

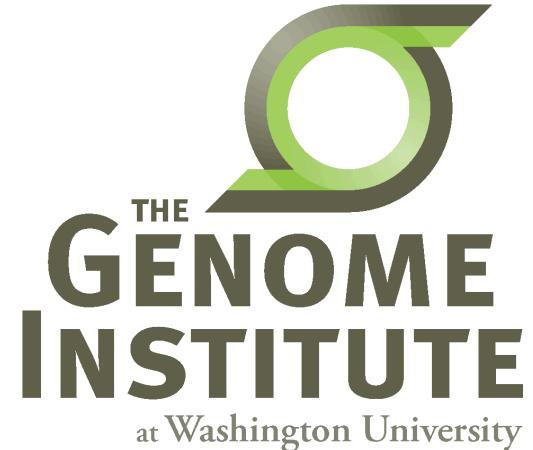


Cold
Spring
Harbor
Laboratory

Introduction to cloud computing

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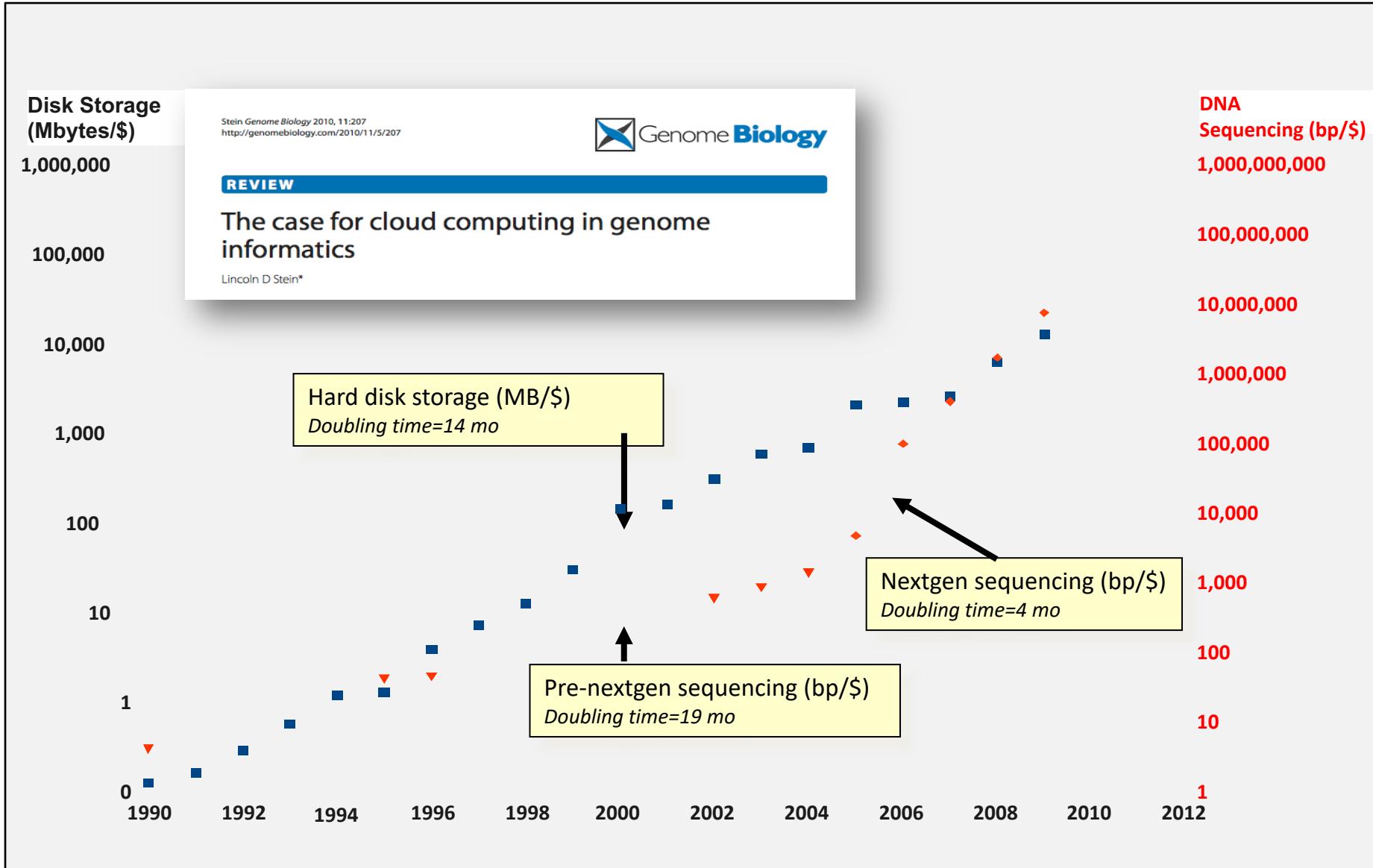
Advanced Sequencing Technologies & Bioinformatics Analysis November 16-20, 2020



Learning Objectives

- Introduction to cloud computing concepts
- Introduction to cloud computing providers
- Use the Amazon EC2 console to create an instance for each student
 - Will be used for many hands-on tutorials throughout the course
- How to log into your cloud instance

Disk Capacity vs Sequencing Capacity, 1990-2012



About DNA and computers

- We hit the \$1000 genome* in ~2016
 - Need to think about the \$100 genome
- The doubling time of sequencing has been ~5-6 months.
- The doubling time of storage and network bandwidth is ~12 months.
- The doubling time of CPU speed is ~18 months.
- The cost of sequencing a base pair will eventually equal the cost of storing a base pair

What is the general biomedical scientist to do?

- Lots of data
- Poor IT infrastructure in many labs
- Where do they go?
- Write more grants?
- Get bigger hardware?

Cloud computing providers

- Amazon AWS
 - <https://aws.amazon.com/>
- Google cloud
 - <https://cloud.google.com/>
- Digital ocean
 - <https://www.digitalocean.com/>
- Microsoft Azure
 - <https://azure.microsoft.com/en-us/>
- More...

Amazon Web Services (AWS)

- Infinite storage (scalable): S3 (simple storage service)
- Compute per hour: EC2 (elastic cloud computing)
- Ready when you are High Performance Computing
- Multiple football fields of HPC throughout the world
- HPC are expanded at one container at a time:



Some of the challenges of cloud computing:

- Not cheap!
- Getting files to and from there
- Not the best solution for everybody
- Standardization
- PHI: personal health information & security concerns
- In the USA: HIPAA act, PSQIA act, HITECH act, Patriot act, CLIA and CAP programs, etc.
 - <http://www.biostars.org/p/70204/>

Some of the advantages of cloud computing:

- We received a grant from Amazon, so supported by ‘AWS in Education grant award’.
- There are better ways of transferring large files, and now AWS makes it free to upload files.
- A number of datasets exist on AWS (e.g. 1000 genome data).
- Many useful bioinformatics AMI’s (Amazon Machine Images) exist on AWS: e.g. cloudbiolinux & CloudMan (Galaxy) – now one for this course!
- Many flavors of cloud available, not just AWS

Key AWS concepts and terminology

- **AWS** - Amazon Web Services. A collection of cloud computing services provided by Amazon.
- **EC2** - Elastic Compute. An AWS service that allows you to configure and rent computers to meet your compute needs on an as needed basis.
- **EBS** - Elastic Block Storage. A data storage solution that allows you to rent disk storage and associate that storage with your compute resources. EBS volumes are generally backed by SSD devices.

Key AWS concepts and terminology

- **S3** - Simple storage service. Cheaper than EBS and allows for storage of larger amounts of data with some drawbacks compared to EBS. S3 volumes store data as objects that are accessed by an API or command line interface or other application designed to work with S3. EBS volumes on the other hand can be mounted as if they were a local disk drive associated with the Instance.
- **SSD** - Solid state drive. A particular type of storage hardware that is generally faster and more expensive than traditional hard drives.

Key AWS concepts and terminology

- **HDD** - Hard disk drive. A particular type of storage hardware that is generally cheaper and larger but slower than SSD. HDD drives are traditional hard drives that access data on a spinning magnetic disk.
- **Ephemeral storage** - Also known as Instance Store storage. Data storage associated with an EC2 instance that is local to the host computer. This storage does not persist when the instance is stopped or terminated. In other words, anything you store in this way will be lost if the system is stopped or terminated. Instance store volumes may be backed by SSD or HDD devices.

What is a Region?

- An AWS Region is set of compute resources that Amazon maintains (like the Data Center image shown before)
- Each Region corresponds to a physical warehouse of compute hardware (computers, storage, networking, etc.).
- At the time of writing there are 22 regions: (US East (N.Virginia), US East (Ohio), US West (Oregon), US West (N. California), GovCloud (US-West), GovCloud (US-East), Canada (Montreal), EU (Ireland), EU (Frankfurt), EU (London), EU (Paris), EU (Milan), EU (Stockholm), Middle East (Bahrain), Asia Pacific (Singapore), Asia Pacific (Sydney), Asia Pacific (Seoul), Asia Pacific (Tokyo), Asia Pacific (Mumbai), Asia Pacific (Hong Kong), Asia Pacific (Beijing), and South America (Sao Paulo).
- When you are logged into the AWS EC2 console, you are always operating in one of these regions.

What is a Region?

- Current region shown in the upper right corner of console
- It is important to pay attention to what region you are using for several reasons.
 - When you create an EC2 instance (EBS volume, etc) in one region you won't see it in another region.
 - The cost to use many AWS resources varies by region.
 - The region may influence network performance when you are accessing the instance, especially if you need to transfer large amounts of data in or out.
 - Billing is tracked separately for each region
 - Generally you should choose a region that is close to you or your users. But cost is also a consideration.

What is difference between the 'Start', 'Stop', 'Reboot', and 'Terminate' (Instance States)?

