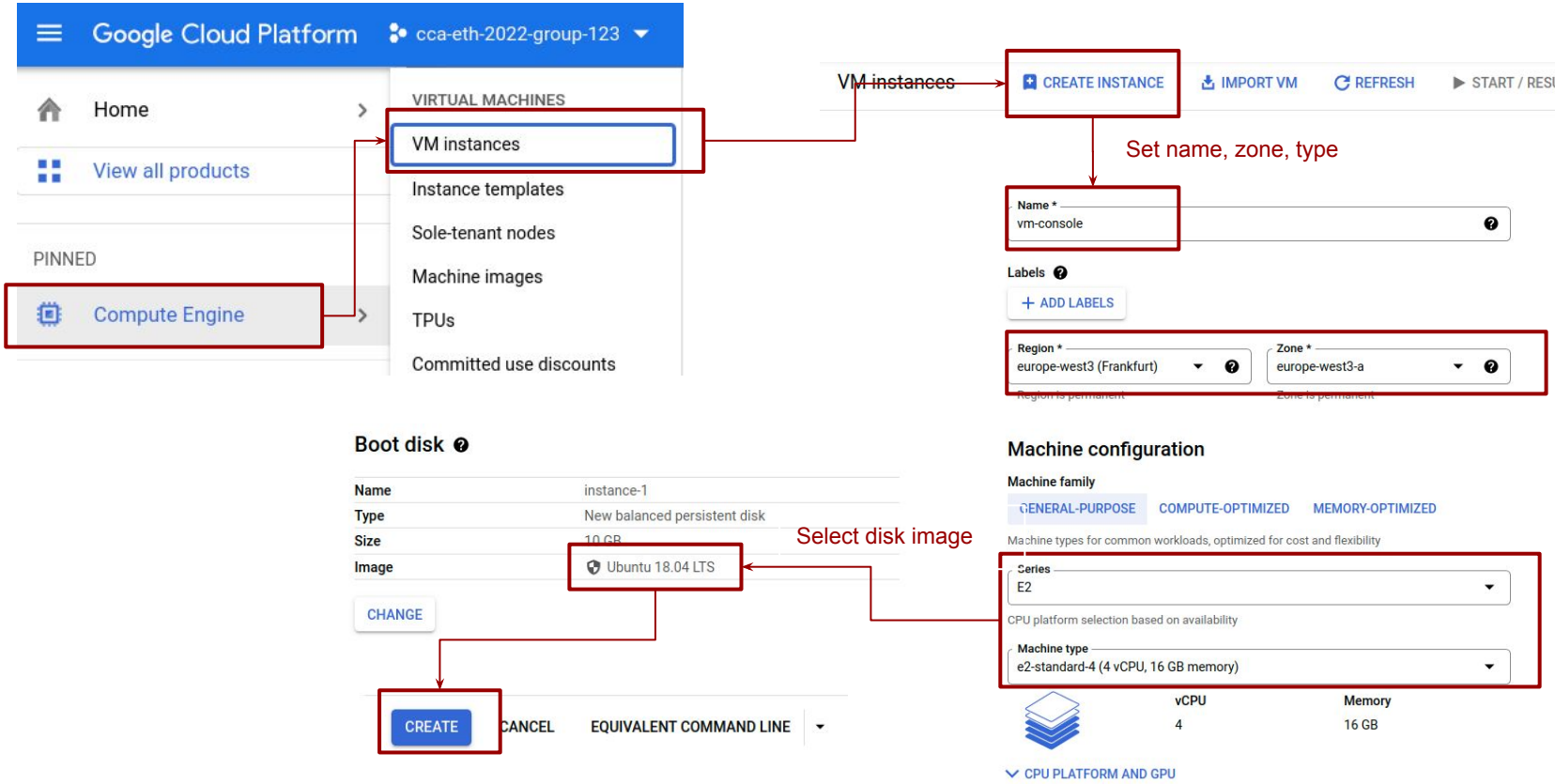
- Create the VM

```
$ gcloud compute instances create vm-gcloud --image-family=ubuntu-1804-lts --image-project=ubuntu-os-cloud
--machine-type=e2-standard-2 --project=cca-eth-2023-group-fstrati --zone=europe-west3-a

Created
[https://www.googleapis.com/compute/v1/projects/cca-eth-2023-group-fstrati/zones/europe-west3-a/instances/vm-gcloud]

NAME       ZONE            MACHINE_TYPE    PREEMPTIBLE  INTERNAL_IP  EXTERNAL_IP     STATUS
vm-gcloud  europe-west3-a  e2-standard-2                10.156.0.2   35.159.171.70   RUNNING
```

