Cloud Computing

Term project

소프트웨어학부

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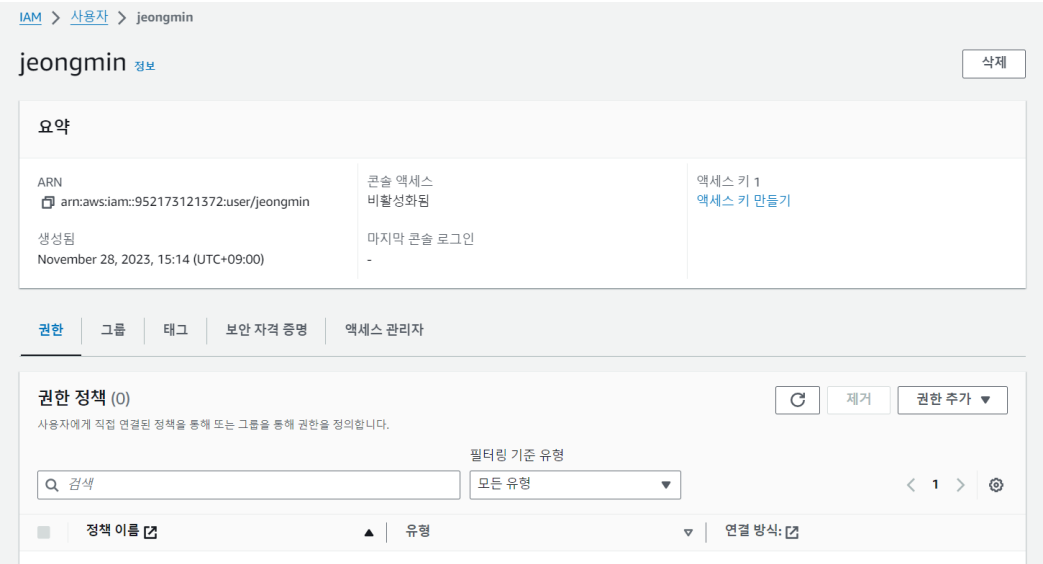
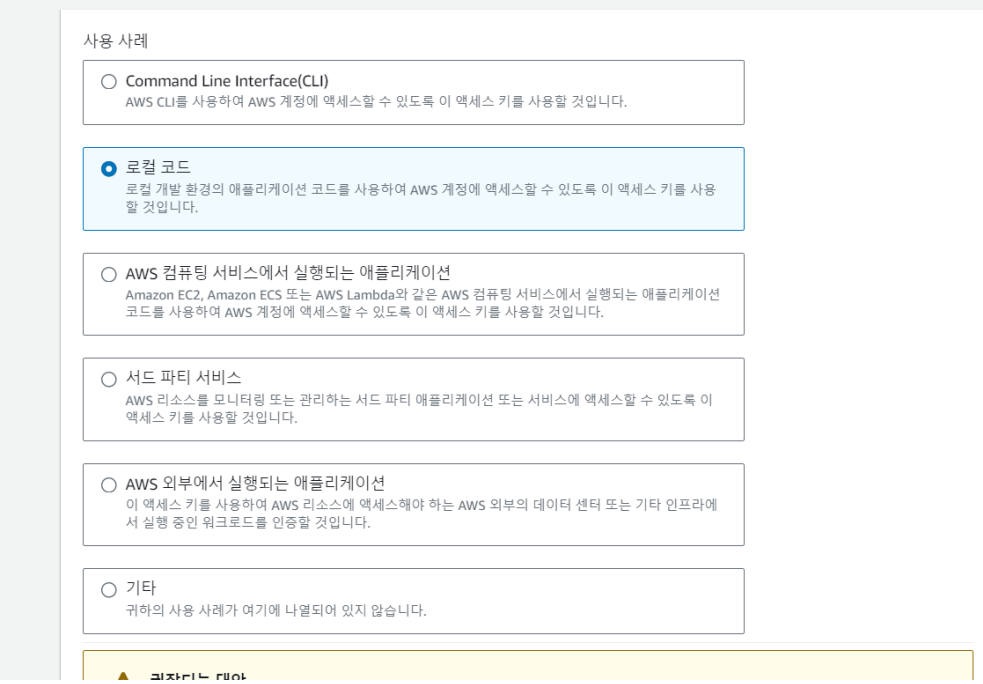
이정민

