

Cloud Computing with AWS

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Contents

1	Introduction	1
2	Web App	2
2.1	Software Stack	2
2.2	Database Design	2
2.3	Interface Design	4
3	VPC and Subnets	7
4	EC2	8
5	S3	11
6	CloudFront	12
7	CloudWatch	13
8	CloudTrail	14
9	Relational Database Service	15
10	Availability Zones	16
11	Elastic Load Balancing	17
12	Security Practices	18
13	Cost Breakdown	19
13.1	Estimated Costs	19
13.2	Scaling Up to 10,000 Users	19
13.3	Scaling Up to 1 Million Users	19
13.4	Scaling Up to 10 Million Users	19
14	Testing	20
14.1	Testing EC2	20
14.2	Testing S3	20
14.3	Testing CloudFront	20
14.4	Testing Server and Database	20
14.5	Testing CloudWatch	20

15 Future Enhancements	21
16 Conclusion	22
Bibliography	23
A Screenshots	24

List of Figures

2.1 Database tables overview	3
2.2 migrations table	3
2.3 users table	3
2.4 stories table	4
2.5 <i>Digital-Ink</i> home page log in and sign up forms	4
2.6 <i>Digital-Ink</i> story creation form	5
2.7 <i>Digital-Ink</i> account page	6
2.8 <i>Digital-Ink</i> stories page and story view	6
4.1 Selection of EC2 OS Image	8
4.2 Selection of EC2 Instance	9
4.3 Selection of EC2 Storage Configuration	9
A.1 After Allocating Elastic IP Address	24
A.2 Allocating Elastic IP Address	24
A.3 Cloning the App	25
A.4 CloudWatch Conditions	25
A.5 CloudWatch Specify Metric	26
A.6 Create Instance - Application and OS Images	26
A.7 Create Instance - Configure Storage	27
A.8 Create Instance - Instance Type	27
A.9 Create Instance - Name & Tags	28
A.10 Create Instance - Network Settings	28
A.11 Creating Key Pair	29
A.12 Digital Ink	29
A.13 Docker Compose	30
A.14 Edit Instance - Network Settings	30
A.15 Installing Docker using Package Manager	31
A.16 Installing Docker using Package Manager (In Progress)	31
A.17 Installing Git	32
A.18 Starting Docker systemd Service	32
A.19 Instances	33
A.20 Launching Instance	33
A.21 Log In with Key Pair	34
A.22 Selecting a VPC Configuration	34
A.23 Successfully Initiated Instance	35
A.24 VPC Successfully Created	35

A.25 VPC with Public and Private Subnets, Loading	36
A.26 VPC with Public and Private Subnets	36
A.27 Your VPCs	37

Chapter 1

Introduction

This report details the process of designing, developing, and deploying a cloud application onto Amazon Web Services (AWS). The application is called *Digital Ink* and allows users to create, edit, and delete their own short stories. Users can then view their own short stories and other users' short stories. It was first developed locally using a LAMP stack. This consisted of Linux - hosted through Docker - for the operating system, an Apache HTTP Server, MySQL for the relational database management, and PHP as the programming language.

After the application was built locally, it was gradually integrated onto AWS. This involved implementing several AWS cloud features to enhance the application, ensure application security, and increase availability. This was accomplished by using Simple Storage Service (S3), Elastic Compute Cloud (EC2), ELB (Elastic Load Balancing), and more. The process of implementing these cloud features will be discussed throughout the report.

After the application was integrated onto AWS, an evaluation of the process was conducted. This includes a discussion of the security practices used, estimated costs for different user scales, and thorough testing. Lastly, several enhancements which could be made to the application in the future will be discussed.

Chapter 2

Web App

This chapter of the report will detail the local design and development of the *Digital Ink* web application. We will first discuss the software stack used to develop the app, then the design of the database used, and, lastly, the design of the user interface.

2.1 Software Stack

Digital Ink was first developed locally using a LAMP stack. LAMP refers to a generic software stack, where each letter in the acronym stands for one the following open source building blocks: Linux, Apache HTTP Server, MySQL, and PHP (Lee and Ware, 2003). The web app is hosted within a Docker container (Anderson, 2015) which runs a mini-fied version of the Linux operating system. Apache is an open-source web server software which is used to host the app on the web (Fielding and Kaiser, 1997). MySQL is an open-source relational database management system (Widenius, Axmark and Arno, 2002) which is used to store all the data used within the app, including user details and story details. PHP is a programming language aimed towards web development, chosen due to its stability and reliability (Lerdorf et al., 2002). Additionally, all developers involved have prior experience with PHP.

2.2 Database Design

As mentioned before, the web app uses the MySQL relational database management system to store its data. MySQL is a relational database management system (RDBMS) which stores data in the form of tables, where Structured Query Language (SQL) is used to access the database. As shown in Figure 2.1, the database which this web app uses consists of three tables: `users`, `stories`, and `migrations`.

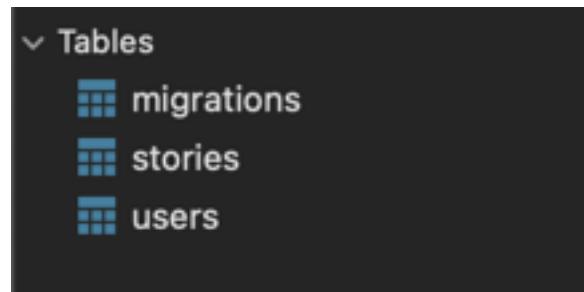


Figure 2.1: Database tables overview.

The `migrations` table (see Figure 2.2) contains records which correspond to the migrations within the Laravel web app. These migrations contain the scripts required to automatically generate the `users` and `stories` tables in SQL. It contains the following three columns:

- `id`: the unique ID for each migration.
- `migration`: points to the scripts used to create tables.
- `batch`: how many times the script has been ran.

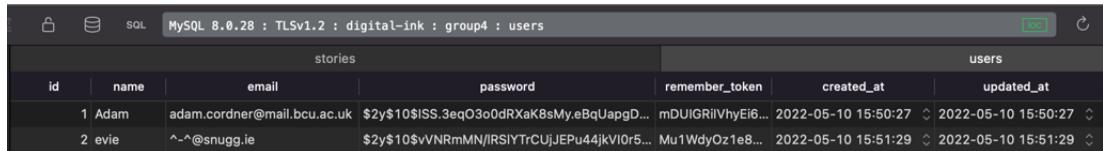
<code>id</code>	<code>migration</code>	<code>batch</code>
1	2014_10_12_000000_create_users_table	1
4	2020_03_13_105916_create_stories_table	1

Figure 2.2: `migrations` table.

The `users` table (see Figure 2.3) contains all the information about user accounts, and it contains the following seven columns:

- `id`: the unique ID for each user account.
- `name`: the name associated with user account.
- `email`: the unique email used to log in.
- `password`: the password used to log in, encrypted with 184 bit hashing by Bcrypt (Laravel, 2022b).

- `remember_token`: keeps the user logged into the device if the user selects "Remember me".
- `created_at`: records what date and time the user account was first created at.
- `updated_at`: records what date and time the user account was last updated at.



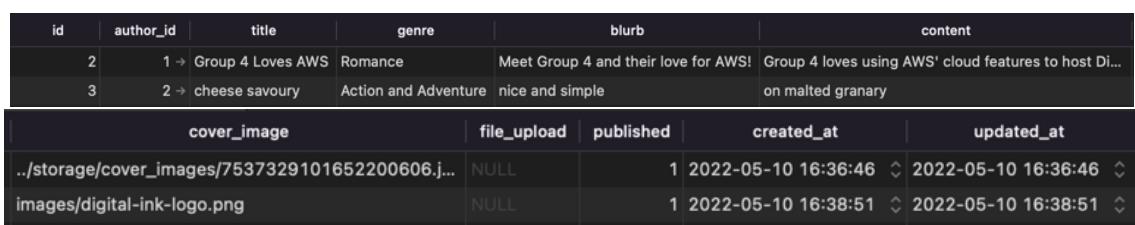
The screenshot shows a MySQL Workbench interface with a connection named 'TLSv1.2 : digital-link : group4 : users'. The 'stories' table is selected, displaying two rows of data. The columns are: id, name, email, password, remember_token, created_at, and updated_at. The data for the first row is: id=1, name='Adam', email='adam.cordner@mail.bcu.ac.uk', password='\$2y\$10\$ISS.3eqO3o0dRXaK8sMy.eBqUapgD...', remember_token='mDUIGRilVhyEl6...', created_at='2022-05-10 15:50:27', updated_at='2022-05-10 15:50:27'. The data for the second row is: id=2, name='evie', email='^~^@snugg.ie', password='\$2y\$10\$vNRmMN/IRSIYTrCUJEPu44jkVI0r5...', remember_token='Mu1WdyOz1e8...', created_at='2022-05-10 15:51:29', updated_at='2022-05-10 15:51:29'.

stories							users		
id	name	email	password	remember_token	created_at	updated_at			
1	Adam	adam.cordner@mail.bcu.ac.uk	\$2y\$10\$ISS.3eqO3o0dRXaK8sMy.eBqUapgD...	mDUIGRilVhyEl6...	2022-05-10 15:50:27	2022-05-10 15:50:27			
2	evie	^~^@snugg.ie	\$2y\$10\$vNRmMN/IRSIYTrCUJEPu44jkVI0r5...	Mu1WdyOz1e8...	2022-05-10 15:51:29	2022-05-10 15:51:29			

Figure 2.3: users table.

The `stories` table (see Figure 2.4) contains all the information about user-created stories, and it contains the following 11 columns:

- `id`: the unique ID for each story.
- `author_id`: the unique ID associated with the user who created the story.
- `title`: the title associated with the story.
- `genre`: the genre associated with the story, which can be one of eight different genres.
- `blurb`: a brief description of the story.
- `content`: the full content of the story.
- `cover_image`: a thumbnail image for the story.
- `file_upload`: an optional PDF upload of the story.
- `published`: 1 if the story has been made public, or 0 if it is a draft.
- `created_at`: records what date and time the story was first created at.
- `updated_at`: records what date and time the story was last updated at.