- Start – turn on an EC2 instance that you have previously created
- Stop – turn off an EC2 instance that you have previously created
- Reboot – restart an EC2 instance
- Terminate – permanently stop and destroy an EC2 instance. Any associated EBS volumes may also be destroyed at this time depending on configuration

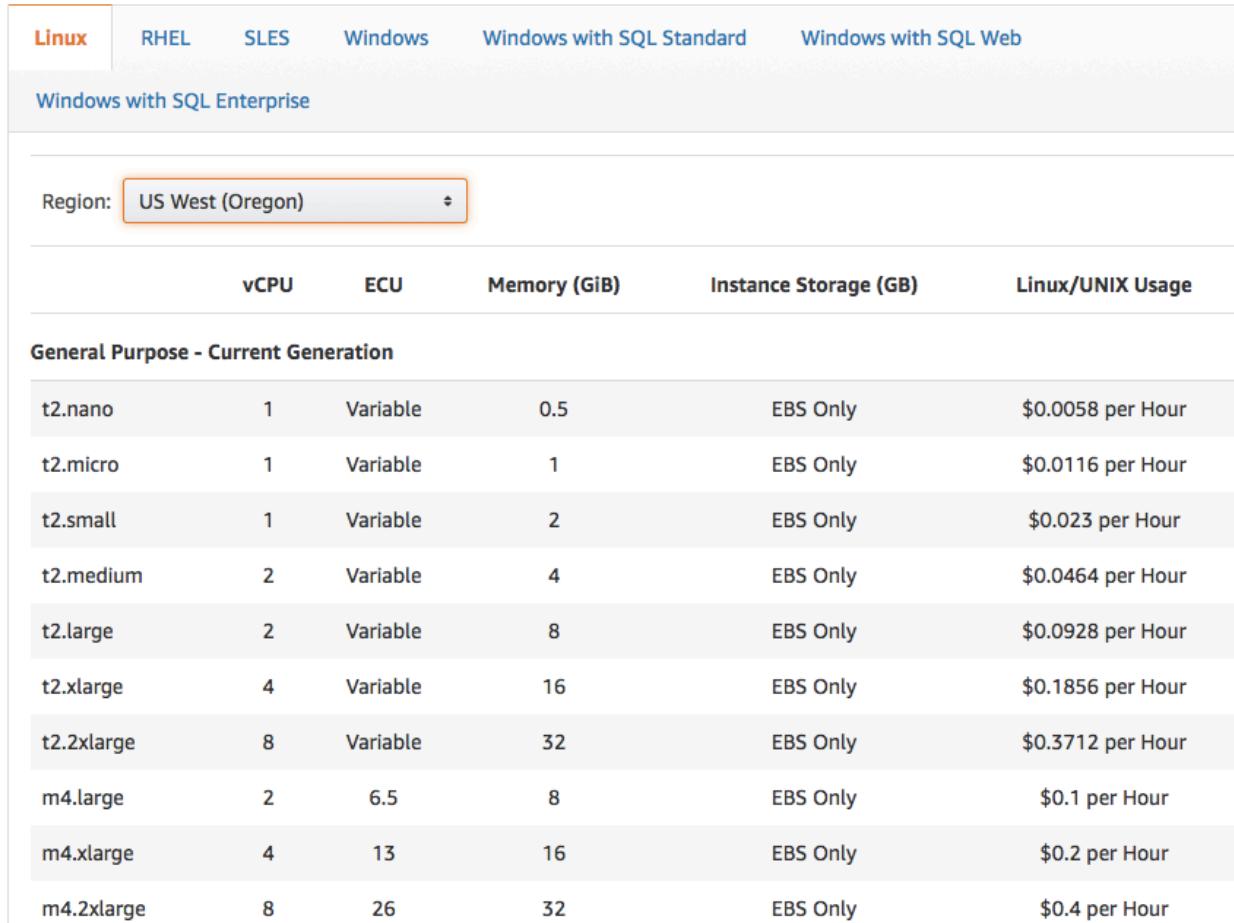
What is an AMI/snapshot?

- AMI (Amazon Machine Image) – a template that specifies how to launch EC2 instances
 - Root volume with operating system (OS), pre-installed applications, etc
 - Launch permissions determine who can use the AMI
 - Specification of (data) volumes to attach when launched
- You can create an AMI for any instance you have created/configured
- AMI can be made public for sharing (region-specific)
- Creating an AMI involves creating a snapshot of the root and any attached volumes. You will be charged to store this snapshot.

I can not log into my EC2 instance, what might have gone wrong?

- Is your instance running?
- Are you providing the correct path to your key file?
- Is it the correct key file?
- Have you set the permissions for your key file correctly?
- Did you specify a valid user for your AMI (e.g., ubuntu)?
- Did you specify the correct IP address?
- Does the Security Group for the instance allow access for your connection protocol (e.g., SSH) and location?

How much does it cost to use AWS EC2 resources?



The screenshot shows the AWS CloudWatch Metrics Insights search interface. At the top, there are tabs for Linux, RHEL, SLES, Windows, Windows with SQL Standard, and Windows with SQL Web. Below these tabs, the Windows with SQL Enterprise tab is selected. A dropdown menu labeled "Region:" shows "US West (Oregon)" with an orange border. The main area displays a table of AWS Lambda metrics. The table has columns for vCPU, ECU, Memory (GiB), Instance Storage (GB), and Linux/UNIX Usage. The rows are grouped under "General Purpose - Current Generation".

	vCPU	ECU	Memory (GiB)	Instance Storage (GB)	Linux/UNIX Usage
General Purpose - Current Generation					
t2.nano	1	Variable	0.5	EBS Only	\$0.0058 per Hour
t2.micro	1	Variable	1	EBS Only	\$0.0116 per Hour
t2.small	1	Variable	2	EBS Only	\$0.023 per Hour
t2.medium	2	Variable	4	EBS Only	\$0.0464 per Hour
t2.large	2	Variable	8	EBS Only	\$0.0928 per Hour
t2.xlarge	4	Variable	16	EBS Only	\$0.1856 per Hour
t2.2xlarge	8	Variable	32	EBS Only	\$0.3712 per Hour
m4.large	2	6.5	8	EBS Only	\$0.1 per Hour
m4.xlarge	4	13	16	EBS Only	\$0.2 per Hour
m4.2xlarge	8	26	32	EBS Only	\$0.4 per Hour

Data transfer (GB): In: free or \$0.01; Out: free, \$0.01 or \$0.02

EBS storage (GB/Month): \$0.10

S3 storage (GB/Month): \$0.023 standard, \$0.0125 infrequent access, or
\$0.004 glacier

Why am I still getting a monthly bill?

- Generally you get an accounting of usage and cost on a 30 day cycle
 - Pricing is per instance-hour (now instance-second!) consumed for each instance type.
 - Also charges for storage, transfers, etc
- Be aware of regions!
- Even when an instance is stopped, storage for root or other EBS volumes persist
- Creating AMIs/snapshots requires storage
- Explore the billing and cost management tools of AWS to track your spending, set warnings, etc

Amazon AWS documentation

https://rnabio.org/module-00-setup/0000/04/01/Intro_to_AWS/

<http://aws.amazon.com/console/>

In this workshop:

- Some tools (data) are
 - on your computer
 - on the web
 - on the cloud.
- You will become efficient at traversing these various spaces, and finding resources you need, and using what is best for you.
- There are different ways of using the cloud:
 1. Command line (like your own very powerful Unix box)
 2. With a web-browser (e.g. Galaxy): not in this workshop

Things we have set up:

- Loaded data files to a web server
- We brought up an Ubuntu (Linux) instance, and loaded a whole bunch of software for NGS analysis.
- We will clone this and create separate instances for everybody in the class.
- We've simplified the security: you basically all have the same login and file access, and opened ports. In your own world you would be more secure.

Logging into Amazon AWS

Go to course wiki, “Accessing the cloud” page

The screenshot shows a wiki page titled "Accessing The Cloud" under the "C-SEQTEC 2018: Wiki" header. The page includes a navigation bar with links for Home, View, Edit, Info, History, Watch, and Search, along with a recent changes link and a search bar. The main content area contains the following text:

Instructions for students to access their AWC EC2 cloud instance

Most hands on components of this workshop will be performed on Amazon AWS EC2 instances. Each student is assigned their own instance (instance type) running the Ubuntu operating system. Use the following instructions to log in.

Visit AWS Console to create instance:

- AWS Console Signin: <https://cshlworkshops.signin.aws.amazon.com/console>
- User Name: cshl.student
- Password: seqtec2018
- Zone: US West (Oregon)
- Course AMI: cshl-seqtech-2018v2 (ami-0ee7d04a5b96e28c6)

Download pem file (right-click and "Save Link As..."; take note of where you download it to):

- [cshl_2018_student.pem](#)

Connect to AWS instance via Terminal:

```
chmod 400 cshl_2018_student.pem
ssh -i cshl_2018_student.pem ubuntu@YOUR_IP_ADDRESS
```

Login to AWS console



Account ID or alias

cshlworkshops

IAM user name

cshl.student

Password

.....

Sign In



[Sign-in using root account credentials](#)

[Forgot password?](#)

<https://cshlworkshops.signin.aws.amazon.com/console>

Select "EC2" service

The screenshot shows the AWS Services Catalog interface. On the left, a sidebar lists services: History, EC2, Console Home, S3, Billing, IAM, and Simple Queue Service. The main area is titled "Compute" and contains icons for EC2, Lightsail, ECR, ECS, EKS, Lambda, Batch, Elastic Beanstalk, Serverless Application Repository, Storage, Satellite, Database, and Blockchain. A red arrow points to the EC2 icon. To the right, categories include Robotics, Customer Enablement, Analytics, Business Applications, Security, Identity, & Compliance, and Internet Of Things. A red arrow also points to the "Group" button at the top right of the search bar. A large red arrow points upwards from the "Group" button towards the "N. Virginia" region indicator. A text overlay on the right side reads: "Make sure you are in Virginia region".

