Getting Started with the Cloud

Teacher Version

Software Architecture

March 15, 2023

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1 This Week

This week our goal is to get acquainted with AWS Academy. Throughout the course we will use AWS Academy to learn how to deploy and manage infrastructure with AWS. Additionally, AWS Academy will be used to develop the Cloud assignment. Specifically, this week you need to:

- Enrol in
  1. AWS Academy Cloud Foundations [40465] course;
  2. AWS Academy Learner Lab [40046] course; and
  3. AWS Academy Cloud Architecting [40466] course.
- Navigate the AWS Academy interface.

- Enter the AWS Console from an AWS Academy lab.
- Provision an EC2 instance that deploys a simple static website.

We will then start using an Infrastructure as Code tool, specifically, Terraform, to deploy the static website instead of using the AWS Console. Specifically, this week you need to:

- Authenticate Terraform to use the AWS learner lab.
- Configure a single server website in Terraform and deploy.
- Create a Terraform module for deploying arbitrary single server websites.

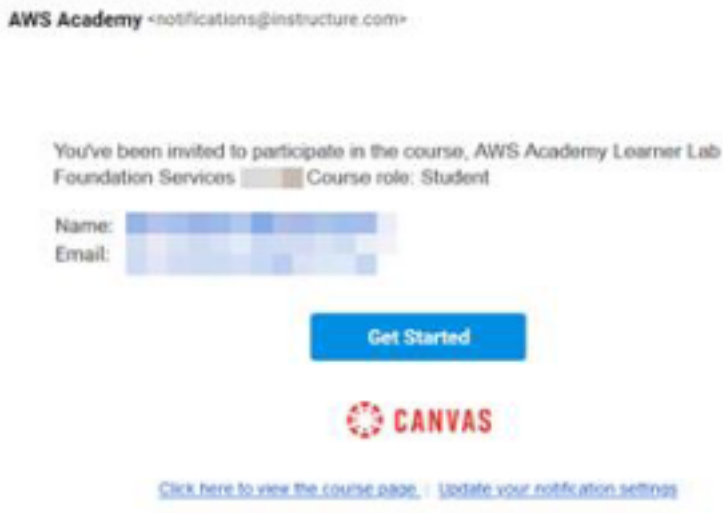
2 AWS Academy

AWS Academy is an educational platform to support teaching AWS services. In this course, we will be using it in two ways:

1. The AWS Cloud Foundations and AWS Cloud Architecting courses will be used as supplementary material to help cement your ability to use AWS. The use of these courses is optional.
2. The AWS Learner Lab provides access to an environment which will be used in these practicals to learn AWS. Later Learn Labs will be used to develop your Cloud assignment.

3 Enrol in AWS Academy

1. Set up your AWS Academy account by responding to your email invitation and clicking **Get Started**. The email invitation will come from AWS Academy. Check your junk/spam folders.



2. Go to `https://www.awsacademy.com/vforcesite/LMS_Login` to login.
   (a) Press **Student Login**.
   (b) Use the email address that received the email invitation.

