GCP INFRASTRUCTURE BUILD

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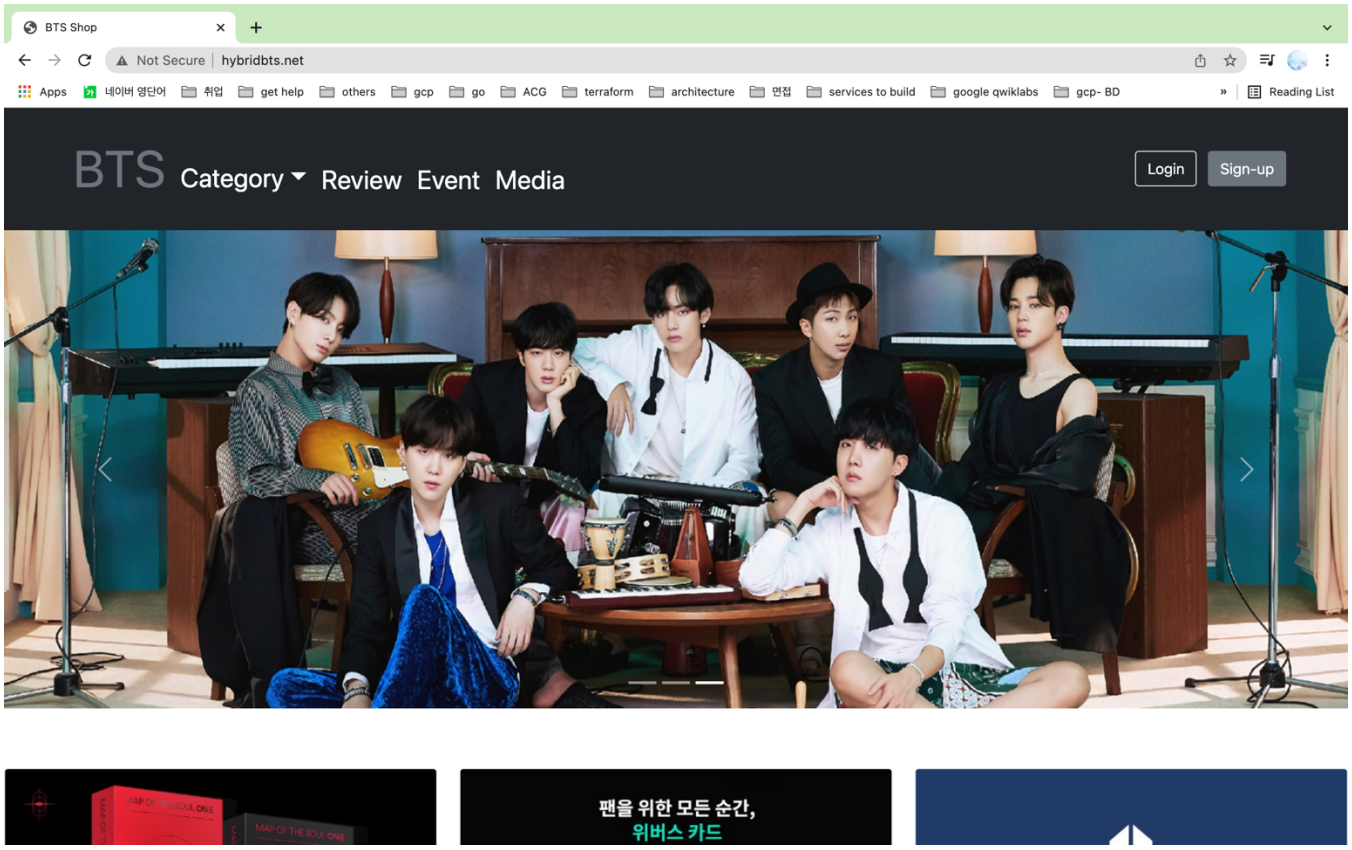
hybridbts.net



Virtual Private Cloud (VPC)

Custom VPC 를 생성하여 public subnet 과 private subnet 을 생성했습니다. NAT 라우터와 NAT 게이트웨이를 생성하여 VPC 의 프라이빗 인스턴스들이 인터넷에 접근 가능하도록 했습니다.

Create a custom VPC

```
gcloud projects create hybrid-bts
gcloud config set project hybrid-bts

gcloud compute networks create bts-vpc --subnet-mode=custom

gcloud compute networks subnets create bts-priv-sub-1 --network=bts-vpc \
--region=asia-northeast3 --range=10.0.0.0/24 --enable-private-ip-google-access
```

```
dntwkzz79@cloudshell:~ (hybrid-bts)$ gcloud compute networks list
NAME: bts-vpc
SUBNET_MODE: CUSTOM
BGP_ROUTING_MODE: REGIONAL
IPV4_RANGE:
GATEWAY_IPV4:
```

Update

```
gcloud compute networks subnets update bts-priv-sub-1 \
--region=asia-northeast3 --enable-private-ip-google-access

gcloud compute networks subnets delete private1 --region=asia-northeast3
```

List

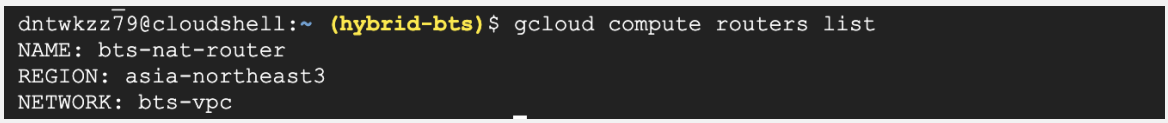
```
gcloud compute regions list
```

```
gcloud compute networks list
gcloud compute networks subnets list --network=bts-vpc
gcloud compute firewall-rules list --network=bts-vpc
gcloud compute networks subnets describe bts-priv-sub-1 --region=asia-northeast3 \
--format="get(privateIpGoogleAccess)"
```

NAT

```
gcloud compute routers create bts-nat-router \
    --network bts-vpc \
    --region asia-northeast3

gcloud compute routers nats create bts-nat-config \
    --router-region asia-northeast3 \
    --router bts-nat-router \
    --auto-allocate-nat-external-ips \
    --nat-all-subnet-ip-ranges \
    --enable-logging
```



Firewall

Custom VPC 에 배치된 인스턴스들에 HTTP, HTTPS, ICMP, SSH 접근을 개방하였습니다.

Create

```
gcloud compute firewall-rules create btsvpc-allow-http-https-icmp-ssh
--direction=INGRESS \
--priority=1000 --network=bts-vpc --action=ALLOW --rules=icmp,tcp:80,443,22 \
--source-ranges=0.0.0.0/0
```

```
NAME: btsvpc-allow-icmp-ssh
NETWORK: bts-vpc
DIRECTION: INGRESS
PRIORITY: 1000
ALLOW: tcp:22,tcp:80,tcp:443,icmp
DENY:
DISABLED: False
```

Compute Engine

관리자가 프라이빗 GKE 클러스터 내의 인스턴스들을 관리할 수 있도록 bastion host 를 public subnet 에 생성하였습니다. Bastion host 에 kubectl 패키지를 설치하였습니다.