GCP - Create VM - Console



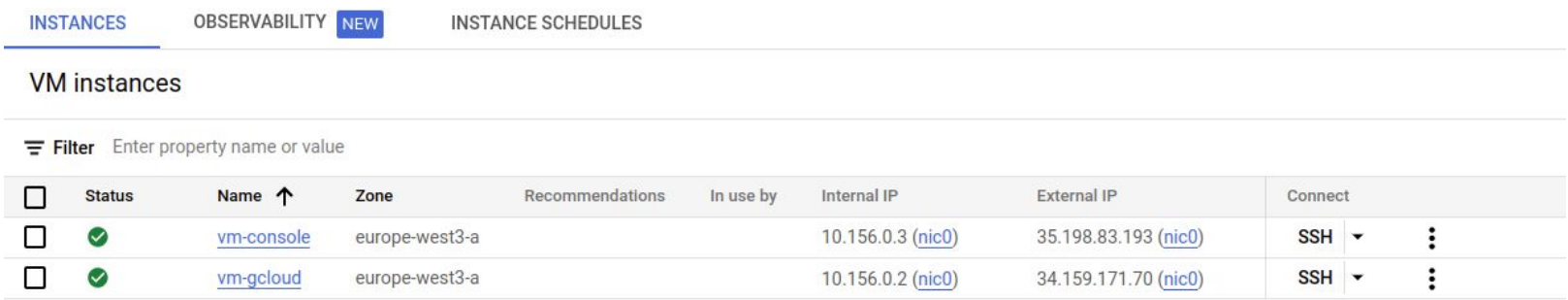
GCP - Inspect VM

- From CLI

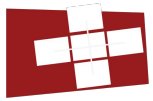
```
$ gcloud compute instances list

NAME         ZONE            MACHINE_TYPE  PREEMPTIBLE  INTERNAL_IP  EXTERNAL_IP     STATUS
vm-console   europe-west3-a  e2-standard-4               10.156.0.3   35.198.83.193   RUNNING
vm-gcloud    europe-west3-a  e2-standard-2               10.156.0.2   35.159.171.70   RUNNING
```

- From Console



GCP - Connect to VM



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- Connect via SSH

```
$ gcloud compute ssh vm-console --project cca-eth-2023-group-fstrati --zone europe-west3-a

[...]
Welcome to Ubuntu 18.04.6 LTS (GNU/Linux 5.4.0-1064-gcp x86_64)

user@vm-console:~$
```

