



Canadian Bioinformatics Workshops

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RNA-Seq Module 0

Introduction to Cloud Computing

Malachi Griffith and Obi Griffith

Modification of slides from Francis Ouellette

Informatics for RNA-seq Analysis

May 28-30, 2018



Learning objectives of the course

- **Module 0: Introduction to Cloud Computing**
- Module 1: Introduction to RNA Sequencing
- Module 2: Alignment and Visualization
- Module 3: Expression and Differential Expression
- Module 4: Alignment Free Expression Estimation
- Module 5: Isoform Discovery and Alternative Expression
- Tutorials
 - Provide a working example of an RNA-seq analysis pipeline
 - Run in a ‘reasonable’ amount of time with modest computer resources
 - Self contained, self explanatory, portable

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

Disk Storage
(Mbytes/\$)

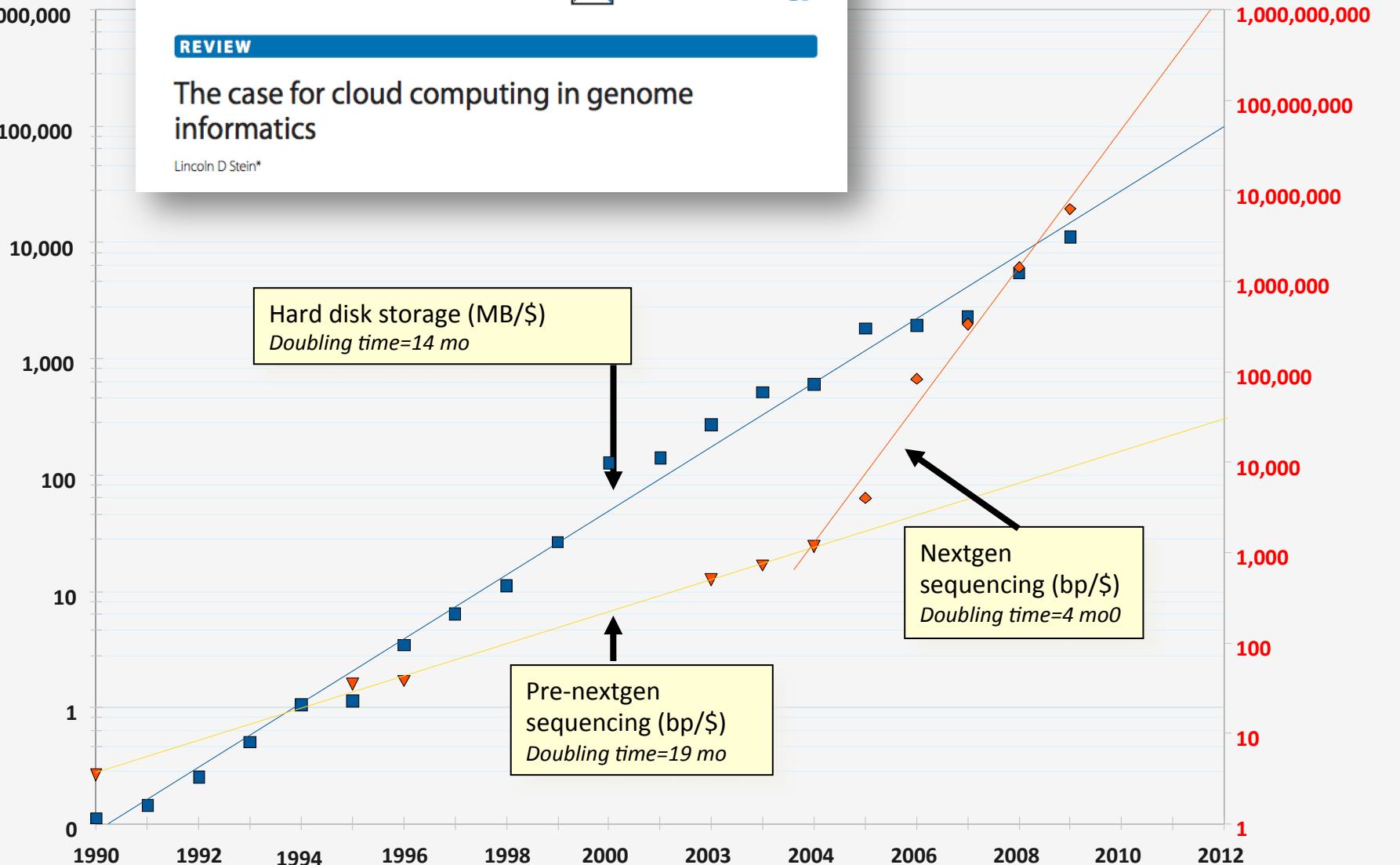
Stein *Genome Biology* 2010, 11:207
<http://genomebiology.com/2010/11/5/207>