Create

```
gcloud compute instances create bts-bastion-vm --zone=asia-northeast3-a \
 --machine-type=f1-micro --subnet=bts-pub-sub-1 --image-family=debian-10 \
 --image-project=debian-cloud --boot-disk-size=10GB --boot-disk-type=pd-standard \
--boot-disk-device-name=bts-bastion-vm
```

```
NAME: bts-bastion-vm
ZONE: asia-northeast3-a
MACHINE_TYPE: e2-micro
PREEMPTIBLE:
INTERNAL_IP: 10.0.0.2
EXTERNAL_IP:
STATUS: TERMINATED
```

Manage

```
gcloud compute instances start bts-bastion-vm --zone asia-northeast3-a
gcloud compute instances stop bts-bastion-vm --zone asia-northeast3-a
gcloud compute instances set-machine-type bts-bastion-vm --zone asia-northeast3-a \
   --machine-type e2-medium
gcloud compute instances list --sort-by=ZONE
gcloud compute ssh bts-bastion-vm --zone asia-northeast3-a --tunnel-through-iap
```

Install packages

```
sudo apt-get update
sudo apt-get install -y apt-transport-https ca-certificates curl

sudo curl -fsSLo /usr/share/keyrings/kubernetes-archive-keyring.gpg
https://packages.cloud.google.com/apt/doc/apt-key.gpg
echo"deb [signed-by=/usr/share/keyrings/kubernetes-archive-keyring.gpg]
https://apt.kubernetes.io/ kubernetes-xenial main"| sudo tee
/etc/apt/sources.list.d/kubernetes.list
```

```
sudo apt-get update
sudo apt-get install -y kubectl
```

Google Cloud Storage(GCS)

웹사이트의 static contents 들을 저장할 버킷을 생성하고 오브젝트에 ACL 을 설정하였습니다.

Create

```
gsutil mb -l asia-northeast3 gs://bts-static
gsutil cp album.svg gs://bts-static/images
gsutil cp gs://bts-static/images/album.svg .
```

```
NAME: gs://bts-static
LOCATION: US
STORAGE_CLASS: STANDARD
```

ACL

```
export BUCKET_NAME_1=bts-static

gsutil cp album.svg gs://$BUCKET_NAME_1/
gsutil acl get gs://$BUCKET_NAME_1/ album.svg > acl.txt
cat acl.txt

gsutil acl set private gs://$BUCKET_NAME_1/album.svg
gsutil acl get gs://$BUCKET_NAME_1/album.svg > acl2.txt
```

```
cat acl2.txt

gsutil acl ch -u AllUsers:R gs://$BUCKET_NAME_1/album.svg
gsutil acl get gs://$BUCKET_NAME_1/album.svg > acl3.txt
cat acl3.txt
```

Cloud SQL

웹사이트의 회원정보를 저장하기 위해 Cloud SQL 인스턴스와 데이터베이스, 테이블을 생성했습니다.

Create

```
gcloud beta sql instances create bts-sql-2 --database-version=MYSQL_5_7 \
--cpu=1 --memory=3840MB \
--network=projects/hybrid-bts/global/networks/bts-vpc \
--region=asia-northeast3 --root-password=admin123 --no-assign-ip

gcloud sql instances list

gcloud sql instances delete bts-sql
```

```
NAME: bts-sql-1
DATABASE_VERSION: MYSQL_5_7
LOCATION: asia-northeast3-a
TIER: db-f1-micro
PRIMARY_ADDRESS: -
PRIVATE_ADDRESS: 10.58.112.4
STATUS: RUNNABLE
```

Connect

```
gcloud auth activate-service-account vm-ser-acc@hybrid-bts.iam.gserviceaccount.com
\
--key-file=/home/dntwkzz79/hybrid-bts-97203600b216.json --project=hybrid-bts

gcloud sql connect bts-sql-1 --user=root

mysql -u root -h 10.58.112.4 -p
```

Create Database & Tables

```
create database bts;

CREATE TABLE board (
num int primary key auto_increment,
id char(15),
name char(10),
subject char(200),
content text,
regist_day char(20),
hit int,
file_name char(40),
file_type char(40),
file_copied char(40)
);
```

```
CREATE TABLE members (
num int primary key auto_increment,
id char(15),
pass char(15),
name char(10),
email char(80),
regist_day char(20),
level int,
point int
);
```

IAM- Service Account

리소스들이 다른 리소스에 대한 관리자 권한을 가질 수 있도록 service account 를 생성했습니다.

```
gcloud auth activate-service-account vm-ser-acc@hybrid-bts.iam.gserviceaccount.com
\
--key-file='./credentials.json' --project=hybrid-bts

kubectl create clusterrolebinding clu-admin \
   --clusterrole=cluster-admin --serviceaccount=default:vm-ser-acc

gcloud iam service-accounts list

gcloud iam service-accounts create jenkins-admin \
   --display-name="jenkins-admin"
```

```
gcloud iam service-accounts keys create key.json --iam-account= jenkins-admin
@hybrid-bts.iam.gserviceaccount.com

gcloud projects add-iam-policy-binding $PROJECT_ID \
  --member="serviceAccount: jenkins-admin@hybrid-bts.iam.gserviceaccount.com" \
  --role="roles/container.admin"
```

```
displayName: vm-ser-acc
email: vm-ser-acc@hybrid-bts.iam.gserviceaccount.com
etag: MDEwMjE5MjA=
name: projects/hybrid-bts/serviceAccounts/vm-ser-acc@hybrid-bts.iam.gserviceaccount.com
oauth2ClientId: '101819087859158478884'
projectId: hybrid-bts
```

Cloud DNS

웹서버에 hybridbts.net 도메인을 연결하였습니다.

Create DNS records

```
gcloud dns managed-zones create hybridbts \
  --description=”” \
  --dns-name=hybridbts.net.

gcloud dns --project=hybrid-bts managed-zones create hybridbtsnet \
--dns-name=hybridbts.net --description="for web server"

--visibility="public" --dnssec-state="off"
```

gcloud dns record-sets create hybridbts.net. --rrdatas="34.102.162.191" --type=A --ttl=60 \
--zone="hybridbts"

gcloud dns record-sets create www.hybridbts.net. --rrdatas="34.102.162.191" \
 --type=CNAME --ttl=60 \
 --zone="hybridbts"

```
dntwkzz79@cloudshell:~ (hybrid-bts)$ gcloud dns managed-zones list
NAME: hybridbts
DNS_NAME: hybridbts.tech.
DESCRIPTION:
VISIBILITY: public
```

Cloud Source Repository(CSR)

애플리케이션 소스 코드를 CRS 에 업로드하여 GKE, Cloud Build, Cloud Run 등 GCP 내 서비스와 연동이 쉽게 했습니다.

Repository

```
gcloud source repos create bts-web

git init
git config credential.helper gcloud.sh
export PROJECT_ID=$(gcloud config get-value project)
git remote add origin https://source.developers.google.com/p/$PROJECT_ID/r/bts-web

git config --global user.email "dntwkzz79@gmail.com"
git config --global user.name "yeseul park"

git add .
git commit -m "Initial commit"
git push origin master
```

```
dntwkzz79@cloudshell:~ (hybrid-bts)$ gcloud source repos list
REPO_NAME: bts-web
PROJECT_ID: hybrid-bts
URL: https://source.developers.google.com/p/hybrid-bts/r/bts-web
```

Cloud Build

Cloud Build 로 애플리케이션 배포의 CI/CD 를 했습니다.

Build submit

```
docker pull python

export PROJECT_ID=$(gcloud config list --format 'value(core.project)')

gcloud builds submit --tag gcr.io/hybrid-bts/bts-review
```

Build trigger

```
gcloud beta builds triggers create cloud-source-repositories \
   --repo="bts_review_app" \
   --branch-pattern="^master$" \
   --build-config="trigger_build.yaml" \
   --name="bts-review"

* 코드 수정
git status
git add .
git commit -m "updated"
git push origin master
```

```
dntwkzz79@cloudshell:~ (hybrid-bts)$ gcloud alpha builds triggers list
---
createTime: '2021-12-26T18:02:00.233566912Z'
filename: trigger_build.yaml
id: f64e9358-c250-460d-bc69-a0eb875aa03c
name: bts-review
triggerTemplate:
  branchName: ^master$
  projectId: hybrid-bts
  repoName: bts_review_app
```

Trigger_build.yaml

```
steps:
- name: 'gcr.io/cloud-builders/docker'
  args: ['build', '-t', 'gcr.io/hybrid-bts/bts-review', '.']
- name: 'gcr.io/cloud-builders/docker'
  args: ['push', 'gcr.io/hybrid-bts/bts-review']
```

Google Kubernetes Engine(GKE)

웹 서버 애플리케이션을 컨테이너로 GKE 에 배포하고 운영했습니다. 프라이빗 클러스터로 생성하여 ingress 를 통해서만 외부에서 접근이 가능하도록 했습니다.