4 Exploring the Interface

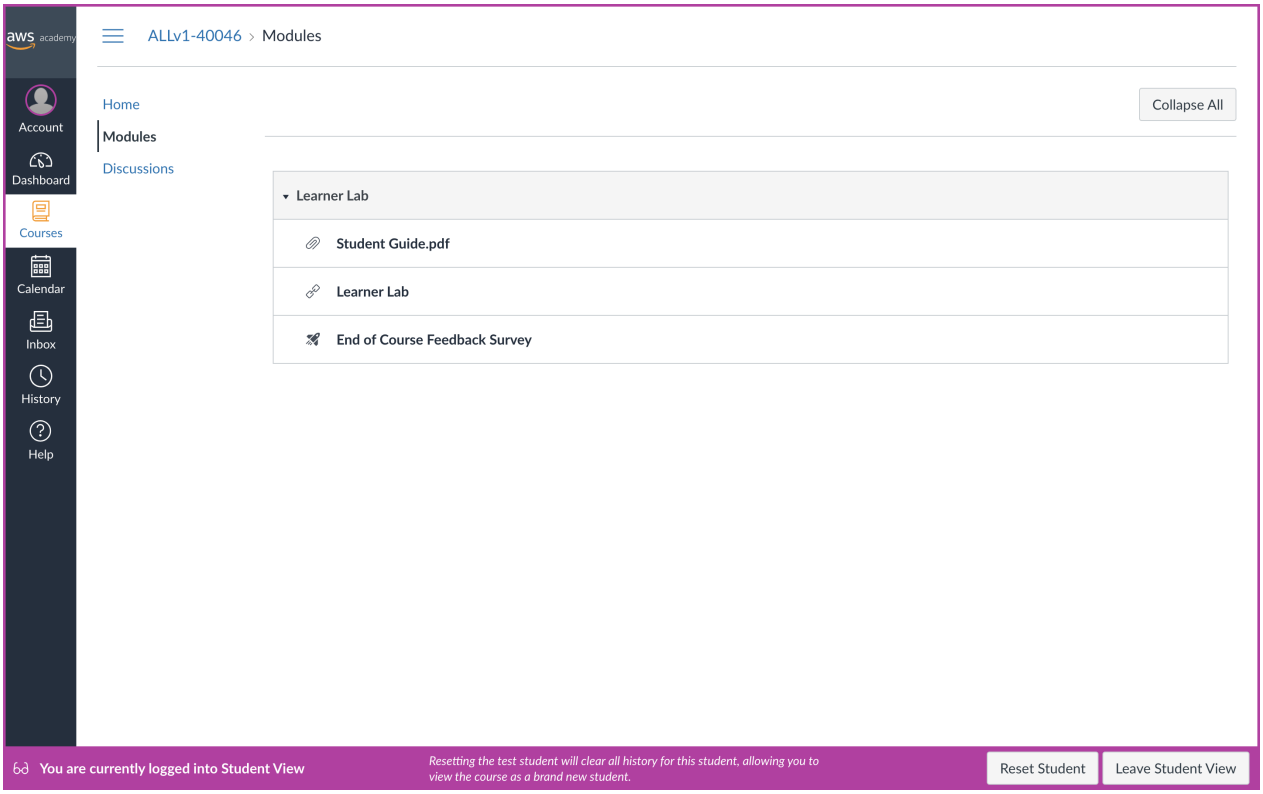
Aside

We will just be looking at the learner lab today, please ask on the Slack if you need help using the supplementary AWS Academy courses.

The following steps will enter the learner lab:

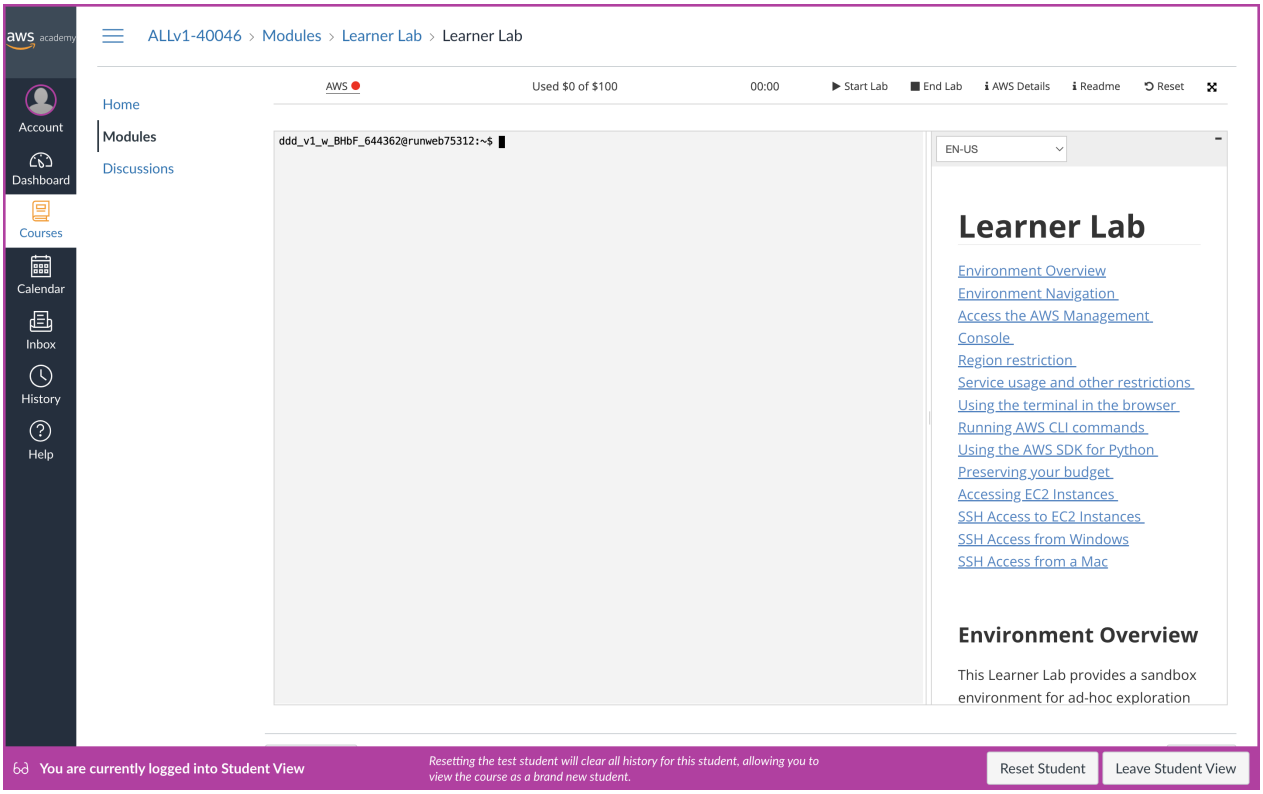
1. Once you have enrolled in the course, you should see this course page (minus everything in pink):

2. Navigate to the `Modules` tab and select the link for “Learner Lab”. You may also open and browse the “Student Guide.pdf” link which covers some of the content of this practical.



