

# Getting Started with the Cloud

Software Architecture

March 13, 2024

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## Aside

Github Classroom links for this practical can be found on Edstem <https://edstem.org/au/courses/15375/discussion/1753712>

## 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 [73523] course;

2. AWS Academy Learner Lab [[73527](#)] course;
  3. AWS Academy Cloud Architecting [[73526](#)] course; and
  4. AWS Academy Cloud Developing [[73525](#)] 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 teach you how to use AWS services. In this course, we will be using it in two ways:

1. The AWS Cloud Foundations, Cloud Architecting, and Cloud Developing courses are supplementary material to help cement your ability to use AWS. You are encouraged to work your way through at least the AWS Cloud Foundations and Cloud Architecting courses.
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 Infrastructure 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.

# Course Invitation

Inbox ×



AWS Academy <notifications@instructure.com>  
to me ▾

13:33 (14 minutes ago)



You've been invited to participate in a class at AWS Academy . The class is called AWS Academy Learner Lab [73527]. Course role: Student

Name: [REDACTED]

Email: [REDACTED]

Username: **none**

You'll need to register with Canvas before you can participate in the class.

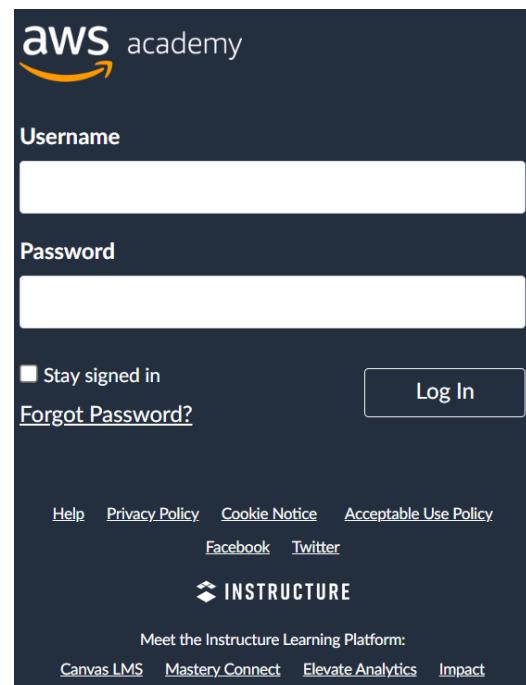
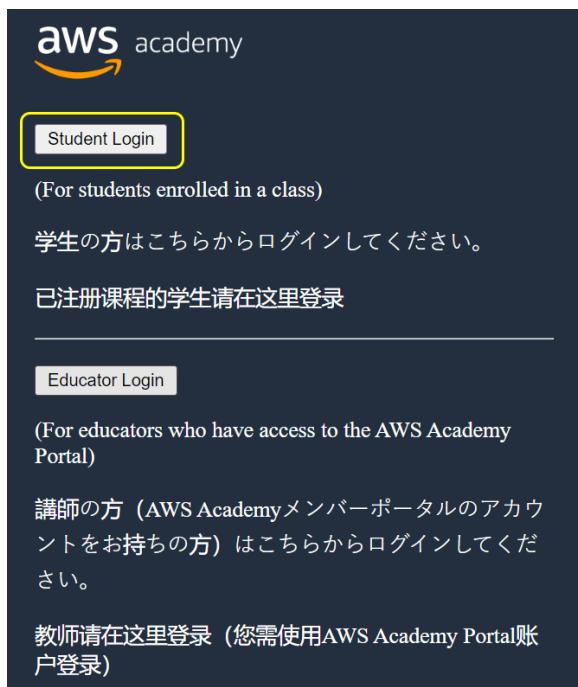
[Get Started](#)



2. Go to [https://www.awsacademy.com/vforcesite/LMS\\_Login](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 Ed Discussion board if you need help using the supplementary AWS Academy courses.

Enter the learner lab via the following steps.