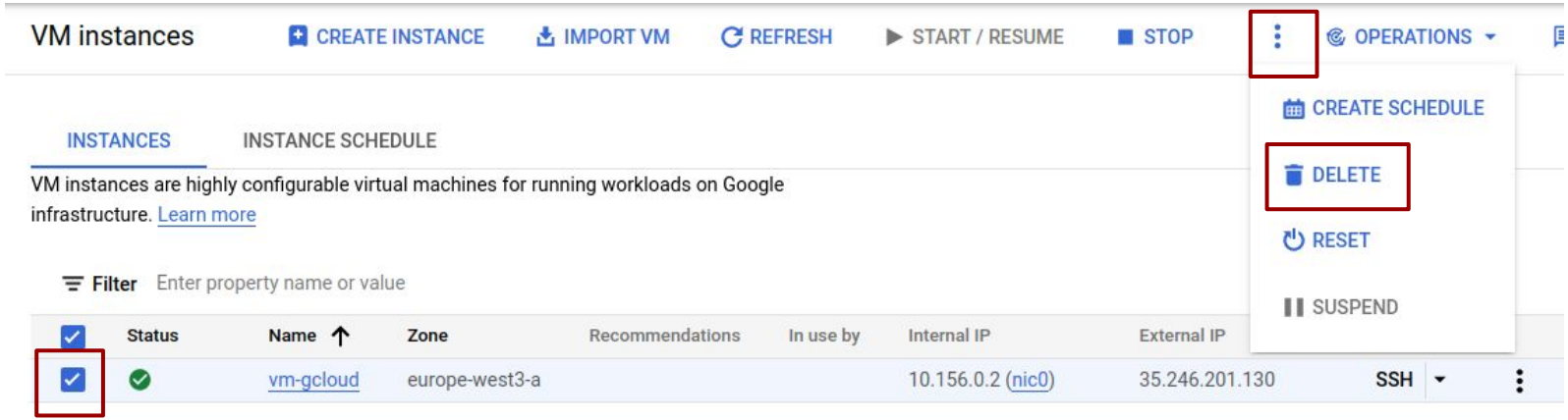
GCP - Terminate VM

- From CLI

```
$ gcloud compute instances delete vm-console --project cca-eth-2023-group-fstrati --zone europe-west3-a

The following instances will be deleted. Any attached disks configured to be auto-deleted will be deleted unless they are
attached to any other instances or the `--keep-disks` flag is given and specifies
them for keeping. Deleting a disk is irreversible and any data on the disk will be lost.
 - [vm-console] in [europe-west3-a]

Do you want to continue (Y/n)?  Y

Deleted
[https://www.googleapis.com/compute/v1/projects/cca-eth-2023-group-fstrati/zones/europe-west3-a/instances/vm-console].
```

GCP - Terminate VM

- From Console



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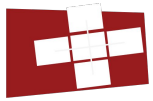
Setting up a cluster with Kops

Kops



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- Tool to create, maintain, update and delete Kubernetes-enabled clusters [1]
- Users define a *cluster specification* (e.g. a yaml file)
  - We will describe how our GCP VMs should look like (number of machines, machine type, etc.)
- Supports multiple cloud providers such as AWS, GCP

[1] Kops guide

Kops yaml file

```
apiVersion: kops.k8s.io/v1alpha2
kind: Cluster
metadata:
  creationTimestamp: null
  name: part1.k8s.local
spec:
  …
  configBase:
gs://cca-eth-2023-group-XXX-ethzid/part1.k8s.local
  …
  project:  cca-eth-2023-group-XXX
  …
```

Change these!

```
apiVersion: kops.k8s.io/v1alpha2
kind: InstanceGroup
metadata:
  creationTimestamp: null
  labels:
    kops.k8s.io/cluster: part1.k8s.local
  name: memcache-server
spec:
  image: ubuntu-os-cloud/ubuntu-1804-bionic-v20210211
  machineType: t2d-standard-2
  maxSize: 1
  minSize: 1
  nodeLabels:
    cloud.google.com/metadata-proxy-ready: "true"
    kops.k8s.io/instancegroup: nodes-europe-west3-a
    cca-project-nodetype: "memcached"
…
```

Create a cluster with Kops

```
$ gsutil mb gs://cca-eth-2023-group-XXX-ethzid/
$ export KOPS_STATE_STORE=gs://cca-eth-2023-group-XXX-ethzid/
```
→ For the cluster configuration

```
$ cd ~/.ssh & ssh-keygen -t rsa -b 4096 -f cloud-computing
```
→ Generate login keys

```
$ PROJECT=`gcloud config get-value project`
$ export KOPS_FEATURE_FLAGS=AlphaAllowGCE
$ kops create -f part1.yaml
```
→ Set configuration

```
$ kops create secret --name part1.k8s.local sshpublickey admin -i ~/.ssh/cloud-computing.pub
```
→ Add login keys

```
$ kops update cluster --name part1.k8s.local --yes --admin
```
→ Deploy the cluster

```
$ kops validate cluster --wait 10m
```
→ Wait…