Create clusters

```
export bts_network='bts-vpc'
export bts_region='asia-northeast3'
export bts_cluster='bts-cluster'
```

```
gcloud container clusters create $bts_cluster \
   --network $bts_network --subnetwork bts-priv-sub-1 --region $bts_region \
   --machine-type e2-medium \
   --enable-autoscaling \
   --num-nodes 1 \
   --min-nodes 0 \
   --max-nodes 5 \
   --service-account vm-ser-acc@hybrid-bts.iam.gserviceaccount.com \
   --enable-master-global-access \
   --enable-master-authorized-networks \
   --enable-ip-alias \
   --enable-private-nodes \
   --enable-private-endpoint \
   --master-ipv4-cidr 10.2.0.0/28

gcloud container clusters update $bts_cluster --region $bts_region \
   --enable-master-authorized-networks \
   --master-authorized-networks 10.0.0.2/32

gcloud container clusters resize $bts_cluster --region=$bts_region --num-nodes=0
```

```
NAME: bts-cluster
LOCATION: asia-northeast3
MASTER_VERSION: 1.21.5-gke.1302
MASTER_IP: 10.2.0.2
MACHINE_TYPE: e2-medium
NODE_VERSION: 1.21.5-gke.1302
NUM_NODES: 3
STATUS: RUNNING
```

Connect to clusters & configs

```
gcloud container clusters get-credentials $bts_cluster --region $bts_region


kubectl config view
kubectl cluster-info
kubectl config current-context
kubectl config get-contexts
kubectl top nodes
```

Create a sample job

```
Kubectl apply -f sample-job.yaml
kubectl delete job sample-job
kubectl describe jobs
```

Sample-job.yaml

```
apiVersion: batch/v1
kind: Job
metadata:
  name: sample-job
spec:
  template:
    metadata:
      name: sample-jobs
```

```
spec:
  containers:
  - name: sample-container
    image: gcr.io/hybrid-bts/bts-web
  restartPolicy: OnFailure
```

Create secrets

```
kubectl create secret generic credentials-key \
 --from-file=$HOME/credentials.json --namespace=production
kubectl create secret generic credentials-key \
--from-file=$HOME/credentials.json –namespace=default

kubectl delete secret generic credentials-key
kubectl get secrets
kubectl describe credentials-key
rm -rf ~/credentials.json
```

Create deployments

```
kubectl create ns production
kubectl --namespace=production apply -f k8s/production
kubectl --namespace=production apply -f k8s/canary
kubectl --namespace=production apply -f k8s/services

kubectl --namespace=production scale deployment bts-web-production --replicas=4
```

kubectl get deployments

kubectl describe pod bts-web-canary --namespace=production

kubectl get pods --namespace=production

kubectl --namespace=production get service bts-web-service

kubectl describe deployments --namespace=production

```
dntwkzz79@cloudshell:~ (hybrid-bts)$ kubectl get deployments --namespace=production
NAME                READY   UP-TO-DATE   AVAILABLE   AGE
bts-web-canary      1/1     1            1           156m
bts-web-production  1/1     1            1           156m
```

k8s/bts-web-production.yaml

```
kind: Deployment
apiVersion: apps/v1
metadata:
  name: bts-web-production
  labels:
    app: bts-web
spec:
  replicas: 1
  selector:
    matchLabels:
      app: bts-web
      role: web
      env: production
  template:
    metadata:
```

```
  name: web
  labels:
    app: bts-web
    role: web
    env: production
spec:
  volumes:
  - name: google-cloud-key
    secret:
      secretName: credentials-key
  containers:
  - name: bts-web
    image: gcr.io/hybrid-bts/bts-web
    resources:
      limits:
        memory: "500Mi"
        cpu: "100m"
    imagePullPolicy: Always
    volumeMounts:
    - name: google-cloud-key
      mountPath: /var/secrets/google
    env:
    - name: GOOGLE_APPLICATION_CREDENTIALS
      value: /var/secrets/google/key.json
    ports:
    - name: web
      containerPort: 80
```

k8s/ bts-web-canary.yaml

```
kind: Deployment
apiVersion: apps/v1
metadata:
  name: bts-web-canary
  labels:
    app: bts-web
spec:
  replicas: 1
  selector:
    matchLabels:
      app: bts-web
      role: web
      env: canary
  template:
    metadata:
      name: web
      labels:
        app: bts-web
        role: web
        env: canary
    spec:
      volumes:
      - name: google-cloud-key
        secret:
          secretName: credentials-key
      containers:
      - name: bts-web
        image: gcr.io/hybrid-bts/bts-web
```

```
        resources:
          limits:
            memory: "500Mi"
            cpu: "100m"
        imagePullPolicy: Always
        volumeMounts:
        - name: google-cloud-key
          mountPath: /var/secrets/google
        env:
        - name: GOOGLE_APPLICATION_CREDENTIALS
          value: /var/secrets/google/key.json
        ports:
        - name: web
          containerPort: 80
```

k8s/bts-web-dev.yaml

```
kind: Deployment
apiVersion: apps/v1
metadata:
  name: bts-web-dev
  labels:
    app: bts-web
spec:
  replicas: 1
  selector:
    matchLabels:
      app: bts-web
      role: web
```

```
    env: dev
template:
  metadata:
    name: web
    labels:
      app: bts-web
      role: web
      env: dev
  spec:
    volumes:
    - name: google-cloud-key
      secret:
        secretName: credentials-key
    containers:
    - name: bts-web
      image: gcr.io/hybrid-bts/bts-web
      resources:
        limits:
          memory: "500Mi"
          cpu: "100m"
      imagePullPolicy: Always
      volumeMounts:
      - name: google-cloud-key
        mountPath: /var/secrets/google
      env:
      - name: GOOGLE_APPLICATION_CREDENTIALS
        value: /var/secrets/google/key.json
      ports:
      - name: web
        containerPort: 80
```

k8s/services/bts-web-service.yaml

```
apiVersion: v1
kind: Service
metadata:
  name: bts-web-service
  #annotations:
   # networking.gke.io/load-balancer-type: "Internal"
  labels:
    app: bts-web
spec:
  type: LoadBalancer
  selector:
    app: bts-web
  ports:
  - name: http
    protocol: TCP
    port: 80
    targetPort: 80
```

k8s/services/bts-ingress.yaml

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: bts-ingress
  annotations:
    kubernetes.io/ingress.global-static-ip-name: "bts-ingress"
```

```
spec:
  rules:
  - http:
      paths:
      - path: /review/.*
        pathType: Prefix
        backend:
          service:
            name: bts-review-service
            port:
              number: 80
      - path: /
        pathType: Prefix
        backend:
          service:
            name: bts-web-service
            port:
              number: 80
```

Deployment rollout & rollback

```
kubectl set image deployment bts-web-production \
bts-web=gcr.io/hybrid-bts/bts-web:latest –-namespace=production

kubectl rollout status deployment/bts-web-production
kubectl rollout history deployment/bts-web-production
```