REVIEW

The case for cloud computing in genome informatics

Lincoln D Stein*



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 14 regions: (US East (N.Virginia), US East (Ohio), US West (Oregon), US West (N. California), Canada (Central), EU (Ireland), EU (Frankfurt), EU (London), Asia Pacific (Singapore), Asia Pacific (Sydney), Asia Pacific (Seoul), Asia Pacific (Tokyo), Asia Pacific (Mumbai) 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?

| Linux | RHEL | SLES | Windows | Windows with SQL Standard | Windows with SQL Web |
|--------------------------------------|------|--------------|-----------------------|---------------------------|----------------------|
| Windows with SQL Enterprise | | | | | |
| Region: US West (Oregon) | | | | | |
| 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://github.com/griffithlab/rnaseq_tutorial/wiki/Intro-to-AWS-Cloud-Computing

<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 web-based wiki interface for the C-SEQTEC 2017 workshop. The left sidebar contains links to Home, Wiki (which is selected), Resources, Roster, Announcements, Drop Box, Polls, Forums, Chat Room, Email Archive, Meetings & Courses, CSHL RSS, Statistics, Site Info, and Help. The main content area has a header "C-SEQTEC 2017: Wiki" and a sub-header "Accessing The Cloud". It includes a search bar and navigation buttons for Home, View, Edit, Info, History, Watch, and a recent changes link. The page content starts with a section titled "Instructions for students to access their AWC EC2 cloud instance". It explains that most hands-on components will be performed on Amazon AWS EC2 instances and provides instructions for logging in via the AWS Console. It also shows terminal commands for connecting to the AWS instance via SSH.

Accessing The Cloud last modified by Obi Griffith on November 10, 2017 11:43:40 AM EST

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://workshops.signin.aws.amazon.com/console>
- User Name: cshl.student
- Password: seqtec2017

Connect to AWS instance via Terminal:

```
wget genomedata.org/seq-tec-workshop/cshl_2017.pem
chmod 400 cshl_2017.pem
ssh -i cshl_2017.pem ubuntu@YOUR_IP_ADDRESS
```

Be the first to comment

Login to AWS console



i Coming Soon: Changes to Multi-Factor Authentication (MFA)

Entry of an MFA security code for IAM users will move from this sign-in page to a subsequent page

Account: 364840684323

User Name: cshl.student

Password:
 I have an MFA Token (more info)

Sign In

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



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

Select "EC2" service

The screenshot shows the AWS Management Console homepage. At the top, there is a navigation bar with icons for AWS, Services (selected), Edit, and Support. To the right, it shows the user's name (cshl.student @ 3648-4068-4323), location (Oregon), and a Support link. Below the navigation bar, there is a section titled "Shortcuts and Recently Viewed Services" with two items: IAM and EC2. A large red arrow points to the EC2 icon. To the right of this section is a "Service Health" status bar with a green checkmark indicating all services are operating normally, updated on Nov 10 2016 at 15:34:00 GMT-0600. A second red arrow points upwards from the "Service Health" section towards the "Oregon" location indicator. Below the shortcuts, there is a "Quick Starts" section with six items: Build a web app (Start now), Launch a Virtual Machine (EC2 Instance), Back up your files (Learn more), Build a back end for your mobile app (Start now), Host a static website, and Analyze big data (Learn more). Further down is a "AWS Services" section with a search bar and a list of services categorized into Compute, Storage & Content Delivery, Database, Developer Tools, Management Tools, Security & Identity, Internet of Things, Game Development, Mobile Services, Application Services, and others.

Shortcuts and Recently Viewed Services

AWS Services

Compute

Storage & Content Delivery

Database

Developer Tools

Management Tools

Security & Identity

Internet of Things

Game Development

Mobile Services

Application Services

Service Health

All services are operating normally.
Updated Nov 10 2016 15:34:00 GMT-0600

View Dashboard

Make sure you are in Oregon region

Amazon Appstore, Google Play, or iTunes.

AWS Marketplace

Find and buy software , launch with 1-Click, and pay by the hour.

Feedback

Tell us what you think about the new console home page.

Launch a new Instance

Screenshot of the AWS EC2 Dashboard showing the 'Create Instance' section. A red arrow points to the 'Launch Instance' button.