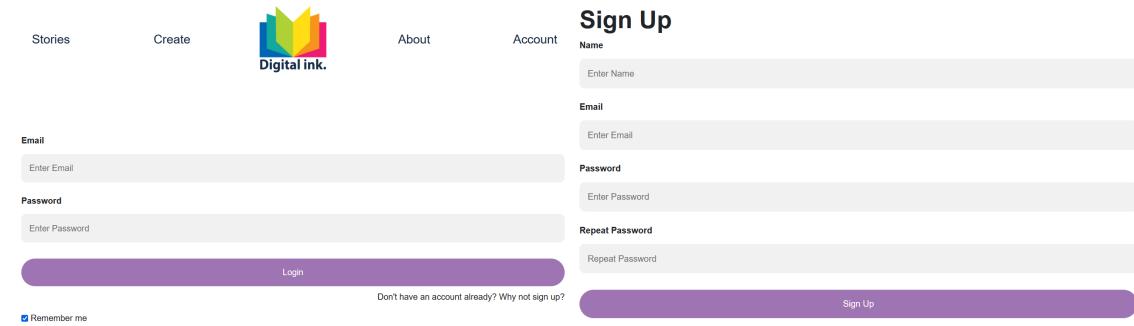
The screenshot shows a MySQL Workbench interface with a connection named 'TLSv1.2 : digital-link : group4 : users'. The 'stories' table is selected, displaying two rows of data. The columns are: id, author_id, title, genre, blurb, content, cover_image, file_upload, published, created_at, and updated_at. The data for the first row is: id=2, author_id=1, title='Group 4 Loves AWS', genre='Romance', blurb='Meet Group 4 and their love for AWS!', content='Group 4 loves using AWS' cloud features to host Di...', cover_image='..../storage/cover_images/7537329101652200606.j...', file_upload='NULL', published='1', created_at='2022-05-10 16:36:46', updated_at='2022-05-10 16:36:46'. The data for the second row is: id=3, author_id=2, title='cheese savoury', genre='Action and Adventure', blurb='nice and simple', content='on malted granary', cover_image='images/digital-ink-logo.png', file_upload='NULL', published='1', created_at='2022-05-10 16:38:51', updated_at='2022-05-10 16:38:51'.

id	author_id	title	genre	blurb	content	cover_image	file_upload	published	created_at	updated_at
2	1	Group 4 Loves AWS	Romance	Meet Group 4 and their love for AWS!	Group 4 loves using AWS' cloud features to host Di.../storage/cover_images/7537329101652200606.j...	NULL	1	2022-05-10 16:36:46	2022-05-10 16:36:46
3	2	cheese savoury	Action and Adventure	nice and simple	on malted granary	images/digital-ink-logo.png	NULL	1	2022-05-10 16:38:51	2022-05-10 16:38:51

Figure 2.4: stories table.

2.3 Interface Design

The design of the web app was created using Blade, a powerful templating engine (Laravel, 2022a). When the user initially accesses the web app, they are able to log in or sign up. This can be seen in Figure 2.5. When a user has created an account, a record is written to the `users` table in the database.



The figure shows the Digital-Ink home page. On the left, there is a navigation bar with links for 'Stories', 'Create', 'About', and 'Account'. Below this is a logo for 'Digital ink.' featuring a stylized yellow and green graphic. On the right, there is a 'Sign Up' form. The form fields include 'Name' (with placeholder 'Enter Name'), 'Email' (with placeholder 'Enter Email'), 'Password' (with placeholder 'Enter Password'), and 'Repeat Password' (with placeholder 'Repeat Password'). There is also a link 'Don't have an account already? Why not sign up?' and a 'Sign Up' button. At the bottom left of the page, there is a 'Login' button and a 'Remember me' checkbox.

Figure 2.5: *Digital-Ink* home page log in and sign up forms.

Once a user is signed in, they can create a story. Creating a story requires the user to enter a title, a genre, the story itself, a blurb, and, optionally, a thumbnail image. This can be seen in Figure 2.6. Once a story has been created, it is written to the `stories` table.

After this, the user can see all of their uploaded stories on their account page. This can be seen in Figure 2.7. From here, a story can be edited or deleted, which either updates a record in the `stories` table or removes a record from it.

Lastly, on the Stories page, a user can view and search through all uploaded stories across all users. Each story's title, genre, and blurb is shown in a list view. A user can click into one of these stories to see the thumbnail image and read the full story. These pages can be seen in Figure 2.8.

Create your story!

Author Reference Number: *

Title: *

Every story needs a good title!

Genre: *

What type of story are you creating?

Your Story: *

Add the content of your story below.

Group 4 loves using AWS' cloud features to host Digital Ink.

No file selected.

Blurb: *

Add a short description of your story!

Meet Group 4 and their love for AWS!

index.jpg

Nearly finished! *

Do you want to save your story as a draft or publish it onto our site?

- Save as a Draft
 Upload

[Complete](#)

Figure 2.6: *Digital-Ink* story creation form.

Hi Adam!

Yay! Your story has been published!

Here are your published stories:

TITLE	GENRE	ACTIONS
Group 4 Loves AWS	Romance	Edit Delete

Figure 2.7: *Digital-Ink* account page.

Stories

Search

AUTHOR ID	TITLE	GENRE	BLURB
1	Group 4 Loves AWS	Romance	Meet Group 4 and their love for AWS!
2	cheese savoury	Action and Adventure	nice and simple

Group 4 Loves AWS



Written by: 1 Genre: Romance

Group 4 loves using AWS' cloud features to host Digital Ink.

[Back](#)

Figure 2.8: *Digital-Ink* stories page and story view.

Chapter 3

VPC and Subnets

Chapter 4

EC2

After the configuration of the VPC and subnets was completed, the initial deployment of the web app began through setting up EC2. This AWS service allows for scalable computing capacity through the use of a virtual computing environment hosted in the cloud (Amazon Web Services (AWS)). The web app will be stored on an EC2 instance of Amazon Linux, known as Amazon machine images (AMIs), which will then be launched through a docker container stored on the app.

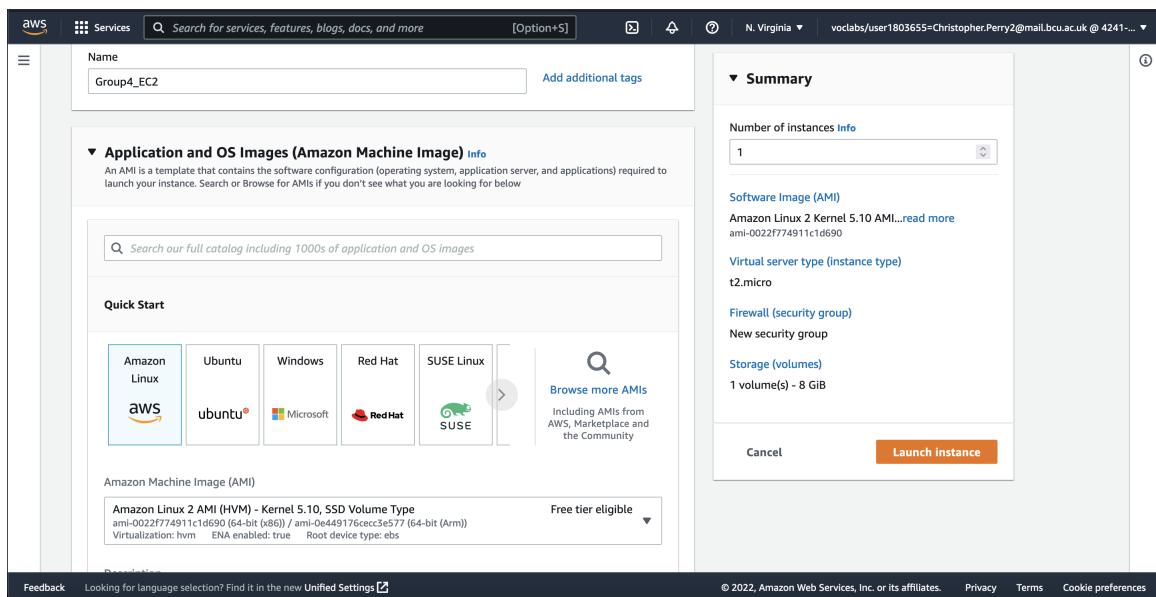


Figure 4.1: Selection of EC2 OS Image.

Figure 4.1 details the selection of the Operating System (OS) that will be used for the EC2 instance. The *Amazon Linux 2 AMI* was selected, as it is already configured with Linux and does not need any more setup.

Now that an AMI has been chosen, the specific instance type that will be used within this AMI can be selected. It was decided that the instance type of *t2.micro* would be used, as it contains only 1GB of Random Access Memory (RAM). The selection of this can be found in Figure 4.2.

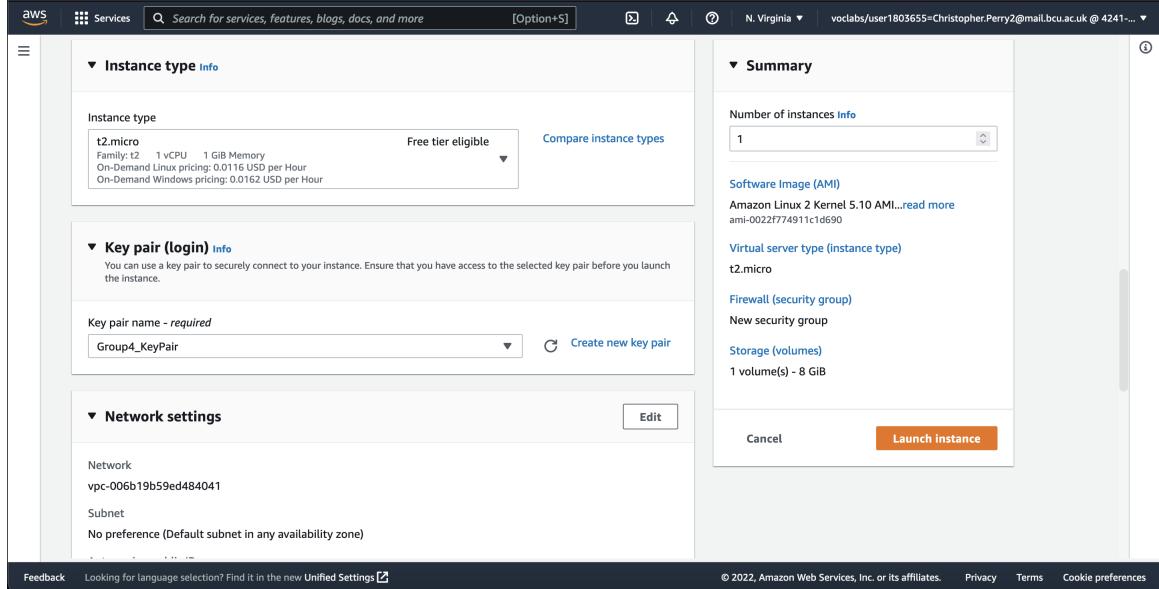


Figure 4.2: Selection of EC2 Instance.

This is enough to comfortably run the web app without any issues. Storage for the AMI was subsequently chosen. It was decided that 8GB of storage would be used, as this is enough to run the web app and still provide leftover storage for any system-critical tasks.