1. Once you have enrolled in the course, you should see the course page.

The screenshot shows the AWS Academy Learner Lab [73527] course page. On the left is a sidebar with navigation links: Account, Dashboard, Courses, Calendar, Inbox, History, and Help. The main content area has a title "AWS Academy Learner Lab [73527]" and a large graphic of a classical building with columns and a cloud above it, labeled "aws academy". To the right are three buttons: "View Course Stream", "View Course Calendar", and "View Course Notifications". Below these are sections for "To Do" (empty), "Recent Feedback" (empty), and "Nothing for now". At the bottom left is a "Get Started" button.

AWS Academy Learner Lab provides a long-running sandbox environment for ad hoc exploration of AWS services. Within this class, students will have access to **a restricted set of AWS services**. Not all AWS documentation walk-through or sample labs that operate in an AWS Production account will work in the Learner Lab environment. You will retain access to the AWS resources set up in this environment for the duration of this course. We limit your budget (\$100USD), so you should exercise caution to prevent charges that will deplete your budget too quickly. If you exceed your budget, you will lose access to your environment and lose all of your work.

Each session lasts for 4 hours by default, although you can extend a session to run longer by pressing the start button to reset your session timer. At the end of each session, any resources you created will persist. However, we automatically shut EC2 instances down. Other resources, such as RDS instances, keep running. Keep in mind that we do not stop some AWS features, so they can still incur charges between sessions. For example, an Elastic Load Balancer or a NAT. You may wish to delete those types of resources and recreate them as needed to test your work during a session. You will have access to this environment for the duration of the class that you are enrolled in. When the class ends, your access to the learner lab will also end.

**Educator / Teacher Only**  
If you are an educator using a Learner Lab in your course, see the [Resources](#) area of the AWS Academy Portal home page for the list of supported services for each Learner Lab class. This sandbox is for educator designed project work, lab exercises, or practice that is created and tested within Learner Lab.

[Get Started](#)

2. Navigate to the Modules tab and select the link for “Launch AWS Academy Learner Lab”. You will need to accept the AWS Learner Lab terms and conditions to be able to launch learner lab. You may also open and browse the “AWS Academy Learner Lab Student Guide” and “Learn how to effectively use the AWS Academy Learner Lab” links which cover some of the content of this practical.

The screenshot shows the AWS Academy Learner Lab interface. On the left is a dark sidebar with icons for Account, Dashboard, Courses, Calendar, Inbox, History, and Help. The main area has a header 'ALLv1EN-LT13-73527 > Modules'. A 'Collapse All' button is in the top right. The 'Modules' tab is selected. The 'Course Welcome and Overview' module is expanded, showing 'Pre-Course Survey' and 'AWS Academy Learner Lab Student Guide'. The 'AWS Academy Learner Lab Compliance and Security' module is also expanded, showing 'Learn how to effectively use the AWS Academy Learner Lab' and a 'Module Knowledge Check' section with a progress bar. Below these are sections for 'AWS Academy Learner Lab' (with 'Launch AWS Academy Learner Lab') and 'AWS Academy Learner Lab Resources' (with 'Demo - How to Access Learner Lab', 'Demo - General Troubleshooting Tips', 'Demo - How to Launch Services through AWS Console', and 'Learner Lab Activity - CodeWhisperer').

### 3. You should now see the learner lab interface.

- The AWS text, near the top left of the window, with the (currently) red circle is the link to open the AWS console.
- You can 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 close, 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 README text has a lot of important information including what AWS services are available in the learner labs environment, please read it.
- The terminal interface is an environment with the SSH keys required to connect to AWS instances semi-automatically (we will use this today).