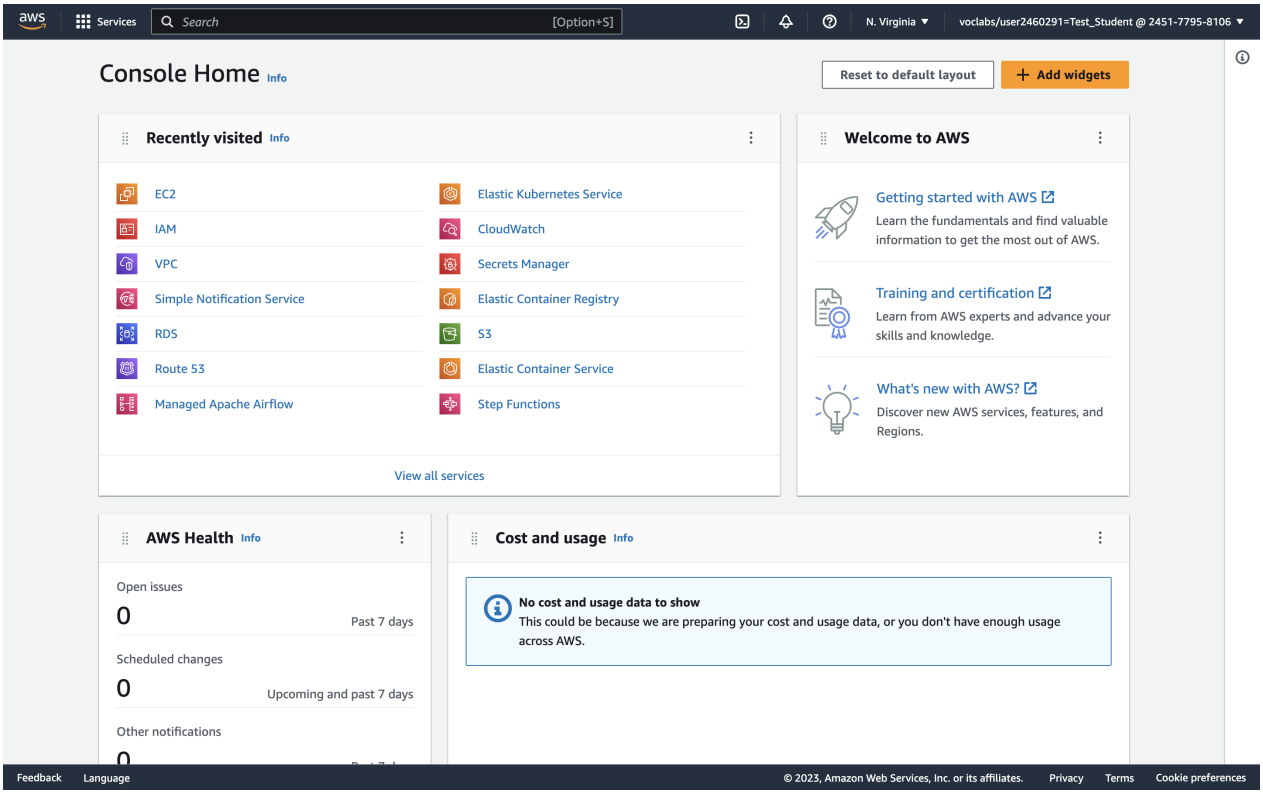
3. Now we have entered the main part of the interface, the learner lab.

   - The AWS text with the (currently) red circle is the link to open the AWS console.
   - You also see your budget, note that the budget is not updated in real-time, so avoid creating multiple resources at once.
   - The `00:00` is a countdown of hours remaining for your lab. A lab can only remain active for 4 hours, after which it will be closed, unless you press start lab again before the 4 hours expires. Once the lab is started, `00:00` will change to `04:00`.
   - AWS details will become important later but are not needed now.
   - The README button will re-open the text panel currently on the right of the terminal interface.
   - The right-hand has a lot of important information including what AWS services are available in the learner labs environment, please read it.
   - The terminal interface is a environment with the SSH keys required to connect to AWS instances semi-automatically (we will use this today).



4. Go ahead and start the lab. It will take a few moments to get ready and the red/yellow circle will turn green once it is. Click on the green circle when it is available. This will open the AWS Console in a new tab. If you end up working for a company which uses AWS, welcome to your new home.

> **For the teacher**
>
> It can take much more than a few moments for some students.