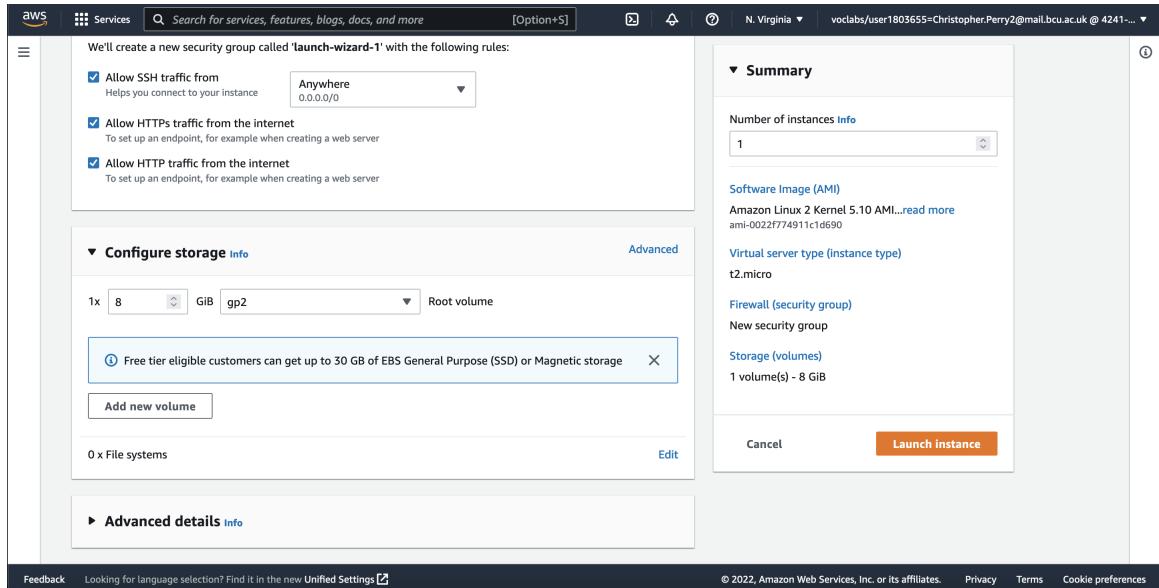


Figure 4.3: Selection of EC2 Storage Configuration.

The selection of these options can be found in Figure 4.3. In addition to this, the chosen options are eligible for "Free Tier", which means that it will use a limited amount of the

\$100 budget allocated for the project.

Once the AMI and storage options were selected, the next stage of the setup process was to set up networking for the EC2 instance, in order for the web app to work with Docker.

Chapter 5

S3

Chapter 6

CloudFront

Chapter 7

CloudWatch

Chapter 8

CloudTrail

Chapter 9

Relational Database Service

Amazon's RBS service allows a user to create a fully-featured and highly-available SQL database that is automatically replicated to another availability zone. (TODO: Oops, no multi-az) This means that if the primary database becomes unavailable, there is automatic failover providing redundancy for all the data stored within.

To create an Amazon RBS instance, an suitable name/identifier for the database is required before created as well as a selection for the resource limits for the virtual server. The database requires a username and passphrase, although for additional security there is the option to automatically generate a passphrase.

Afterwards, the type of SQL database required (such as MySQL, PostgreSQL, MariaDB or others) will be selected and then the database should begin provisioning.

Chapter 10

Availability Zones

Chapter 11

Elastic Load Balancing

Chapter 12

Security Practices

Chapter 13

Cost Breakdown

- 13.1 Estimated Costs**
- 13.2 Scaling Up to 10,000 Users**
- 13.3 Scaling Up to 1 Million Users**
- 13.4 Scaling Up to 10 Million Users**

Chapter 14

Testing

14.1 Testing EC2

14.2 Testing S3

14.3 Testing CloudFront

14.4 Testing Server and Database

14.5 Testing CloudWatch

Chapter 15

Future Enhancements

Chapter 16

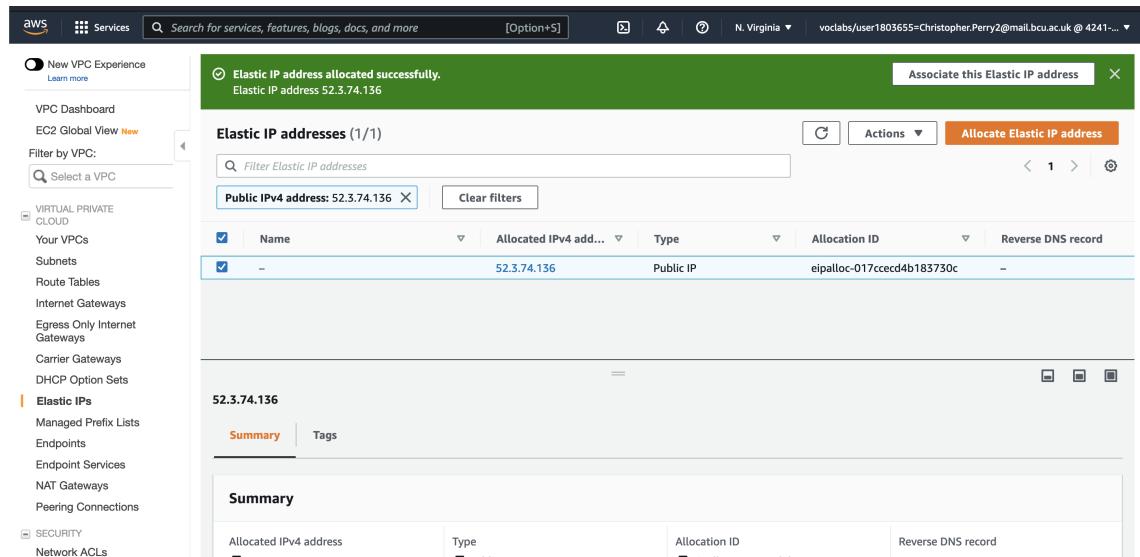
Conclusion

Bibliography

- Amazon Web Services (AWS). *What is amazon ec2?* Available from: <https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/concepts.html>.
- Anderson, C., 2015. Docker [software engineering]. *IEEE Software*, 32(3), pp.102–c3. Available from: <http://doi.org/10.1109/MS.2015.62>.
- Fielding, R.T. and Kaiser, G., 1997. The apache http server project. *IEEE Internet Computing*, 1(4), pp.88–90. Available from: <http://doi.org/10.1109/4236.612229>.
- Laravel, 2022a. *Blade templates*. Available from: <https://laravel.com/docs/9.x/blade>.
- Laravel, 2022b. *Hashing*. Available from: <https://laravel.com/docs/9.x/hashing>.
- Lee, J. and Ware, B., 2003. *Open source web development with lamp: Using linux, apache, mysql, perl, and php*. Addison-Wesley Professional.
- Lerdorf, R., Tatroe, K., Kaehms, B. and McGredy, R., 2002. *Programming php*. " O'Reilly Media, Inc.".
- Widenius, M., Axmark, D. and Arno, K., 2002. *Mysql reference manual: documentation from the source*. " O'Reilly Media, Inc.".

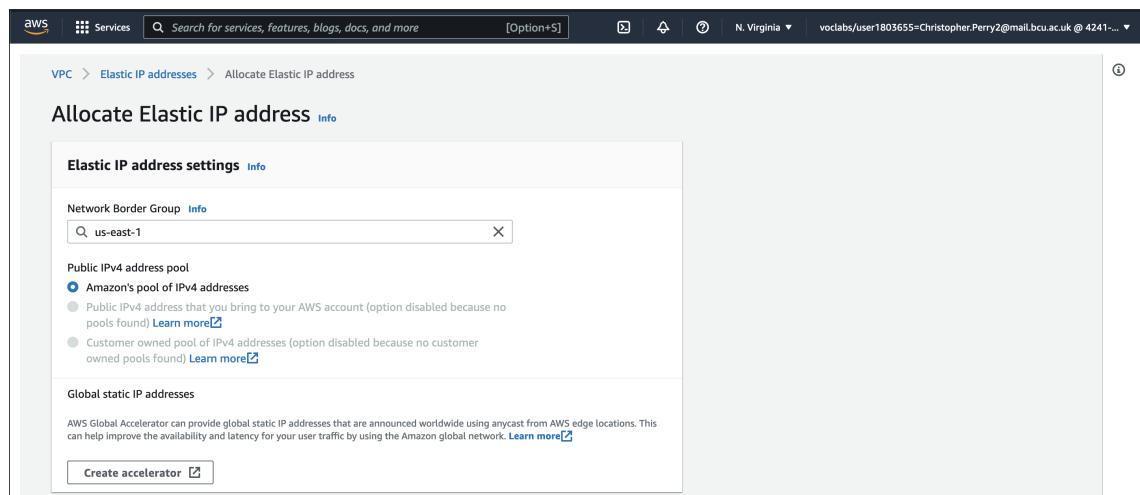
Appendix A: Screenshots

I am an appendix, please be kind.



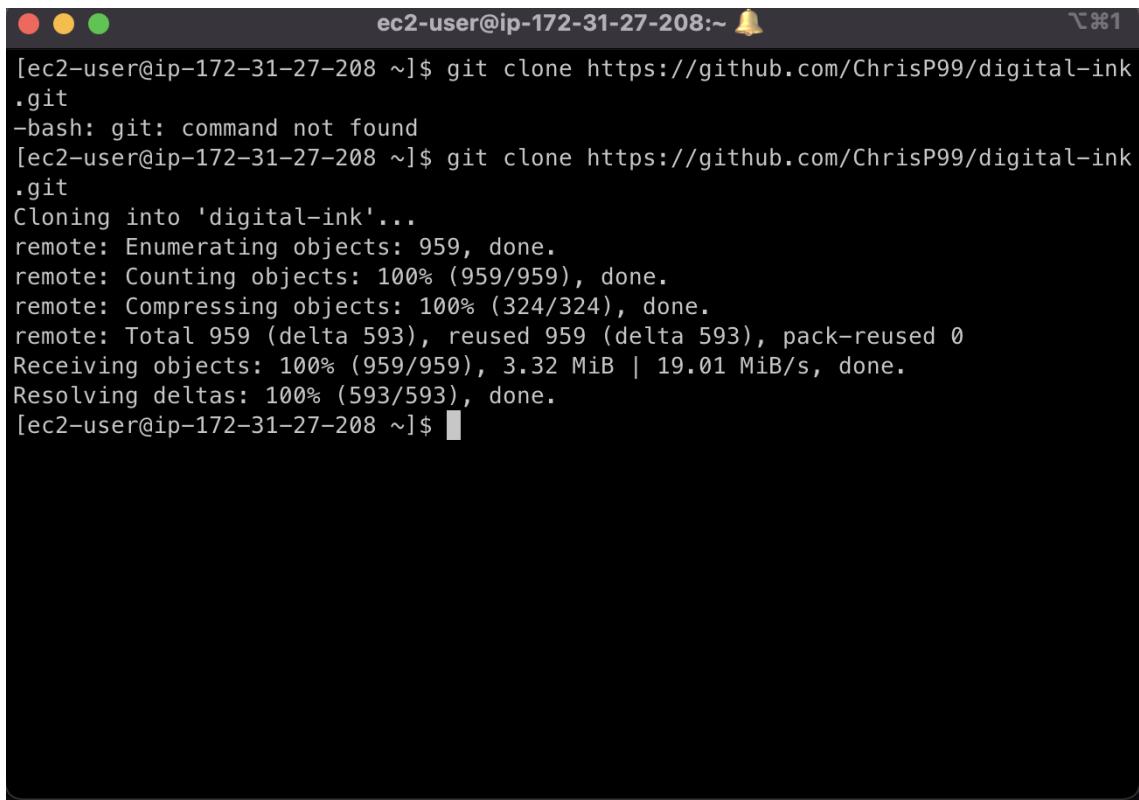
The screenshot shows the AWS VPC Elastic IP addresses page. A green success message at the top states "Elastic IP address allocated successfully. Elastic IP address 52.3.74.136". Below this, the "Elastic IP addresses (1/1)" section displays a table with one row. The table columns are Name, Allocated IPv4 add..., Type, Allocation ID, and Reverse DNS record. The single entry is "52.3.74.136" with Type "Public IP" and Allocation ID "eipalloc-017ccecd4b183730c". At the bottom, there is a "Summary" tab showing basic details like Allocated IPv4 address, Type, Allocation ID, and Reverse DNS record.