The screenshot shows the AWS EC2 Dashboard with the following details:

- EC2 Dashboard** (selected)
- 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
- AUTO SCALING**

Resources
You are using the following Amazon EC2 resources in the US West (Oregon) region:

| | |
|---------------------|-------------------|
| 4 Running Instances | 0 Elastic IPs |
| 7 Volumes | 9 Snapshots |
| 3 Key Pairs | 0 Load Balancers |
| 0 Placement Groups | 2 Security Groups |

Easily deploy and operate applications - use Chef recipes, manage SSH users, and more. Try OpsWorks now. [Hide](#)

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 West (Oregon) region

Service Health
Service Status:

- US West (Oregon): This service is operating normally

Availability Zone Status:

- us-west-2a: Availability zone is operating normally
- us-west-2b: Availability zone is operating normally
- us-west-2c: Availability zone is operating normally

Scheduled Events
US West (Oregon):
No events

Account Attributes
Supported Platforms
VPC
Default VPC
vpc-ebcc188e

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 AMIs:
Tableau Server (10 users)
Provided by Tableau
Rating ★★★★☆
Pay by the hour for Tableau software and AWS usage
View all Business Intelligence
SAP HANA One 244GiB
Provided by SAP America, Inc
Rating ★★★★☆

Choose an AMI – Find the CSHL SEQTEC 2017 AMI in the Community AMIs

Step 1: Choose an Amazon Machine Image (AMI)

An AMI is a template that contains the software configuration (operating system, application server, and applications) required to launch your instance. You can select an AMI provided by AWS, our user community, or the AWS Marketplace; or you can select one of your own AMIs.

Quick Start

My AMIs

AWS Marketplace

Community AMIs

Operating system

- Amazon Linux
- Cent OS
- Debian
- Fedora
- Gentoo
- OpenSUSE
- Other Linux
- Red Hat
- SUSE Linux
- Ubuntu
- Windows

cshl_seqtec_2015_v2 - ami-28130249

Root device type: ebs Virtualization type: hvm

cshl_seqtec_2015_v2_noworkspace - ami-e9100188

Root device type: ebs Virtualization type: hvm

Select 64-bit

Select 64-bit

Search for: "cshl_seqtec_2017_v1" (US West - Oregon)

Choose “m4.2xlarge” instance type, then “Next: Configure Instance Details”.

Screenshot of the AWS EC2 instance creation wizard, Step 2: Choose an Instance Type. The instance type **m4.2xlarge** is selected. A red arrow points to the **m4.2xlarge** row in the table, and a red box highlights the **Next: Configure Instance Details** button.

Step 2: Choose an Instance Type

Amazon EC2 provides a wide selection of instance types optimized to fit different use cases. Instances are virtual servers that can run applications. They have varying combinations of CPU, memory, storage, and networking capacity, and give you the flexibility to choose the appropriate mix of resources for your applications. [Learn more](#) about instance types and how they can meet your computing needs.

Filter by: All instance types Current generation Show/Hide Columns

Currently selected: m4.2xlarge (26 ECUs, 8 vCPUs, 2.4 GHz, Intel Xeon E5-2676v3, 32 GiB memory, EBS only)

| | Family | Type | vCPUs | Memory (GiB) | Instance Storage (GB) | EBS-Optimized Available | Network Performance |
|-------------------------------------|-----------------|---|----------|--------------|-----------------------|-------------------------|---------------------|
| <input type="checkbox"/> | General purpose | t2.micro <small>Free tier eligible</small> | 1 | 1 | EBS only | - | Low to Moderate |
| <input type="checkbox"/> | General purpose | t2.small | 1 | 2 | EBS only | - | Low to Moderate |
| <input type="checkbox"/> | General purpose | t2.medium | 2 | 4 | EBS only | - | Low to Moderate |
| <input type="checkbox"/> | General purpose | t2.large | 2 | 8 | EBS only | - | Low to Moderate |
| <input type="checkbox"/> | General purpose | m4.large | 2 | 8 | EBS only | Yes | Moderate |
| <input type="checkbox"/> | General purpose | m4.xlarge | 4 | 16 | EBS only | Yes | High |
| <input checked="" type="checkbox"/> | General purpose | m4.2xlarge | 8 | 32 | EBS only | Yes | High |
| <input type="checkbox"/> | General purpose | m4.4xlarge | 16 | 64 | EBS only | Yes | High |

Cancel Previous Review and Launch **Next: Configure Instance Details**

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

The screenshot shows the AWS Launch Wizard interface for launching an Amazon Linux 2 AMI instance. The top navigation bar includes 'AWS', 'Services', 'Edit', and user information 'cshl.student @ 3648-4068-4323' for the Oregon region.

The current step is '3. Configure Instance'. Below it, the steps are listed: 1. Choose AMI, 2. Choose Instance Type, 3. Configure Instance (highlighted in orange), 4. Add Storage, 5. Tag Instance, 6. Configure Security Group, and 7. Review.

Step 3: Configure Instance Details

Configure the instance to suit your requirements. You can launch multiple instances from the same AMI, request Spot instances to take advantage of the lower pricing, assign an access management role to the instance, and more.

Number of instances: 1

Purchasing option: Request Spot instances

Network: vpc-ebcc188e (172.31.0.0/16) (default)

Subnet: No preference (default subnet in any Availability Zone)

Auto-assign Public IP: Use subnet setting (Enable)

IAM role: None

Shutdown behavior: Stop

Enable termination protection: Protect against accidental termination (highlighted with a red arrow)

Monitoring: Enable CloudWatch detailed monitoring
Additional charges apply.