Github Repository: https://github.com/jeongmin99/CloudComputing

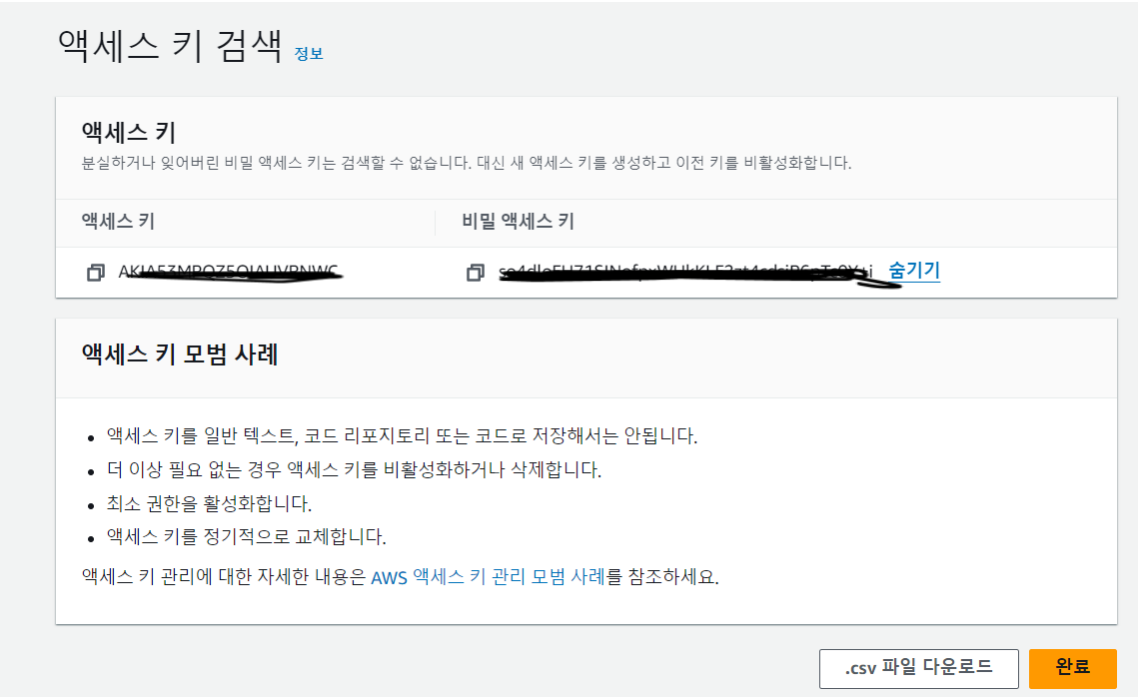
AWS SDK를 위한 IAM 설정

AWS IAM 페이지에서 IAM 사용자 추가

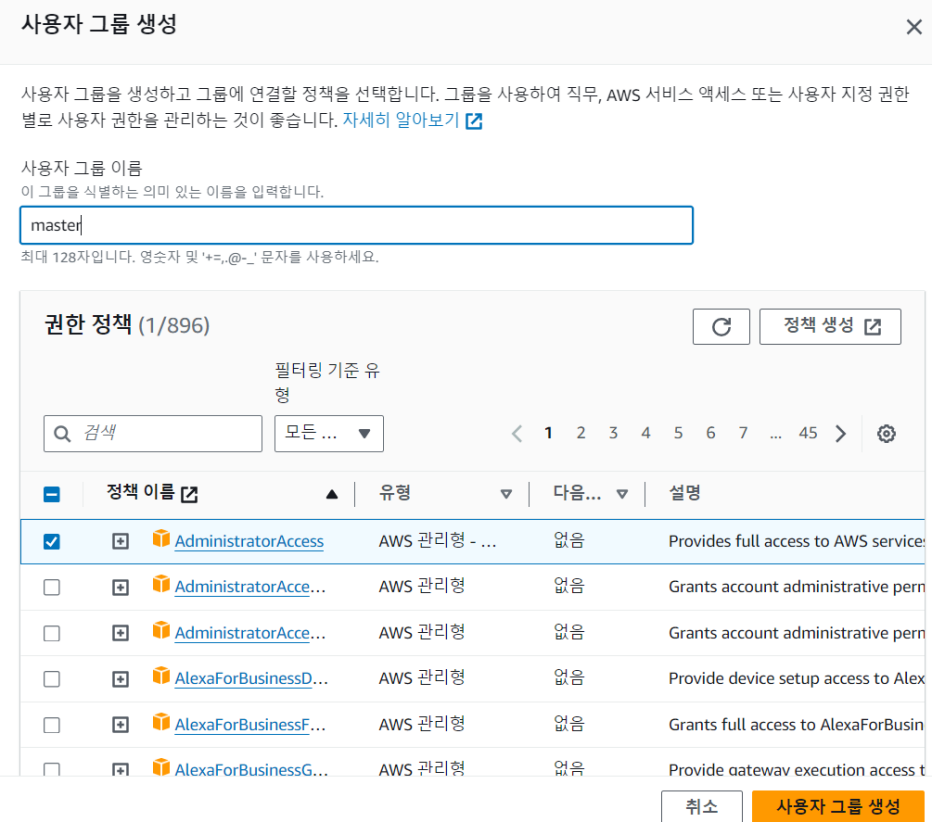




IAM 사용자 access key 및 secret access key 발급



사용자 그룹 생성 및 권한 정책(AdminstratorAccess) 설정 후 사용자를 그룹에 추가



Master node setting

인스턴스 생성 후 ssh로 접근

Htcondor GPG-KEY 및 레포지토리 다운로드

```
root@ip-172-31-36-244:~
[root@ip-172-31-36-244 ~]# wget https://research.cs.wisc.edu/htcondor/yum/RPM-GP
G-KEY-HTCondor
--2023-11-30 05:05:02--  https://research.cs.wisc.edu/htcondor/yum/RPM-GPG-KEY-H
TCondor
Resolving research.cs.wisc.edu (research.cs.wisc.edu)... 128.105.7.58
Connecting to research.cs.wisc.edu (research.cs.wisc.edu)|128.105.7.58|:443... c
onnected.
HTTP request sent, awaiting response... 200 OK
Length: 1752 (1.7K)
Saving to: 'RPM-GPG-KEY-HTCondor'

100%[===================================>] 1,752       --.-K/s   in 0s

2023-11-30 05:05:03 (217 MB/s) - 'RPM-GPG-KEY-HTCondor' saved [1752/1752]

[root@ip-172-31-36-244 ~]# rpm --import RPM-GPG-KEY-HTCondor
[root@ip-172-31-36-244 ~]#
```

```
root@ip-172-31-36-244:~
[root@ip-172-31-36-244 ~]# wget https://research.cs.wisc.edu/htcondor/yum/repo.d
/htcondor-stable-rhel7.repo
--2023-11-30 05:05:51--  https://research.cs.wisc.edu/htcondor/yum/repo.d/htcond
or-stable-rhel7.repo
Resolving research.cs.wisc.edu (research.cs.wisc.edu)... 128.105.7.58
Connecting to research.cs.wisc.edu (research.cs.wisc.edu)|128.105.7.58|:443... c
onnected.
HTTP request sent, awaiting response... 200 OK
Length: 254
Saving to: 'htcondor-stable-rhel7.repo'

100%[===================================>] 254         --.-K/s   in 0s

2023-11-30 05:05:52 (33.9 MB/s) - 'htcondor-stable-rhel7.repo' saved [254/254]

[root@ip-172-31-36-244 ~]# ls
htcondor-stable-rhel7.repo  RPM-GPG-KEY-HTCondor
[root@ip-172-31-36-244 ~]# cp htcondor-stable-rhel7.repo /etc/yum.repos.d/
[root@ip-172-31-36-244 ~]#
```

HTCondor 패키지 설치

```
root@ip-172-31-36-244:~
[root@ip-172-31-36-244 ~]# yum install condor
Loaded plugins: extras_suggestions, langpacks, priorities, update-motd
htcondor-stable                                          | 2.9 kB     00:00
htcondor-stable/primary_db                               | 124 kB   00:01
Resolving Dependencies
--> Running transaction check
---> Package condor.x86_64 0:8.8.17-1.el7 will be installed
--> Processing Dependency: condor-procd = 8.8.17-1.el7 for package: condor-8.8.1
7-1.el7.x86_64
--> Processing Dependency: condor-external-libs(x86-64) = 8.8.17-1.el7 for packa
ge: condor-8.8.17-1.el7.x86_64
--> Processing Dependency: condor-classads = 8.8.17-1.el7 for package: condor-8.
8.17-1.el7.x86_64
--> Processing Dependency: libcgroup >= 0.37 for package: condor-8.8.17-1.el7.x8
6_64
--> Processing Dependency: policycoreutils-python for package: condor-8.8.17-1.e
l7.x86_64
--> Processing Dependency: perl(Archive::Tar) for package: condor-8.8.17-1.el7.x
86_64
--> Processing Dependency: libltdl.so.7()(64bit) for package: condor-8.8.17-1.el
7.x86_64
--> Processing Dependency: libclassad.so.14()(64bit) for package: condor-8.8.17-
1.el7.x86_64
--> Running transaction check
```

Master 노드로 사용할 인스턴스 이므로 해당 인스턴스의 internal hostname과 사용 데몬 (MASTER, SCHEDD, STARTD, COLLECTOR, NEGOTIAOR) 명시

```
root@ip-172-31-36-244:/etc/condor/config.d
[root@ip-172-31-36-244 ~]# hostname
ip-172-31-36-244.ap-northeast-2.compute.internal
[root@ip-172-31-36-244 ~]# cd /etc/condor/config.d/
[root@ip-172-31-36-244 config.d]# ls
[root@ip-172-31-36-244 config.d]# vi condor_config.local
[root@ip-172-31-36-244 config.d]# ^C
[root@ip-172-31-36-244 config.d]# vi condor_config.local
[root@ip-172-31-36-244 config.d]# cat condor_config.local
ALLOW_WRITE = *
CONDOR_HOST = ip-172-31-36-244.ap-northeast-2.compute.internal
DAEMON_LIST = MASTER, SCHEDD, STARTD, COLLECTOR, NEGOTIATOR
[root@ip-172-31-36-244 config.d]#
```