ALLv1EN-LT113-73527 > Modules > AWS Academy Learner Lab > Launch AWS Academy Learner Lab

AWS

Home

Modules

Discussions

Grades

Calendar

Inbox

History

Help

eee\_lc\_2897588@runueb113194:~\$

EN-US

## Learner Lab

Environment Overview

Environment Navigation

Access the AWS Management Console

Region restriction

Service usage and other restrictions

Using the terminal in the browser

Running AWS CLI commands

Using the AWS SDK for Python

Preserving your budget

Accessing EC2 Instances

SSH Access to EC2 Instances

SSH Access from Windows

SSH Access from a Mac

Instructions last updated: 2024-01-18

### Environment Overview

This Learner Lab provides a sandbox environment for ad-hoc exploration of AWS services.

**This environment is long-lived.** When the session timer runs to 0:00, the session will end, but any data and resources that you created in the AWS account will be retained. If you later launch a new session (for example, the next day), you will find that your work is still in the lab environment.

Running EC2 instances will be stopped and then automatically restarted the next time you start a session. SageMaker notebook instances will be stopped, but not restarted the next time you start a session. SageMaker canvas apps will remain running unless you delete them.

**IMPORTANT:** Monitor your lab budget in the lab interface above. Whenever you have an active lab session, the latest known remaining budget

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

The screenshot shows the AWS Console Home page. At the top left is the AWS logo and a navigation bar with 'Services' and a search bar. The top right shows the region 'N. Virginia' and a user session. Below the header, there are several cards:

- Recently visited**: Shows a cube icon and a message 'No recently visited services'. It includes links to EC2, S3, RDS, and Lambda.
- Applications**: Shows a message 'No applications' and a 'Create application' button. It also includes a 'Find applications' search bar and a 'Go to myApplications' link.
- Welcome to AWS**: Includes sections for 'Getting started with AWS', 'Training and certification', and 'What's new with AWS?'. It features a rocket icon, a certificate icon, and a lightbulb icon.
- AWS Health**: Shows 'Open issues 0' (Past 7 days), 'Scheduled changes 0' (Upcoming and past 7 days), and 'Other notifications 0' (Past 7 days). It includes a 'Go to AWS Health' link.
- Cost and usage**: Displays current month costs '\$0.00', total costs per month (No cost data available), forecasted month end costs (insufficient data), last month costs '\$0.00', and average month costs '\$0.00'. It includes a 'Go to Billing and Cost Management' link.
- Build a solution**: Offers four quick-start options: 'Launch a virtual machine' (With EC2 2 mins), 'Register a domain' (With Route 53 3 mins), 'Start a development project', 'Start migrating to AWS' (With AWS MGN 2 mins), 'Host a static web app' (With AWS Amplify Console 2 mins), and 'Build SQL Server on AWS'.
- Explore AWS**: Promotes 'Innovate faster with AWS for RISE ...' (Accelerate your move to cloud ERP, improve performance and reliability, etc.) and 'Amazon SageMaker HyperPod' (Reduce time to train FMs by up to 40% with purpose-built infrastructure for...).
- Security**: Shows the region 'US East (N. Virginia)' and a network icon.

## Aside

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 on a pay as you go model, meaning you only pay for the seconds you use a service. We will now get acquainted with some simple services offered by AWS.

## 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.

The screenshot shows the AWS CloudSearch interface with the search term 'ec2'. The results page has a sidebar on the left with sections like 'Recent' and 'Welcome'. The main area displays 'Services (13)' and 'Features (57)'. The top result is the 'EC2' service card, which includes a star icon, a thumbnail, and the text 'Virtual Servers in the Cloud'. Below it are cards for 'EC2 Image Builder', 'Recycle Bin', and 'Amazon Inspector'. A 'Top features' section highlights 'Dashboard', 'Launch templates', 'Instances', 'Spot Instance requests', and 'Savings plans'. The 'Dashboard' link is underlined. A 'See all 13 results' link is at the top right.

Today, we only need the Instances dashboard. Navigate to there and select “Launch instance”.