Tenancy: Shared tenancy (multi-tenant hardware)
Additional charges will apply for dedicated tenancy.

Advanced Details

Cancel Previous Review and Launch Next: Add Storage (highlighted with a red border)

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.

| Type | Device | Snapshot | Size (GiB) | Volume Type | IOPS | Delete on Termination | Encrypted |
|------|-----------|---------------|------------|-----------------------|-------------|-------------------------------------|---------------|
| Root | /dev/sda1 | snap-6f450833 | 32 | General Purpose (SSD) | 96 / 3000 | <input checked="" type="checkbox"/> | Not Encrypted |
| EBS | /dev/sdb | snap-11e6954e | 500 | General Purpose (SSD) | 1500 / 3000 | <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: Tag Instance**

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

The screenshot shows the AWS EC2 instance creation wizard at Step 5: Tag Instance. The top navigation bar includes icons for Home, AWS, Services, Edit, and account information (cshl.student @ 3648-4068-4323, Oregon, Support). Below the navigation is a progress bar with steps 1 through 7. Step 5, "Tag Instance", is highlighted with an orange bar. The main area is titled "Step 5: Tag Instance" with the sub-instruction: "A tag consists of a case-sensitive key-value pair. For example, you could define a tag with key = Name and value = Webserver. [Learn more](#) about tagging your Amazon EC2 resources." It features two input fields: "Key" (127 characters maximum) and "Value" (255 characters maximum). The "Value" field contains the text "ObiGriffith". A red arrow points upwards from the bottom of the page towards this value. At the bottom are buttons for "Create Tag" (disabled), "Cancel", "Previous", "Review and Launch" (highlighted in blue), and "Next: Configure Security Group" (surrounded by a red box).

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

Screenshot of the AWS EC2 instance creation wizard Step 6: Configure Security Group.

The screenshot shows the configuration of an existing security group named "SSH_HTTP". A red arrow points to the "Select an existing security group" radio button, and another red arrow points to the selected security group "SSH_HTTP".

Inbound rules for sg-4e1b6128 (Selected security groups: sg-4e1b6128)

| Type | Protocol | Port Range | Source |
|------|----------|------------|-----------|
| HTTP | TCP | 80 | 0.0.0.0/0 |
| SSH | TCP | 22 | 0.0.0.0/0 |

At the bottom right, the "Review and Launch" button is highlighted with a red box.

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

The screenshot shows the AWS Step 7: Review Instance Launch interface. At the top, there's a navigation bar with tabs: 1. Choose AMI, 2. Choose Instance Type, 3. Configure Instance, 4. Add Storage, 5. Tag Instance, 6. Configure Security Group, and 7. Review. The 7. Review tab is highlighted.

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.

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](#).

[Don't show me this again](#)

Improve your instances' security. Your security group, SSH_HTTP_8081_IN_ALL_OUT, 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](#)

AMI Details

cshl_seqtec_2015_v2 - ami-28130249

Root Device Type: ebs Virtualization type: hvm

Instance Type

| Instance Type | ECUs | vCPUs | Memory (GiB) | Instance Storage (GB) | EBS-Optimized Available | Network Performance |
|---------------|------|-------|--------------|-----------------------|-------------------------|---------------------|
| m3.2xlarge | 26 | 8 | 30 | 2 x 80 | | High |

Security Groups

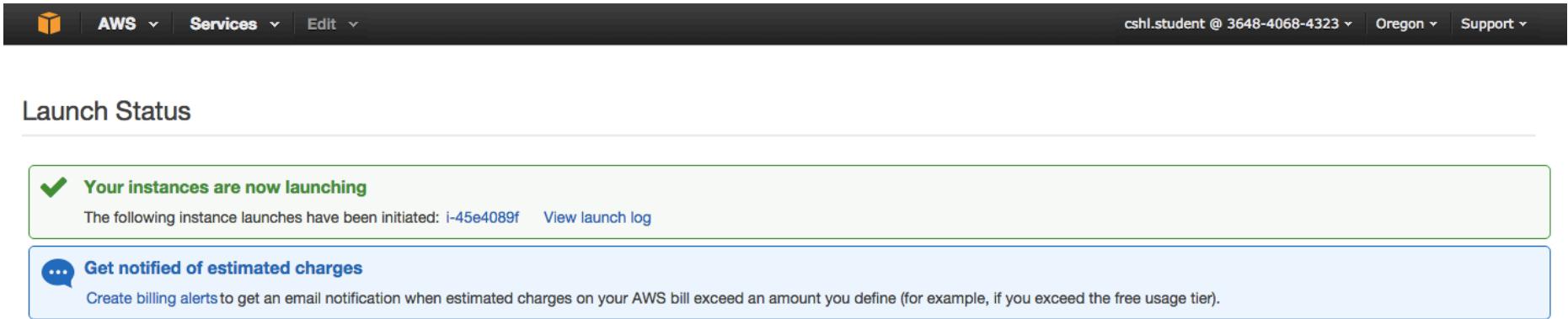
[Edit security groups](#)

Cancel Previous **Launch**

Choose an existing key pair: "cshl_2017" and then Launch.