Aside

A short introduction to AWS: Amazon Web Services (AWS) is an Infrastructure as a Service (IaaS) and Software as a Service (SaaS) provider. They offer a collection of services which are helpful for development. For example, they offer virtual compute resources, database storage options, and networking to tie it all together. Services are offered with a pay as you go model, meaning you only pay for the seconds you use a service. We will get acquainted with some simple services offered by AWS now.

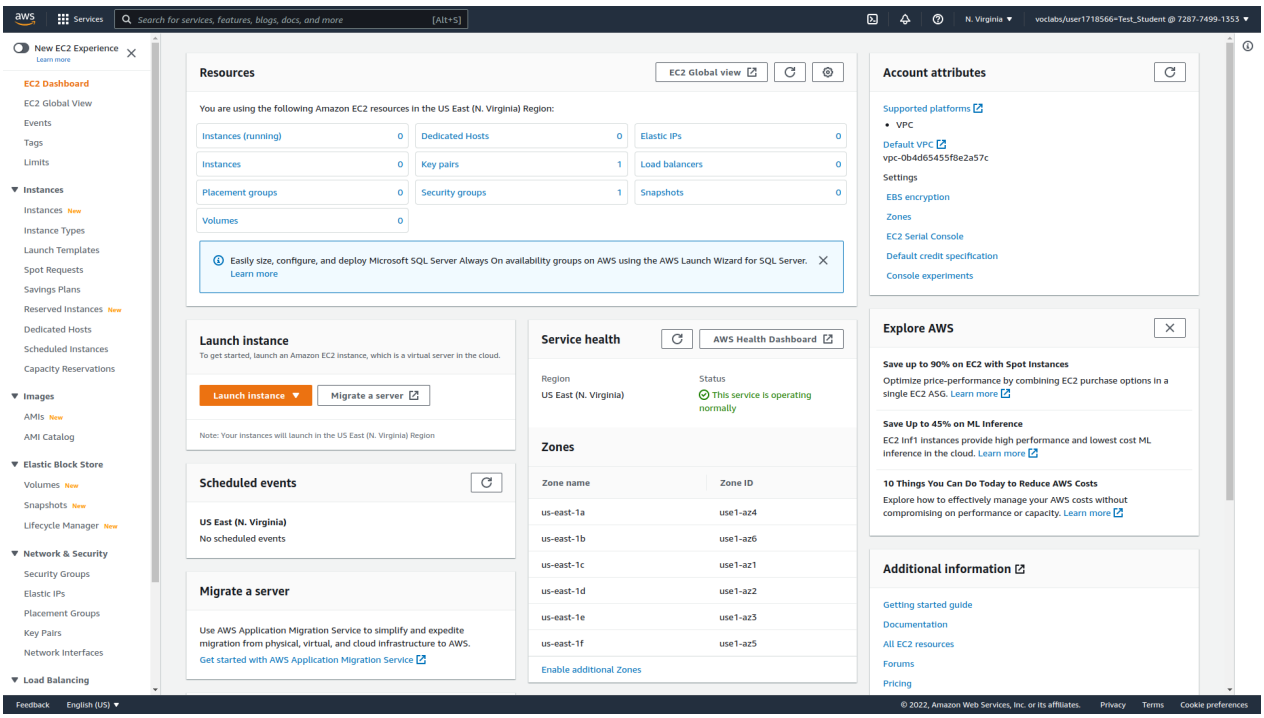
5 AWS EC2

Today we are going to focus on using AWS's EC2 service. Elastic Compute Cloud (EC2) is the primary compute service offered by AWS. It allows you to create virtual machines on Amazon's infrastructure. You have full control over this machine and can configure it for whatever purpose you need.

Navigate to the search bar in the top left and find the EC2 service. You might find this interface overwhelming. It is important to note that since EC2 is one of the primary services offered by AWS, many smaller services we do not need are bundled into the service.

For the teacher

The foundation course has a module (6) that covers EC2 in more depth, feel free to direct students to it for after the hextris example.



Today, we will just need the `Instances` dashboard. Navigate to there and select "Launch instances".

5.1 EC2 AMI

First we will need to select an Amazon Machine Image (AMI). An AMI is the template (cookie cutter) which provides instructions on how an instance should be provisioned. Amazon offers a range of built-in AMIs.

There are also community AMIs or you can create your own. As we just want a simple server today, we will use one of the built-in AMIs.

Every AMI has a unique AMI code, something that looks like `ami-005f9685cb30f234b`. We will use this AMI today, it is considered one of the fundamental images. Search for it via the code and select it.

> **For the teacher**
>
> This AMI is an instance of Amazon Linux 2 which is a RedHat style distro with yum as its package manager.