Inspect the cluster

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$ kubectl get nodes -o wide

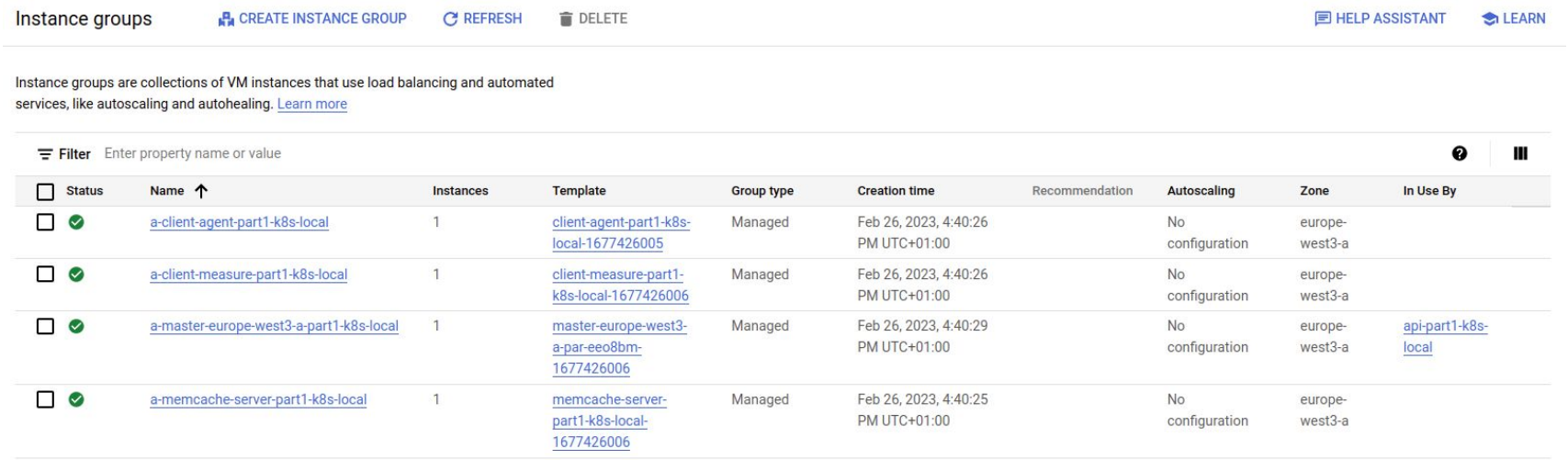
NAME	STATUS	ROLES	AGE	VERSION	INTERNAL-IP	EXTERNAL-IP	OS-IMAGE	KERNEL-VERSION	CONTAINER-RUNTIME
client-agent-4v0l	Ready	node	2m38s	v1.23.16	10.0.16.4	34.159.225.244	Ubuntu 18.04.5 LTS	5.4.0-1036-gcp	docker://20.10.17
client-measure-0svs	Ready	node	2m41s	v1.23.16	10.0.16.3	34.141.87.51	Ubuntu 18.04.5 LTS	5.4.0-1036-gcp	docker://20.10.17
master-europe-west3-a-459v	Ready	control-plane,master	3m53s	v1.23.16	10.0.16.5	34.89.151.210	Ubuntu 18.04.5 LTS	5.4.0-1036-gcp	docker://20.10.17
memcache-server-z82c	Ready	node	2m45s	v1.23.16	10.0.16.2	34.159.171.70	Ubuntu 18.04.5 LTS	5.4.0-1036-gcp	docker://20.10.17