The screenshot shows the AWS Step 7: Review Instance Launch interface. The main page displays instance launch details, including an AMI selection (cshl_seqtec_2015_v4), an instance type (t2.micro), and a security group (sg-4e1b6128). A modal dialog box titled "Select an existing key pair or create a new key pair" is overlaid on the page. The dialog contains instructions about key pairs and a note about selecting a key pair for the instance. It features a dropdown menu for selecting an existing key pair, which has "CSHL_2016" selected. A checkbox for acknowledging access to the private key file is checked. Red arrows point from the text "Choose an existing key pair" to the dropdown menu, from "Select a key pair" to the dropdown menu, and from the acknowledgement note to the checkbox. A red box highlights the "Launch Instances" button at the bottom right of the dialog. The overall background shows the AWS navigation bar and other launch steps.

View Instances to see your new instance spinning up!



The screenshot shows the AWS CloudWatch Launch Status page. At the top, there's a navigation bar with icons for CloudWatch Metrics, AWS, Services, Edit, and user information (cshl.student @ 3648-4068-4323, Oregon, Support). Below the navigation is a section titled "Launch Status". It contains a green box with a checkmark and the text "Your instances are now launching" followed by "The following instance launches have been initiated: i-45e4089f" and a link to "View launch log". There's also a blue box with a speech bubble icon and the text "Get notified of estimated charges" followed by "Create billing alerts to get an email notification when estimated charges on your AWS bill exceed an amount you define (for example, if you exceed the free usage tier)".

How to connect to your instances

Your instances are launching, and it may take a few minutes until they are in the **running** state, when they will be ready for you to use. Usage hours on your new instances will start immediately and continue to accrue until you stop or terminate your instances.

Click [View Instances](#) to monitor your instances' status. Once your instances are in the **running** state, you can **connect** to them from the Instances screen. [Find out](#) how to connect to your instances.

▼ Here are some helpful resources to get you started

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

While your instances are launching you can also

[Create status check alarms](#) to be notified when these instances fail status checks. (Additional charges may apply)

[Create and attach additional EBS volumes](#) (Additional charges may apply)

[Manage security groups](#)

[View Instances](#)

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 Dashboard. The 'Instances' section is selected, displaying a list of running instances. A red arrow points to the 'ObiGriffith' instance, which is highlighted with a blue selection bar. Above the instance list, there is a navigation bar with tabs: 'Launch Instance', 'Connect' (which is highlighted with a red box), and 'Actions'. Below the instance list, a detailed view for the selected instance (i-45e4089f) is shown. The instance details include:

| Description | Value |
|-------------------|---|
| Instance ID | i-45e4089f |
| Instance state | running |
| Instance type | m3.2xlarge |
| Private DNS | ip-172-31-4-176.us-west-2.compute.internal |
| Public DNS | ec2-52-33-240-196.us-west-2.compute.amazonaws.com |
| Public IP | 52.33.240.196 |
| Elastic IP | - |
| Availability zone | us-west-2c |

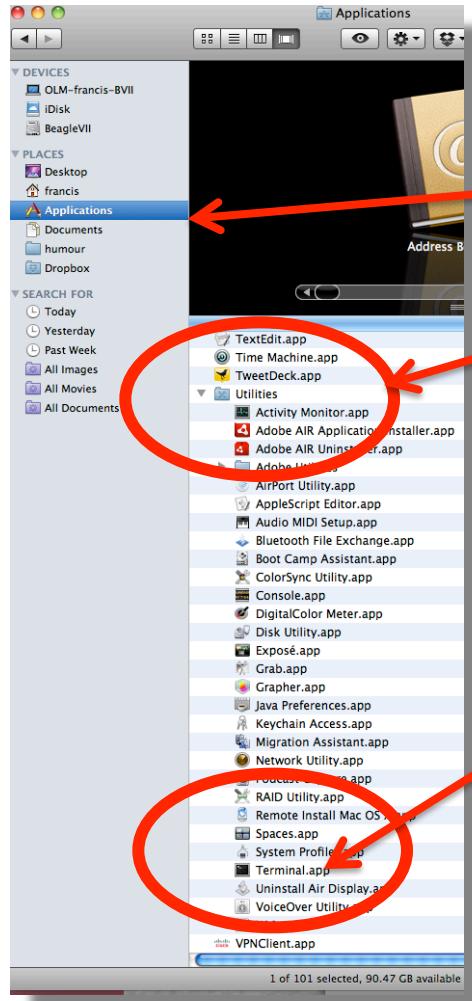
Take note of your Public DNS/IP and the instructions on changing permissions for the key file (Note, we will login as ubuntu NOT root)

The screenshot shows the AWS EC2 Dashboard with the 'Instances' section selected. A modal window titled 'Connect To Your Instance' is open. It contains instructions for connecting to the instance using a standalone SSH client or a Java SSH Client. It provides steps for opening an SSH client, locating the private key file (CSHL.pem), and connecting using the Public IP (52.33.240.196). An example command is shown: `ssh -i "CSHL.pem" root@52.33.240.196`. It also includes a note about reading AMI usage instructions and a link to connection documentation. The background shows a list of instances with their Public DNS and Public IP addresses.