History

EC2

Console Home

S3

Billing

IAM

Simple Queue Service

Compute

EC2

Lightsail ↗

ECR

ECS

EKS

Lambda

Batch

Elastic Beanstalk

Serverless Application Repository

Storage

S3

EFS

FSx

S3 Glacier

Storage Gateway

AWS Backup

Database

RDS

DynamoDB

Robotics

AWS RoboMaker

Customer Enablement

AWS IQ ↗

Support

Managed Services

Blockchain

Amazon Managed Blockchain

Analytics

Athena

EMR

CloudSearch

Elasticsearch

Kinesis

QuickSight ↗

Data Pipeline

AWS Glue

AWS Lake Formation

MSK

Security, Identity, & Compliance

IAM

Resource Access Manager

Cognito

Secrets Manager

GuardDuty

Inspector

Amazon Macie ↗

AWS Single Sign-On

Certificate Manager

Business Applications

Alexa for Business

Group

A-Z

N. Virginia

Make sure you are in Virginia region

Launch a new Instance

The screenshot shows the AWS EC2 Dashboard. On the left sidebar, under the 'INSTANCES' section, the 'Launch Instances' option is selected. In the main content area, there is a 'Create Instance' section with a prominent blue 'Launch Instance' button. A large red arrow points to this button. To the right of the button, there is descriptive text about launching a virtual server and a 'Migrate a Machine' section.

EC2 Dashboard

- Events
- Tags
- Reports
- Limits
- INSTANCES**
 - Instances
 - Launch Templates
 - Spot Requests
 - Savings Plans
 - Reserved Instances
 - Dedicated Hosts
 - Scheduled Instances
 - Capacity Reservations
- IMAGES**
 - AMIs
 - Bundle Tasks
- ELASTIC BLOCK STORE**
 - Volumes
 - Snapshots
 - Lifecycle Manager

Resources

You are using the following Amazon EC2 resources in the US East (N. Virginia) region:

3 Running Instances	0 Elastic IPs
0 Dedicated Hosts	4 Snapshots
5 Volumes	0 Load Balancers
3 Key Pairs	3 Security Groups
0 Placement Groups	

Learn more about the latest in AWS Compute from AWS re:Invent by viewing the [EC2 Videos](#).

Create Instance

To start using Amazon EC2 you will want to launch a virtual server, known as an Amazon EC2 instance.

Launch Instance 

Note: Your instances will launch in the US East (N. Virginia) region

Migrate a Machine

Use CloudEndure Migration to simplify, expedite, and automate large-scale migrations from physical, virtual, and cloud-based infrastructure to AWS.

[Get started with CloudEndure Migration](#)

Service Health

Service Status:

US East (N. Virginia): 

Scheduled Events

US East (N. Virginia):
No events

Account Attributes

Supported Platforms
VPC
Default VPC
vpc-ad2c8fd7

Console experiments
Settings

Additional Information

Getting Started Guide
Documentation
All EC2 Resources
Forums
Pricing
Contact Us

AWS Marketplace

Find free software trial products in the AWS Marketplace from the [EC2 Launch Wizard](#). Or try these popular software:
[CloudEndure Migration](#)

Choose an AMI – Find the CSHL SEQTEC 2019 AMI in the My AMIs

The screenshot shows the AWS Step 1: Choose an Amazon Machine Image (AMI) interface. The top navigation bar includes the AWS logo, Services dropdown, Resource Groups dropdown, a notification bell, user information (cshl.student @ cshlworkshops), location (N. Virginia), and Support dropdown.

The main content area is titled "Step 1: Choose an Amazon Machine Image (AMI)". It displays two AMI options:

- cshl-seqtech-2019 - ami-0031e653e6b611b81**
Root device type: ebs Virtualization type: hvm Owner: 577255725291 ENA Enabled: Yes
Select button (64-bit (x86))
- cshl-seqtec-2019 - ami-018b3bf40f9926ac5**
Root device type: ebs Virtualization type: hvm Owner: 577255725291 ENA Enabled: Yes
Select button (64-bit (x86))

The left sidebar contains the following filters:

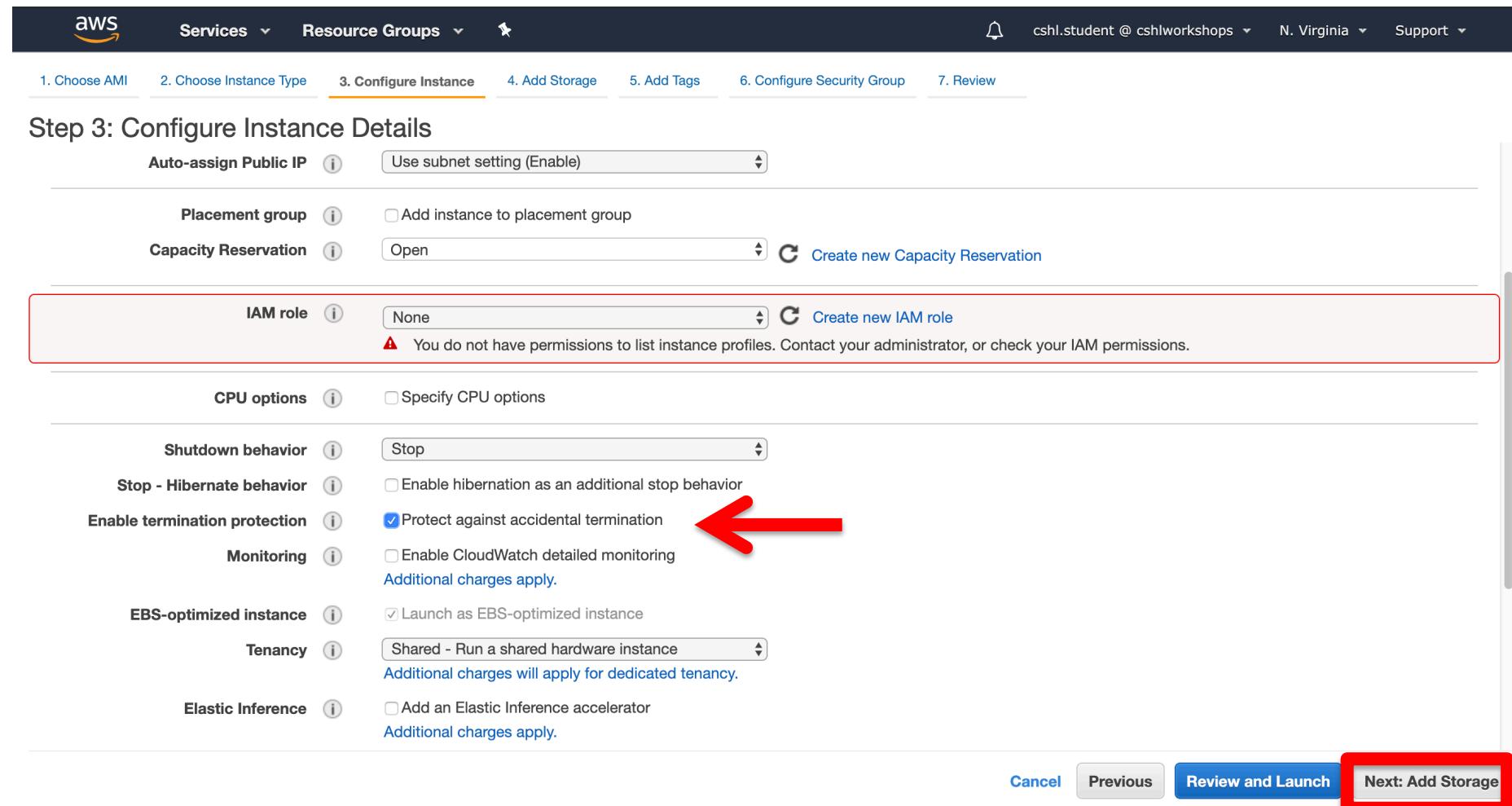
- Quick Start
- My AMIs** (highlighted with a red arrow)
- AWS Marketplace
- Community AMIs
- Ownership**
 - Owned by me
 - Shared with me
- Architecture**
 - 32-bit (x86)
 - 64-bit (x86)
 - 64-bit (Arm)
- Root device type**

Choose “m5.2xlarge” instance type, then “Next: Configure Instance Details”.

The screenshot shows the AWS CloudFormation console interface. The top navigation bar includes the AWS logo, Services dropdown, Resource Groups dropdown, a bell icon, user information (cshl.student @ cshlworkshops), region (N. Virginia), and Support dropdown. Below the navigation is a progress bar with steps: 1. Choose AMI, 2. Choose Instance Type (which is active and highlighted in orange), 3. Configure Instance, 4. Add Storage, 5. Add Tags, 6. Configure Security Group, and 7. Review. The main content area is titled "Step 2: Choose an Instance Type". It displays a table of instance types with columns: Name, Type, Cores, RAM, Storage, EBS only, Support, Up to 10 Gigabit, and Yes. The "m5.2xlarge" row is selected, indicated by a blue checkbox in the first column and a red arrow pointing to the "Support" column. At the bottom are three buttons: "Cancel", "Previous", "Review and Launch" (which is highlighted with a red box), and "Next: Configure Instance Details".

	Name	Type	Cores	RAM	Storage	EBS only	Support	Up to 10 Gigabit	Yes
<input type="checkbox"/>	General purpose	m5.large	2	8	EBS only	Yes	Up to 10 Gigabit	Yes	
<input type="checkbox"/>	General purpose	m5.xlarge	4	16	EBS only	Yes	Up to 10 Gigabit	Yes	
<input checked="" type="checkbox"/>	General purpose	m5.2xlarge	8	32	EBS only	Yes	Up to 10 Gigabit	Yes	
<input type="checkbox"/>	General purpose	m5.4xlarge	16	64	EBS only	Yes	Up to 10 Gigabit	Yes	
<input type="checkbox"/>	General purpose	m5.8xlarge	32	128	EBS only	Yes	10 Gigabit	Yes	
<input type="checkbox"/>	General purpose	m5.12xlarge	48	192	EBS only	Yes	10 Gigabit	Yes	
<input type="checkbox"/>	General purpose	m5.16xlarge	64	256	EBS only	Yes	20 Gigabit	Yes	
<input type="checkbox"/>	General purpose	m5.24xlarge	96	384	EBS only	Yes	25 Gigabit	Yes	
<input type="checkbox"/>	General purpose	m5.metal	96	384	EBS only	Yes	25 Gigabit	Yes	
<input type="checkbox"/>	General purpose	m4.large	2	8	EBS only	Yes	Moderate	Yes	
<input type="checkbox"/>	General purpose	m4.xlarge	4	16	EBS only	Yes	High	Yes	
<input type="checkbox"/>	General purpose	m4.2xlarge	8	32	EBS only	Yes	High	Yes	
<input type="checkbox"/>	General purpose	m4.4xlarge	16	64	EBS only	Yes	High	Yes	

Select "Protect against accidental termination", then "Next: Add Storage".