5.2 Instance Settings

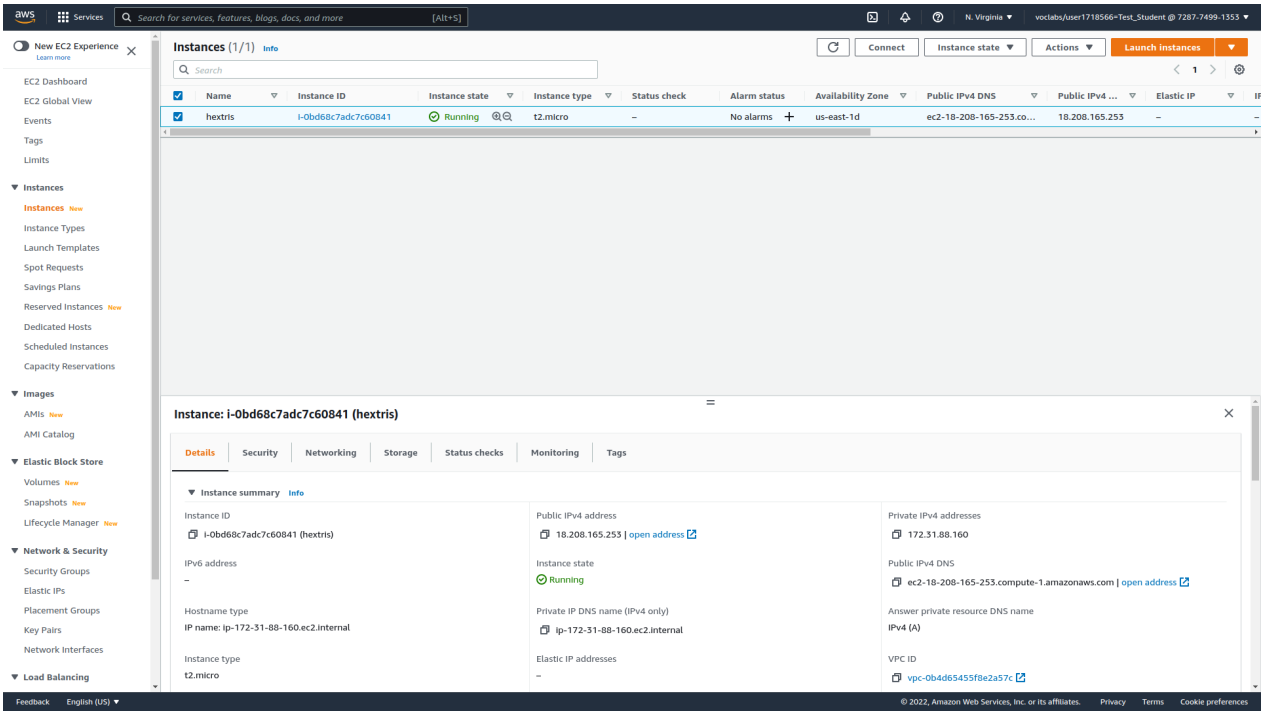
The next few settings for configuring your instance are:

1. Add a 'Name' tag, call it the name of your website, e.g. `hextris`.
2. Select an appropriate AMI, `ami-005f9685cb30f234b`.
3. We do not need a large server, choose `t2.micro`.
4. Select the existing `vockey | RSA` Key pair option.
5. Choose 'Create security group' and tick Allow SSH traffic, HTTPS, and HTTP access from everywhere.
6. Keep the 'Configure Storage' settings as default.

> **For the teacher**
>
> To make the box pingable dont forget to add the All-ICMP4 with source anywhere.

6 Accessing the Instance

Return to the `Instances` dashboard. You should now see a new instance created, its instance state might not yet be `Running`, if not, wait.



Note the public IPv4 address as we will need to use this to connect to the server.

1. Return to the AWS Learner Lab interface.
2. Run the following, replacing `127.0.0.1` with the public IP of your instance. This command uses the `vockey | RSA` key pair to gain SSH access to the machine.

```
$ ssh -i ~/.ssh/labsuser.pem ec2-user@127.0.0.1
```

Example:

```
ddd_v1_644362@runweb75312:~$ ssh -i ~/.ssh/labsuser.pem ec2-user@35.173.230.42
The authenticity of host '35.173.230.42 (35.173.230.42)' can not be established.
ECDSA key fingerprint is SHA256:W7OzzZm6nhwM9tB9Kb7enONPryo1a4259hJmSAZX7HQ.
Are you sure you want to continue connecting (yes/no)?

# At this point you will want to type yes and press enter
Warning: Permanently added '35.173.230.42' (ECDSA) to the list of known hosts.

       __| __|_ )
       _| ( / Amazon Linux 2 AMI
      ___|\___|___|

https://aws.amazon.com/amazon-linux-2/
[ec2-user@ip-172-31-53-4 ~]$
```

7 Installing Hextris

Hextris is very simple to install, using an EC2 interface is perhaps overkill for it. It is an entirely client-side/static web application which means we just have to serve the static files.