VM instances

Filter Enter property name or value

Status	Name	Zone	Recommendations	In use by	Internal IP	External IP	Connect
✓	client-agent-4v0l	europe-west3-a		a-client-agent-part1-k8s-local	10.0.16.4 (nic0)	34.159.225.244 (nic0)	SSH
✓	client-measure-0svs	europe-west3-a		a-client-measure-part1-k8s-local	10.0.16.3 (nic0)	34.141.87.51 (nic0)	SSH
✓	master-europe-west3-a-459v	europe-west3-a		a-master-europe-west3-a-part1-k8s-local, api-part1-k8s-local	10.0.16.5 (nic0)	34.89.151.210 (nic0)	SSH
✓	memcache-server-z82c	europe-west3-a		a-memcache-server-part1-k8s-local	10.0.16.2 (nic0)	34.159.171.70 (nic0)	SSH

Instance Groups



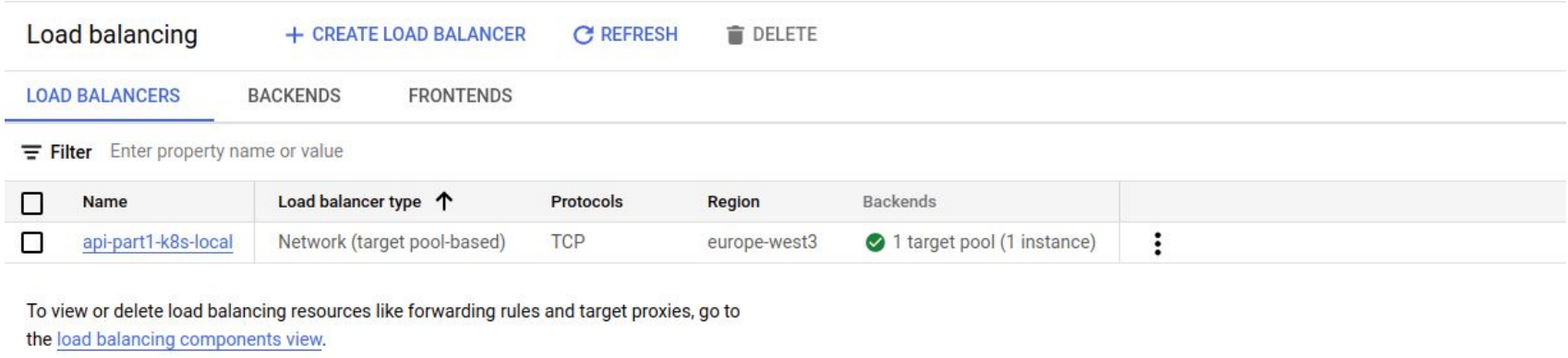
Instance groups | CREATE INSTANCE GROUP | REFRESH | DELETE | HELP ASSISTANT | LEARN

Instance groups are collections of VM instances that use load balancing and automated services, like autoscaling and autohealing. Learn more

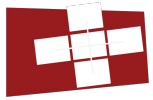
Filter: Enter property name or value

Status	Name	Instances	Template	Group type	Creation time	Recommendation	Autoscaling	Zone	In Use By
✓	a-client-agent-part1-k8s-local	1	client-agent-part1-k8s-local-1677426005	Managed	Feb 26, 2023, 4:40:26 PM UTC+01:00		No configuration	europe-west3-a	
✓	a-client-measure-part1-k8s-local	1	client-measure-part1-k8s-local-1677426006	Managed	Feb 26, 2023, 4:40:26 PM UTC+01:00		No configuration	europe-west3-a	
✓	a-master-europe-west3-a-part1-k8s-local	1	master-europe-west3-a-par-eeo8bm-1677426006	Managed	Feb 26, 2023, 4:40:29 PM UTC+01:00		No configuration	europe-west3-a	api-part1-k8s-local
✓	a-memcache-server-part1-k8s-local	1	memcache-server-part1-k8s-local-1677426006	Managed	Feb 26, 2023, 4:40:25 PM UTC+01:00		No configuration	europe-west3-a	

Load Balancers



Delete the cluster



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```
$ kops delete cluster part1.k8s.local --yes