```
kubectl rollout undo deployments bts-web-production
kubectl rollout history deployment bts-web-production
```

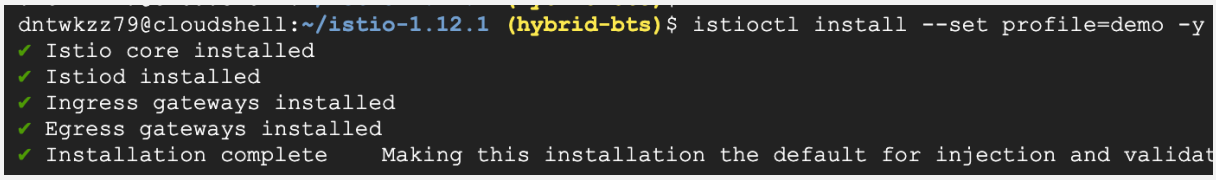
Inject Istio sidecar

```
curl -L https://istio.io/downloadIstio | sh -
cd istio-1.12.1
export PATH=$PWD/bin:$PATH

istioctl install --set profile=demo -y

kubectl label namespace default istio-injection=enabled
kubectl label namespace production istio-injection=enabled

kubectl --namespace=production apply -f k8s/production
kubectl apply -f k8s/review-deployment.yaml
```



CI/CD pipeline(Jenkins)

Jenkins 를 사용하여 CSR 의 소스코드가 업데이트 되면 자동으로 클러스터에 배포가 이루어지도록 CI/CD pipeline 을 생성했습니다. Dev environment 를 사용하여 CD 를 하고 Canary environment 를 사용하여 카나리 배포로 테스트 후에 Production environment 에 최종적으로 업데이트가 됩니다.

Install Jenkins

```
kubectl create clusterrolebinding cluster-admin-binding \
--clusterrole=cluster-admin --user=$(gcloud config get-value account)


helm repo add jenkinsci https://charts.jenkins.io
helm repo update
helm install cd-jenkins -f jenkins/values.yaml jenkinsci/jenkins --wait
```

Jenkins/values.yaml

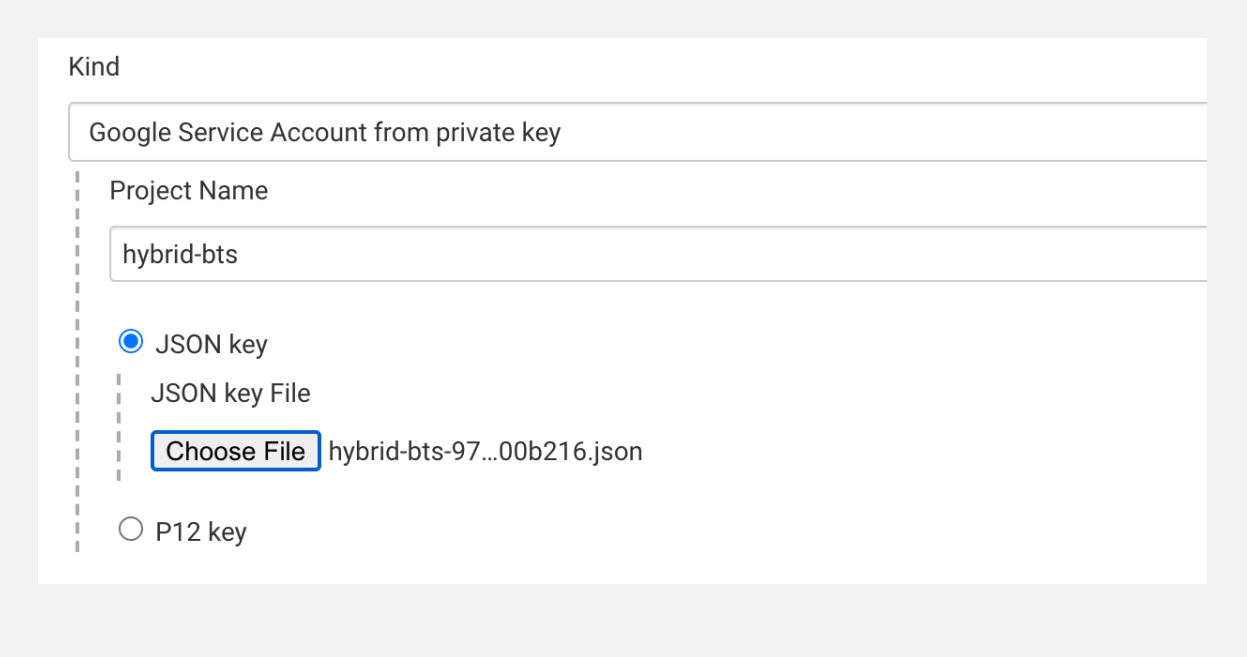
```
controller:
  installPlugins:
    - kubernetes:latest
    - workflow-job:latest
    - workflow-aggregator:latest
    - credentials-binding:latest
    - git:latest
    - google-oauth-plugin:latest
    - google-source-plugin:latest
    - google-kubernetes-engine:latest
    - google-storage-plugin:latest
  resources:
    requests:
      cpu: "50m"
      memory: "1024Mi"
    limits:
```

```
      cpu: "1"
      memory: "3500Mi"
  javaOpts: "-Xms3500m -Xmx3500m"
  serviceType: ClusterIP
agent:
  resources:
    requests:
      cpu: "500m"
      memory: "256Mi"
    limits:
      cpu: "1"
      memory: "512Mi"
persistence:
  size: 100Gi
serviceAccount:
  name: 'vm-ser-acc'
```

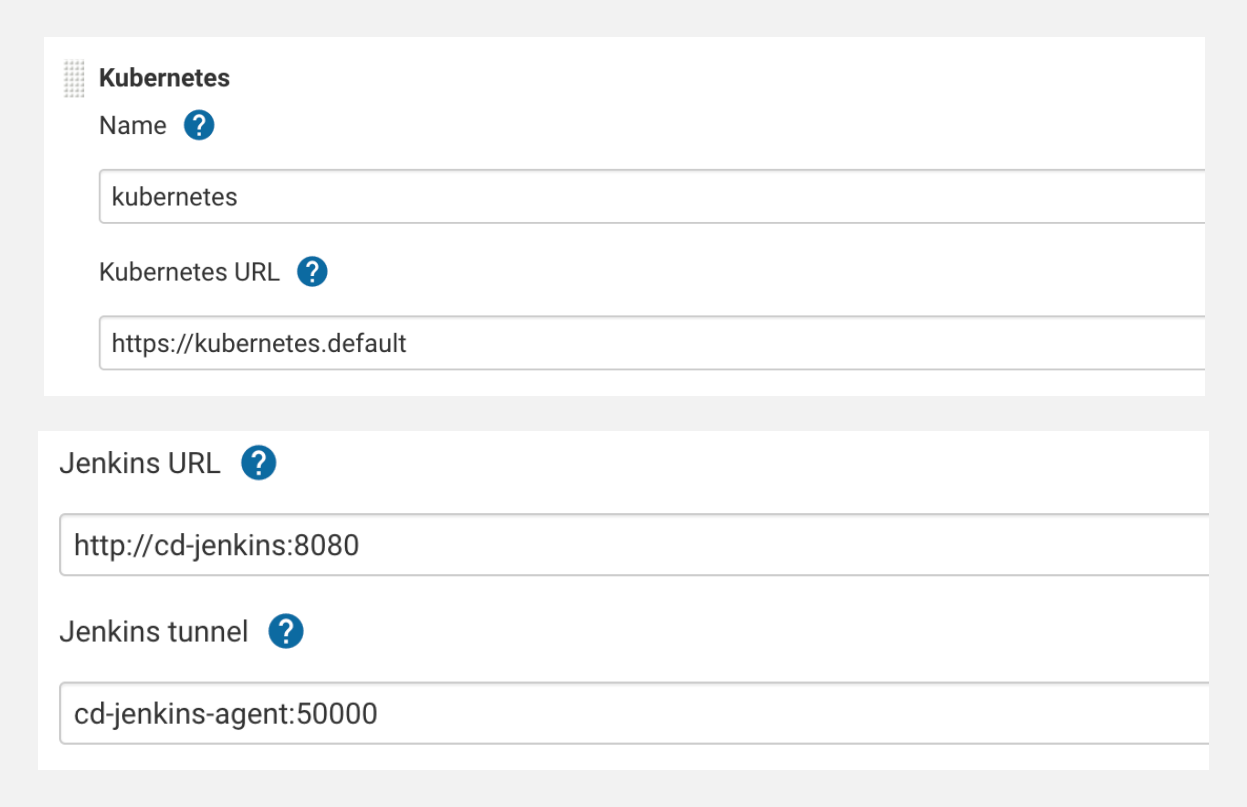
Connect to Jenkins