Condor_status 명령을 통해 master 노드가 클러스터에 편입된 것을 확인(STARTD)

```
root@ip-172-31-36-244:/etc/condor/config.d
[root@ip-172-31-36-244 config.d]# condor_status
Name                                          OpSys      Arch   State     Ac

ip-172-31-36-244.ap-northeast-2.compute.internal LINUX      X86_64 Unclaimed Be

               Machines Owner Claimed Unclaimed Matched Preempting  Drain

  X86_64/LINUX        1     0       0         1       0          0      0

         Total        1     0       0         1       0          0      0
[root@ip-172-31-36-244 config.d]#
```

Condor 데몬 enable & start

```
root@ip-172-31-36-244:/etc/condor/config.d
[root@ip-172-31-36-244 config.d]# systemctl enable condor
Created symlink from /etc/systemd/system/multi-user.target.wants/condor.service
to /usr/lib/systemd/system/condor.service.
[root@ip-172-31-36-244 config.d]# systemctl is-enabled condor
enabled
[root@ip-172-31-36-244 config.d]# systemctl status condor
● condor.service - Condor Distributed High-Throughput-Computing
   Loaded: loaded (/usr/lib/systemd/system/condor.service; enabled; vendor prese
t: disabled)
   Active: active (running) since Thu 2023-11-30 05:16:58 UTC; 51s ago
 Main PID: 3518 (condor_master)
   Status: "All daemons are responding"
   CGroup: /system.slice/condor.service
           ├─3518 /usr/sbin/condor_master -f
           ├─3561 condor_procd -A /var/run/condor/procd_pipe -L /var/log/cond...
           ├─3562 condor_shared_port -f
           ├─3563 condor_collector -f
           ├─3564 condor_schedd -f
           ├─3567 condor_startd -f
           └─3570 condor_negotiator -f

Nov 30 05:16:58 ip-172-31-36-244.ap-northeast-2.compute.internal systemd[1]: ...
Nov 30 05:16:58 ip-172-31-36-244.ap-northeast-2.compute.internal htcondor[3523]:
 ...
```

Slave 이미지 생성을 위한 인스턴스 생성 후 ssh로 접근

```
root@ip-172-31-33-56:~
login as: ec2-user
Authenticating with public key "htcondor"
  ,     #_
  ~\_  ####_        Amazon Linux 2
 ~~  \_#####\
 ~~     \###|       AL2 End of Life is 2025-06-30.
 ~~       \#/ ___
  ~~       V~' '->
   ~~~         /    A newer version of Amazon Linux is available!
     ~~._.   _/
        _/ _/       Amazon Linux 2023, GA and supported until 2028-03-15.
      _/m/'           https://aws.amazon.com/linux/amazon-linux-2023/

[ec2-user@ip-172-31-33-56 ~]$ sudo su -
[root@ip-172-31-33-56 ~]#
```

HTCondor GPG-KEY, 레포지토리 파일 다운로드

```
root@ip-172-31-33-56:~
[root@ip-172-31-33-56 ~]# wget https://research.cs.wisc.edu/htcondor/yum/RPM-GPG
-KEY-HTCondor
--2023-11-30 05:21:27--  https://research.cs.wisc.edu/htcondor/yum/RPM-GPG-KEY-H
TCondor
Resolving research.cs.wisc.edu (research.cs.wisc.edu)... 128.105.7.58
Connecting to research.cs.wisc.edu (research.cs.wisc.edu)|128.105.7.58|:443... c
onnected.
HTTP request sent, awaiting response... 200 OK
Length: 1752 (1.7K)
Saving to: 'RPM-GPG-KEY-HTCondor'

100%[===================================>] 1,752       --.-K/s   in 0s

2023-11-30 05:21:28 (231 MB/s) - 'RPM-GPG-KEY-HTCondor' saved [1752/1752]

[root@ip-172-31-33-56 ~]# rpm --import RPM-GPG-KEY-HTCondor
[root@ip-172-31-33-56 ~]# wget https://research.cs.wisc.edu/htcondor/yum/repo.d/
htcondor-stable-rhel7.repo
--2023-11-30 07:06:36--  https://research.cs.wisc.edu/htcondor/yum/repo.d/htcond
or-stable-rhel7.repo
Resolving research.cs.wisc.edu (research.cs.wisc.edu)... 128.105.7.58
Connecting to research.cs.wisc.edu (research.cs.wisc.edu)|128.105.7.58|:443... c
onnected.
HTTP request sent, awaiting response... 200 OK
```

Slave 노드 HTCondor 패키지 설치

```
root@ip-172-31-33-56:~
[root@ip-172-31-33-56 ~]# cp htcondor-stable-rhel7.repo /etc/yum.repos.d/
[root@ip-172-31-33-56 ~]# yum install condor
Loaded plugins: extras_suggestions, langpacks, priorities, update-motd
amzn2-core                                                | 3.6 kB     00:00
htcondor-stable                                           | 2.9 kB     00:00
htcondor-stable/primary_db                                  | 124 kB   00:01
Resolving Dependencies
--> Running transaction check
---> Package condor.x86_64 0:8.8.17-1.el7 will be installed
--> Processing Dependency: condor-procd = 8.8.17-1.el7 for package: condor-8.8.1
7-1.el7.x86_64
--> Processing Dependency: condor-external-libs(x86-64) = 8.8.17-1.el7 for packa
ge: condor-8.8.17-1.el7.x86_64
--> Processing Dependency: condor-classads = 8.8.17-1.el7 for package: condor-8.
8.17-1.el7.x86_64
--> Processing Dependency: libcgroup >= 0.37 for package: condor-8.8.17-1.el7.x8
6_64
--> Processing Dependency: policycoreutils-python for package: condor-8.8.17-1.e
l7.x86_64
--> Processing Dependency: perl(Archive::Tar) for package: condor-8.8.17-1.el7.x
86_64
--> Processing Dependency: libltdl.so.7()(64bit) for package: condor-8.8.17-1.el
7.x86_64
--> Processing Dependency: libclassad.so.14()(64bit) for package: condor-8.8.17-
```

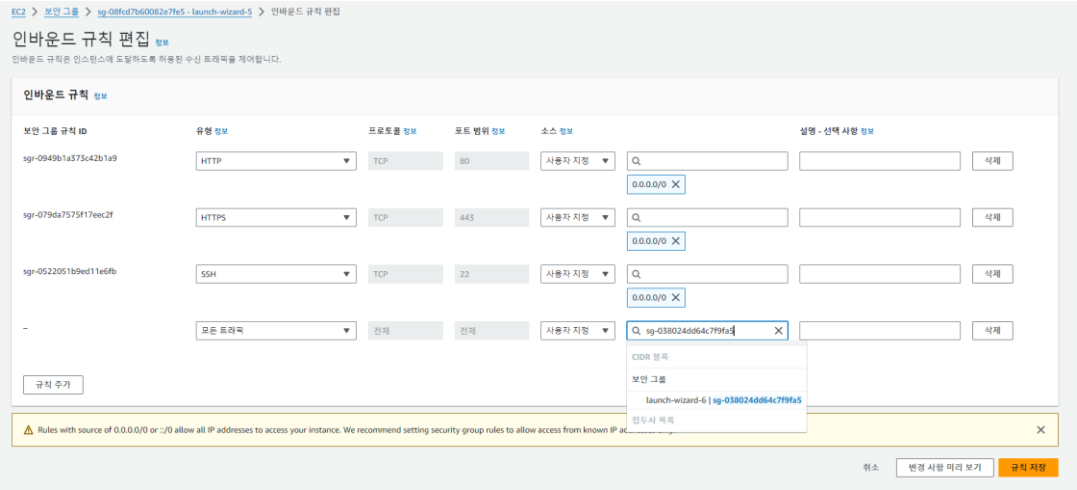
Condor 설정에 master 노드의 hostname 명시, 데몬은 MASTER와 STARTD 사용

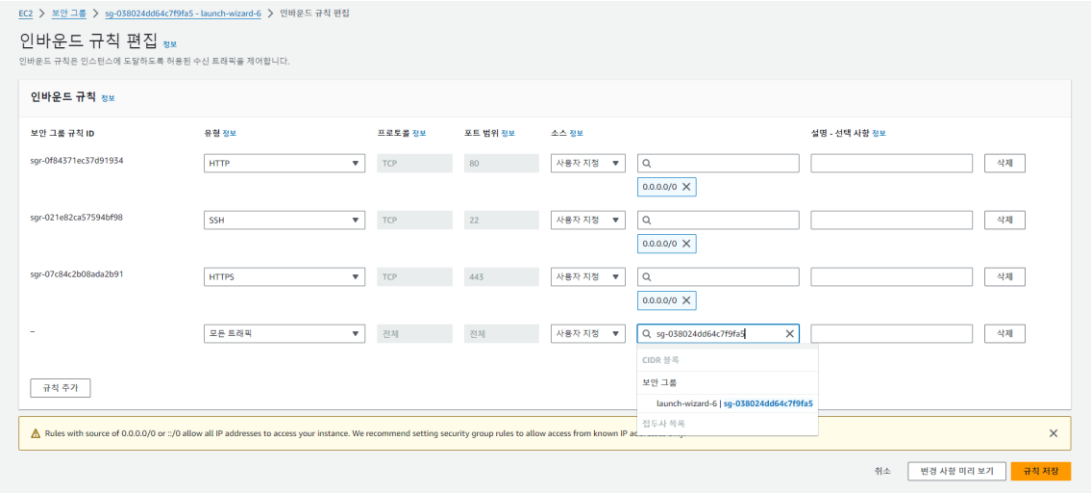
Condor 데몬 enable & start