You should see "snap-xxxxxxx" (32GB) and "snap-xxxxxxx" (250GB) as the two storage volumes selected. Then, "Next: Tag Instance"

Step 4: Add Storage

Your instance will be launched with the following storage device settings. You can attach additional EBS volumes and instance store volumes to your instance, or edit the settings of the root volume. You can also attach additional EBS volumes after launching an instance, but not instance store volumes. [Learn more](#) about storage options in Amazon EC2.

Volume Type	Device	Snapshot	Size (GiB)	Volume Type	IOPS	Throughput (MB/s)	Delete on Termination	Encryption
Root	/dev/sda1	snap-0a7ab6edecdfe0af	32	General Purpose SSD (gp2)	100 / 3000	N/A	<input checked="" type="checkbox"/>	Not Encrypted
EBS	/dev/sdb	snap-03d6703e94734	250	General Purpose SSD (gp2)	750 / 3000	N/A	<input checked="" type="checkbox"/>	Not Encrypted

Add New Volume

Free tier eligible customers can get up to 30 GB of EBS General Purpose (SSD) or Magnetic storage. [Learn more](#) about free usage tier eligibility and usage restrictions.

Cancel Previous Review and Launch **Next: Add Tags**

Create a tag like “Name=KelsyCotto” [use your own name]. Then hit “Next: Configure Security Group”.

The screenshot shows the AWS EC2 instance creation wizard at Step 5: Add Tags. The navigation bar includes links for Choose AMI, Choose Instance Type, Configure Instance, Add Storage, Add Tags (which is highlighted), Configure Security Group, and Review. The main area is titled "Step 5: Add Tags" with instructions about tags. It shows a table with one row: Key "Name" and Value "KelsyCotto". Buttons for "Add another tag" and "Instances" and "Volumes" are visible. A large red arrow points to the Value field. Below the screenshot, bold text reads "Important: Don't forget to name your instance! (FirstnameLastname)". At the bottom, buttons include Cancel, Previous, Review and Launch (highlighted with a red box), and Next: Configure Security Group.

Key (128 characters maximum) Value (256 characters maximum) Instances | Volumes

Name: KelsyCotto

Add another tag (Up to 50 tags maximum)

Important: Don't forget to name your instance!
(FirstnameLastname)

Cancel Previous Review and Launch **Next: Configure Security Group**

Select an Existing Security Group, choose "SSH_HTTP". Then hit "Review and Launch".

The screenshot shows the AWS EC2 instance creation wizard at Step 6: Configure Security Group. The user has selected the 'Select an existing security group' option and chosen the 'SSH and HTTP' security group. The 'Review and Launch' button is highlighted with a red box.

Step 6: Configure Security Group

A security group is a set of firewall rules that control the traffic for your instance. On this page, you can add rules to allow specific traffic to reach your instance. For example, if you want to set up a web server and allow Internet traffic to reach your instance, add rules that allow unrestricted access to the HTTP and HTTPS ports. You can create a new security group or select from an existing one below. [Learn more](#) about Amazon EC2 security groups.

Assign a security group:

- Create a new security group
- Select an existing security group

Security Group ID	Name	Description	Actions
<input type="checkbox"/> sg-384f5b79	default	default VPC security group	Copy to new
<input type="checkbox"/> sg-06a8108faf3523284	launch-wizard-1	launch-wizard-1 created 2019-10-23T14:17:30.512-05:00	Copy to new
<input type="checkbox"/> sg-048f9a165ed38304a	launch-wizard-2	launch-wizard-2 created 2019-10-24T11:23:58.265-05:00	Copy to new
<input checked="" type="checkbox"/> sg-0087dc3a8b6e37a2d	SSH and HTTP	created 2019-11-08T09:43:29.293-05:00	Copy to new

Inbound rules for sg-0087dc3a8b6e37a2d (Selected security groups: sg-0087dc3a8b6e37a2d)

Type	Protocol	Port Range	Source	Description
HTTP	TCP	80	0.0.0.0/0	
HTTP	TCP	80	::/0	
SSH	TCP	22	0.0.0.0/0	

[Cancel](#) [Previous](#) [Review and Launch](#)

Review the details of your instance, note the warnings, then hit Launch

The screenshot shows the AWS Step 7: Review Instance Launch page. At the top, there's a navigation bar with the AWS logo, Services, Resource Groups, a user icon, and links for cshl.student @ cshlworkshops, N. Virginia, and Support. Below the navigation, a progress bar shows steps 1 through 7, with step 7 being the current one.

Step 7: Review Instance Launch

Please review your instance launch details. You can go back to edit changes for each section. Click **Launch** to assign a key pair to your instance and complete the launch process.

Warnings:

- ⚠ Improve your instances' security. Your security group, SSH and HTTP, is open to the world.**
Your instances may be accessible from any IP address. We recommend that you update your security group rules to allow access from known IP addresses only.
You can also open additional ports in your security group to facilitate access to the application or service you're running, e.g., HTTP (80) for web servers. [Edit security groups](#)
- ⚠ Your instance configuration is not eligible for the free usage tier**
To launch an instance that's eligible for the free usage tier, check your AMI selection, instance type, configuration options, or storage devices. Learn more about [free usage tier](#) eligibility and usage restrictions.

AMI Details:

cshl-seqtech-2019 - ami-0031e653e6b611b81 ←

Root Device Type: ebs Virtualization type: hvm

Instance Type:

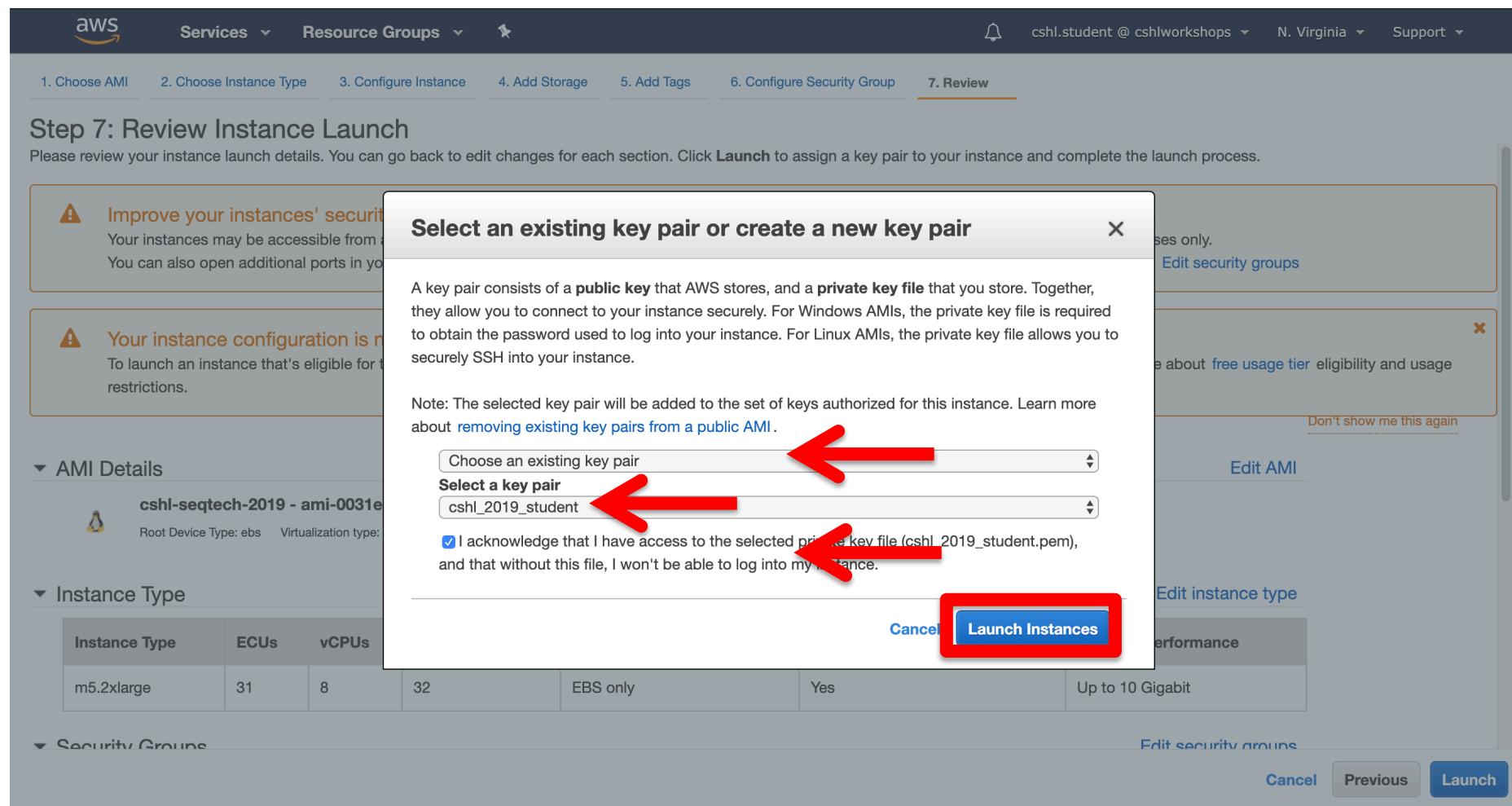
Instance Type	ECUs	vCPUs	Memory (GiB)	Instance Storage (GB)	EBS-Optimized Available	Network Performance
m5.2xlarge	31	8	32	EBS only	Yes ←	Up to 10 Gigabit

Security Groups:

[Edit security groups](#)

Cancel Previous Launch

Choose an existing key pair: "cshl_2019_student" and then Launch.