```
export POD_NAME=$(kubectl get pods --namespace default -l
"app.kubernetes.io/component=jenkins-master" -l "app.kubernetes.io/instance=cd-
jenkins" -o jsonpath="{.items[0].metadata.name}")
kubectl port-forward $POD_NAME 8080:8080 >> /dev/null 2>&1 &
```

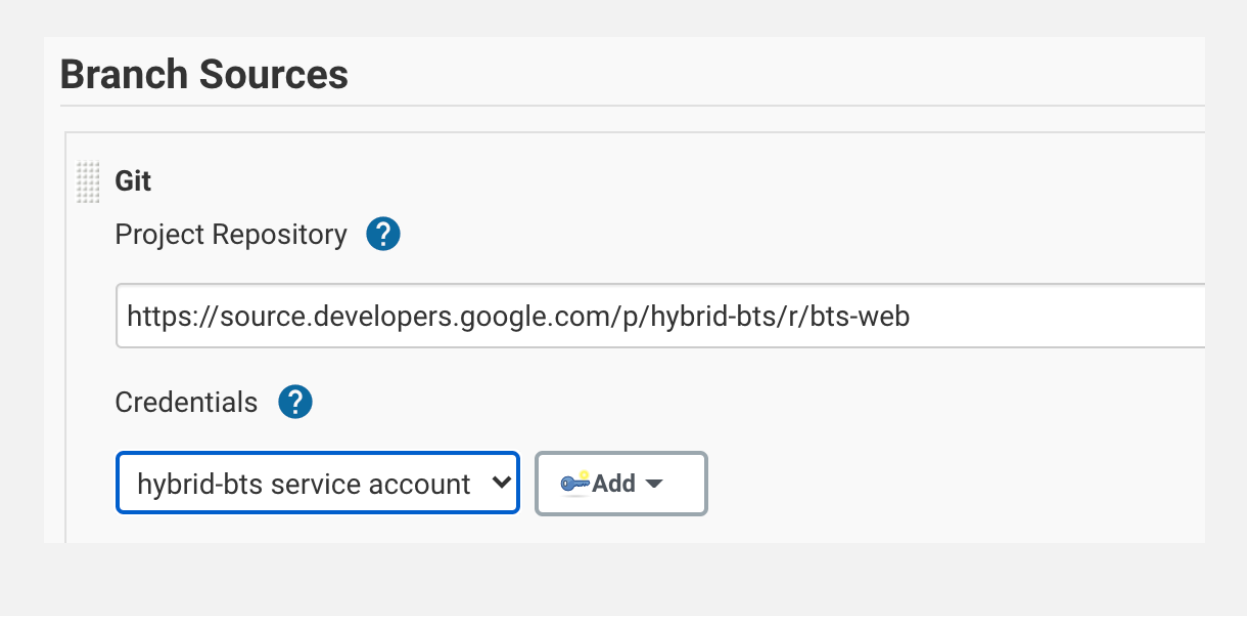
Create credentials



Configure clouds



Create a multibranch pipeline job



Jenkinsfile

```
pipeline {

  environment {
    PROJECT = "hybrid-bts"
    APP_NAME = "bts-web"
    SVC_NAME = "${APP_NAME}-service"
    CLUSTER = "bts-cluster-10"
    CLUSTER_LOCATION = "asia-northeast3"
    IMAGE_TAG =
"gcr.io/${PROJECT}/${APP_NAME}:${env.BRANCH_NAME}.${env.BUILD_NUMBER}"
    JENKINS_CRED = "${PROJECT}"
  }

  agent {
    kubernetes {
```

```
      defaultContainer 'jnlp'
      yaml """
apiVersion: v1
kind: Pod
metadata:
labels:
  component: ci
spec:
  serviceAccountName: 'vm-ser-acc'
  containers:
  - name: gcloud
    image: gcr.io/cloud-builders/gcloud
    command:
    - cat
    tty: true
  - name: kubectl
    image: gcr.io/cloud-builders/kubectl
    command:
    - cat
    tty: true
"""
}
  }
  stages {
    stage('Build and push image with Container Builder') {
      steps {
        container('gcloud') {
          sh "PYTHONUNBUFFERED=1 gcloud builds submit -t ${IMAGE_TAG} ."
        }
      }
    }
```

```
    stage('Deploy Canary') {
      when { branch 'canary' }
      steps {
        container('kubectl') {
          sh("sed -i.bak 's#gcr.io/hybrid-bts/bts-web#${IMAGE_TAG}#' ./k8s/canary/*.yaml")
          step([$class: 'KubernetesEngineBuilder', namespace:'production', projectId:
env.PROJECT, clusterName: env.CLUSTER, location: env.CLUSTER_LOCATION,
manifestPattern: 'k8s/services', credentialsId: env.JENKINS_CRED, verifyDeployments:
false])
          step([$class: 'KubernetesEngineBuilder', namespace:'production', projectId:
env.PROJECT, clusterName: env.CLUSTER, location: env.CLUSTER_LOCATION,
manifestPattern: 'k8s/canary', credentialsId: env.JENKINS_CRED, verifyDeployments:
true])
          sh("echo http://`kubectl --namespace=production get service/${SVC_NAME} -o
jsonpath='{.status.loadBalancer.ingress[0].ip}'` > ${SVC_NAME}")
        }
      }
    }
    stage('Deploy Production') {
      when { branch 'master' }
      steps{
        container('kubectl') {
          sh("sed -i.bak 's#gcr.io/hybrid-bts/bts-
web#${IMAGE_TAG}#' ./k8s/production/*.yaml")
          step([$class: 'KubernetesEngineBuilder', namespace:'production', projectId:
env.PROJECT, clusterName: env.CLUSTER, location: env.CLUSTER_LOCATION,
manifestPattern: 'k8s/services', credentialsId: env.JENKINS_CRED, verifyDeployments:
false])
          step([$class: 'KubernetesEngineBuilder', namespace:'production', projectId:
env.PROJECT, clusterName: env.CLUSTER, location: env.CLUSTER_LOCATION,
```