```
root@ip-172-31-33-56:/etc/condor/config.d
[root@ip-172-31-33-56 config.d]# cat condor_config.local
ALLOW_WRITE = *
CONDOR_HOST =  ip-172-31-36-244.ap-northeast-2.compute.internal
DAEMON_LIST= MASTER, STARTD
[root@ip-172-31-33-56 config.d]# systemctl enable condor
Created symlink from /etc/systemd/system/multi-user.target.wants/condor.service
to /usr/lib/systemd/system/condor.service.
[root@ip-172-31-33-56 config.d]# systemctl is-enabled condor
enabled
[root@ip-172-31-33-56 config.d]# systemctl status condor
● condor.service - Condor Distributed High-Throughput-Computing
   Loaded: loaded (/usr/lib/systemd/system/condor.service; enabled; vendor prese
t: disabled)
   Active: inactive (dead)
[root@ip-172-31-33-56 config.d]# systemctl start condor
[root@ip-172-31-33-56 config.d]# systemctl status condor
● condor.service - Condor Distributed High-Throughput-Computing
   Loaded: loaded (/usr/lib/systemd/system/condor.service; enabled; vendor prese
t: disabled)
   Active: active (running) since Thu 2023-11-30 07:10:28 UTC; 970ms ago
 Main PID: 32546 (condor_master)
    Tasks: 2 (limit: 4194303)
   Memory: 1.6M
   CGroup: /system.slice/condor.service
```

보안 그룹 설정

Master 노드의 보안 그룹과 Slave 노드가 속하는 보안 그룹 간 모든 트래픽에 대해 통신이 가능하도록 설정

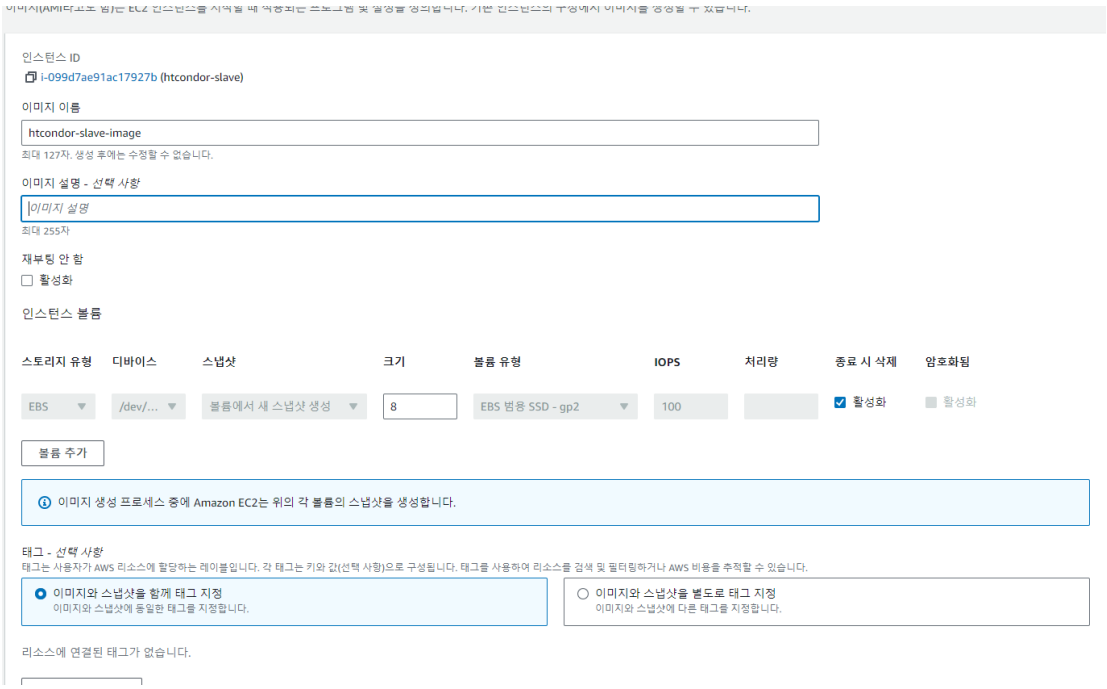


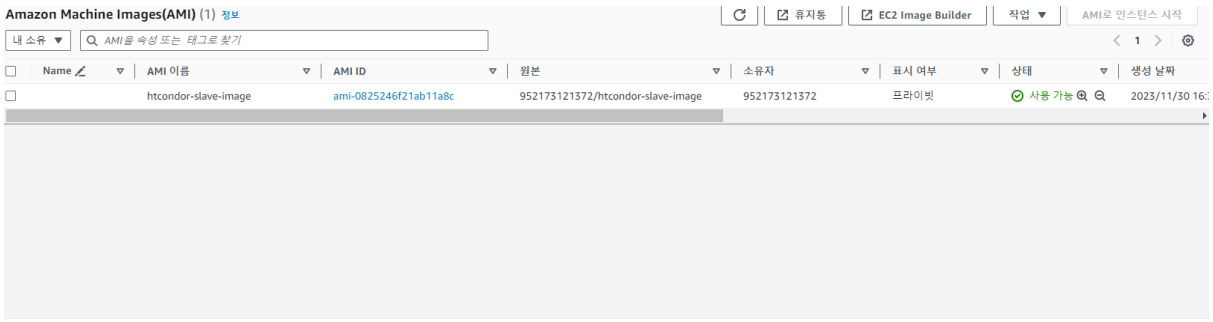


Condor_status 명령 시 slave 인스턴스가 클러스터에 편입된 것을 확인

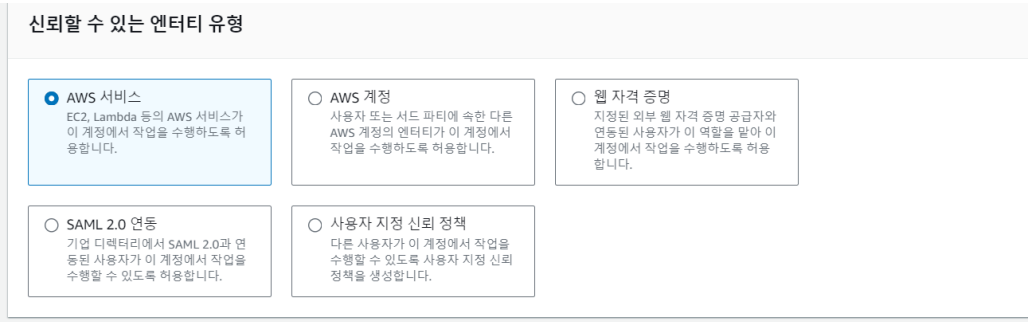
```
[root@ip-172-31-33-56 ~]# condor_status
Name                                          OpSys      Arch   State     Ac