View Instances to see your new instance spinning up!

The screenshot shows the AWS Launch Status page. At the top, there's a navigation bar with the AWS logo, 'Services' dropdown, 'Resource Groups' dropdown, a star icon, a bell icon, user information 'cshl.student @ cshlworkshops', location 'N. Virginia', and 'Support' dropdown.

The main content area is titled 'Launch Status'. It contains a green box with a checkmark icon and the text 'Your instances are now launching'. Below this, it says 'The following instance launches have been initiated: i-08e73e43f17783273' and a 'View launch log' link.

Below this is a blue box with an info icon and the text 'Get notified of estimated charges'. It includes a link to 'Create billing alerts' and a descriptive text about receiving email notifications for estimated charges.

A section titled 'How to connect to your instances' follows. It explains that instances are launching and may take a few minutes to reach the 'running' state. It suggests clicking 'View Instances' to monitor status and provides a link to find out how to connect.

Under 'Helpful resources', there are two columns of links:

- How to connect to your Linux instance
- Learn about AWS Free Usage Tier
- Amazon EC2: User Guide
- Amazon EC2: Discussion Forum

At the bottom, there are links for creating status check alarms, attaching EBS volumes, managing security groups, and a large red 'View Instances' button.

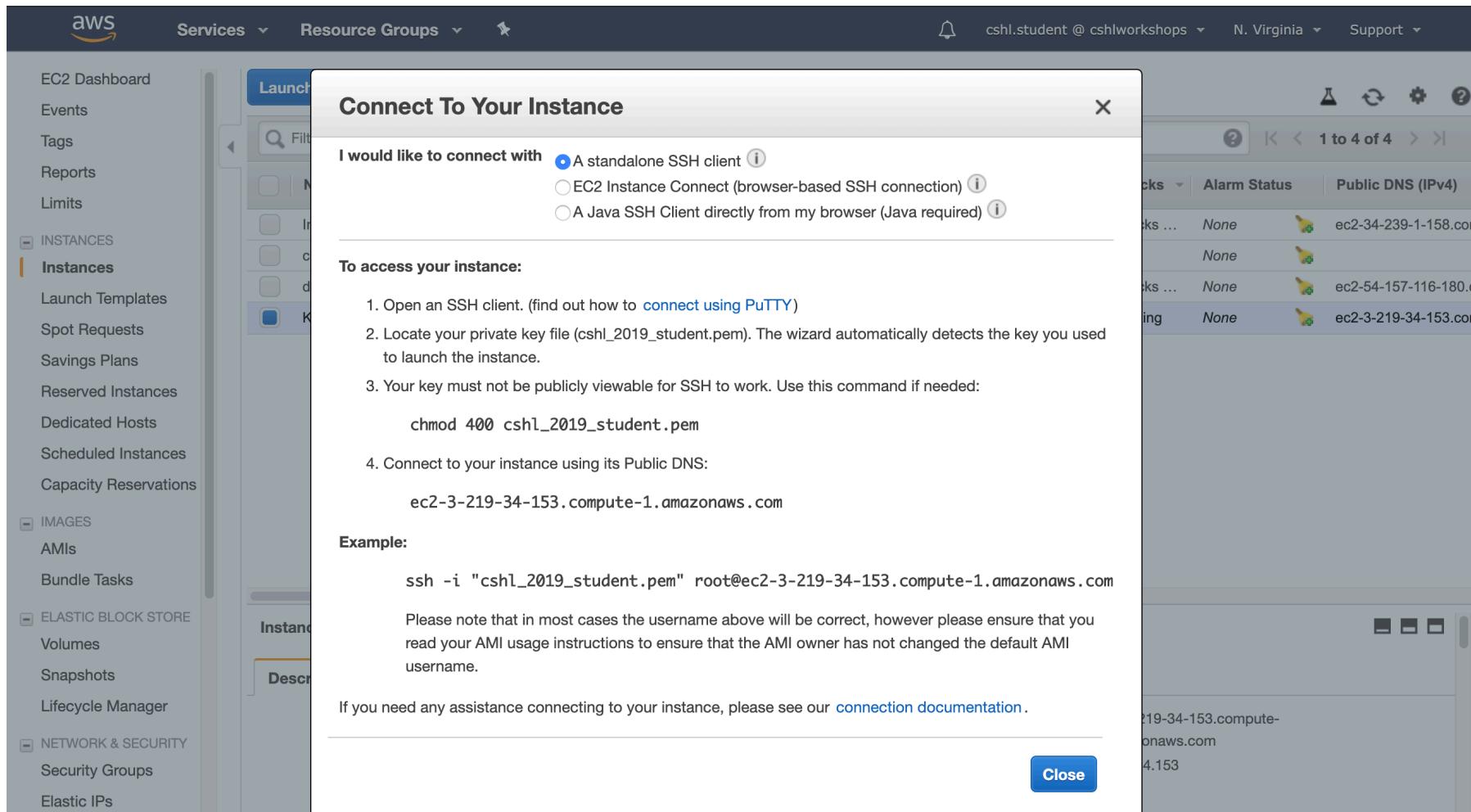
Find YOUR instance, select it, and then hit connect for instructions on how to connect (It may take some time for your instance to be ready)

The screenshot shows the AWS EC2 Instances page. The top navigation bar includes the AWS logo, Services dropdown, Resource Groups dropdown, a user icon, and account information (cshl.student @ cshlworkshops, N. Virginia, Support). The left sidebar has a tree view with 'Instances' expanded, showing 'Instances' (selected), 'Launch Templates', 'Spot Requests', 'Savings Plans', 'Reserved Instances', 'Dedicated Hosts', 'Scheduled Instances', and 'Capacity Reservations'. Below this is another tree view for 'Images' with 'AMIs' and 'Bundle Tasks'. The main content area has a 'Launch Instance' button, a 'Connect' button (which is highlighted with a red box), and an 'Actions' dropdown. A search bar at the top of the table says 'Filter by tags and attributes or search by keyword'. The table lists four instances:

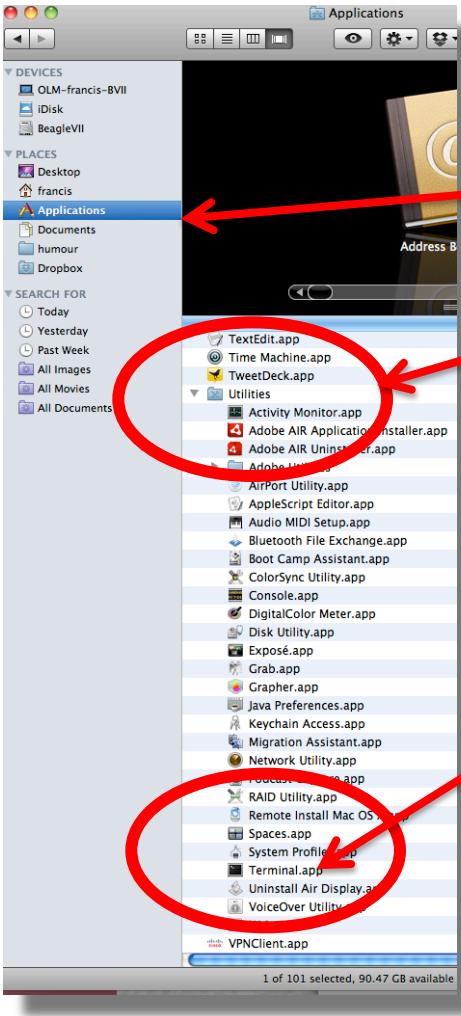
Name	Instance ID	Instance Type	Availability Zone	Instance State	Status Checks	Alarm Status	Public DNS (IPv4)
Instructor_test_insta...	i-06601eed1b1bfa657	m5.2xlarge	us-east-1c	running	2/2 checks ...	None	ec2-34-239-1-158.co...
command_line_boot...	i-00ebf20b2fb63ce3d	t2.xlarge	us-east-1b	terminated		None	ec2-34-239-1-158.co...
developer_instance	i-0088e20bb99bbbd...	m5.2xlarge	us-east-1c	running	2/2 checks ...	None	ec2-54-157-116-180.co...
KelsyCotto	i-0088e20bb99bbbd17783273	m5.2xlarge	us-east-1c	running	Initializing	None	ec2-3-219-34-153.co...

A red arrow points to the 'KelsyCotto' instance in the table, and a red box highlights the 'Connect' button in the top navigation bar.