```
manifestPattern: 'k8s/production', credentialsId: env.JENKINS_CRED, verifyDeployments:
true])
        sh("echo http://`kubectl --namespace=production get service/${SVC_NAME} -o
jsonpath='{.status.loadBalancer.ingress[0].ip}'` > ${SVC_NAME}")
      }
    }
  }
  stage('Deploy Dev') {
    when {
      not { branch 'master' }
      not { branch 'canary' }
    }
    steps {
      container('kubectl') {
        sh("kubectl get ns ${env.BRANCH_NAME} || kubectl create ns
${env.BRANCH_NAME}")
        sh("sed -i.bak 's#LoadBalancer#ClusterIP#' ./k8s/services/${APP_NAME}-
service.yaml")
        sh("sed -i.bak 's#gcr.io/hybrid-bts/bts-web#${IMAGE_TAG}#' ./k8s/dev/*.yaml")
        step([$class: 'KubernetesEngineBuilder', namespace: "${env.BRANCH_NAME}",
projectId: env.PROJECT, clusterName: env.CLUSTER, location:
env.CLUSTER_LOCATION, manifestPattern: 'k8s/services', credentialsId:
env.JENKINS_CRED, verifyDeployments: false])
        step([$class: 'KubernetesEngineBuilder', namespace: "${env.BRANCH_NAME}",
projectId: env.PROJECT, clusterName: env.CLUSTER, location:
env.CLUSTER_LOCATION, manifestPattern: 'k8s/dev', credentialsId: env.JENKINS_CRED,
verifyDeployments: true])
      }
    }
  }
 }
```

```
}
```

cluster-role-binding.yaml

```
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRoleBinding
metadata:
  name: sa-role-binding
subjects:
- kind: ServiceAccount
  name: vm-ser-acc
  namespace: default
roleRef:
  kind: ClusterRole
  name: cluster-admin
  apiGroup: rbac.authorization.k8s.io

kubectl apply -f cluster-role-binding.yaml
```

Jenkins-ingress.yaml

```
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: jenkins-ingress
  annotations:
    kubernetes.io/ingress.global-static-ip-name: "jenkins-ingress"
```

```
    nginx.ingress.kubernetes.io/rewrite-target: /
spec:
  rules:
  - http:
      paths:
      - path: /
        pathType: Prefix
        backend:
          service:
            name: cd-jenkins
            port:
              number: 8080
```

CI/CD process – Dev environment

```
git checkout -b new-feature
*소스코드 수정
git push origin new-feature

kubectl proxy &

curl http://localhost:8001/api/v1/namespaces/new-feature/services/bts-web-service:80/proxy/
```

CI/CD process – Canary environment

```
git checkout canary
```

```
git merge new-feature
git push origin canary
```

CI/CD process – Production environment

```
git checkout master
git merge canary
git push origin master

git push origin :new-feature
kubectl delete ns new-feature
```

CI/CD Results

```
DONE
--------------------------------------------------------------------------------
ID                                    CREATE_TIME                DURATION  SOURCE
IMAGES                                STATUS
8c12d3ce-95df-4bd0-a06f-ed90cebd1a1e  2021-12-26T16:02:35+00:00  58S       gs://hybrid-bts_cloudbuild/source/1640534547.842045-
5e632d10b8f044ffa2b9a7bf3f9328e1.tgz  gcr.io/hybrid-bts/bts-web:master.2  SUCCESS
```

```
[Pipeline] stage
[Pipeline] { (Deploy Production)
[Pipeline] container
[Pipeline] {
[Pipeline] sh
+ sed -i.bak s#gcr.io/hybrid-bts/bts-web#gcr.io/hybrid-bts/bts-web:master.2# ./k8s/production/bts-web-production.yaml
[Pipeline] step
[Pipeline] step
Verifying manifests: /home/jenkins/agent/workspace/bts-web_master/k8s/production
Verifying 2 objects:
Verifying: apps/v1/Deployment: bts-web-production
Successfully verified apps/v1/Deployment: bts-web-production
AvailableReplicas = 1, MinimumReplicas = 1

Verifying: apps/v1/Deployment: bts-web-production
Successfully verified apps/v1/Deployment: bts-web-production
AvailableReplicas = 1, MinimumReplicas = 1
```

```
[Pipeline] sh
+ kubectl --namespace=production get service/bts-web-service -o jsonpath={.status.loadBalancer.ingress[0].ip}
+ echo http://34.64.184.156
[Pipeline] }
[Pipeline] // container
[Pipeline] }
[Pipeline] // stage
[Pipeline] stage
[Pipeline] { (Deploy Dev)
Stage "Deploy Dev" skipped due to when conditional
[Pipeline] }
[Pipeline] // stage
[Pipeline] }
[Pipeline] // withEnv
[Pipeline] }
[Pipeline] // withEnv
[Pipeline] }
[Pipeline] // node
[Pipeline] }
[Pipeline] // podTemplate
[Pipeline] End of Pipeline
Finished: SUCCESS
```

Big Data

SQL, Google Cloud Storage, Dataproc, PySpark, Python

Products 에 대한 고객의 ratings 데이터셋을 기반으로 머신러닝 모델을 적용하여 사용자에게 적합한 Recommendation 데이터셋을 생성합니다. GCS 에 있는 csv 파일을 SQL 에 옮기고, Dataproc 을 이용하여 Data processing 을 합니다. Python 스크립트로 SQL 데이터를 불러와 PySpark 머신러닝 모델을 train 하고 적용한 데이터셋을 생성하고 SQL 에 저장합니다.

Cloud SQL

```
gcloud beta sql instances create bts-products \
 --database-version=MYSQL_5_7 --cpu=1 --memory=3840MB \
--network=projects/hybrid-bts/global/networks/bts-vpc \
--region=asia-northeast3 --root-password=admin123

gcloud sql connect bts-products --user=root --quiet;

CREATE DATABASE IF NOT EXISTS products_spark;
USE products_spark;
DROP TABLE IF EXISTS Recommendation;
DROP TABLE IF EXISTS Rating;
DROP TABLE IF EXISTS Products;

CREATE TABLE IF NOT EXISTS Products;
(
 id varchar(255),
 title varchar(255),
 location varchar(255),
 price int,
 rooms int,
 rating float,
 type varchar(255),
 PRIMARY KEY (ID)
);
CREATE TABLE  IF NOT EXISTS Rating
(
 userId varchar(255),
 accoId varchar(255),
 rating int,
 PRIMARY KEY(accoId, userId),
 FOREIGN KEY (accoId)
```

```
   REFERENCES Products(id)
);
CREATE TABLE  IF NOT EXISTS Recommendation
(
  userId varchar(255),
  prodId varchar(255),
  prediction float,
  PRIMARY KEY(userId, prodId),
  FOREIGN KEY (prodId)
   REFERENCES Products(id)
);
```

Google Cloud Storage

```
gsutil mb gs://bts-product-info
gsutil cp gs://cloud-training/bdml/v2.0/data/accommodation.csv gs://bts-product-info
gsutil cp gs://cloud-training/bdml/v2.0/data/rating.csv gs://bts-product-info
gsutil cp gs://bts-product-info/rating.csv .
gsutil cp gs://bts-product-info/products.csv .

gcloud sql instances describe bts-products | grep serviceAccountEmailAddress
SA_SQL=p786846853700-j6wg5s@gcp-sa-cloud-sql.iam.gserviceaccount.com

gsutil acl ch -u ${SA_SQL}:R gs://bts-product-info/rating.csv
gsutil acl ch -u ${SA_SQL}:R gs://bts-product-info/products.csv

gcloud sql import csv bts-products gs://bts-product-info/rating.csv \
--database=products_spark \
--table=Rating;
```

```
gcloud sql import csv bts-products gs://bts-product-info/products.csv \
--database=products_spark \
--table=Products;
```

```
dntwkzz79@cloudshell:~ (hybrid-bts)$ gcloud sql import csv bts-products gs://bts-product
-info/rating.csv --database=products_spark --table=Rating;

Data from [gs://bts-product-info/rating.csv] will be imported to [bts-products].