ip-172-31-33-56.ap-northeast-2.compute.internal  LINUX      X86_64 Unclaimed Id
ip-172-31-36-244.ap-northeast-2.compute.internal LINUX      X86_64 Unclaimed Id

               Machines Owner Claimed Unclaimed Matched Preempting  Drain

  X86_64/LINUX        2     0       0         2       0          0      0

         Total        2     0       0         2       0          0      0
[root@ip-172-31-33-56 ~]#
```

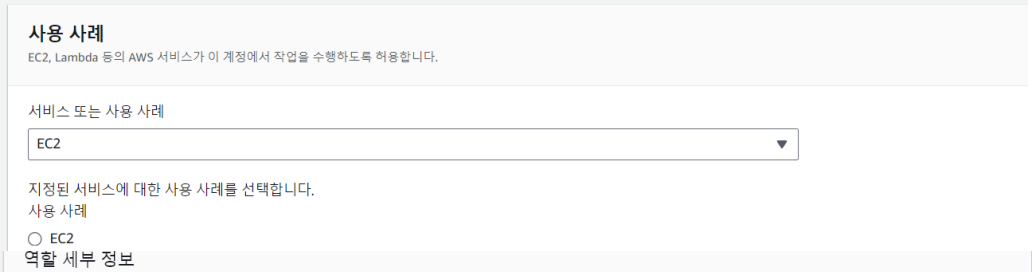
Slave 인스턴스 기반 이미지를 생성

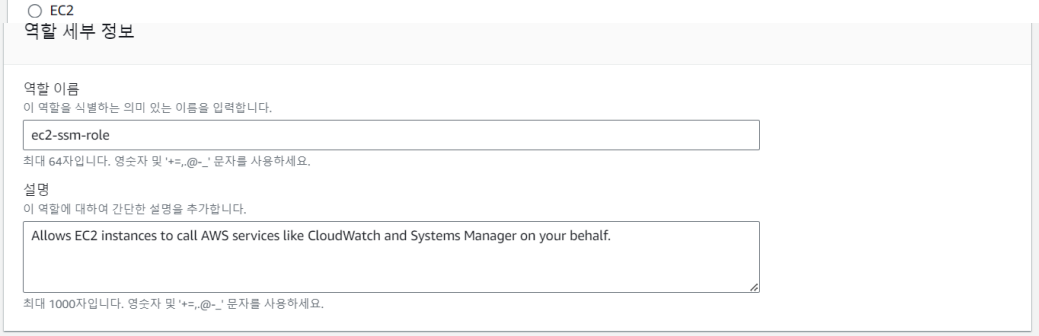


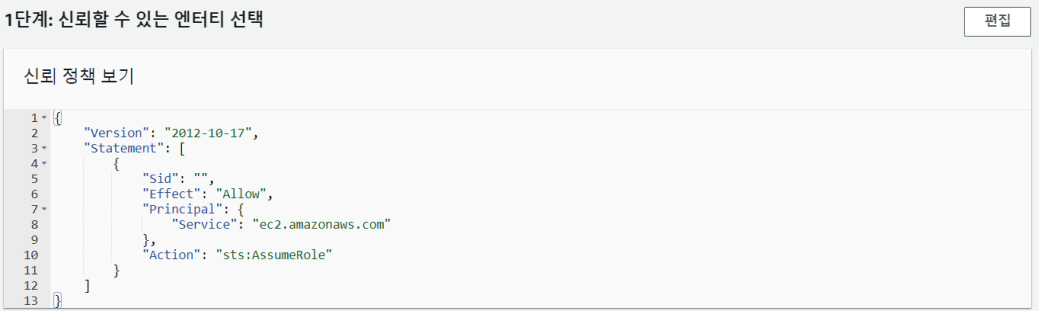


인스턴스에 IP, pem key 없이 명령을 내릴 수 있는 AWS SSM을 사용하기 위한 IAM 역할 생성

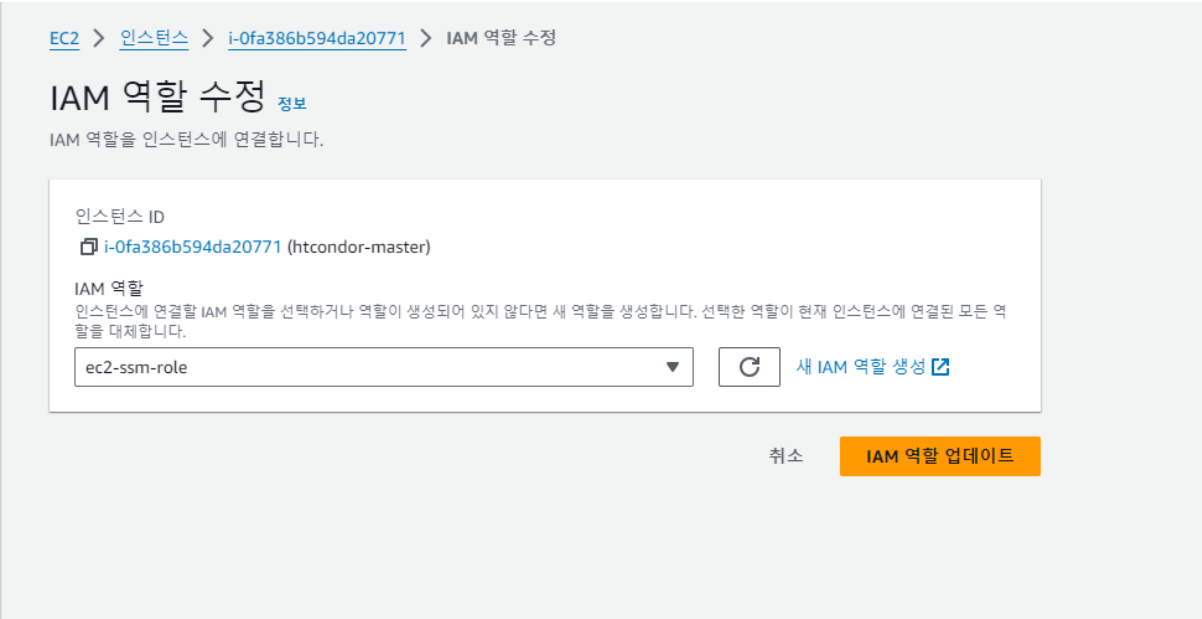




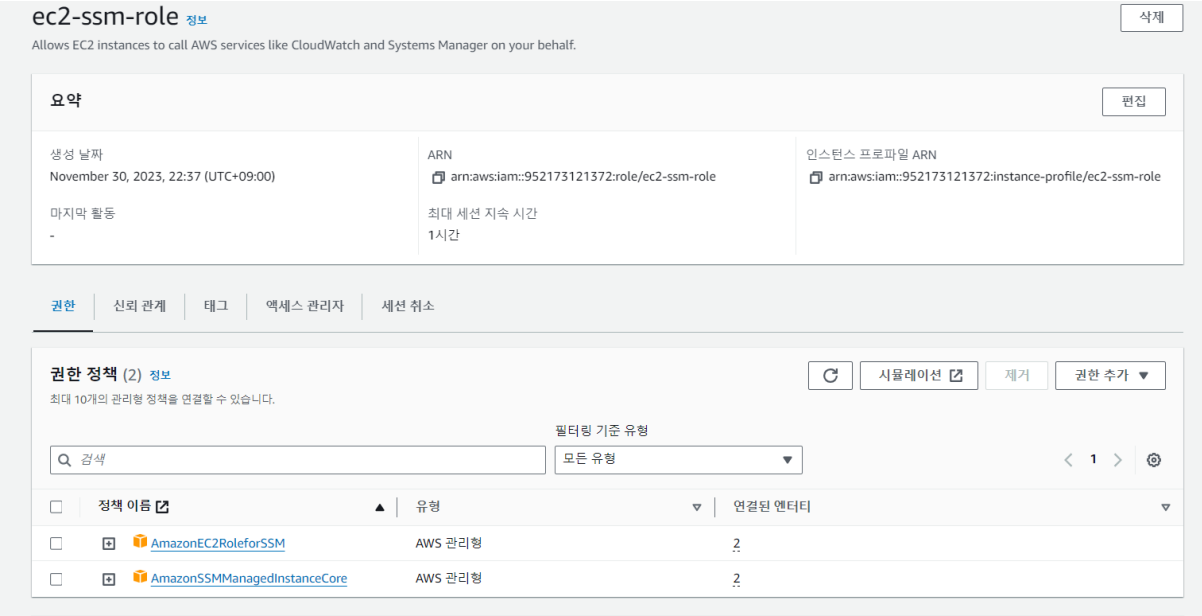




Master 인스턴스에 생성한 IAM 역할 부여



IAM 역할에 SSM 권한 부여



List instance

인스턴스 id, 이미지 id, type, state, monitoring state를 출력한다.