Figure A.1: After Allocating Elastic IP Address



The screenshot shows the "Allocate Elastic IP address" settings page. It includes sections for "Elastic IP address settings" (with a "Network Border Group" dropdown set to "us-east-1"), "Public IPv4 address pool" (radio button selected for "Amazon's pool of IPv4 addresses"), and "Global static IP addresses" (a note about AWS Global Accelerator). A "Create accelerator" button is at the bottom.

Figure A.2: Allocating Elastic IP Address



```
ec2-user@ip-172-31-27-208:~$ git clone https://github.com/ChrisP99/digital-ink.git
-bash: git: command not found
[ec2-user@ip-172-31-27-208 ~]$ git clone https://github.com/ChrisP99/digital-ink.git
Cloning into 'digital-ink'...
remote: Enumerating objects: 959, done.
remote: Counting objects: 100% (959/959), done.
remote: Compressing objects: 100% (324/324), done.
remote: Total 959 (delta 593), reused 959 (delta 593), pack-reused 0
Receiving objects: 100% (959/959), 3.32 MiB | 19.01 MiB/s, done.
Resolving deltas: 100% (593/593), done.
[ec2-user@ip-172-31-27-208 ~]$
```

Figure A.3: Cloning the App

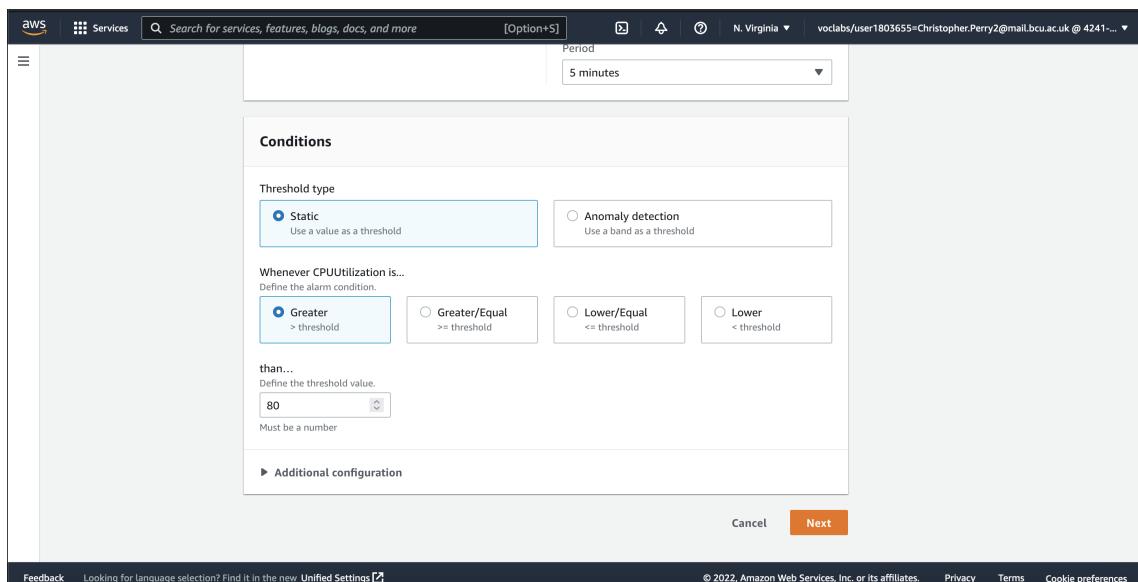


Figure A.4: CloudWatch Conditions

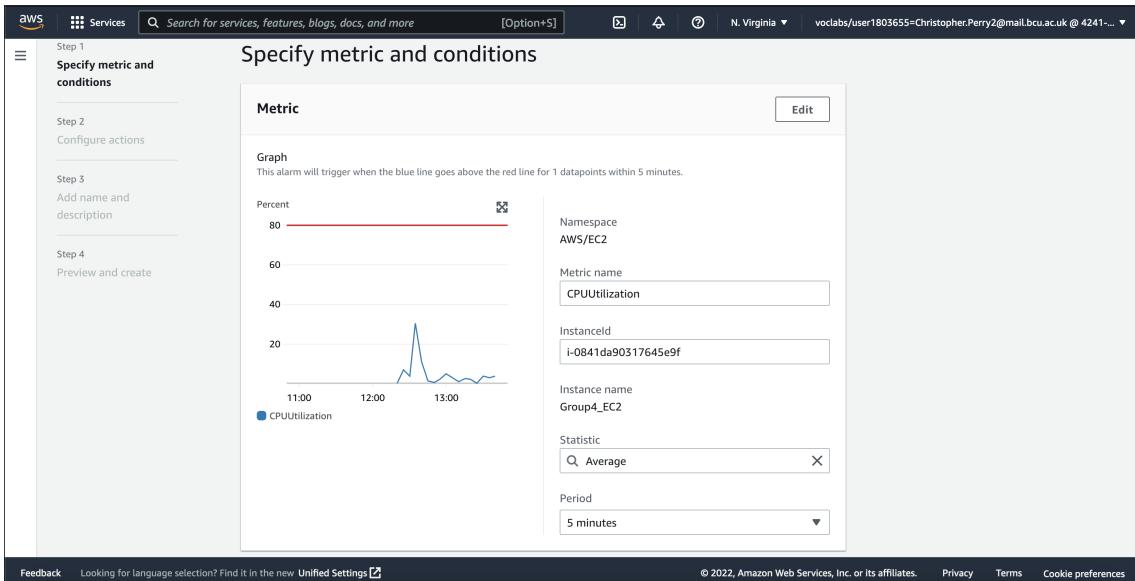


Figure A.5: CloudWatch Specify Metric

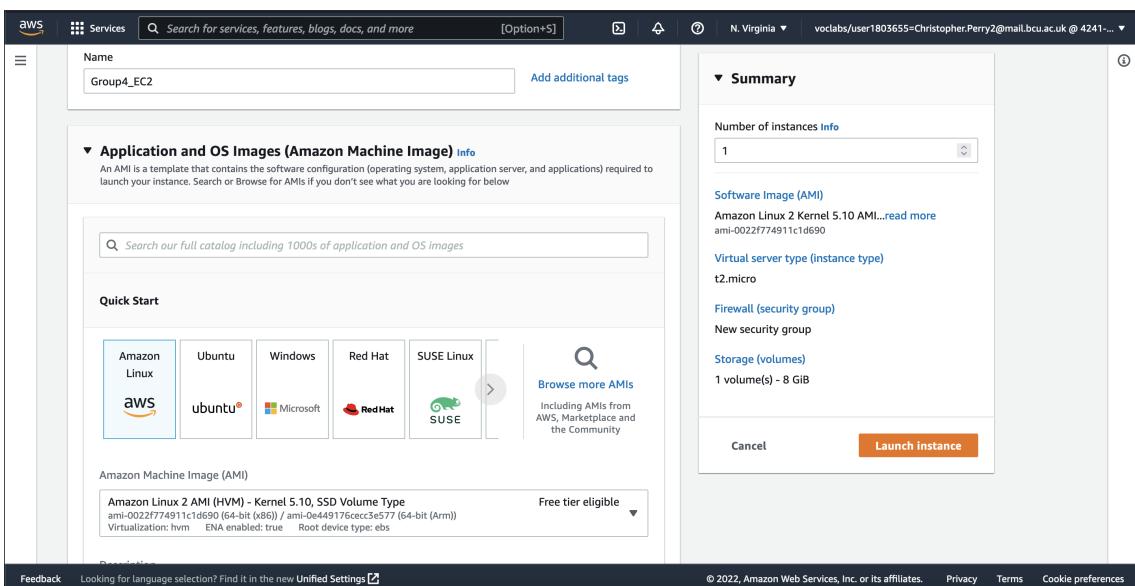


Figure A.6: Create Instance - Application and OS Images

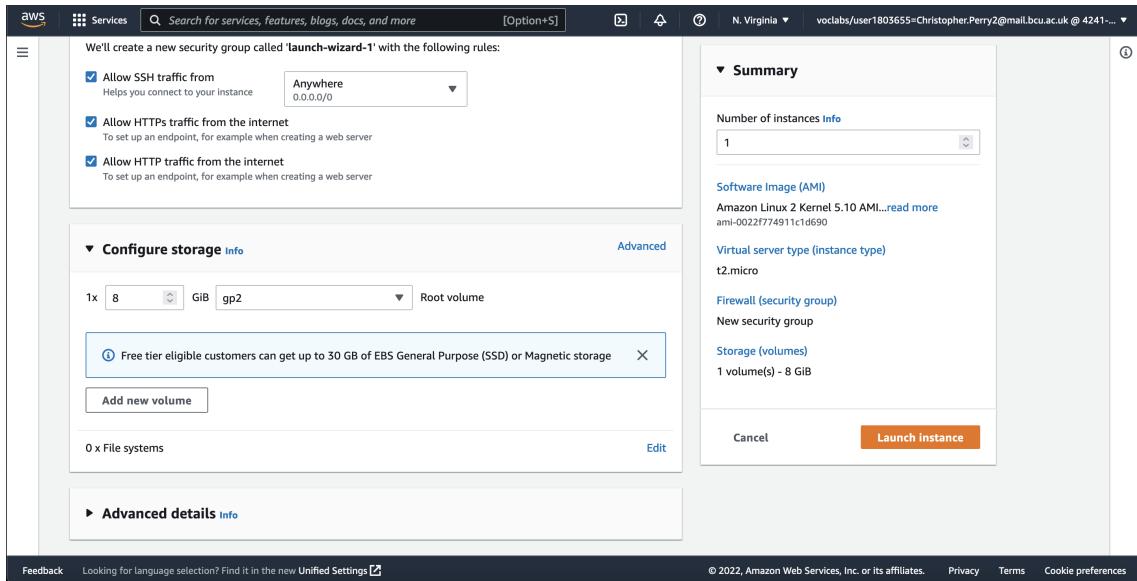


Figure A.7: Create Instance - Configure Storage

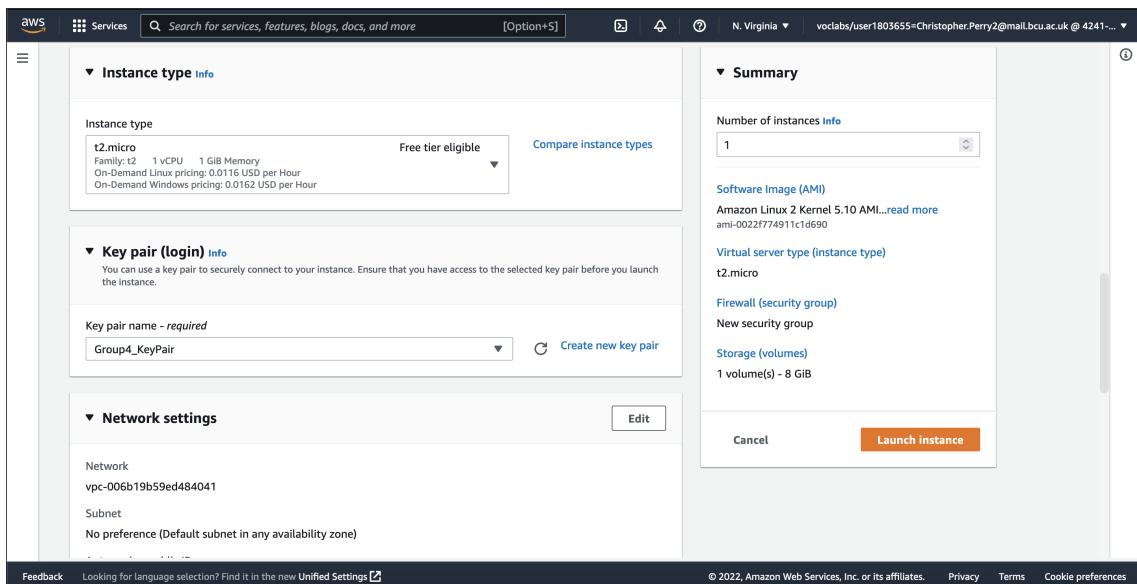


Figure A.8: Create Instance - Instance Type

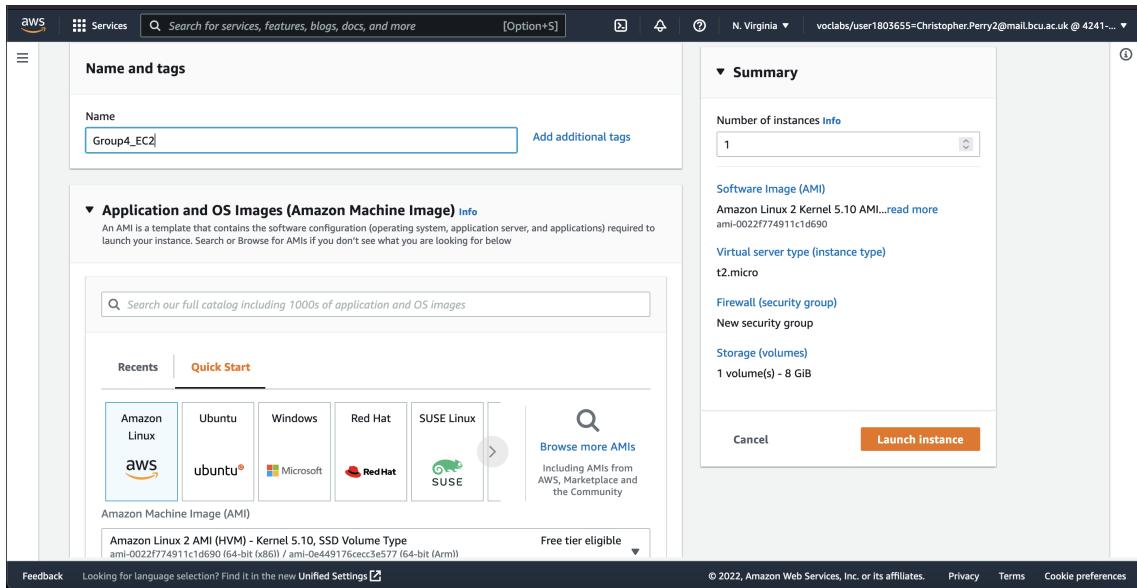


Figure A.9: Create Instance - Name & Tags

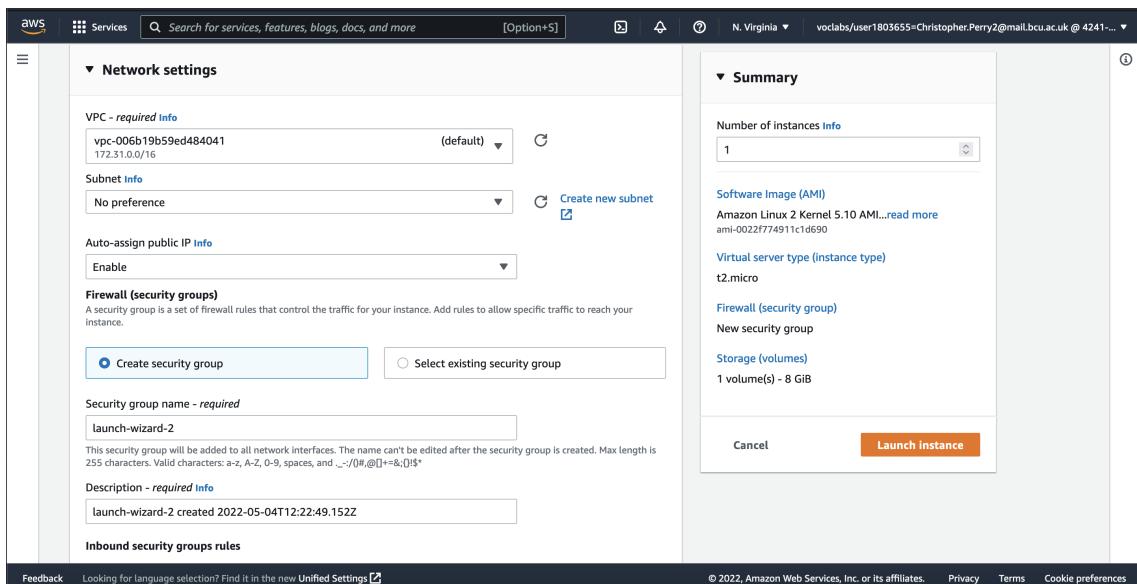


Figure A.10: Create Instance - Network Settings

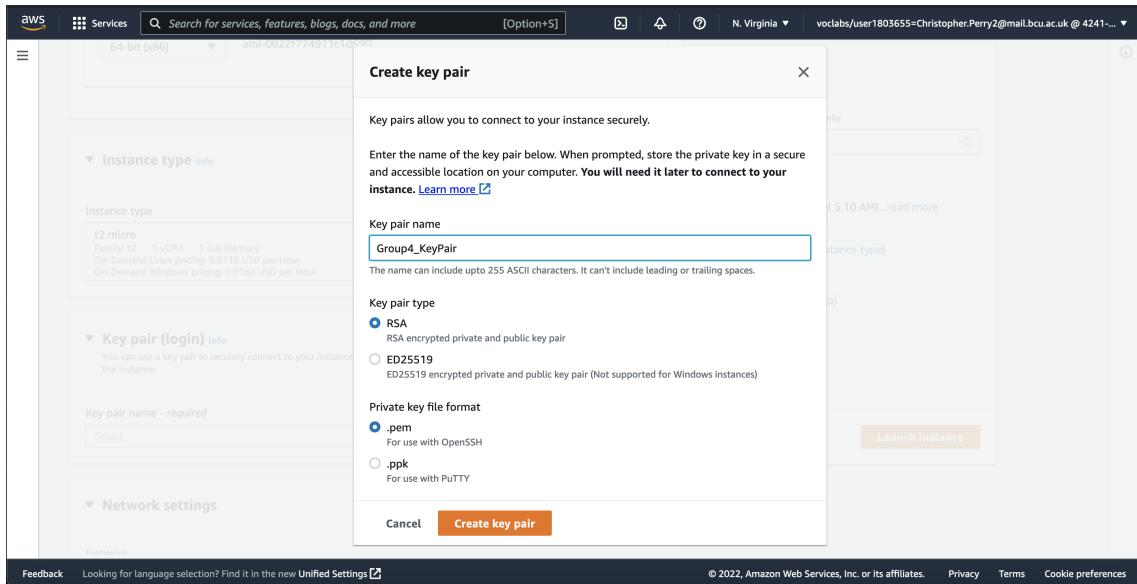


Figure A.11: Creating Key Pair

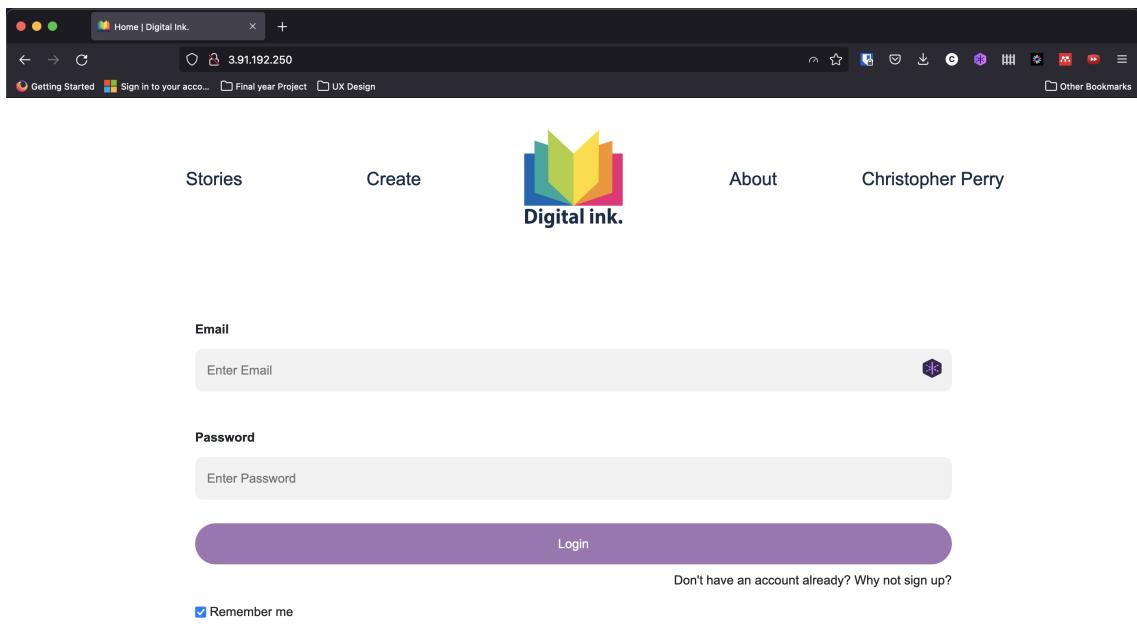


Figure A.12: Digital Ink

```
ec2-user@ip-172-31-27-208:~/digital-ink

: phpmyadmin Pulling