The screenshot shows the AWS EC2 Instances dashboard. The left sidebar lists categories such as EC2 Dashboard, Instances, Images, Elastic Block Store, Network & Security, Load Balancing, and Auto Scaling. The main content area is titled 'Resources' and shows a summary of resources: 0 instances (running), 0 auto scaling groups, 0 dedicated hosts, 0 elastic IPs, 0 instances, 1 key pair, 0 load balancers, 0 placement groups, 1 security group, 0 snapshots, and 0 volumes. Below this is the 'Launch instance' section, which contains a 'Launch instance' button and a 'Migrate a server' button. It also includes a note about launching in the US East (N. Virginia) Region. The 'Service health' section links to the AWS Health Dashboard. The 'Zones' section lists availability zones: us-east-1a, us-east-1b, us-east-1c, us-east-1d, us-east-1e, and us-east-1f, each associated with a zone ID. On the right side, there are sections for 'EC2 Free Tier' (info), 'Account attributes' (with a 'Default VPC' link), and 'Explore AWS' (with a 'Get started with AWS Application Migration Service' link). A sidebar on the far right shows the user's session details: 'voclabs/user3080935=R\_Thomas @ 0582-6412-3001'.

## 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.

We will use the Amazon Linux 2023 AMI today, it is considered one of the fundamental images. Every AMI has a unique AMI code, which is `ami-0e731c8a588258d0d` for the Amazon Linux 2023 AMI.

The screenshot shows the AWS EC2 'Launch an instance' wizard. In the 'Name and tags' step, a name 'My Web Server' is entered. In the 'Application and OS Images (Amazon Machine Image)' step, 'Amazon Linux 2023 AMI' is selected. In the 'Instance type' step, 't2.micro' is chosen. A callout box highlights the 'Free tier' information: 'In your first year includes 750 hours of t2.micro (or t3.micro in the Regions in which t2.micro is unavailable) instance usage on free tier AMIs per month, 30 GiB of EBS storage, 2 million I/Os, 1 GiB of snapshots, and 100 GiB of bandwidth to the internet.' The 'Launch instance' button is visible at the bottom right.

## 5.2 Instance Settings

The settings to configure your instance are:

1. Add a 'Name' tag. Call it the name of your website, e.g. hextris.
2. Select an appropriate AMI, i.e. Amazon Linux 2023 AMI, `ami-0e731c8a588258d0d`.
3. Select a 64-bit (x86) architecture.
4. The instance type defines the computing, memory, networking and storage capabilities of your instance. We do not need a large server, choose `t2.micro`.
5. Select the existing vockey (Type: RSA) key pair option.

6. In network settings, choose 'Create security group' and select to allow SSH traffic from anywhere, and HTTPS and HTTP access from the internet.
7. Keep the 'Configure storage' settings as default.
8. Do not worry about the 'Advanced details' options for now.
9. You can now launch the instance to start your server.

## 6 Accessing the Instance

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

The screenshot shows the AWS EC2 Instances dashboard. On the left, a sidebar lists various services like EC2 Dashboard, EC2 Global View, Events, Console-to-Code, Instances (selected), Instance Types, Launch Templates, Spot Requests, Savings Plans, Reserved Instances, Dedicated Hosts, Capacity Reservations, Images, AMIs, AMI Catalog, Elastic Block Store, Volumes, Snapshots, Lifecycle Manager, Network & Security, Security Groups, Elastic IPs, Placement Groups, Key Pairs, Network Interfaces, and Load Balancing. The main pane displays a table of instances with one row selected. The instance details are shown in a large panel below the table. The instance is named 'hextris' with ID 'i-057f2a7c192a26cec'. It is currently 'Running'. Other details include Public IP address (3.86.214.179), Private IP DNS name (ip-172-31-88-93.ec2.internal), Instance type (t2.micro), VPC ID (vpc-02bba0776992b50a0), Subnet ID (subnet-0b9e0ef6a63826634), AMI ID (ami-0e731c8a588258d0d), and AMI name (Amazon Linux (Inferred)). The status bar at the bottom indicates the user is 'voclabs/user3080935=R\_Thomas @ 0582-6412-3001'.