```
def listInstances():
    print("Listing instances...")
    done = False
    while done==False:
        list=resource.instances.all()
        for instance in list:
            print("[id] %s, [AMI] %s, [type] %s, [state] %10s, [monitoring
state] %s" %
(instance.instance_id,instance.image_id,instance.instance_type,instance.state[
'Name'],instance.monitoring['State']))

        done=True
```

```
------------------------------------------------------------
          Amazon AWS Control Panel using SDK
------------------------------------------------------------
  1. list instance                2. available zones
  3. start instance               4. available regions
  5. stop instance                6. create instance
  7. reboot instance              8. list images
  9. condor_status               10. scaling
  11. condor_q                   99. exit
------------------------------------------------------------
Enter an integer: 1
Listing instances...
[id] i-03e639c4290101b11, [AMI] ami-0f52ba4acb7f8f76a, [type] t2.micro, [state]    stopped, [monitoring state] disabled
[id] i-0fa386b594da20771, [AMI] ami-05e02e6210658716f, [type] t2.micro, [state]    running, [monitoring state] disabled
[id] i-099d7ae91ac17927b, [AMI] ami-05e02e6210658716f, [type] t2.micro, [state]    stopped, [monitoring state] disabled
```

Available zones

가용한 zone의 정보를 출력한다.

```
def availableZones():
    print("Available zones...")
    done = False
    while done==False:
        res=ec2.describe_availability_zones()
        list=res['AvailabilityZones']
        for zone in list:
            print("[id] %s  [region] %15s [zone] %15s" % (zone['ZoneId'],
zone['RegionName'], zone['ZoneName']))

        done=True
```

```
-----------------------------------------------------------
           Amazon AWS Control Panel using SDK
-----------------------------------------------------------
  1. list instance                2. available zones
  3. start instance               4. available regions
  5. stop instance                6. create instance
  7. reboot instance              8. list images
  9. condor_status               10. scaling
  11. condor_q                   99. exit
-----------------------------------------------------------
Enter an integer: 2
Available zones...
[id] apne2-az1  [region]  ap-northeast-2 [zone] ap-northeast-2a
[id] apne2-az2  [region]  ap-northeast-2 [zone] ap-northeast-2b
[id] apne2-az3  [region]  ap-northeast-2 [zone] ap-northeast-2c
[id] apne2-az4  [region]  ap-northeast-2 [zone] ap-northeast-2d
```

Start instance

인스턴스의 id를 입력 받고, id에 해당하는 인스턴스를 시작한다.

```
def startInstance(id):
    print("Starting .... %s" % id)
    done= False
    while done==False:
        res=ec2.start_instances(InstanceIds=[id])
        instance=resource.Instance(id)
        #인스턴스 시작 시 까지 대기
        instance.wait_until_running(Filters=[{'Name': 'instance-
id','Values':[id]}])
        print("Successfully started instance %s" % id)
        done=True
```

```
-----------------------------------------------------------
           Amazon AWS Control Panel using SDK
-----------------------------------------------------------
  1. list instance                2. available zones
  3. start instance               4. available regions
  5. stop instance                6. create instance
  7. reboot instance              8. list images
  9. condor_status               10. scaling
  11. condor_q                   99. exit
-----------------------------------------------------------
Enter an integer: 3
Enter instance id: i-099d7ae91ac17927b
Starting .... i-099d7ae91ac17927b
Successfully started instance i-099d7ae91ac17927b
```

Available regions

가용 리전의 정보를 출력한다.