Take note of your Public DNS/IP and the instructions on changing permissions for the key file (Note, we will login as ubuntu NOT root)



Opening a ‘terminal session’ on a Mac

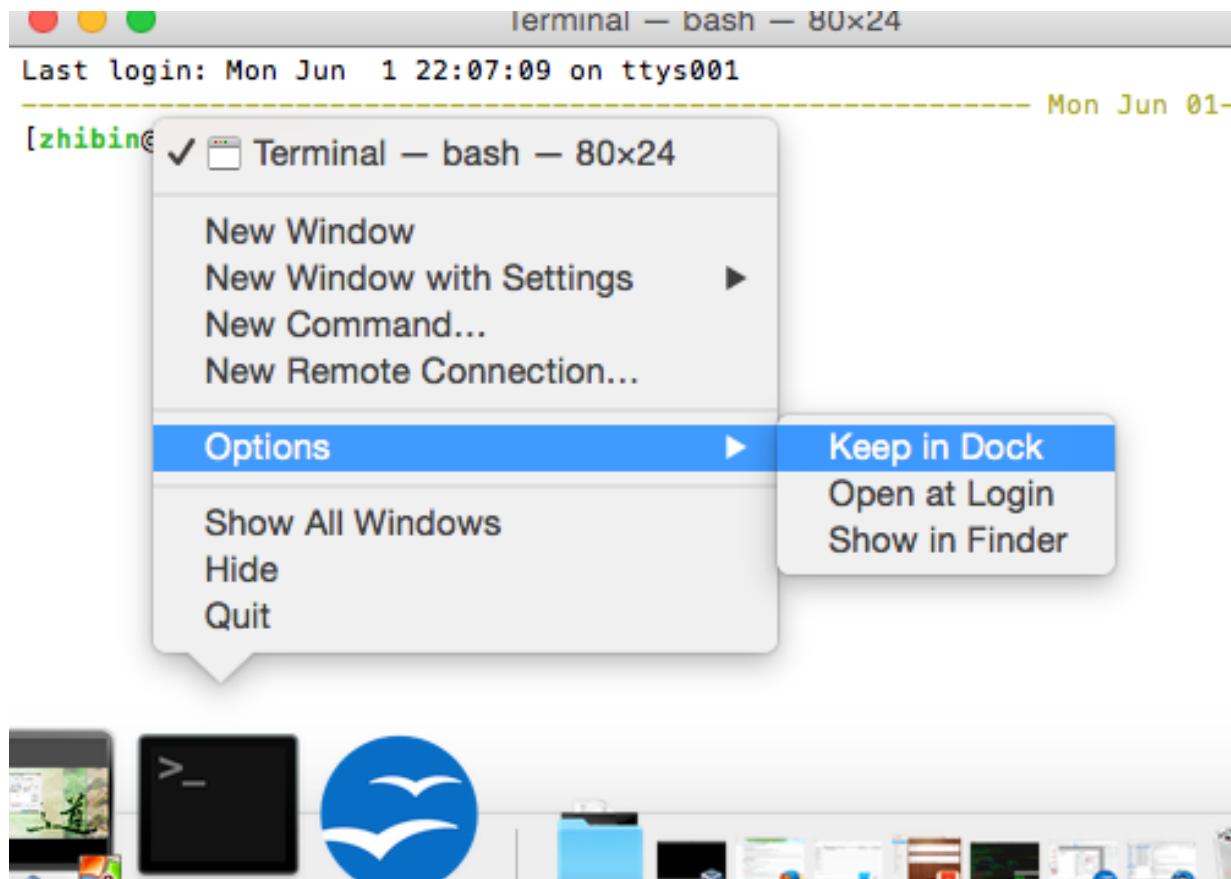


In a Finder window
‘Applications’ -> ‘Utilities’ -> ‘Terminal’



Or on your dock

Add the terminal App to your dock



Creating a working directory on your Mac called ‘cshl’

```
obis-air:~ ogriffit$ pwd
/Users/ogriffit
obis-air:~ ogriffit$ ls
Applications   Desktop      Dropbox      Movies       Public      gittemp     temp
Attachments    Documents    Google Drive  Music        bin         igv
Box Sync       Downloads    Library      Pictures    git         ncbi
obis-air:~ ogriffit$ mkdir cshl
obis-air:~ ogriffit$ cd cshl
obis-air:cshl ogriffit$ ls -la
total 0
drwxr-xr-x  2 ogriffit  staff   68 Nov 13 22:18 .
drwxr-xr-x+ 58 ogriffit  staff  1972 Nov 13 22:18 ..
obis-air:cshl ogriffit$ █
```

mkdir cshl
cd cshl

Download .pem file to cshl directory from course wiki

C-SEQTEC 2019: Wiki

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Instructions For Students To Access Their Awc Ec2 Cloud Instance

Instructions For Students To Access Their Awc Ec2 Cloud Instance last modified by Kelsy Cotto on November 8, 2019 9:42:52 AM EST

Most hands on components of this workshop will be performed on the cloud using Amazon AWS EC2 instances. Each student is assigned their own instance running the Ubuntu operating system. Use the following instructions to log in.

Visit AWS EC2 Console to create instance:

- o AWS Console Signin: <https://cshlworkshops.signin.aws.amazon.com/console>
- o User Name: cshl.student
- o Password: seqtec2019
- o Services -> Compute -> EC2
- o Zone: US East (us-east-1) (N. Virginia)
- o Course AMI: cshl-seqtec-2019 (ami-018b3bf40f9926ac5)
- o Instance Type: m5.2xlarge

Download pem file (right-click and "Save Link As..."; take note of where you download it to):

- o [cshl_2019_student.pem](#) 

Connect to AWS instance via Terminal:

```
chmod 400 cshl_2019_student.pem
ssh -i cshl_2019_student.pem ubuntu@YOUR_IP_ADDRESS
```

Viewing the ‘key’ file once downloaded

`cat cshl_2019_student.pem`

```
Kelsys-MacBook-Pro:keys kcotto$ cat cshl_2019_student.pem
-----BEGIN RSA PRIVATE KEY-----
MIIEpAIBAAKCAQEAgGtpnqERtEu/SCmeF2r1HMEsMao0fEJiAwQwk2/SNXK8izr0IH0zTVvmE1D
VUwWq7pkvhjh05pDb+2U9HiZe3sxLv3S1NrkATYF/NsrpwB+q1vwqzGW9sQ6uj45RWrPkiZlsaj
TQZmyFRu+t1JTRU3hQDqA0MRWTx1Wxv0gFzuZy/qb+DALuFQsInrEKnijrwdLmd6usaBTvhc0gFS
B9oEelH0bZHJTZFW/wP+Z0uZq0Ujir7Qw0LTM45QH/L0dBdUl3k/mBeez00yvnKMwj8E4Xi0rQ0t
hHtQ7F9iSILK80W1rRH0qwxwt9ycEH1JtNMQmUTif0vE2XJ6l06chQIDAQABAoIBABG7P/FHu/Qp
WFgg+89myuqR6GvA2X55CFSzFyG0aQyrj5jDleFtdu2uXiISG8gUBZYvlzxx82aOC0P5j04SBq0
xD/qRlukY/jyXyPn77w/ExmaNoLJjl1W9RUSH0JYLIzVpFPGes3u5zGSGDTSDNh3sSdWhq1FX3l
7vY5b6UAQgahXf0dpGFxt6P6qb/BKFQFsThXk7GXMyS/kr4w7ZlhPWHRMSu2UBdS/a/beAVN76qU
E/10HR30oAuqghusZabpbX7MJl00VcviaQgeF8Z+xf2uugDEAKut1PxW0+yvGM4SpZZ0skFZz6YI
pBnX4ELWPhCeMzq4M18QY6ptR2UCgYEAc6YfNlymg24NJu8PANx8navTi50WYuXWXrj0mrLr3SR
/XY+w26cgipM+K5eQfxSr4Yb8BQKjRktMzBzf5nKdaX4pzYIquQH02B0HDhTooHAhkbTMTmKukv4
oEW06wcEE6RQi fw4xbMEnfQfHJB121am+jwI8Xb7idwMG4pU/nsCgYEAtD0x4bNC1X3A5by50uY0
WXrtgQszCXycbkrpbjRET12f9hgz9MRMHY/xH/XGvMutZSFV2rCZRwd7lm+QWGadk/MQS0kouzW6
gSasyjFq+MKCkqYnS3/JTbx8yrLZmzl0LtX6pwmwg0Zy8aJjYHo9a2/EI8Tjh2d0SxeadIRVYP8C
gYAToiXww1Vdu+dj/7TDLqYCdHOVAxJX/utI9Q3yoIryuh+bWmFvEIvAmIGXyyQZRyoZwgIS4A
PNH03+bEa+69wbzlhksiK5g8GKgISVdLC4rZZXB5ehgTmWV7IgJ89y/SF4G/Ityo30K0ohALh597
NcvNEzzqrutja1IIMvTKMwKBgQCkM+QP1Tqc0TbVlfvClviXuJBLsiJLCImYeZL0nZVmIMusbhxX
b8ZQYGSyUz09nulXau1G1QDvXvf089CzWL1SomxBoHlFJQvGwa9FfYQRIVPHuqut8rs4oPGn0QzC
h7M7QCJcr00oAcrSLLkQmgz+phIw7BzFr039J4HFiRIInjQKBgQCtdEvcbtyk8Jh4WH3z0wpkc43f
U8DZhZwjRQpGWlD8CPj9RgRnE4+1PCH6s/RLQf7SiE1ZjX/0Ud0WPEvr0j5sVjy0IujohRbty0CM
oqWeSeUb1sLogRvMrTfCEpl/rz3GpoQ1SC/5s6XvjnnKK8RN8s7MseLuuJ63T/CRBpIs8A==
-----END RSA PRIVATE KEY-----Kelsys-MacBook-Pro:keys kcotto$
```

Changing file permissions of your ‘key’ file (Mac/Linux)

ls -l (long listing)

```
-rw-r--r--@ 1 kcotto staff 1696 Nov 9 09:19 cshl_2019_student.pem
```

 rwx : owner

 rwx : group

 rwx: world

 r read (4)

 w write (2)

 x execute (1)

Which ever way you add these 3 numbers, you know which integers were used (6 is always 4+2, 5 is 4+1, 4 is by itself, 0 is none of them etc ...)