[...]
Deleted kubectl config for part1.k8s.local
Deleted cluster: "part1.k8s.local"
```

It is very important to delete your cluster,

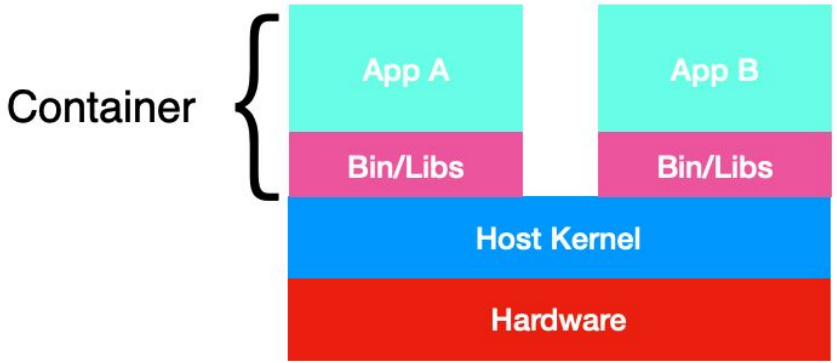
otherwise you may spend your credits quite quickly!

ETH zürich

Running applications with Kubernetes

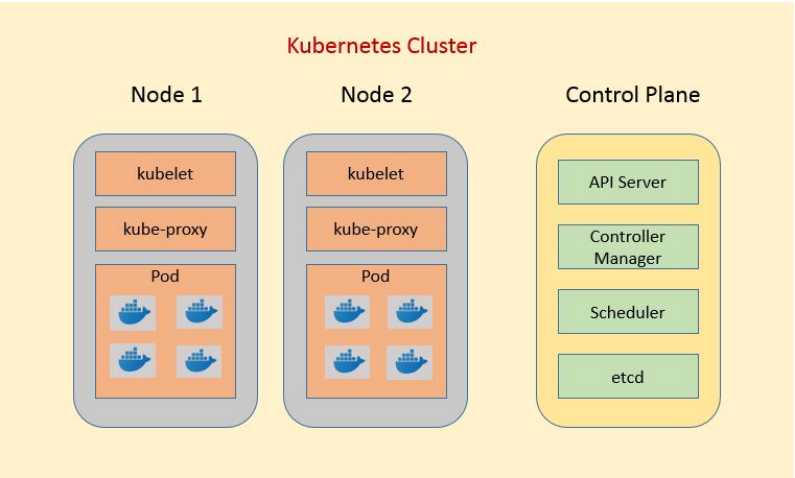
Containers

- Packages of software (application code and dependencies)
- Allow applications to be “packed” and run in any environment
- In this project, we are going to use **Docker** containers



Kubernetes

- Runs, monitors, and manages containers
- Schedules containers on the cluster (unit of scheduling: **pod**) and migrates them
- Load balancing across containers
- … and many more (we will see more later during the semester)



Workloads

- Memcached: distributed, in memory, key-value store - latency-sensitive
  - mcperf: load generator for memcache
- PARSEC: benchmark suite of multi-threaded applications [1]
- iBench: suite of microbenchmarks that cause interference to various resources (CPU, caches, memory bandwidth)

[1] The PARSEC benchmark suite

Run workloads with kubectl

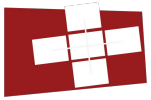
```
$ kubectl create -f memcache-t1-cpuset.yaml
$ kubectl expose pod some-memcached --name some-memcached-11211 \
                  --type LoadBalancer --port 11211 \
                  --protocol TCP
$ sleep 60
$ kubectl get service some-memcached-11211


$ kubectl get pods -o wide

NAME              READY  STATUS   RESTARTS  AGE    IP          NODE
some-memcached    1/1    Running  0         4m40s  100.96.2.3  memcache-server-z82c
```

→ Launch memcached

You will need this for mcperf

Yaml file for workload description

```
apiVersion: v1
kind: Pod
metadata:
  name: some-memcached
  labels:
    name: some-memcached
spec:
  containers:
    - image: anakli/memcached:t1
      name: memcached
      imagePullPolicy: Always
      command: ["/bin/sh"]
      args: ["-c", "taskset -c 0 ./memcached -t 1 -u memcache"]
  nodeSelector:
    cca-project-nodetype: "memcached"
```



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Thank you!
Questions?