```
def availableRegions():
    print("Available regions...")
    done = False
    while done==False:
        res=ec2.describe_regions()
        list=res['Regions']
        for region in list:
            print("[region] %15s, [endpoint] %s" %
(region['RegionName'],region['Endpoint']))

        done=True
```

```
------------------------------------------------------------
            Amazon AWS Control Panel using SDK
------------------------------------------------------------
  1. list instance                2. available zones
  3. start instance               4. available regions
  5. stop instance                6. create instance
  7. reboot instance              8. list images
  9. condor_status               10. scaling
  11. condor_q                   99. exit
------------------------------------------------------------
Enter an integer: 4
Available regions...
[region]      ap-south-1, [endpoint] ec2.ap-south-1.amazonaws.com
[region]      eu-north-1, [endpoint] ec2.eu-north-1.amazonaws.com
[region]       eu-west-3, [endpoint] ec2.eu-west-3.amazonaws.com
[region]       eu-west-2, [endpoint] ec2.eu-west-2.amazonaws.com
[region]       eu-west-1, [endpoint] ec2.eu-west-1.amazonaws.com
[region]  ap-northeast-3, [endpoint] ec2.ap-northeast-3.amazonaws.com
[region]  ap-northeast-2, [endpoint] ec2.ap-northeast-2.amazonaws.com
[region]  ap-northeast-1, [endpoint] ec2.ap-northeast-1.amazonaws.com
[region]    ca-central-1, [endpoint] ec2.ca-central-1.amazonaws.com
[region]       sa-east-1, [endpoint] ec2.sa-east-1.amazonaws.com
[region]  ap-southeast-1, [endpoint] ec2.ap-southeast-1.amazonaws.com
[region]  ap-southeast-2, [endpoint] ec2.ap-southeast-2.amazonaws.com
[region]    eu-central-1, [endpoint] ec2.eu-central-1.amazonaws.com
[region]       us-east-1, [endpoint] ec2.us-east-1.amazonaws.com
[region]       us-east-2, [endpoint] ec2.us-east-2.amazonaws.com
[region]       us-west-1, [endpoint] ec2.us-west-1.amazonaws.com
[region]       us-west-2, [endpoint] ec2.us-west-2.amazonaws.com
------------------------------------------------------------
```

Stop instance

instance id에 해당하는 인스턴스를 정지한다.

```
def stopInstance(id):
    print("Stopping .... %s" % id)
    done= False
    while done==False:
        res=ec2.stop_instances(InstanceIds=[id])
        instance=resource.Instance(id)
        #인스턴스 종료 시 까지 대기
        instance.wait_until_stopped(Filters=[{'Name': 'instance-
id','Values':[id]}])
        print("Successfully stopped instance %s" % id)
        done=True
```

```
------------------------------------------------------------
           Amazon AWS Control Panel using SDK
------------------------------------------------------------
  1. list instance                2. available zones
  3. start instance               4. available regions
  5. stop instance                6. create instance
  7. reboot instance              8. list images
  9. condor_status               10. scaling
  11. condor_q                   99. exit
------------------------------------------------------------
Enter an integer: 5
Enter instance id: i-0d61aa9f733857194
Stopping .... i-0d61aa9f733857194
Successfully stopped instance i-0d61aa9f733857194
------------------------------------------------------------
```

Create instance

AMI id를 입력 받고, 해당 ami를 기반으로 인스턴스를 생성한다. 이 때 생성되는 인스턴스는 condor pool에 포함되어야 하므로, master와 통신이 가능하도록 설정해야 한다. 따라서 condor slave 노드 용 보안그룹으로 설정한다.

```
def createInstance(id):
     print("Creating...")
     done= False
     while done==False:
        #htcondor-slave-image 기반 생성, 보안그룹 설정
        res=resource.create_instances(ImageId=id,InstanceType='t2.micro',MaxCo
unt=1,MinCount=1,SecurityGroupIds=['sg-038024dd64c7f9fa5'])
        instance=resource.Instance(res[0].instance_id)
```

```
        #인스턴스 실행 시 까지 대기
        instance.wait_until_running(Filters=[{'Name': 'instance-
id','Values':[res[0].instance_id]}])
        print("Successfully started EC2 instance %s based on AMI %s" %
(res[0].instance_id,id))
        done=True
```

```
-----------------------------------------------------------
          Amazon AWS Control Panel using SDK
-----------------------------------------------------------
  1. list instance                2. available zones
  3. start instance               4. available regions
  5. stop instance                6. create instance
  7. reboot instance              8. list images
  9. condor_status               10. scaling
  11. condor_q                   99. exit
-----------------------------------------------------------
Enter an integer: 6
Enter ami id: ami-0825246f21ab11a8c
Creating...
Successfully started EC2 instance i-0d61aa9f733857194 based on AMI ami-0825246f21ab11a8c
```

Reboot instance

실행 중인 인스턴스의 id를 입력 받고, 해당 id를 가진 인스턴스를 재시작 한다.

```
def rebootInstance(id):
    print("Rebooting .... %s" % id)
    done= False
    while done==False:
        res=ec2.reboot_instances(InstanceIds=[id])
        instance=resource.Instance(id)
        #인스턴스 실행 시 까지 대기
        instance.wait_until_running(Filters=[{'Name': 'instance-
id','Values':[id]}])
        print("Successfully rebooted instance %s" % id)
        done=True
```

```
-----------------------------------------------------------
          Amazon AWS Control Panel using SDK
-----------------------------------------------------------
  1. list instance                2. available zones
  3. start instance               4. available regions
  5. stop instance                6. create instance
  7. reboot instance              8. list images
  9. condor_status               10. scaling
  11. condor_q                   99. exit
-----------------------------------------------------------
Enter an integer: 7
Enter instance id: i-0d61aa9f733857194
Rebooting .... i-0d61aa9f733857194
Successfully rebooted instance i-0d61aa9f733857194
-----------------------------------------------------------
```

List image

가상머신 이미지 리스트를 출력한다. 본 프로그램에서는 htcondor-slave-image라는 이름을 가진 이미지의 정보만 출력한다.

```
def listImages():
    print("Listing images ....")
    done = False
    while done==False:
        #이름이 htcondor-slave-image 인 이미지만 출력
        res=ec2.describe_images(Filters=[{'Name':'name','Values':['htcondor-
slave-image']}])
        list=res['Images']
        for image in list:
            print("[ImageID] %s, [Name] %s, [Owner] %s" %
(image['ImageId'],image['Name'],image['OwnerId']))

        done=True
```

```
-----------------------------------------------------------
          Amazon AWS Control Panel using SDK
-----------------------------------------------------------
  1. list instance                2. available zones
  3. start instance               4. available regions
  5. stop instance                6. create instance
  7. reboot instance              8. list images
  9. condor_status               10. scaling
  11. condor_q                   99. exit
-----------------------------------------------------------
Enter an integer: 8
Listing images ....
[ImageID] ami-0825246f21ab11a8c, [Name] htcondor-slave-image, [Owner] 952173121372
```

Condor_status

HTCondor 클러스터의 상태를 출력한다. 본 프로그램에서는 IP 명시와 pem key 없는 접근을 위해 ssh가 아닌 AWS SSM을 사용하여 master 노드에 명령을 수행한다. Condor_status 명령을 master 노드에 전달하여 그 결과를 터미널에 출력한다.