Public DNS | Public IP

| Public DNS | Public IP | State |
|--------------------------|---------------|-------|
| ec2-52-33-240-196.us... | 52.33.240.196 | C |
| ec2-52-34-44-168.us-w... | 52.34.44.168 | in |
| ec2-52-10-59-49.us-w... | 52.10.59.49 | C |
| ec2-52-34-43-79.us-w... | 52.34.43.79 | C |
| ec2-52-11-219-138.us... | 52.11.219.138 | in |

Opening a ‘terminal session’ on a Mac

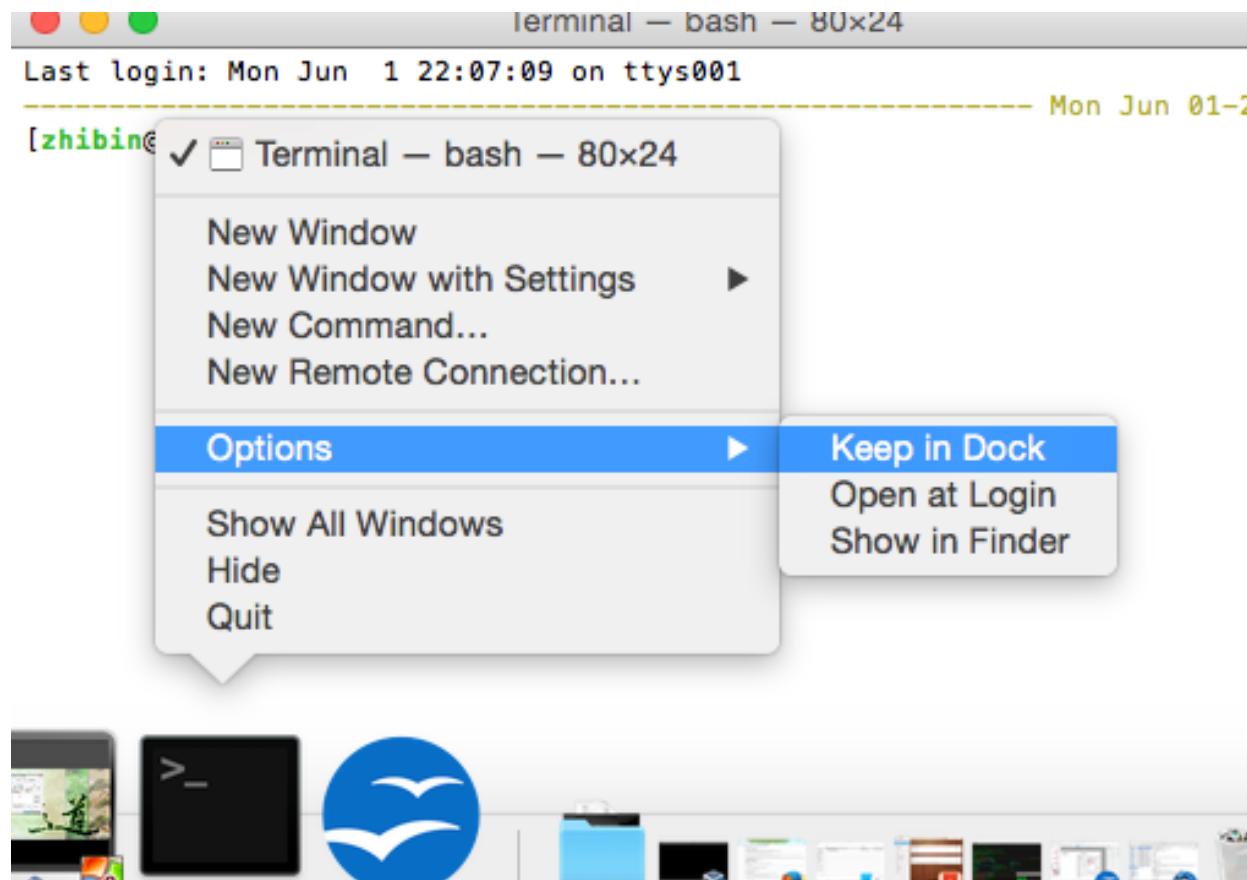


In a Finder window
‘Applications’ -> ‘Utilities’ -> ‘Terminal’