First, we will need to enable serving of static files. We can install and start the `httpd` service for this. The AMI we have picked uses the yum package manager, so to install httpd we run:

```
> sudo yum install httpd
Loaded plugins: extras_suggestions, langpacks, priorities, update-motd
Resolving Dependencies
.....
.....
Total download size: 1.9 M
Installed size: 5.2 M
Is this ok [y/d/N]:

# enter y to install
.....
.....
Complete!
```

```
> sudo systemctl enable httpd
Created symlink from /etc/systemd/system/multi-user.target.wants/httpd.service to /
   usr/lib/systemd/system/httpd.service.
> sudo systemctl start httpd
```

All files in the `/var/www/html` directory will now be served when accessed via HTTP. Navigate to the public IP address of your EC2 instance in the browser. You should see the Apache test page.

Change to the `/var/www/html` directory and notice that it is currently empty. We need to download the static files to this directory so that they can be served. We can use git for this (though it is not the most suited tool), but first git needs to be installed on the machine.

```
$ sudo yum install git
```

Finally, let's double check we are in the `/var/www/html` directory.

```
$ cd /var/www/html
```

For the teacher

This path will currently be owned by root, proper permissions can be done (but are not nesscary) by following https://docs.aws.amazon.com/AmazonRDS/latest/UserGuide/CHAP_Tutorials.WebServerDB.CreateWebServer.html

And clone the repository into that directory.

```
$ sudo git clone https://github.com/Hextris/hextris .
```

For the teacher

Mention to not forget about the "." as it is easily missed.

For the teacher

If git is prompting for a username and password then there may be a typo in the repository url.

Now if you navigate to the **http** address of the public IP address (e.g. http://18.208.165.253), you should be able to see your newly deployed website. Congradulations!

Notice

If you're having timeout issues, one problem could be using `https` to connect rather than `http`.

For the teacher

Make sure they delete their instances.

8 Switching to Terraform

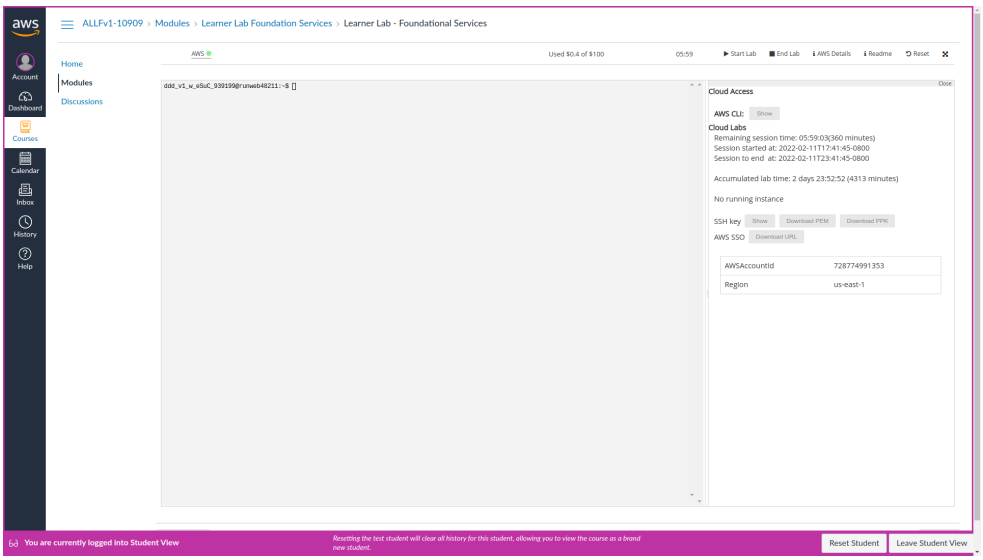
For the remainder of the practical we will be using Terraform to provision the same instance we just created.

1. First, please delete any running instances in your AWS account using the AWS Console.
2. Next, navigate to the GitHub Classroom link for this practical provided by your tutor in Slack. This will create a new repository where we can work on Terraform.

9 Using Terraform in AWS Learner Labs

We will now redeploy our Hextris application but use Infrastructure As Code (IaC) to do so. You will need to keep your lab running for the next steps (now is a good time to click start to refresh your 4 hours).

1. Click on 'AWS Details' to display information about the lab.



2. Click on the first 'Show' button next to 'AWS CLI' which will display a text block starting with `[default]`.
3. Within your repository create a `credentials` file and copy the contents of the text block into the file. **Do not share this file contents — do not commit it**. This file is added to the `.gitignore` of your repository by default.
4. Create a `main.tf` file in the same directory with the following contents:

```
terraform {
    required_providers {
        aws = {
            source = "hashicorp/aws"
            version = "~> 4.0"
        }
    }
}

provider "aws" {
    region = "us-east-1"
    shared_credentials_files = ["./credentials"]
}
```

The `terraform` block specifies the required external dependencies, here we need to use the AWS provider above version 4.0. The `provider` block configures the AWS provider, instructing it which region to use and how to authenticate (using the credentials file we created).