: 5eb5b503b376 Extracting      27.53MB/31.37MB      5.9s
: 8b1a0d84cf101 Download complete      5.7s
: 38c937addeb7 Download complete      5.7s
: 6a2f1dc96e59 Download complete      5.7s
: f8c3f82c39d4 Download complete      5.7s
: 90fc6462b088 Download complete      5.7s
[+] Running 0/319 Download complete      5.7s
: phpmyadmin Pulling
: 5eb5b503b376 Extracting      27.53MB/31.37MB      6.0s
: 8b1a0d84cf101 Download complete      5.8s
: 38c937addeb7 Download complete      5.8s
: 6a2f1dc96e59 Download complete      5.8s
: f8c3f82c39d4 Download complete      5.8s
: 90fc6462b088 Download complete      5.8s
[+] Running 7/319 Download complete      5.8s
: phpmyadmin Pulling
: 5eb5b503b376 Pull complete      7.6s
: 8b1a0d84cf101 Pull complete      7.9s
: 38c937addeb7 Extracting      [=====] 32.31MB/91.6MB      12.8s
: 6a2f1dc96e59 Download complete      12.8s
: f8c3f82c39d4 Download complete      12.8s
: 90fc6462b088 Download complete      12.8s
: c670d99116c9 Download complete      12.8s
: 268554d6fe96 Download complete      12.8s
: 6c29fa0d4492 Download complete      12.8s
: 73c23c0a259 Download complete      12.8s
: 81ac13c96fc2 Download complete      12.8s
: b60a3e6c23949 Download complete      12.8s
: dac5dd67fd59 Download complete      12.8s
: fd46866d9c36 Download complete      12.8s
: 443a80ef4c80 Download complete      12.8s
: 5e0049224f95 Download complete      12.8s
: 213e66cdf7f56 Download complete      12.8s
: 9b9b44731108 Download complete      12.8s
[+] db Pulling
: 15bb15f562f Pull complete      13.0s
: 96c2ab037a1b Pull complete      8.5s
: 8aa3ac85066b Pull complete      9.8s
: ac7e524fc98 Pull complete      9.4s
: f6a88631064f Pull complete      9.8s
: 15bb3ec3f5f0 Extracting      [=====] 13.11MB/14.06MB      10.1s
: ae65dc337dc0 Download complete      12.7s
: ad4c4c43ad5f52 Download complete      12.7s
: c6cab33e8ff1 Download complete      12.7s
: 2e1c1f2c43f6 Download complete      12.7s
: 2e5ee322aaf48 Download complete      12.7s
```