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

Use ‘wget’ at command line to download pem file

```
Obis-MacBook-Air:~ ogriffit$ cd cshl/
Obis-MacBook-Air:cshl ogriffit$ wget http://genomedata.org/seq-tec-workshop/cshl_2017.pem
--2017-11-10 11:29:03--  http://genomedata.org/seq-tec-workshop/cshl_2017.pem
Resolving genomedata.org... 34.210.251.2
Connecting to genomedata.org|34.210.251.2|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 1696 (1.7K)
Saving to: 'cshl_2017.pem'

cshl_2017.pem          100%[=====] 1.66K --.-KB/s in 0s

2017-11-10 11:29:03 (116 MB/s) - 'cshl_2017.pem' saved [1696/1696]
```

```
cd ~/cshl
wget genomedata.org/seq-tec-workshop/cshl_2017.pem
```

Viewing the ‘key’ file once downloaded

```
cat cshl_2017.pem
```

```
obis-air:cshl ogriffit$ cd ~/cshl/
obis-air:cshl ogriffit$ ls -la
total 8
drwxr-xr-x  3 ogriffit  staff   102 Nov 13 22:21 .
drwxr-xr-x+ 58 ogriffit  staff  1972 Nov 13 22:18 ..
-rw-r-----@ 1 ogriffit  staff  1696 Nov 13 22:21 CSHL.pem
obis-air:cshl ogriffit$ cat CSHL.pem
-----BEGIN RSA PRIVATE KEY-----
MIIEpgIBAAKCAQEAvJ5gwmtby9QZ2Idz+ugiEQQHW6Ps0ZAZFvr+mWDnM4pKpccaVmDh7XjcE0LF
0kJzaP9+jj0kSF0yNinitoB32DgrmVhgNhymeEqH5XMn28szxUj1EuoNXAogNuY7mWMo6MoWssSW
Rqy+rj19vMGQn5rsnMLjCM1smebPoqY0L8EPa1ccRbdGXG1dMTlCC1ho/Hk9bZweamGiZLaAWVm
z0K/L0zsgY3K4cwaL48HV6oGuMh5lTDpnobxXghQ4oC5Mej+DpCRF8C+EG2uNDuyuLzRJfQmFBV2
GKDWDwhdgGmKmX9IpMT9ubvNoQPy0vYLvM80eG3cMbZ2IzpaNryihwIDAQABoIBAQCYT0TvF04
a3DdCEEC/rN9HMaS+bjFkm0kp9RTi15XJhTPvBmptjzibA6gWJfDaXgKIQGbzxJrEkxwCR2IB03v
0LV7jEcomZ2ggRMDPeJitFoUCuDnkZZtivppSk2az0zeaD+0/ZeqPx0L+Yr+7HSbpVLVoxEV/l5a
xDuCawBMSY2cnGWkfEB1SPnB6fGZj8luGzv0aP/CETx/K78TIS56m4yrTIQIeEPfFt/PQr/EUqoL
7co5oy9K3sD1noPLDhk3vJa1VNrMjHkMZLkbZua0HPzgSQHninm80Ca25WWTGsSZ8vQsBIUTlGI1
W7lzXH3wD1jJNd+03QK4bnKaZ+DZAoGBAPVpisa49JY/6K2f9B8naqtX/ljzVWTl3Q7r6t6uh21Y
oexmC8ej2wQwd0qNjZWVxSMVksIwdM6xcsBIJRMmltWTVdmD0fkDv0fjd8CM4nctH76tvSvZz02e
qI9wSshHY1fh+09CoLZeefSURxqWbkJfREjoZ4UGUWMi3k1rxC9AoGBAMTB1BB0WQ+5ojzQYu0L
Q4YrsIPg1/ni0WmJ+05vcTCJ2aeI88VhK5c2PoXPWWiJ9CdD2VFZDiCm2XuJA5iwJmnhuwGGHHe
BFBqEF/ueJrW+r43pRcYRuRIXjih4mQQLK4Zemecym5fAHvxZxq4fs2kWfMPySfaVufcP0VC7X6T
AoGBAMhro0xbxFQwaU0yh9oRhMneGPhn8WtvVjNjc/LcMfmZEtRPGnuhF965/hJCvEhXgiH+8lXo
4NwUixBVtXnA/P0WX5Ea2ykIth2Kkx0Qlb14SEGh7RZ0saRiLqmcZ9gXFpkm6rimByrDMezVr
nU7CcwNWSB0jaOgluZoJv6k5AoGBAJJuFsmD5ZhkaS+lTtpnlZtXDIk5XsMkYQGQpS0clzqufQPI
UtPEm3Jv9lwTktDQSpmTifShUcbpaPgtoJ+JjiKvGh7QbxKK7II00kULG760SD+S0U972Rdj3Q
M1aRWHWx1h1kH0vDXFLhuAAU6poVBLR2PRPLbf4k1hmvt05xtAoGBAJVQy1GF8uVNwkOCNzLIqmky
uk9M24hfqn3N2GY3Zgqf43bD4kdYgL4rvsgp08QzotPf+19kVlCv0ciolSjEHLyUdlyPGzj4CTTH
1f1RoGHmYzVn9VuFTu4hJ17J+uwgXgIr9Sx/UTjwkmCjPf7CEyIuGxaThG/ZoR9stufZB5db
-----END RSA PRIVATE KEY-----obis-air:cshl ogriffit$
```