5. We need to initialise terraform which will download the required dependencies. This is done with the `terraform init` command.

```
$ terraform init
```

This command will create a `.terraform` directory which stores providers and a provider lock file, `.terraform.lock.hcl`.

6. To verify that we have setup Terraform correctly, use `terraform plan`.

```
$ terraform plan
```

As we currently have no resources configured, it should find that no changes are required. Note that this does not ensure our credentials are correctly configured as Terraform has no reason to try authenticating yet.

10 Deploying Hextris

First, we will need to create an EC2 instance resource. The AWS provider calls this resource an `aws_instance`[1]. Get familiar with the documentation page. Most Terraform providers have reasonable documentation, reading the argument reference section helps to understand what a resource is capable of.

We will start off with the basic information for the resource. We configured it to use a specific Amazon Machine Instance (AMI) and chose the `t2.micro` size. We will also give it a name so that it is easy to find. Add the following basic resource to `main.tf`:

```
» cat main.tf
resource "aws_instance" "hextris-server" {
    ami = "ami-005f9685cb30f234b"
    instance_type = "t2.micro"
    key_name = "vockey"

    tags = {
        Name = "hextris"
    }
}
```

To create the server, invoke `terraform apply` which will first do `terraform plan` and prompt us to confirm if we want to apply changes.

[1] https://registry.terraform.io/providers/hashicorp/aws/latest/docs/resources/instance

```
$ terraform apply
```

You should be prompted with something similar to the output below.

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

Terraform will perform the following actions:

  # aws_instance.hextris-server will be created
  + resource "aws_instance" "hextris-server" {
      + ami = "ami-005f9685cb30f234b"
      (omitted)
      + instance_type = "t2.micro"
      (omitted)
      + tags = {
          + "Name" = "hextris"
        }
    }

Plan: 1 to add, 0 to change, 0 to destroy.

Do you want to perform these actions?
  Terraform will perform the actions described above.
  Only 'yes' will be accepted to approve.

  Enter a value:
```

If the plan looks sensible enter `yes` to enact the changes.

```
  Enter a value: yes

aws_instance.hextris-server: Creating...
aws_instance.hextris-server: Still creating... [10s elapsed]
aws_instance.hextris-server: Still creating... [20s elapsed]
aws_instance.hextris-server: Still creating... [30s elapsed]
aws_instance.hextris-server: Still creating... [40s elapsed]
aws_instance.hextris-server: Creation complete after 47s [id=i-08c92a097ae7c5b18]

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

You can now check in the AWS Console that another EC2 instance with the name `hextris` has been created. Now we have got a server, we should try to configure it to serve hextris. We will use the `user_data` field which configures commands to run when launching the instance. First we need a script to provision the server, if we combine all our commands from the last practical, we will produce this script:

```
» cat serve-hextris.sh
#!/bin/bash
yum install -y httpd
systemctl enable httpd
systemctl start httpd

yum install -y git
cd /var/www/html
git clone https://github.com/Hextris/hextris .
```

For the teacher

The hash bang is required.

For the teacher

Don't forget the -y on yum install

Now we can add the following field to our Terraform resource. It uses the Terraform `file` function to load the contents of a file named `serve-hextris.sh` relative to the Terraform directory. The contents of that file is passed to the `user_data` field.

```
user_data = file("./serve-hextris.sh")
```

If you run the `terraform plan` command now, you will notice that Terraform has identified that this change will require creating a new EC2 instance. Where possible, Terraform will try to update a resource in-place but since this changes how an instance is started, it needs to be replaced. Go ahead and apply the changes.

Now, in theory, we should have deployed hextris to an EC2 instance. But how do we access that instance? We *could* go to the AWS Console and find the public IP address. However, it turns out that Terraform already knows the public IP address. In fact, if you open the Terraform state file (`terraform.tfstate`), you should be able to find it hidden away in there. But we do not want to go hunting through this file all the time. Instead we will use the `output` keyword.

We can specify certain attributes as 'output' attributes. Output attributes are printed to the terminal when the module is invoked directly but as we will see later, they can also be used by other Terraform configuration files.

```
» cat main.tf
output "hextris-url" {
  value = aws_instance.hextris-server.public_ip
}
```

This creates a new output attribute, `hextris-url`, which references the `public_ip` attribute of our `hextris-server` resource. Note that resources in Terraform are addressed by the resource type (`aws_instance`) followed by the name of the resource (`hextris-server`).

If you plan or apply the changes, it should tell you the public IP address of the instance resource.

```
$ terraform plan
```

```
aws_instance.hextris-server: Refreshing state... [id=i-043a61ff86aa272e0]

Changes to Outputs:
  + hextris-url = "3.82.225.65"
```

You can apply this plan to save these new output values to the Terraform state, without changing any real infrastructure.