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

Importing data into Cloud SQL instance...done.
Imported data from [gs://bts-product-info/rating.csv] into [https://sqladmin.googleapis.
com/sql/v1beta4/projects/hybrid-bts/instances/bts-products].
```

Dataproc

```
gcloud dataproc clusters create bts-products \
   --region=asia-northeast3

gcloud sql instances patch $CLOUDSQL --authorized-networks $ips
```

Bash script for authorizing Dataproc to connect to Cloud SQL

```
CLUSTER=bts-products
CLOUDSQL=bts-products
ZONE=asia-northeast3-a
NWORKERS=2
machines="$CLUSTER-m"
for w in `seq 0 $(($NWORKERS - 1))`; do
  machines="$machines $CLUSTER-w-$w"
```

```
done

ips=""
for machine in $machines; do
  IP_ADDRESS=$(gcloud compute instances describe $machine --zone=$ZONE --
format='value(networkInterfaces.accessConfigs[].natIP)' | sed "s/\['//g" | sed
"s/'\]//g" )/32

  if [ -z  $ips ]; then
    ips=$IP_ADDRESS
  else
    ips="$ips,$IP_ADDRESS"
  fi
done
```

Machine Learning Model

```
gsutil cp train_and_apply.py gs://bts-product-info
```

train_and_apply.py

```
#!/usr/bin/env python
import os
import sys
import pickle
import itertools
from math import sqrt
```

```
from operator import add
from os.path import join, isfile, dirname
from pyspark import SparkContext, SparkConf, SQLContext
from pyspark.mllib.recommendation import ALS, MatrixFactorizationModel, Rating
from pyspark.sql.types import StructType, StructField, StringType, FloatType

CLOUDSQL_INSTANCE_IP = '104.155.188.32'
CLOUDSQL_DB_NAME = 'products_spark'
CLOUDSQL_USER = 'root'
CLOUDSQL_PWD  = 'admin123'

conf = SparkConf().setAppName("train_model")
sc = SparkContext(conf=conf)
sqlContext = SQLContext(sc)
jdbcDriver = 'com.mysql.jdbc.Driver'
jdbcUrl    = 'jdbc:mysql://%s:3306/%s?user=%s&password=%s' %
(CLOUDSQL_INSTANCE_IP, CLOUDSQL_DB_NAME, CLOUDSQL_USER,
CLOUDSQL_PWD)

sc.setCheckpointDir('checkpoint/')

dfRates = sqlContext.read.format('jdbc').options(driver=jdbcDriver, url=jdbcUrl,
dbtable='Rating', useSSL='false').load()
dfAccos = sqlContext.read.format('jdbc').options(driver=jdbcDriver, url=jdbcUrl,
dbtable='Products', useSSL='false').load()
print("read ...")

model = ALS.train(dfRates.rdd, 20, 20) # you could tune these numbers, but these are
reasonable choices
print("trained ...")
```

```
allPredictions = None
for USER_ID in range(0, 100):
  dfUserRatings = dfRates.filter(dfRates.userId == USER_ID).rdd.map(lambda r:
r.accoId).collect()
  rddPotential  = dfAccos.rdd.filter(lambda x: x[0] not in dfUserRatings)
  pairsPotential = rddPotential.map(lambda x: (USER_ID, x[0]))
  predictions = model.predictAll(pairsPotential).map(lambda p: (str(p[0]), str(p[1]),
float(p[2])))
  predictions = predictions.takeOrdered(5, key=lambda x: -x[2]) # top 5
  print("predicted for user={0}".format(USER_ID))
  if (allPredictions == None):
    allPredictions = predictions
  else:
    allPredictions.extend(predictions)

schema = StructType([StructField("userId", StringType(), True), StructField("prodId",
StringType(), True), StructField("prediction", FloatType(), True)])
dfToSave = sqlContext.createDataFrame(allPredictions, schema)
dfToSave.write.jdbc(url=jdbcUrl, table='Recommendation', mode='overwrite')
```

Submit Dataproc job

```
gcloud dataproc jobs submit pyspark \
    gs://bts-product-info/train_and_apply.py \
    --cluster=bts-product \
    --region=asia-northeast3
```

```
mysql> select * from Products limit 10;
+----+----------------------------+-----------+-------+---------+--------+---------+
| id | title                      | category  | price | options | rating | type    |
+----+----------------------------+-----------+-------+---------+--------+---------+
| 1  | Comfy Quiet Chalet         | Vancouver |    50 |       3 |    3.1 | cottage |
| 10 | Sizable Calm Country House | Auckland  |   650 |       9 |    4.9 | mansion |
| 11 | Homy Quiet Shanty          | Melbourne |    50 |       1 |    2.8 | cottage |
| 12 | Beautiful Peaceful Villa   | Seattle   |    90 |       2 |    2.1 | house   |
| 13 | Enormous Peaceful Fortress | Melbourne |  3300 |      12 |    2.3 | castle  |
| 14 | Colossal Peaceful Palace   | Melbourne |  1200 |      21 |    1.5 | castle  |
| 15 | Vast Private Fort          | London    |  1300 |      18 |    2.6 | castle  |
| 16 | Large Calm House           | Melbourne |    45 |       3 |    4.1 | house   |
| 17 | Large Calm Sately House    | NYC       |   850 |       9 |    1.2 | mansion |
| 18 | Big Peaceful Hut           | Melbourne |    60 |       2 |    2.4 | cottage |
+----+----------------------------+-----------+-------+---------+--------+---------+
```

```
mysql> select * from Rating limit 10;
+--------+--------+--------+
| userId | prodId | rating |
+--------+--------+--------+
| 10     | 1      |      1 |
| 13     | 1      |      1 |
| 18     | 1      |      2 |
| 12     | 10     |      3 |
| 18     | 10     |      1 |
| 21     | 10     |      2 |
| 4      | 10     |      1 |
| 1      | 11     |      1 |
| 10     | 11     |      1 |
| 11     | 11     |      1 |
+--------+--------+--------+
```

```
mysql> select * from Recommendation;
+--------+--------+------------+
| userId | prodId | prediction |
+--------+--------+------------+
| 12     | 99     |  2.8648407 |
| 0      | 76     |  3.2708821 |
| 0      | 75     |  3.2450237 |
| 12     | 49     |  2.7902086 |
| 12     | 72     |  2.7415967 |
| 0      | 66     |  3.2029953 |
| 0      | 49     |   3.167969 |
| 13     | 3      |  3.0129576 |
| 13     | 76     |  2.9712481 |
| 0      | 39     |  3.1403885 |
| 13     | 75     |  2.9348733 |
```

Big Data

Dataflow, Apache Beam, Google Cloud Storage, Python

고객의 주문 정보 데이터셋에서 거주 도시를 필터로 데이터를 추출하였습니다. Google Cloud Storage 에 저장된 데이터셋을 불러와 Apache Beam 으로 추출한 데이터를 Google Cloud Storage 에 저장하는 Python 스크립트를 Dataflow job 으로 실행했습니다.

Install requirements

```
sudo apt-get install python3-pip
sudo pip3 install apache-beam[gcp]==2.27.0
sudo pip3 install oauth2client==3.0.0
sudo pip3 install -U pip
```

Cloud Storage

```
export BUCKET=beam_df
gsutil cp member_info.txt gs://beam_df

SA_FLOW=service-786846853700@dataproc-accounts.iam.gserviceaccount.com
gsutil acl ch -u ${SA_FLOW}:R gs://beam_df/member_info.txt
gsutil acl ch -u ${SA_FLOW}:W gs://bts-product-info/
```

nyc_grep.py