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

ls -l (long listing)

```
drwx-----+ 67 ogriffit staff 2278 22 May 21:25 ../  
-rw-r--r--@ 1 ogriffit staff 1696 22 May 21:31 cshl_2017.pem  
rwx : owner  
rwx : group  
rwx: world  
r read (4)  
w write (2)  
x execute (1)
```

Whichever 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>

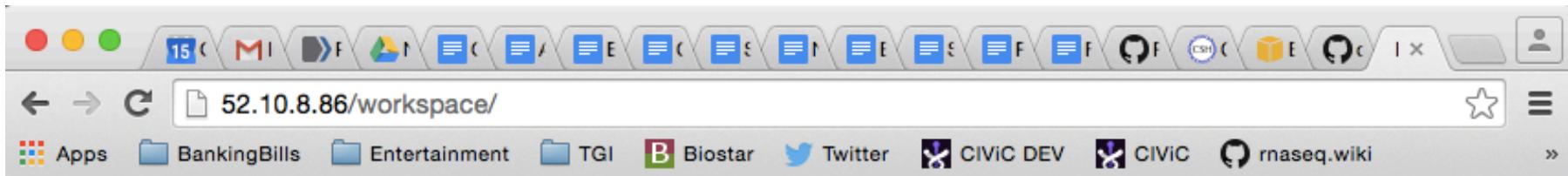
It is “r” for the the file owner **only**

Logging into your instance

Mac/Linux

```
cd ~/cshl  
chmod 400 cshl_2017.pem  
ssh -i cshl_2017.pem ubuntu@[YOUR PUBLIC IP]
```

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



Index of /workspace

| | Name | Last modified | Size | Description |
|--|----------------------------------|-------------------------------|----------------------|-----------------------------|
|  | 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]/

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. On the left, there's a sidebar with various navigation options like EC2 Dashboard, Events, Tags, Reports, Limits, Instances, Images, AMIs, and more. A red arrow points to the 'Instances' tab. In the main area, a table lists several instances. One instance, 'instructor_test2', is selected. A context menu is open over this instance, with 'Instance State' expanded. Under 'Instance State', another red arrow points to the 'Stop' option, which is highlighted. Below the table, it says 'Instance: i-068e6cdc (instructor_test2) Public DNS: ec2-52-10-8-86.us-west-2.compute.amazonaws.com'. A large red box encloses the following text:

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

Next morning, you can “Start” your instance again

The screenshot shows the AWS EC2 Dashboard. On the left, there's a sidebar with various navigation links: EC2 Dashboard, Events, Tags, Reports, Limits, INSTANCES (with 'Instances' selected), 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 (Launch). The main area is titled 'Instances' and shows a table of 23 instances. One instance, 'JasonWalker' (ID i-3246aae8), is highlighted and has a context menu open over it. The menu options are: Connect, Get Windows Password, Launch More Like This, Instance State (with 'Start' highlighted), Instance Settings, Image, Networking, CloudWatch Monitoring, and Terminate. Red arrows point from the left towards the 'Instances' link in the sidebar, and another red arrow points from the bottom towards the 'Start' option in the context menu.

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

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 Instances page. On the left, there's a sidebar with navigation links like EC2 Dashboard, Events, Tags, Reports, Limits, Instances, AMIs, and more. The main area displays a table of instances with columns for Name, Instance ID, Instance Type, Availability Zone, Instance State, Status Checks, Alarm Status, and Public DNS. A red arrow points to the 'Connect' button at the top of the table. Below the table, a specific instance is selected: 'instructor_test2' (Instance ID: i-068e6cdc). The 'Description' tab is active, showing details such as Instance ID, Instance state, Public DNS, and Public IP. A second red arrow points to the 'Public IP' field, which contains '52.10.8.86'. The status bar at the bottom indicates the Public DNS is 'ec2-52-10-8-86.us-west-2.compute.amazonaws.com'.

| 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-west-2... |
| 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-6540acb | 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 | |

Instance: i-068e6cdc (instructor_test2) Public DNS: ec2-52-10-8-86.us-west-2.compute.amazonaws.com

Description Status Checks Monitoring Tags

Instance ID: i-068e6cdc Public DNS: ec2-52-10-8-86.us-west-2.compute.amazonaws.com
Instance state: running Public IP: 52.10.8.86

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

We are on a Coffee Break &
Networking Session