```
def condor_status():
    #ssm module 로 통신
    res=ssm.send_command(InstanceIds=['i-
0fa386b594da20771'],DocumentName='AWS-RunShellScript',Parameters={'commands':
['condor_status']})
    command_id = res['Command']['CommandId']

    #커맨드 실행 결과 받을때 까지 대기
    waiter = ssm.get_waiter("command_executed")
```

```
    try:
        waiter.wait(
        CommandId=command_id,
        InstanceId='i-0fa386b594da20771',
        )
    except WaiterError as ex:
        logging.error(ex)
        return

    #커맨드 실행 결과 출력
    print(ssm.get_command_invocation(CommandId=command_id, InstanceId='i-
0fa386b594da20771')['StandardOutputContent'])
```

```
------------------------------------------------------------
  1. list instance                2. available zones
  3. start instance               4. available regions
  5. stop instance                6. create instance
  7. reboot instance              8. list images
  9. condor_status               10. scaling
  11. condor_q                   99. exit
------------------------------------------------------------
Enter an integer: 9
Name                                          OpSys      Arch   State     Activity LoadAv Mem   ActvtyTime

ip-172-31-33-56.ap-northeast-2.compute.internal  LINUX      X86_64 Unclaimed Idle      0.000  952  0+02:04:46
ip-172-31-34-36.ap-northeast-2.compute.internal  LINUX      X86_64 Unclaimed Idle      0.000  952  0+00:04:47
ip-172-31-36-244.ap-northeast-2.compute.internal LINUX      X86_64 Unclaimed Idle      0.000  952  0+03:47:56

               Machines Owner Claimed Unclaimed Matched Preempting  Drain

  X86_64/LINUX        3     0       0         3       0          0      0

         Total        3     0       0         3       0          0      0

------------------------------------------------------------
```

Scaling

현재 HTCondor queue의 상태를 확인하여, 현재 클러스터에 존재하는 slot의 개수와 큐에 존재하는 작업의 개수를 비교하여, slot보다 작업이 많은 경우 scale out, 그 반대의 경우에는 scale in을 수행한다. 또한 이미 작업이 배치된 노드의 삭제를 방지하기 위해, 해당 노드들의 hostname을 가져와 인스턴스 마다 비교하여 scale in을 수행한다. AWS SSM이 명령 결과를 빠르게 가져오지 못해 slot, job 개수와 작업이 배치된 노드의 hostname을 가져오는 명령을 셸 스크립트를 통해 작성하고, 해당 셸 스크립트를 실행하는 명령을 SSM으로 수행한다. 또한 동일한 명령을 thread programming을 통해 비동기적으로 수행하는 autoscaling 기능도 구현하였다.

```
# get slot, job, hostname
#!/bin/bash
tmp=$(condor_status -l | grep '^Cpus')
uc=$(echo "$tmp" | wc -l)
```

```
jobs=$(condor_q | grep 'Total for all users' | awk -F "jobs" '{ print $0}' | awk -F ' ' '{print $5}')
ud=$(echo "$jobs")

sched=$(condor_status | grep 'internal' | grep 'Claimed' | awk -F " " '{print $1}')
echo "$uc""$ud""$sched"
```

```
def scaling():
     #ssm 을 통해 master 의 shell script 실행
        # queue 의 job 개수, slot 개수, job 이 배치된 instance private-ip
가져오기
        res=ssm.send_command(InstanceIds=['i-
0fa386b594da20771'],DocumentName='AWS-RunShellScript',Parameters={'commands':
[". /home/ec2-user/autoscaling.sh"]})
        command_id = res['Command']['CommandId']
        #커맨드 실행 대기
        waiter = ssm.get_waiter("command_executed")
        try:
            waiter.wait(
            CommandId=command_id,
            InstanceId='i-0fa386b594da20771',
            )
        except WaiterError as ex:
            logging.error(ex)
            return

        #결과 가져오기
        result=ssm.get_command_invocation(CommandId=command_id, InstanceId='i-
0fa386b594da20771')['StandardOutputContent']
        slot=result[0] #슬롯 갯수
        jobs=result[1] #큐 작업 갯수
        sched=result[2] # 작업이 배치된 노드 private ip
        sched=sched.split('\n') # private ip string list split

        if slot<jobs: #슬롯보다 큐 작업이 많으면
            print('scale out')
            createInstance('ami-0825246f21ab11a8c') #slave image 기반 인스턴스
생성

        elif slot>jobs: #슬롯이 큐 작업보다 많으면
            print('scale in')

            #실행 중인 인스턴스 목록 가져오기
            res=list(resource.instances.filter(Filters=[{'Name':'instance-
state-name', 'Values':['running']}]))
            result=[]

            #작업 배치된 슬롯이 아니면 append
```

```
            for i in res:
                for j in range(0,len(sched)-1):
                    if i.private_ip_address != sched[j]:
                        result.append(i)

            #모든 노드가 작업 배치된 것이 아니면
            if len(result)!= 0:
                #리스트 맨 마지막 인스턴스
                id=result[-1].instance_id
                #master 노드가 아니면
                if id !='i-0fa386b594da20771':
                    stopInstance(id) #인스턴스 종료
            else:
                pass

        # 큐 작업 == 슬롯 갯수
        else:
            print('stable')
```

Scale out

```
------------------------------------------------------------
           Amazon AWS Control Panel using SDK
------------------------------------------------------------
  1. list instance                2. available zones
  3. start instance               4. available regions
  5. stop instance                6. create instance
  7. reboot instance              8. list images
  9. condor_status               10. scaling
  11. condor_q                   99. exit
------------------------------------------------------------
Enter an integer: 10
scale out
Creating...
Successfully started EC2 instance i-0bf8542ed1289001c based on AMI ami-0825246f21ab11a8c
```

Scale in

```
------------------------------------------------------------
            Amazon AWS Control Panel using SDK
------------------------------------------------------------
  1. list instance                2. available zones
  3. start instance               4. available regions
  5. stop instance                6. create instance
  7. reboot instance              8. list images
  9. condor_status               10. scaling
  11. condor_q                   99. exit
------------------------------------------------------------
Enter an integer: 10
scale in
Stopping .... i-0bf8542ed1289001c
Successfully stopped instance i-0bf8542ed1289001c
```

Condor_q

HTCondor 클러스터 queue의 상태를 출력한다. Condor_status와 마찬가지로 AWS SSM을 통해 master 노드에 명령을 전달하고, 결과값을 출력한다.

```
def condor_q():
    #ssm module 로 통신
    res=ssm.send_command(InstanceIds=['i-
0fa386b594da20771'],DocumentName='AWS-RunShellScript',Parameters={'commands':
['condor_q']})
    command_id = res['Command']['CommandId']

    #커맨드 실행 결과 받을때 까지 대기
    waiter = ssm.get_waiter("command_executed")
    try:
        waiter.wait(
        CommandId=command_id,
        InstanceId='i-0fa386b594da20771',
        )
    except WaiterError as ex:
        logging.error(ex)
        return

    #커맨드 실행 결과 출력
    print(ssm.get_command_invocation(CommandId=command_id, InstanceId='i-
0fa386b594da20771')['StandardOutputContent'])
```

```
------------------------------------------------------------
           Amazon AWS Control Panel using SDK
------------------------------------------------------------
  1. list instance                2. available zones
  3. start instance               4. available regions
  5. stop instance                6. create instance
  7. reboot instance              8. list images
  9. condor_status               10. scaling
  11. condor_q                   99. exit
------------------------------------------------------------
Enter an integer: 11


-- Schedd: ip-172-31-36-244.ap-northeast-2.compute.internal : <172.31.36.244:5629> @ 12/04/23 02:01:58
OWNER BATCH_NAME      SUBMITTED   DONE   RUN    IDLE   HOLD  TOTAL JOB_IDS

Total for query: 0 jobs; 0 completed, 0 removed, 0 idle, 0 running, 0 held, 0 suspended
Total for all users: 0 jobs; 0 completed, 0 removed, 0 idle, 0 running, 0 held, 0 suspended
```