```
import apache_beam as beam

def nyc_grep(line, term):
  if line.startswith(term):
    yield line

PROJECT='hybrid-bts'
BUCKET='beam_df'

def run():
  argv = [
    '--project={0}'.format(PROJECT),
    '--job_name=nycgrep',
    '--save_main_session',
    '--staging_location=gs://{0}/staging/'.format(BUCKET),
    '--temp_location=gs://{0}/staging/'.format(BUCKET),
    '--region=asia-northeast3',
    '--runner=DataflowRunner'
  ]
  p = beam.Pipeline(argv=argv)
  input = 'gs://{0}/member_info.txt'.format(BUCKET)
  output_prefix = 'gs://{0}/output'.format(BUCKET)
  searchTerm = 'NYC'
  # find all lines that contain the searchTerm
  (p
    | 'GetCSV' >> beam.io.ReadFromText(input)
    | 'Grep' >> beam.FlatMap(lambda line: nyc_grep(line, searchTerm) )
    | 'write' >> beam.io.WriteToText(output_prefix)
```

```
    )
    p.run()

if __name__ == '__main__':
    run()
```

Dataflow

```
python3 nyc_grep.py
gsutil cp gs://beam_df/output* .
cat output*
```

```
NYC   NY   10022   USA   NA   Yu   Kwai
NYC   NY   10022   USA   NA   Frick   Michael
NYC   NY   10022   USA   NA   Yu   Kwai
NYC   NY   10022   USA   NA   Hernandez   Maria
NYC   NY   10022   USA   NA   Yu   Kwai
NYC   NY   10022   USA   NA   Yu   Kwai
NYC   NY   10022   USA   NA   Yu   Kwai
NYC   NY   10022   USA   NA   Frick   Michael
NYC   NY   10022   USA   NA   Yu   Kwai
NYC   NY   10022   USA   NA   Yu   Kwai
```

Big Data

Cloud Bigtable, Cloud Function

고객의 거주 지역에 대한 데이터셋에서 거주 도시가 Paris 인 데이터를 반환합니다. Python script 로 Bigtable 에 데이터를 삽입한 뒤, Cloud Function 의 HTTP trigger 를 사용해서 추출된 데이터를 얻습니다.

Cloud Bigtable

```
 gcloud bigtable instances create members \
--display-name=members \
--cluster-config=id=members-cluster,zone=asia-northeast3-a,\
nodes=1

echo project = hybrid-bts> ~/.cbtrc
echo instance = members >> ~/.cbtrc

cbt createtable member-info
cbt ls
cbt ls member-info
```

Write data to Bigtable

go run write_members.go

```
----------------------------------------
10107
  city:NYC                                 @ 2021/12/29-17:29:07.143000
    "\x00\x00\x00\x00\x00\x00\x00\x01"
  country:USA                              @ 2021/12/29-17:29:07.143000
    "\x00\x00\x00\x00\x00\x00\x00\x01"
  last_name:John                           @ 2021/12/29-17:29:07.143000
    "\x00\x00\x00\x00\x00\x00\x00\x01"
----------------------------------------
10121
  city:Paris                               @ 2021/12/29-17:29:07.143000
    "\x00\x00\x00\x00\x00\x00\x00\x01"
  country:France                           @ 2021/12/29-17:29:07.143000
    "\x00\x00\x00\x00\x00\x00\x00\x01"
  last_name:Young                          @ 2021/12/29-17:29:07.143000
    "\x00\x00\x00\x00\x00\x00\x00\x01"
----------------------------------------
```

write_members.go

```
package main

import (
    "bytes"
    "context"
    "encoding/binary"
    "fmt"

    "cloud.google.com/go/bigtable"
)

func writeBatch(projectID, instanceID string, tableName string) error {
    projectID = "hybrid-bts"
    instanceID = "members"
    tableName = "member-info"

    ctx := context.Background()
    client, err := bigtable.NewClient(ctx, projectID, instanceID)
    if err != nil {
        return fmt.Errorf("bigtable.NewAdminClient: %v", err)
    }
    defer client.Close()
    tbl := client.Open(tableName)

    timestamp := bigtable.Now()

    var muts []*bigtable.Mutation

    binary1 := new(bytes.Buffer)
    binary.Write(binary1, binary.BigEndian, int64(1))
```

```
mut := bigtable.NewMutation()
mut.Set("city", "NYC", timestamp, binary1.Bytes())
mut.Set("country", "USA", timestamp, binary1.Bytes())
mut.Set("last_name", "John", timestamp, binary1.Bytes())
muts = append(muts, mut)

mut = bigtable.NewMutation()
mut.Set("city", "Paris", timestamp, binary1.Bytes())
mut.Set("country", "France", timestamp, binary1.Bytes())
mut.Set("last_name", "Young", timestamp, binary1.Bytes())
muts = append(muts, mut)

mut = bigtable.NewMutation()
mut.Set("city", "San Francisco", timestamp, binary1.Bytes())
mut.Set("country", "USA", timestamp, binary1.Bytes())
mut.Set("last_name", "Mayer", timestamp, binary1.Bytes())
muts = append(muts, mut)

mut = bigtable.NewMutation()
mut.Set("city", "Seoul", timestamp, binary1.Bytes())
mut.Set("country", "Korea", timestamp, binary1.Bytes())
mut.Set("last_name", "Park", timestamp, binary1.Bytes())
muts = append(muts, mut)

mut = bigtable.NewMutation()
mut.Set("city", "Liverpool", timestamp, binary1.Bytes())
mut.Set("country", "UK", timestamp, binary1.Bytes())
mut.Set("last_name", "Devon", timestamp, binary1.Bytes())
muts = append(muts, mut)

rowKeys := []string{"10107", "10121", "10134", "10145", "10159"}
```

```
    if _, err := tbl.ApplyBulk(ctx, rowKeys, muts); err != nil {
        return fmt.Errorf("ApplyBulk: %v", err)
    }
    return nil
}

func main() {
    writeBatch("hybrid-bts", "members", "member-info")
}
```

Cloud Function

```
gcloud functions deploy Paris \
--runtime go116 --trigger-http
```

```
dntwkzz79@cloudshell:~ (hybrid-bts)$ curl "https://us-central1-hybrid-bts.cloudfunctions
.net/Paris" -H "project_id:hybrid-bts" -H "instance_id:members" -H "table_id:member-info
" --output ./test
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
100   170  100   170    0     0     80      0  0:00:02  0:00:02 --:--:--    80
dntwkzz79@cloudshell:~ (hybrid-bts)$ cat test
order number: 10107, for city:
order number: 10121, for city:  Paris
order number: 10134, for city:
order number: 10145, for city:
order number: 10159, for city:
```

Paris.go

```
package bigtable

import (
    "context"
```

```
    "fmt"
    "log"
    "net/http"
    "sync"

    "cloud.google.com/go/bigtable"
)

var client *bigtable.Client
var clientOnce sync.Once

func BigtableRead(w http.ResponseWriter, r *http.Request) {
    clientOnce.Do(func() {
        var err error
        client, err = bigtable.NewClient(context.Background(), r.Header.Get("project_id"),
r.Header.Get("instance_id"))
        if err != nil {
            http.Error(w, "Error initializing client", http.StatusInternalServerError)
            log.Printf("bigtable.NewClient: %v", err)
            return
        }
    })

    tbl := client.Open(r.Header.Get("table_id"))
    err := tbl.ReadRows(r.Context(), bigtable.PrefixRange("10"),
        func(row bigtable.Row) bool {
            city := ""
            for _, col := range row["city"] {
                if col.Column == "city:Paris" {
                    city = "Paris"
                }
```

```
            }

            fmt.Fprintf(w, "order number: %s, for city:  %s\n", row.Key(), city)
            return true
        })

    if err != nil {
        http.Error(w, "Error reading rows", http.StatusInternalServerError)
        log.Printf("tbl.ReadRows(): %v", err)
    }
}

func main() {
}
```