Figure A.13: Docker Compose

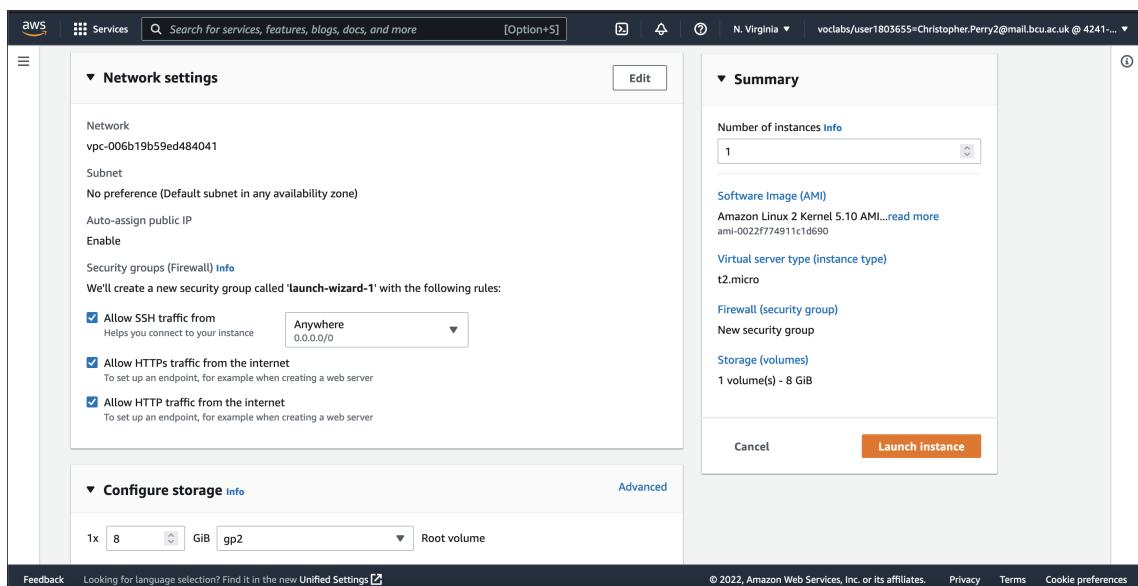


Figure A.14: Edit Instance - Network Settings

```
[ec2-user@ip-172-31-27-208 ~]$ sudo yum update
Loaded plugins: extras_suggestions, langpacks, priorities, update-motd
amzn2-core
No packages marked for update
[ec2-user@ip-172-31-27-208 ~]$ sudo yum install docker docker-compose
Loaded plugins: extras_suggestions, langpacks, priorities, update-motd
No package docker-compose available.
Resolving Dependencies
--> Running transaction check
--> Package docker x86_64 0:20.10.13-2.amzn2 will be installed
--> Processing Dependency: runc >= 1.0.0 for package: docker-20.10.13-2.amzn2.x86_64
--> Processing Dependency: libcgroup >= 0.40.rcl5.15 for package: docker-20.10.13-2.amzn2.x86_64
--> Processing Dependency: containerd >= 1.3.2 for package: docker-20.10.13-2.amzn2.x86_64
--> Processing Dependency: pigz for package: docker-20.10.13-2.amzn2.x86_64
--> Running transaction check
--> Package containerd.x86_64 0:1.4.13-2.amzn2.0.1 will be installed
--> Package libcgroup.x86_64 0:0.41-21.amzn2 will be installed
--> Package pigz.x86_64 0:2.3.4-1.amzn2.0.1 will be installed
--> Package runc.x86_64 0:1.0.3-2.amzn2 will be installed
--> Finished Dependency Resolution

Dependencies Resolved

=====
| Package      | Arch | Version       | Repository | Size |
|=====|=====|=====|=====|=====|
| Installing: |       |             |            |        |
| docker       | x86_64 | 20.10.13-2.amzn2 | amzn2extra-docker | 40 M |
| Installing for dependencies: |       |             |            |        |
| containerd  | x86_64 | 1.4.13-2.amzn2.0.1 | amzn2extra-docker | 23 M |
| libcgroup   | x86_64 | 0.41-21.amzn2 | amzn2-core | 66 k |
| pigz        | x86_64 | 2.3.4-1.amzn2.0.1 | amzn2-core | 81 k |
| runc        | x86_64 | 1.0.3-2.amzn2 | amzn2extra-docker | 3.0 M |
|=====|=====|=====|=====|=====|
Transaction Summary
=====
| Install 1 Package (<4 Dependent packages) |
Total download size: 67 M
Installed size: 280 M
Is this ok [D/y/N]: [ ] | 54% | 5.2 GB | 0 18% | ① 5-04, 1:31 PM | snuffle | ↻ | □ ~ | % ssh + fish + bash + zsh + fish + fish + fish + fish + fish + fish + spacedust |
```

Figure A.15: Installing Docker using Package Manager

```
Resolving Dependencies
--> Running transaction check
--> Package docker.x86_64 0:20.10.13-2.amzn2 will be installed
--> Processing Dependency: runc >= 1.0.0 for package: docker-20.10.13-2.amzn2.x86_64
--> Processing Dependency: libcgroup >= 0.40.rcl5.15 for package: docker-20.10.13-2.amzn2.x86_64
--> Processing Dependency: containerd >= 1.3.2 for package: docker-20.10.13-2.amzn2.x86_64
--> Processing Dependency: pigz for package: docker-20.10.13-2.amzn2.x86_64
--> Running transaction check
--> Package containerd.x86_64 0:1.4.13-2.amzn2.0.1 will be installed
--> Package libcgroup.x86_64 0:0.41-21.amzn2 will be installed
--> Package pigz.x86_64 0:2.3.4-1.amzn2.0.1 will be installed
--> Package runc.x86_64 0:1.0.3-2.amzn2 will be installed
--> Finished Dependency Resolution

Dependencies Resolved

=====
| Package      | Arch | Version       | Repository | Size |
|=====|=====|=====|=====|=====|
| Installing: |       |             |            |        |
| docker       | x86_64 | 20.10.13-2.amzn2 | amzn2extra-docker | 40 M |
| Installing for dependencies: |       |             |            |        |
| containerd  | x86_64 | 1.4.13-2.amzn2.0.1 | amzn2extra-docker | 23 M |
| libcgroup   | x86_64 | 0.41-21.amzn2 | amzn2-core | 66 k |
| pigz        | x86_64 | 2.3.4-1.amzn2.0.1 | amzn2-core | 81 k |
| runc        | x86_64 | 1.0.3-2.amzn2 | amzn2extra-docker | 3.0 M |
|=====|=====|=====|=====|=====|
Transaction Summary
=====
| Install 1 Package (<4 Dependent packages) |
Total download size: 67 M
Installed size: 280 M
Is this ok [D/y/N]: y
Downloading packages:
(1/5): libcgroup-0.41-21.amzn2.x86_64.rpm | 66 kB 00:00:00
(2/5): pigz-2.3.4-1.amzn2.0.1.x86_64.rpm | 81 kB 00:00:00
(3/5): containerd-1.4.13-2.amzn2.0.1.x86_64.rpm | 23 MB 00:00:00
(4/5): docker-20.10.13-2.amzn2.x86_64.rpm | 40 MB 00:00:00
(5/5): runc-1.0.3-2.amzn2.x86_64.rpm | 3.0 MB 00:00:00
=====
Total
Running transaction check
Running transaction test
Transaction test succeeded
Running transaction
  Installing : runc-1.0.3-2.amzn2.x86_64
  1/5
  Installing : containerd-1.4.13-2.amzn2.0.1.x86_64
  2/5
  Installing : libcgroup-0.41-21.amzn2.x86_64
  3/5
  Installing : pigz-2.3.4-1.amzn2.0.1.x86_64
  4/5
  Installing : docker-20.10.13-2.amzn2.x86_64 [#####
] 5/5
  66 MB/s | 67 MB 00:00:01
| 74% | 5.3 GB | 0 18% | ① 5-04, 1:31 PM | snuffle | ↻ | □ ~ | % ssh + fish + bash + zsh + fish + fish + fish + fish + fish + fish + spacedust |
```