So, when you have:

chmod 400 <file name>

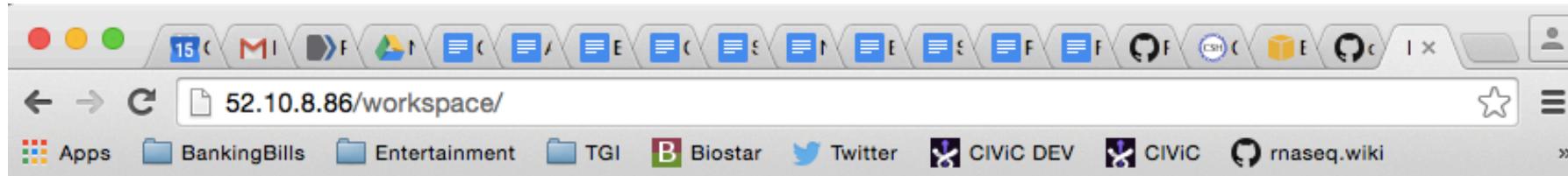
It is “r” for the the file owner **only**

Logging into your instance

Mac/Linux

```
cd ~/cshl  
chmod 400 cshl_2019_student.pem  
ssh -i cshl_2019_student.pem ubuntu@[YOUR PUBLIC IP]
```

Copying files from AWS to your computer (using a web browser)



Index of /workspace

<u>Name</u>	<u>Last modified</u>	<u>Size</u>	<u>Description</u>
Parent Directory		-	
Homo_sapiens/	2015-11-13 06:45	-	
README.txt	2014-06-17 23:53	5.3K	
bam-demo/	2015-11-14 21:03	-	
data/	2015-11-13 01:39	-	
scratch/	2015-11-13 19:43	-	
tools/	2015-11-13 01:54	-	

Apache/2.4.7 (Ubuntu) Server at 52.10.8.86 Port 80

[http://\[YOUR PUBLIC DNS OR IP\]/](http://[YOUR PUBLIC DNS OR IP]/)

Logging out of your instance

Mac/Linux – simply type exit

exit

Note, this disconnects the terminal session (ssh connection) to your cloud instance. But, your cloud instance is still running! See next slide for how to stop your instance.

When you are done for the day you can “Stop” your instance – Don’t Terminate!

The screenshot shows the AWS EC2 Dashboard with the 'Instances' tab selected. A context menu is open over the 'instructor_test2' instance, with 'Stop' highlighted. A red box contains instructions: 'Go to AWS EC2 Dashboard, select “Instances” tab, then find your instance. Right-click and chose ‘Instance State’ -> ‘Stop’'

Name	Instance ID	Instance Type	Availability Zone	Instance State	Status Checks	Alarm Status	Public DNS
instructor_test2	i-068e6cdc	m3.2xlarge	us-west-2c	running	2/2 checks ...	None	ec2-52-10-8-86.us-wes...
pengpeng	i-07f2a2d4	m3.2xlarge	us-west-2c	stopped		None	ec2-52-10-8-87.us-wes...
ALesiak	i-08f2a2d4	m3.2xlarge	us-west-2c	stopped		None	ec2-52-10-8-88.us-wes...
djcoughlin	i-09f2a2d4	m3.2xlarge	us-west-2c	stopped		None	ec2-52-10-8-89.us-wes...
jakesauders	i-0af2a2d4	m3.2xlarge	us-west-2c	stopped		None	ec2-52-10-8-90.us-wes...
YunjuSung	i-0bf2a2d4	m3.2xlarge	us-west-2c	stopped		None	ec2-52-10-8-91.us-wes...
Jonathan.Wan	i-0cf2a2d4	m3.2xlarge	us-west-2c	stopped		None	ec2-52-10-8-92.us-wes...
KateD	i-0df2a2d4	m3.2xlarge	us-west-2c	stopped		None	ec2-52-10-8-93.us-wes...
JenTudor	i-0ef2a2d4	m3.2xlarge	us-west-2c	stopped		None	ec2-52-10-8-94.us-wes...
YanZhang	i-0ff2a2d4	m3.2xlarge	us-west-2c	stopped		None	ec2-52-10-8-95.us-wes...
ArenMarshall	i-10f2a2d4	m3.2xlarge	us-west-2c	stopped		None	ec2-52-10-8-96.us-wes...

Next morning, you can “Start” your instance again

The screenshot shows the AWS EC2 Dashboard. The left sidebar has a tree view with 'Instances' selected. The main area shows a table of instances. A context menu is open over the row for 'pengpeng', with 'Start' highlighted. A red box encloses the following text:

Go to AWS EC2 Dashboard, select “Instances” tab, then find your instance. Right-click and chose ‘Instance State’ -> ‘Start’

Name	Instance ID	Instance Type	Availability Zone	Instance State	Status Checks	Alarm Status	Public DNS
instructor_test2	i-068e6cdc	m3.2xlarge	us-west-2c	running	2/2 checks ...	None	ec2-52-10-8-86.us-wes...
pengpeng	i-3246aae8	m3.2xlarge	us-west-2c	stopped		None	
ALesiak	i-068e6cbd	m3.2xlarge	us-west-2c	stopped		None	
djcoughlin	i-068e6cd7	m3.2xlarge	us-west-2c	stopped		None	
jakesaunders	i-068e6ca8	m3.2xlarge	us-west-2c	stopped		None	
YunjuSung	i-068e6cb0	m3.2xlarge	us-west-2c	stopped		None	
Jonathan.Wan	i-068e6cb2	m3.2xlarge	us-west-2c	stopped		None	
KateD	i-a241ad78	m3.2xlarge	us-west-2c	stopped		None	
JenTudor	i-0e42aed4	m3.2xlarge	us-west-2c	stopped		None	
YanZhang	i-0342aed9	m3.2xlarge	us-west-2c	stopped		None	
ArenMarshall	i-0242aed8	m3.2xlarge	us-west-2c	stopped		None	

When you restart your instance you will need to find your new Public DNS or IP address. Select your instance and “Connect” or look in Description tab. Then go back to instructions for “Logging into your instance”

The screenshot shows the AWS EC2 Dashboard. On the left, there's a sidebar with navigation links like EC2 Dashboard, Events, Tags, Reports, Limits, INSTANCES, Instances, Spot Requests, Reserved Instances, Commands, IMAGES, AMIs, Bundle Tasks, ELASTIC BLOCK STORE, Volumes, Snapshots, NETWORK & SECURITY, Security Groups, Elastic IPs, Placement Groups, Key Pairs, Network Interfaces, LOAD BALANCING, Load Balancers, and AUTO SCALING. The Instances link is currently selected. In the main content area, there's a table of instances. A red arrow points to the 'Actions' button at the top of the table. Below the table, it says 'Instance: i-068e6cdc (instructor_test2) Public DNS: ec2-52-10-8-86.us-west-2.compute.amazonaws.com'. Underneath, there are tabs for Description, Status Checks, Monitoring, and Tags. The 'Description' tab is active. It shows the Instance ID as i-068e6cdc, the Instance state as running, and the Public DNS as ec2-52-10-8-86.us-west-2.compute.amazonaws.com. A second red arrow points to the 'Public IP' field, which is currently empty.

Name	Instance ID	Instance Type	Availability Zone	Instance State	Status Checks	Alarm Status	Public DNS
instructor_test2	i-068e6cdc	m3.2xlarge	us-west-2c	running	2/2 checks ...	None	ec2-52-10-8-86.us-wes...
JasonWalker	i-3246aae8	m3.2xlarge	us-west-2c	stopped		None	
pengpeng	i-6740acbd	m3.2xlarge	us-west-2c	stopped		None	
ALesiak	i-0d42aed7	m3.2xlarge	us-west-2c	stopped		None	
djcoughlin	i-3540acef	m3.2xlarge	us-west-2c	stopped		None	
jakesaunders	i-a747ab7d	m3.2xlarge	us-west-2c	stopped		None	
YunjuSung	i-6540acbf	m3.2xlarge	us-west-2c	stopped		None	
Jonathan.Wan	i-6640acbc	m3.2xlarge	us-west-2c	stopped		None	
KateD	i-a241ad78	m3.2xlarge	us-west-2c	stopped		None	
JenTudor	i-0e42aed4	m3.2xlarge	us-west-2c	stopped		None	
YanZhang	i-0342aed9	m3.2xlarge	us-west-2c	stopped		None	
ArenMarshall	i-0242aed8	m3.2xlarge	us-west-2c	stopped		None	

So, at this point:

- Your Mac desktop is ready for the workshop
- If it is not, you know where to get the information you need
- You know how to login to AWS
- The next step is to login to your linux machine on AWS and learn the basics of a linux command line