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 address 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
```

For example:

```
eee_W_2897588@runweb113237:~$ ssh -i ~/.ssh/labsuser.pem ec2-user@3.95.132.33
The authenticity of host '3.95.132.33 (3.95.132.33)' can't be established.
ECDSA key fingerprint is SHA256:BArUeylQormBYN/FANocVRnn+HM9n8X+cn0BRn7hNiE.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '3.95.132.33' (ECDSA) to the list of known hosts.

          _#
         ~\_ #####_      Amazon Linux 2023
         ~~ \#####\
         ~~   \###|
         ~~     \#/ __ https://aws.amazon.com/linux/amazon-linux-2023
         ~~       V~'-'>
         ~~~        /
         ~~.._.  /_
         ~~/_ /_
         ~~/m/'

[ec2-user@ip-172-31-80-172 ~]$ []
```

## 7 Installing Hextris

Hextris [1] 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
Last metadata expiration check: ...
Dependencies resolved
.....
.....
Total download size: 2.3 M
Installed size: 6.9 M
Is this ok [y/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 an “It works!” landing 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 instance.

```
$ sudo yum install git
```

Finally, confirm that we are in the `/var/www/html` directory.

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

And clone the repository into that directory.

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

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. Congratulations!

### Notice

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

## 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. This will create a new repository where we can work on Terraform.

## 9 Using Terraform in AWS Learner Labs

We will redeploy our Hextris application using 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.

The screenshot shows the AWS Academy Learner Lab interface. On the left is a sidebar with icons for Account, Dashboard, Courses, Calendar, Inbox, History, and Help. The main area has a breadcrumb trail: ALLv1EN-LTI13-73527 > Modules > AWS Academy Learner ... > Launch AWS Academy Learner Lab. The top bar shows AWS, a green status indicator, \$0 used, 01:55 session time, and buttons for Start Lab, End Lab, AWS Details, Readme, and Reset. The central area has a terminal window showing the command [ec2-user@ip-172-31-88-93 html]\$ . To the right is a 'Cloud Access' panel with sections for AWS CLI (Show), Cloud Labs (Remaining session time: 01:55:16(116 minutes), Session started at: 2024-02-15T20:09:23-0800, Session to end at: 2024-02-16T00:09:23-0800, Accumulated lab time: 02:04:00 (124 minutes)), and SSH key, AWS SSO, and Region details (AWSAccountID: 058264123001, Region: us-east-1).

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 = "~> 5.0"
      }
    }
  }

  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 5.0. 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`<sup>1</sup>. 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.

---

<sup>1</sup><https://registry.terraform.io/providers/hashicorp/aws/latest/docs/resources/instance>

We will start off with the basic information for the resource. Configure 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 = "vokey"

    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.

```
$ 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 that we have 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 section 7, 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 .
```

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 is strange. Something has gone wrong.

## 11 Security Groups

When we setup our EC2 instance using the AWS Console, it helpfully 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<sup>2</sup> 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).<sup>3</sup> 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"
  }
}
```

---

<sup>2</sup>Ingress and egress in networking just means incoming and outgoing respectively.

<sup>3</sup>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 are trying to create a new instance that is identical to the original AWS Console in section 7.

```

    cidr_blocks = ["0.0.0.0/0"]
}

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

egress {
  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.hextris-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 finish.

## 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 annoying, 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 are repeatedly not passing the practicals, we may reach out to ensure that you are not being left behind in the content.

## References

- [1] L. Engstrom, G. Finucane, N. Moroze, and M. Yang, "Hextris." <https://github.com/hextris/hextris/>, 2014.
- [2] "Aws global infrastructure." <https://aws.amazon.com/about-aws/global-infrastructure/>, February 2024.

## 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.



Figure 1: AWS Regions as of February 2024 [2]

**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.