Figure A.16: Installing Docker using Package Manager (In Progress)

```

git-core          x86_64      2.32.0-1.amzn2.0.1           amzn2-core          4.8 M
git-core-doc     noarch      2.32.0-1.amzn2.0.1           amzn2-core          2.7 M
perl-Error       noarch      1:0.17020-2.amzn2           amzn2-core          32 k
perl-Git         noarch      2.32.0-1.amzn2.0.1           amzn2-core          43 k
perl-TermReadKey x86_64      2.30-28.amzn2.0.2           amzn2-core          31 k

Transaction Summary
=====
Install 1 Package (+6 Dependent packages)

Total download size: 7.8 M
Installed size: 38 M
Is this ok [y/N]: y
Downloading packages:
(1/7): emacs-filesystem-27.2-4.amzn2.0.1.noarch.rpm | 67 kB 00:00:00
(2/7): git-2.32.0-1.amzn2.0.1.x86_64.rpm | 126 kB 00:00:00
(3/7): git-core-doc-2.32.0-1.amzn2.0.1.noarch.rpm | 2.7 MB 00:00:00
(4/7): perl-Error-0.17020-2.amzn2.noarch.rpm | 32 kB 00:00:00
(5/7): perl-Git-2.32.0-1.amzn2.0.1.noarch.rpm | 43 kB 00:00:00
(6/7): git-core-2.32.0-1.amzn2.0.1.x86_64.rpm | 4.8 MB 00:00:00
(7/7): perl-TermReadKey-2.30-28.amzn2.0.2.x86_64.rpm | 31 kB 00:00:00
29 MB/s | 7.8 MB 00:00:00

Total
Running transaction check
Running transaction test
Transaction test succeeded
Running transaction
  Installing : git-core-2.32.0-1.amzn2.0.1.x86_64
  Installing : git-core-doc-2.32.0-1.amzn2.0.1.noarch
  Installing : 1:emacs-filesystem-27.2-4.amzn2.0.1.noarch
  Installing : perl-TermReadKey-2.30-28.amzn2.0.2.x86_64
  Installing : perl-Git-2.32.0-1.amzn2.0.1.noarch
  Installing : git-2.32.0-1.amzn2.0.1.x86_64
  Verifying  : git-core-doc-2.32.0-1.amzn2.0.1.noarch
  Verifying  : perl-Git-2.32.0-1.amzn2.0.1.noarch
  Verifying  : 1:emacs-filesystem-27.2-4.amzn2.0.1.noarch
  Verifying  : git-2.32.0-1.amzn2.0.1.x86_64
  Verifying  : git-core-2.32.0-1.amzn2.0.1.x86_64
  Verifying  : 1:perl-Error-0.17020-2.amzn2.noarch
Installed:
  git.x86_64 0:2.32.0-1.amzn2.0.1

Dependency Installed:
  emacs-filesystem.noarch 1:27.2-4.amzn2.0.1  git-core.x86_64 0:2.32.0-1.amzn2.0.1  git-core-doc.noarch 0:2.32.0-1.amzn2.0.1  perl-Error.noarch 1:0.17020-2.amzn2  perl-Git.noarch 0:2.32.0-1.amzn2.0.1
  perl-TermReadKey.x86_64 0:2.30-28.amzn2.0.2

Complete!
[ec2-user@ip-172-31-27-208 ~]$ snuffle | ▶ | □ ~ | ⟲ ssh + fish + bash + zsh + fish + fish + fish + fish + fish + fish + spacedust | 59% ↗ 5.4 GB ————— | 19% ↘ 5-04, 1:33 PM

```

Figure A.17: Installing Git

```

ec2-user@ip-172-31... #1
          Load  Upload Total Spent Left Speed
~ (-fish) #2 0   0   0   0   0   0   0   0   0   0   0   0   0
0   0   0   0   0   0   0   0   0   0   0   0   0
100 25.2M 100 25.2M 0   0 39.1M 0   0   0   0   0   0   0
[ec2-user@ip-172-31-27-208 digital-in]$ uname -a
Linux ip-172-31-27-208.ec2.internal 5.10.109-104.500.amzn2.x86_64 #1 SMP Wed Apr 13 20:31:43 UTC 2022 x86_64 x86_64 x86_64 GNU/Linux
[ec2-user@ip-172-31-27-208 digital-in]$ cat /etc/*-release
NAME="Amazon Linux"
VERSION="2"
ID="amzn"
ID_LIKE="centos rhel fedora"
VERSION_ID="2"
PRETTY_NAME="Amazon Linux 2"
ANSI_COLOR="0;33"
CPE_NAME="cpe:2.3:o:amazon:amazon_linux:2"
HOME_URL="https://amazonlinux.com/"
Amazon Linux 2 (Xen)
[ec2-user@ip-172-31-27-208 digital-in]$ sudo chmod +x /usr/local/bin/docker-compose
[ec2-user@ip-172-31-27-208 digital-in]$ docker-compose --version
Docker Compose version v2.5.0
[ec2-user@ip-172-31-27-208 digital-in]$ systemctl status docker
● docker.service - Docker Application Container Engine
  Loaded: loaded (/usr/lib/systemd/system/docker.service; disabled; vendor preset: disabled)
  Active: inactive (dead)
    Docs: https://docs.docker.com
[ec2-user@ip-172-31-27-208 digital-in]$ sudo systemctl start docker
[ec2-user@ip-172-31-27-208 digital-in]$ systemctl status docker
● docker.service - Docker Application Container Engine
  Loaded: loaded (/usr/lib/systemd/system/docker.service; disabled; vendor preset: disabled)
  Active: active (running) since Wed 2022-05-04 12:40:06 UTC; 1s ago
    Docs: https://docs.docker.com
  Process: 3788 ExecStartPre=/usr/libexec/docker/docker-setup-runtimes.sh (code=exited, status=0/SUCCESS)
  Main PID: 3791 (dockerd)
    Tasks: 7
   Memory: 26.9M
      CGroup: /system.slice/docker.service
              └─3791 /usr/bin/dockerd -H fd:// --containerd=/run/containerd/containerd.sock --default-ulimit nofile=32768:65536

May 04 12:40:06 ip-172-31-27-208.ec2.internal dockerd[3791]: time="2022-05-04T12:40:06+00:00" level=info msg="ClientConn switching balancer to \"pick_first\""
May 04 12:40:06 ip-172-31-27-208.ec2.internal dockerd[3791]: time="2022-05-04T12:40:06+00:00" level=warning msg="Your kernel does not support cgroup blkio weight"
May 04 12:40:06 ip-172-31-27-208.ec2.internal dockerd[3791]: time="2022-05-04T12:40:06+00:00" level=warning msg="Your kernel does not support cgroup blkio weight_device"
May 04 12:40:06 ip-172-31-27-208.ec2.internal dockerd[3791]: time="2022-05-04T12:40:06+00:00" level=info msg="Loading containers: start"
May 04 12:40:06 ip-172-31-27-208.ec2.internal dockerd[3791]: time="2022-05-04T12:40:06+00:00" level=info msg="Default bridge (docker0) is assigned with an IP address... address"
May 04 12:40:06 ip-172-31-27-208.ec2.internal dockerd[3791]: time="2022-05-04T12:40:06+00:00" level=info msg="Loading containers: done."
May 04 12:40:06 ip-172-31-27-208.ec2.internal dockerd[3791]: time="2022-05-04T12:40:06+00:00" level=info msg="Docker daemon" commit="906f57f graphdriver(s)=overlay..=20.10.13"
May 04 12:40:06 ip-172-31-27-208.ec2.internal dockerd[3791]: time="2022-05-04T12:40:06+00:00" level=info msg="Daemon has completed initialization"
May 04 12:40:06 ip-172-31-27-208.ec2.internal systemd[1]: Started Docker Application Container Engine.
May 04 12:40:06 ip-172-31-27-208.ec2.internal dockerd[3791]: time="2022-05-04T12:40:06+00:00" level=info msg="API listen on /run/docker.sock"
Hint: Some lines were ellipsized, use -l to show in full.
[ec2-user@ip-172-31-27-208 digital-in]$

snuffle | ▶ | □ ~ | ⟲ ssh + fish + bash + zsh + fish + fish + fish + fish + fish + spacedust | 67% ↗ 5.4 GB ————— | 26% ↘ 5-04, 1:40 PM

```

Figure A.18: Starting Docker systemd Service

The screenshot shows the AWS EC2 Instances page. On the left, there's a sidebar with various navigation options like EC2 Dashboard, EC2 Global View, Events, Tags, Limits, Instances (selected), Instance Types, Launch Templates, Spot Requests, Savings Plans, Reserved Instances, Dedicated Hosts, Scheduled Instances, Capacity Reservations, Images, AMIs, and AMI Catalog. The main content area has a title 'Instances (2) Info' with a search bar and a table. The table lists two instances: 'Group4_EC2' (terminated, t2.micro, us-east-1d) and 'Group4_EC2' (running, t2.micro, us-east-1d). At the bottom, there's a modal titled 'Select an instance'.

Figure A.19: Instances

The screenshot shows the 'Launching instance' step of the AWS EC2 instance launch process. It includes a progress bar at 80% completion, a 'Launch initiation' section, and a 'Details' link. A message at the top says 'You've been opted into the new launch experience. Find out more about this experience or send us feedback. You can still return to the previous version by opting-out.' There's also an 'Opt-out to the old experience' button.

Figure A.20: Launching Instance

```

ec2-user@ip-172-31-27-208:~/digital-ink
logout
Connection to 3.91.192.250 closed.
> ssh -i ~/Desktop/Group4_KeyPair.pem ec2-user@3.91.192.250
Last login: Wed May  4 13:21:09 2022 from 193.60.143.12
  _\|_ _\|_
 _\| (   /  Amazon Linux 2 AMI
  _\|_\|_|_|
https://aws.amazon.com/amazon-linux-2/
[ec2-user@ip-172-31-27-208 ~]$ cd digital-ink
[ec2-user@ip-172-31-27-208 digital-ink]$ cd ..
[ec2-user@ip-172-31-27-208 ~]$ sudo mv digital-ink digital-ink.old
[ec2-user@ip-172-31-27-208 ~]$ git clone https://github.com/ChrisP99/digital-ink.git
Cloning into 'digital-ink'...
remote: Enumerating objects: 9909, done.
remote: Counting objects: 100% (9909/9909), done.
remote: Compressing objects: 100% (6382/6382), done.
remote: Total 9909 (delta 3080), reused 9863 (delta 3034), pack-reused 0
Receiving objects: 100% (9909/9909), 17.59 MiB | 14.30 MiB/s, done.
Resolving deltas: 100% (3080/3080), done.
Updating files: 100% (8963/8963), done.
[ec2-user@ip-172-31-27-208 ~]$ cd digital-ink
[ec2-user@ip-172-31-27-208 digital-ink]$ sudo /usr/local/bin/docker-compose up -d
[*] Running 3/3
  • Container digital-ink-db-1  Running
  • Container phpmyadmin  Running
  • Container digital-ink-app-1 Started
[ec2-user@ip-172-31-27-208 digital-ink]$ sudo /usr/local/bin/docker-compose down
[*] Running 4/4
  • Container phpmyadmin  Removed
  • Container digital-ink-app-1 Removed
  • Container digital-ink-db-1 Removed
  • Network digital-ink_default Removed
[ec2-user@ip-172-31-27-208 digital-ink]$ sudo /usr/local/bin/docker-compose up -d
[*] Running 4/4
  • Network digital-ink_default Created
  • Container digital-ink-db-1 Started
  • Container phpmyadmin  Started
  • Container digital-ink-app-1 Started
[ec2-user@ip-172-31-27-208 digital-ink]$ sudo /usr/local/bin/docker-compose exec app bash
root@c565ab9c37ff:/srv/app# php artisan migrate
Nothing to migrate.
root@c565ab9c37ff:/srv/app# 