So let's try and access that url, hmm. That's strange. Something has gone wrong.

11 Security Groups

When we setup our EC2 instance using the AWS Console, it helpful created a new security group for us. We specified that this security group should allow SSH, HTTP, and HTTPS traffic by allowing traffic from ports 22, 80, and 443 respectively. When configuring with Terraform, security groups and their attachment to EC2 instances are separate resources. Refer back to the Terraform documentation for details or, as is normally quicker, Google "terraform aws security group".

First, let us create an appropriate security group. Recall that in the AWS Console configuration, ingress SSH access (port 22) and all egress[2] traffic was automatically configured and we just added ingress port 80. In Terraform the whole state must be configured so we specify two `ingress` blocks one for HTTP (port 80) and one for SSH access (port 22).[3] Additionally, we will create egress for all outgoing traffic.

```
resource "aws_security_group" "hextris-server" {
  name = "hextris-server"
  description = "Hextris HTTP and SSH access"

  ingress {
    from_port = 80
    to_port = 80
    protocol = "tcp"
    cidr_blocks = ["0.0.0.0/0"]
  }

  ingress {
    from_port = 22
    to_port = 22
    protocol = "tcp"
    cidr_blocks = ["0.0.0.0/0"]
  }

  egress {
```

[2] Ingress and egress in networking just means incoming and outgoing respectively.

[3] We do not actually need SSH access as all the server configuration is done when the machine is provisioned thanks to the `user_data`, but we will try to recreate the original AWS Console exactly.

```
    from_port = 0
    to_port = 0
    protocol = "-1"
    cidr_blocks = ["0.0.0.0/0"]
  }
}
```

Note the following:

- `from_port` and `to_port` are the start and end of a range of ports rather than incoming or outgoing. In this example our range is 80-80.
- `protocol` set to -1 is a special flag to indicate all protocols.
- Explaining `cidr` is outside the scope of the course, but the specified block above means to apply to all IP addresses.

You may now apply the changes to create this new security group resource.

Next, we will attach the security group to the EC2 instance. Return to the `aws_instance.hextrix-server` resource and include the following line:

```
security_groups = [aws_security_group.hextris-server.name]
```

Note that EC2 instances can have multiple security groups. Once again notice the structure of resource identifiers in AWS.

Now apply the changes. If you now try to access via the IP address (the IP address may have changed), you should be able to view the hextris website.

12 Tearing Down

One of the important features of Infrastructure as Code (IaC) is all the configuration we just did is stored in a file. This file can, and should be, version controlled and subject to the same quality rules of code files. It also means that if we want to redeploy hextris at any point, we can easily just run the IaC to deploy it.

To try this out, let us first take everything down. We can do this with:

```
$ terraform destroy
```

You should be prompted to confirm that you want to destroy all of the resources in the state. Once Terraform has finished taking everything down, confirm that you can no longer access the website and that the AWS console says the instances have been destroyed.

Now go ahead and apply the changes to bring everything back:

```
$ terraform apply
```

Confirm that this brings the website back exactly as before (with a different IP address). You can now start any lab you want and almost instantly spin back up the website you have configured. That is the beauty of Infrastructure as Code!

Hint: destroy everything again before you leave.

13 Automated Testing

A quick note about automated testing. As with all the practicals thus far, this practical has automated tests enabled on your repository.

From within your repository, you can run the tests locally with:

```
$ .csse6400/bin/unittest.sh
```

While the emails saying that the tests failed can be annoyed, these automated tests allow us to ensure that everyone is keeping up with the practical content.

If fixing the test failures is not too hard, please try to do so. If you're repeatedly not passing the practicals, we may reach out to ensure that you're not being left behind in the content.

References

[1] D. Poccia, "Now open — third availability zone in the aws canada (central) region." https://aws.amazon.com/blogs/aws/now-open-third-availability-zone-in-the-aws-canada-central-region/, March 2020.

A AWS Networking Terminology

AWS Regions Regions are the physical locations of AWS data centres. When applying Terraform, the changes are being made to one region at a time. In our case we specified the region `us-east-1`. Often you do not need to deploy to more than one region, however, it can help decrease latency and reduce risk from a major disaster. Generally, pick a region and stick with it, we have picked `us-east-1` because it is the least expensive.

Availability Zones An AWS Region will consist of availability zones, normally named with letters. For example, the AWS Region located in Sydney, `ap-southeast-2` has three availability zones: `ap-southeast-2a`, `ap-southeast-2b`, and `ap-southeast-2c`. An availability zone is a collection of resources which run on separate power supplies and networks. Essentially minimising the risk that multiple availability zones would fail at once.

VPC Virtual Private Clouds, or VPCs, are virtual networks under your control, if you have managed a regular network before it should be familiar. VPCs are contained within one region but are spread across multiple availability zones.

Figure 1: AWS Regions as of March 2020 [1]