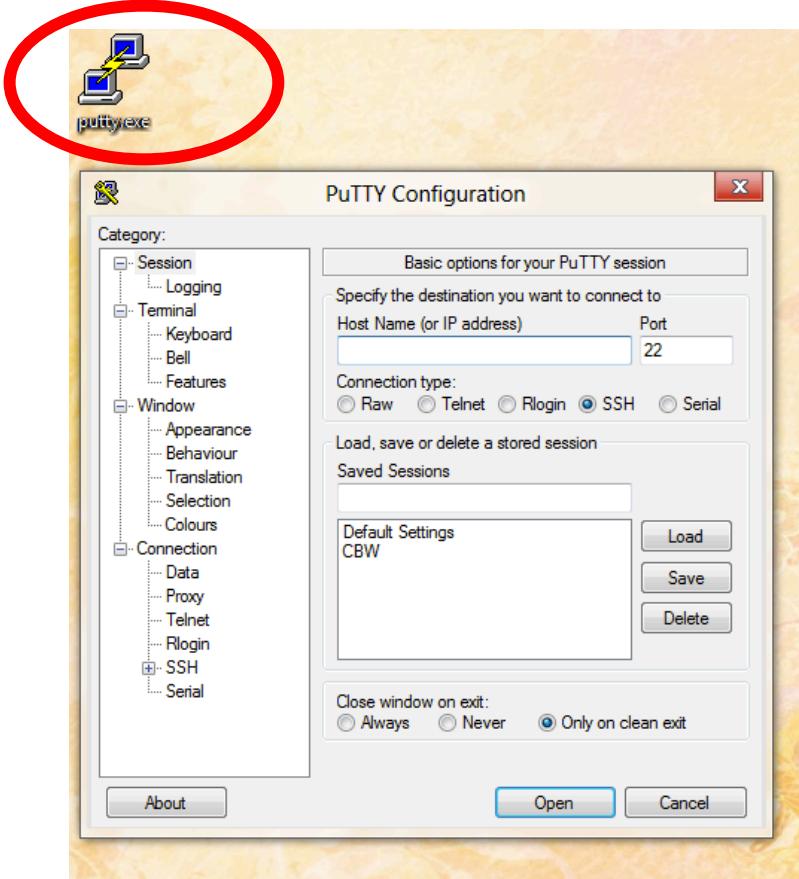
Break

Obtain the course SSH key file

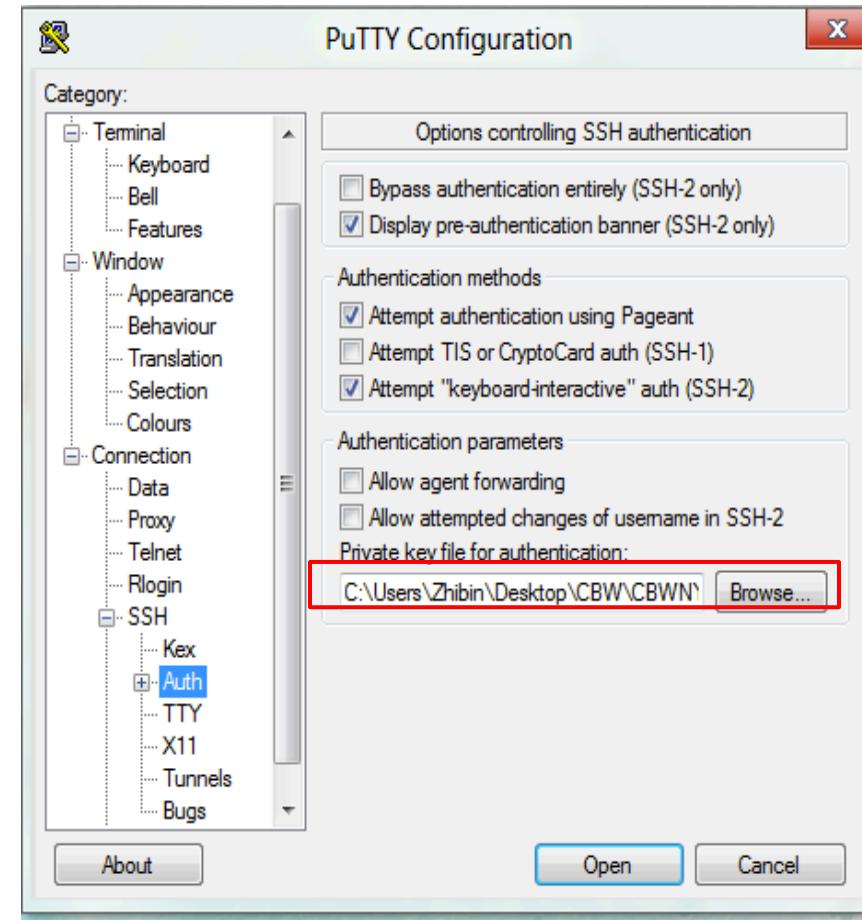
- NOTE for Mac users. You will need to use a “.pem” file
- **NOTE for Windows Users.** You will need to use a “.ppk” file instead.
 - This is created from the “.pem” file.
 - <https://aws.amazon.com/premiumsupport/knowledge-center/convert-pem-file-into-ppk/>
- The SSH key file will be used to securely login to your student instance on the cloud

Logging into your instance (Windows)

Open PuTTY

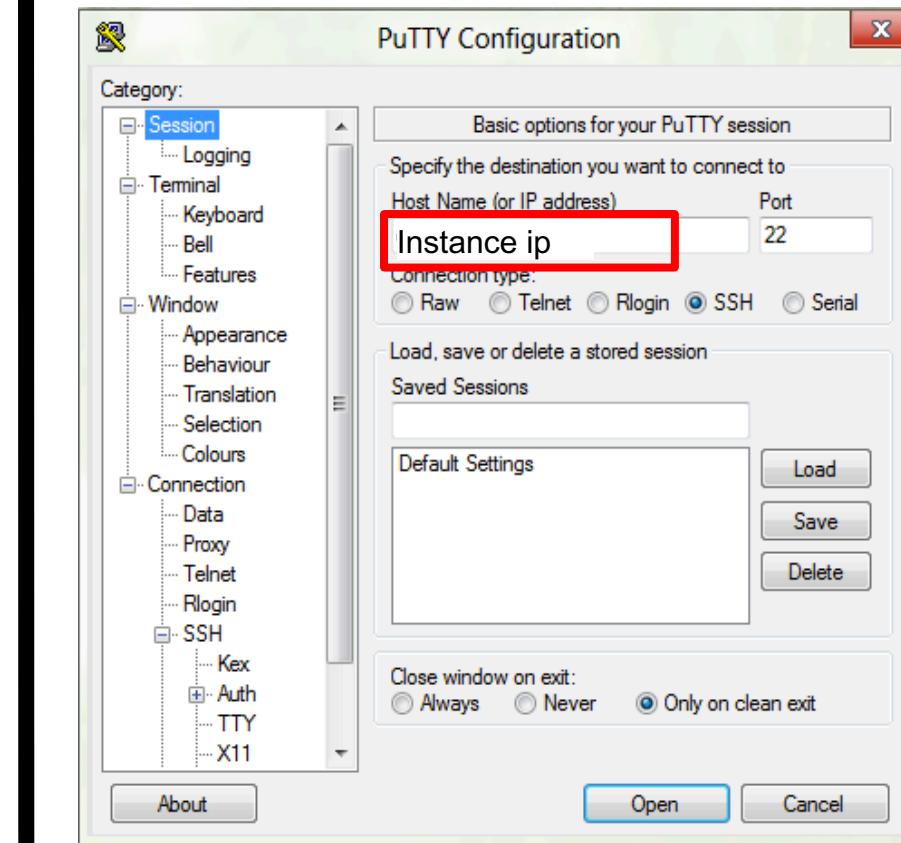
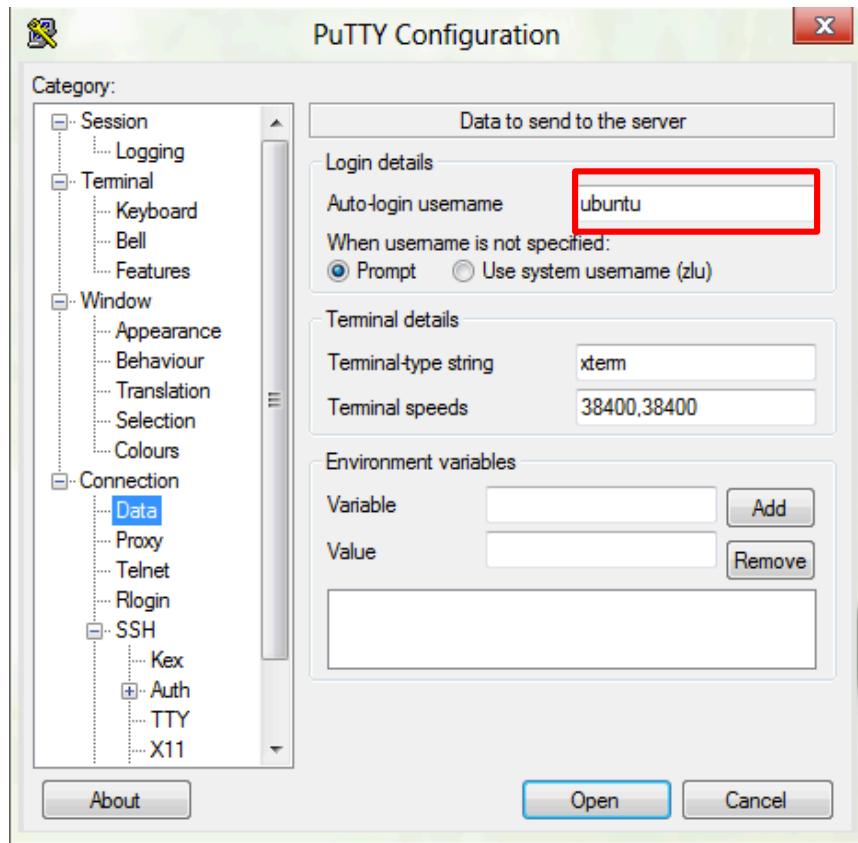


Browse to the
`cshl_2018_student.ppk` file



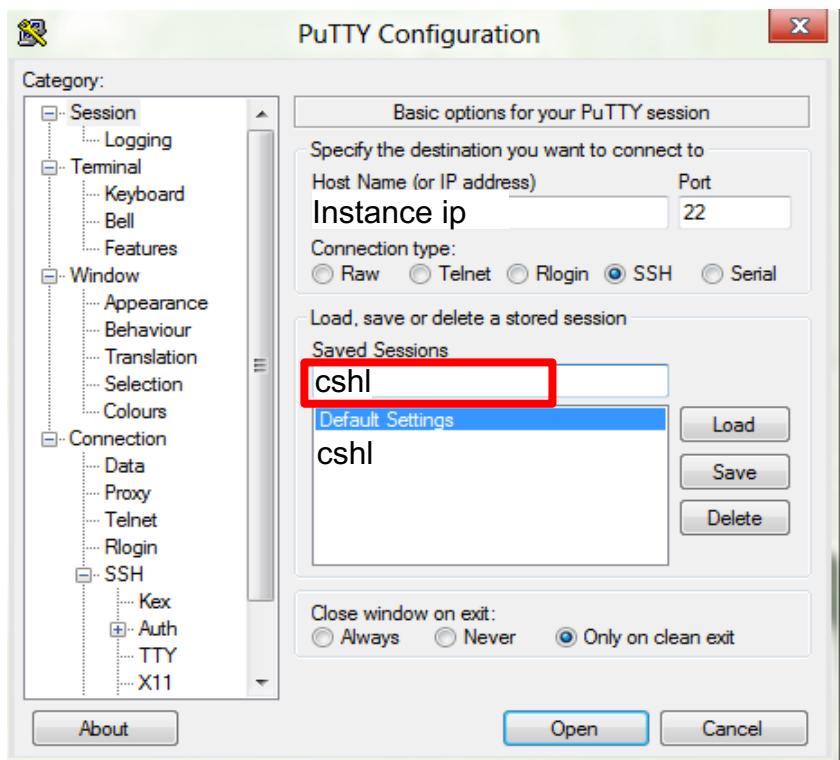
Logging into your instance (Windows)

Enter the user name 'ubuntu' Enter the host name



Logging into your instance (Windows)

Open PuTTY



Break