```

Figure A.21: Log In with Key Pair

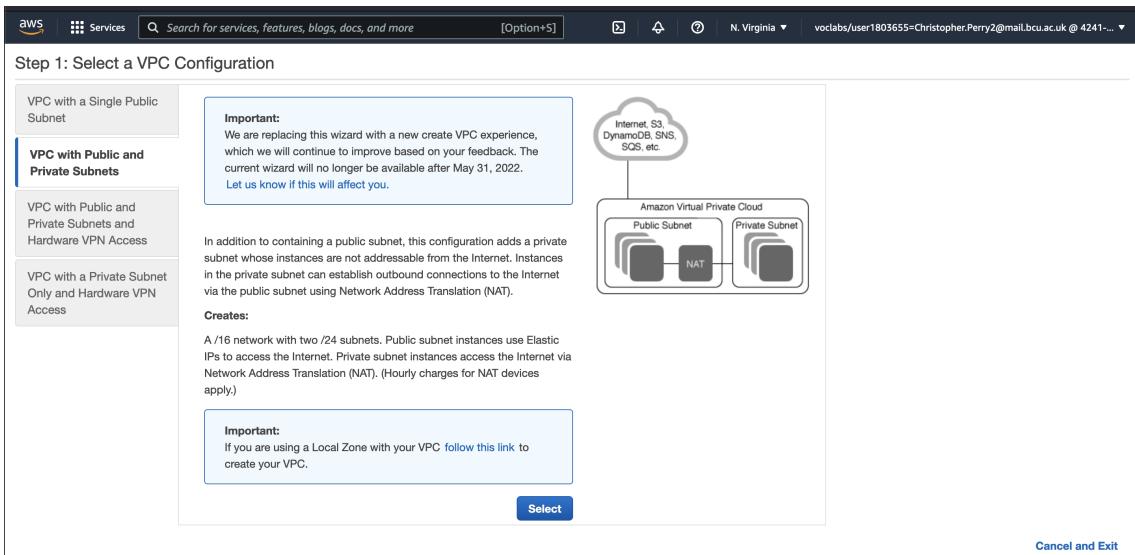


Figure A.22: Selecting a VPC Configuration

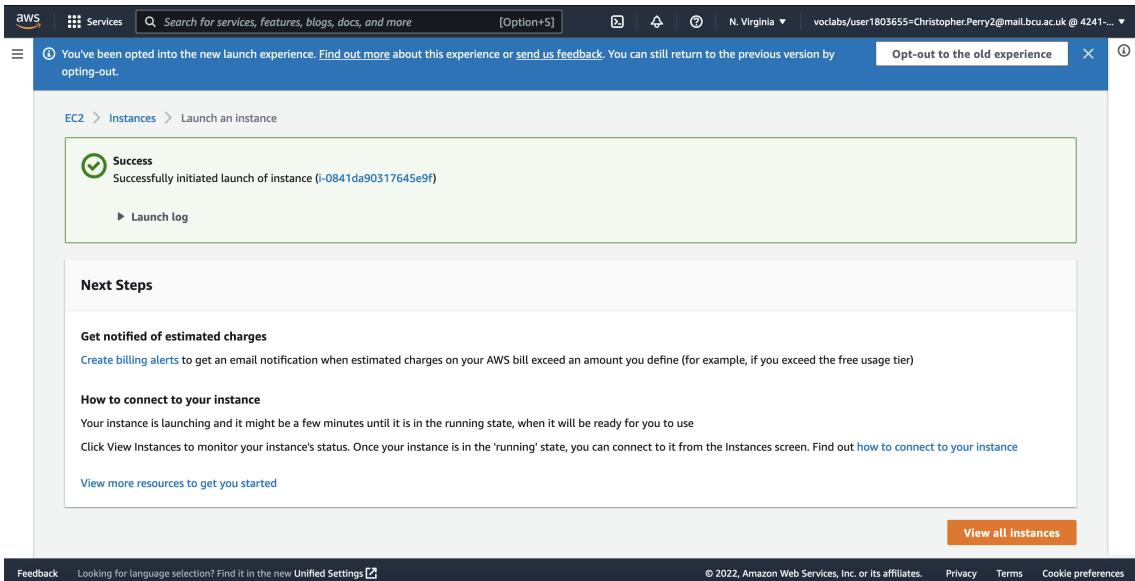


Figure A.23: Successfully Initiated Instance

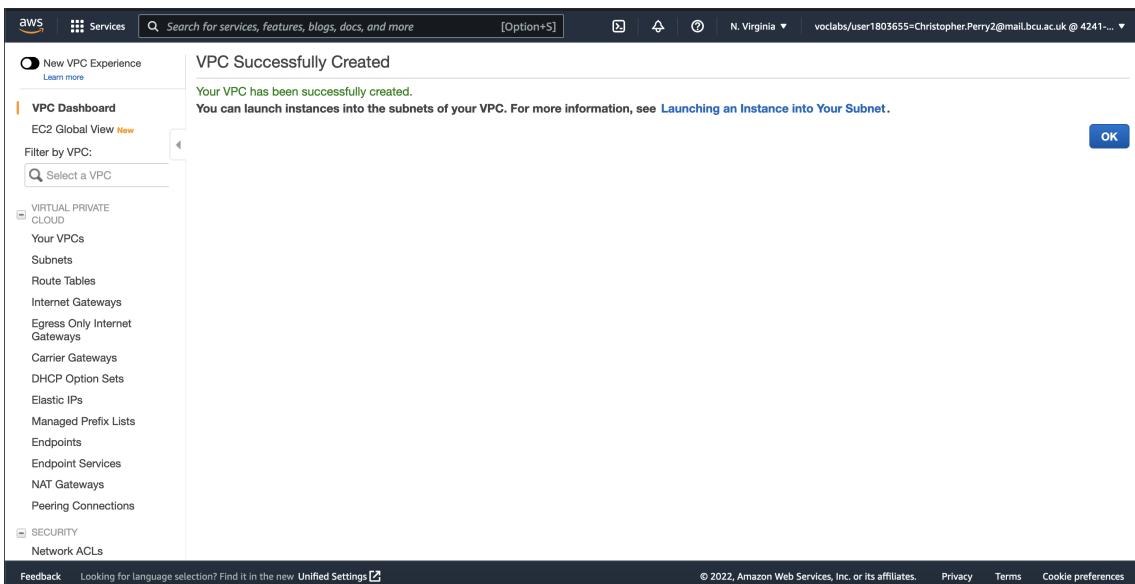


Figure A.24: VPC Successfully Created

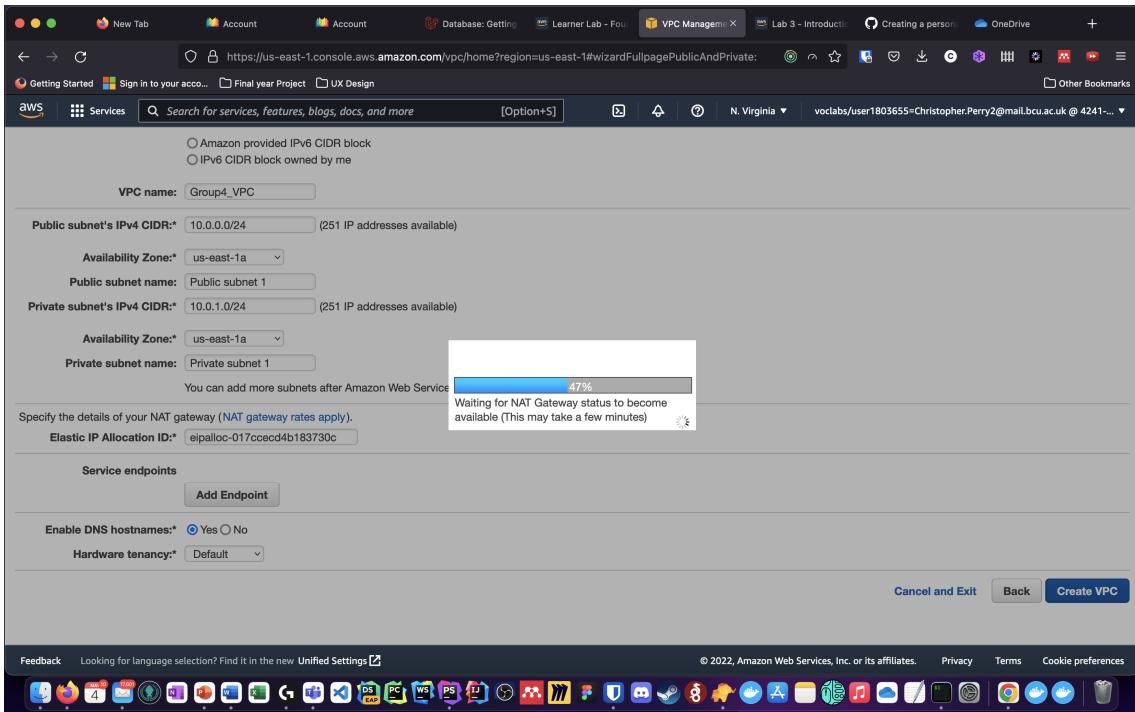


Figure A.25: VPC with Public and Private Subnets, Loading

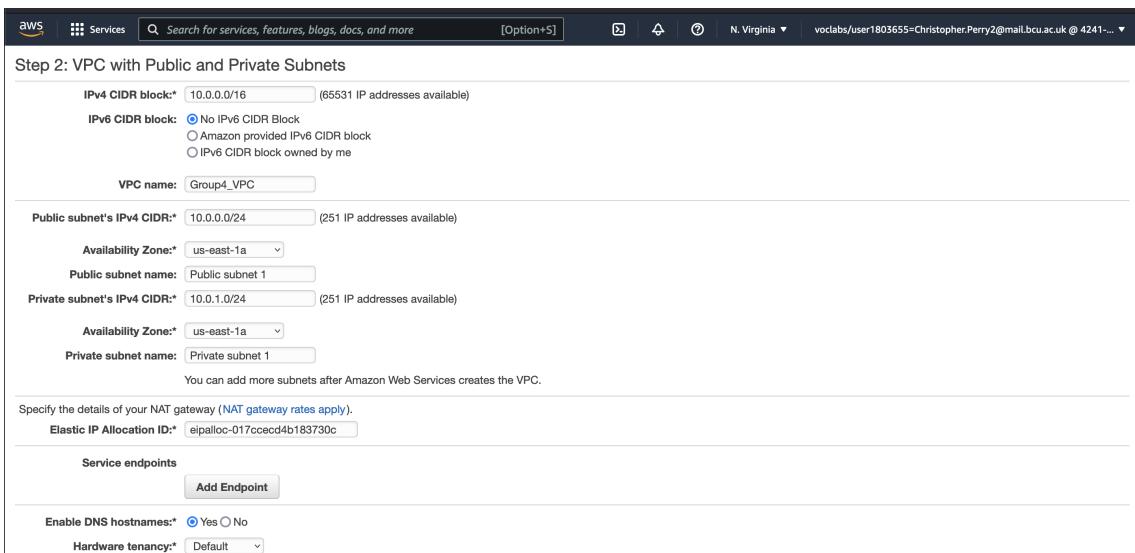


Figure A.26: VPC with Public and Private Subnets

Your VPCs (2) Info

Name	VPC ID	State	IPv4 CIDR	IPv6 CIDR
-	vpc-006b19b59ed484041	Available	172.31.0.0/16	-
Group4_VPC	vpc-0b0472507c8bf18c9	Available	10.0.0.0/16	-

vpc-07657585bc0e3b3b5

Details CIDs | Flow logs | Tags

VPC ID vpc-07657585bc0e3b3b5	State Available	DNS hostnames Disabled	DNS resolution Enabled
---------------------------------	--------------------	---------------------------	---------------------------

Feedback Looking for language selection? Find it in the new Unified Settings [?](#)

Figure A.27: Your VPCs