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Course: Cloud Computing on AWS

By Nirmallya Mukherjee

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Introduction

Cloud fundamentals & VERY useful links

Documentation

- Bookmark these
  - https://aws.amazon.com/documentation
  - https://aws.amazon.com/faqs
  - https://aws.amazon.com/blogs/aws
  - https://aws.amazon.com/whitepapers
- Keep this information handy and if necessary download the PDF wherever available

Certification prep

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Exam overview

- https://aws.amazon.com/certification/certification-prep/
- https://aws.amazon.com/certification/our-certifications/
- https://aws.amazon.com/certification/certified-solutions-architect-associate/

Study materials

- https://aws.amazon.com/whitepapers/
- https://aws.amazon.com/architecture/
- https://aws.amazon.com/ec2/faqs/

- http://docs.aws.amazon.com/autoscaling/latest/userguide/as-instance-termination.html
- http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/ebs-creating-snapshot.html
- https://aws.amazon.com/premiumsupport/knowledge-center/snapshot-ebs-raid-array/
- https://aws.amazon.com/ec2/vm-import/
- http://docs.aws.amazon.com/AmazonVPC/latest/UserGuide/VPC_Subnets.html
- http://docs.aws.amazon.com/AmazonVPC/latest/UserGuide/vpc-endpoints.html
- http://docs.aws.amazon.com/AmazonS3/latest/dev/UsingBucket.html
- http://docs.aws.amazon.com/amazondynamodb/latest/developerguide/LSI.html
- https://aws.amazon.com/devpay/
- http://docs.aws.amazon.com/AWSSimpleQueueService/latest/SQSDeveloperGuide/sqs-visibility-timeout.html
- http://docs.aws.amazon.com/AWSCloudFormation/latest/UserGuide/template-anatomy.html
- http://docs.aws.amazon.com/AmazonCloudWatch/latest/logs/WhatIsCloudWatchLogs.html

- Interesting-> https://www.awsarchitectureblog.com/2014/04/shuffle-sharding.html
- Free datasets-> https://aws.amazon.com/public-datasets/

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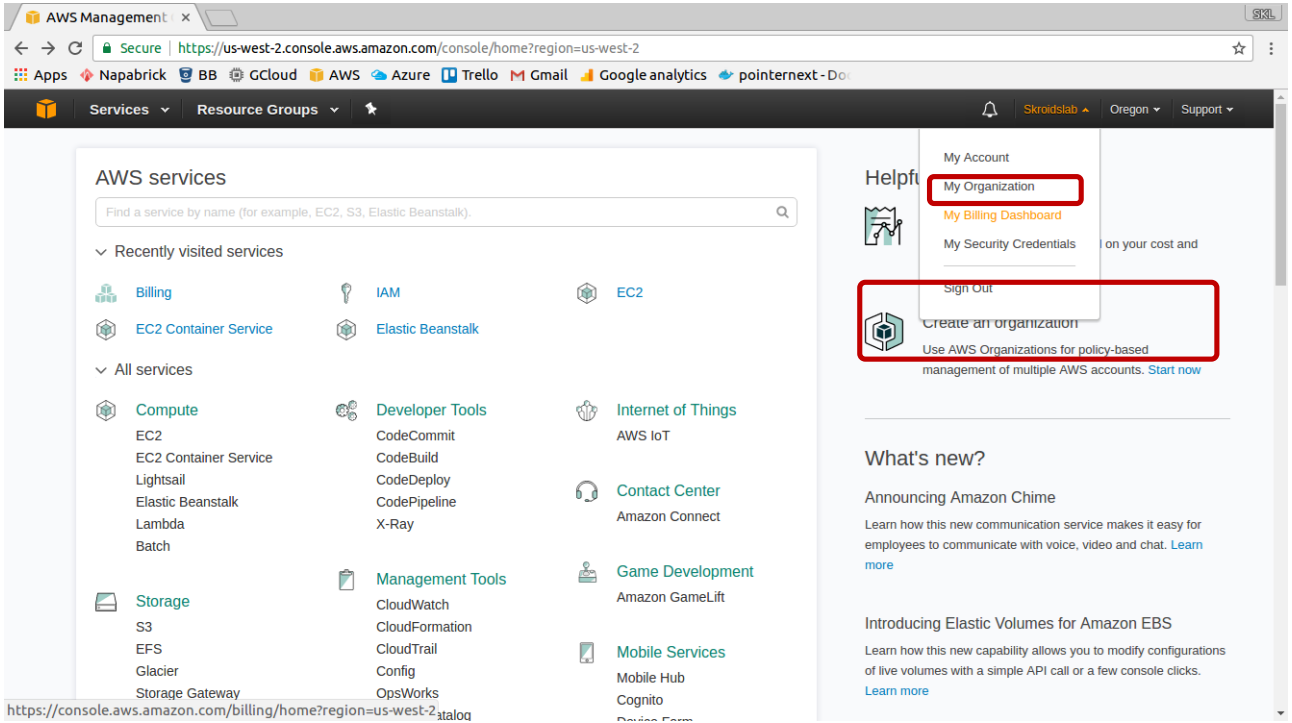
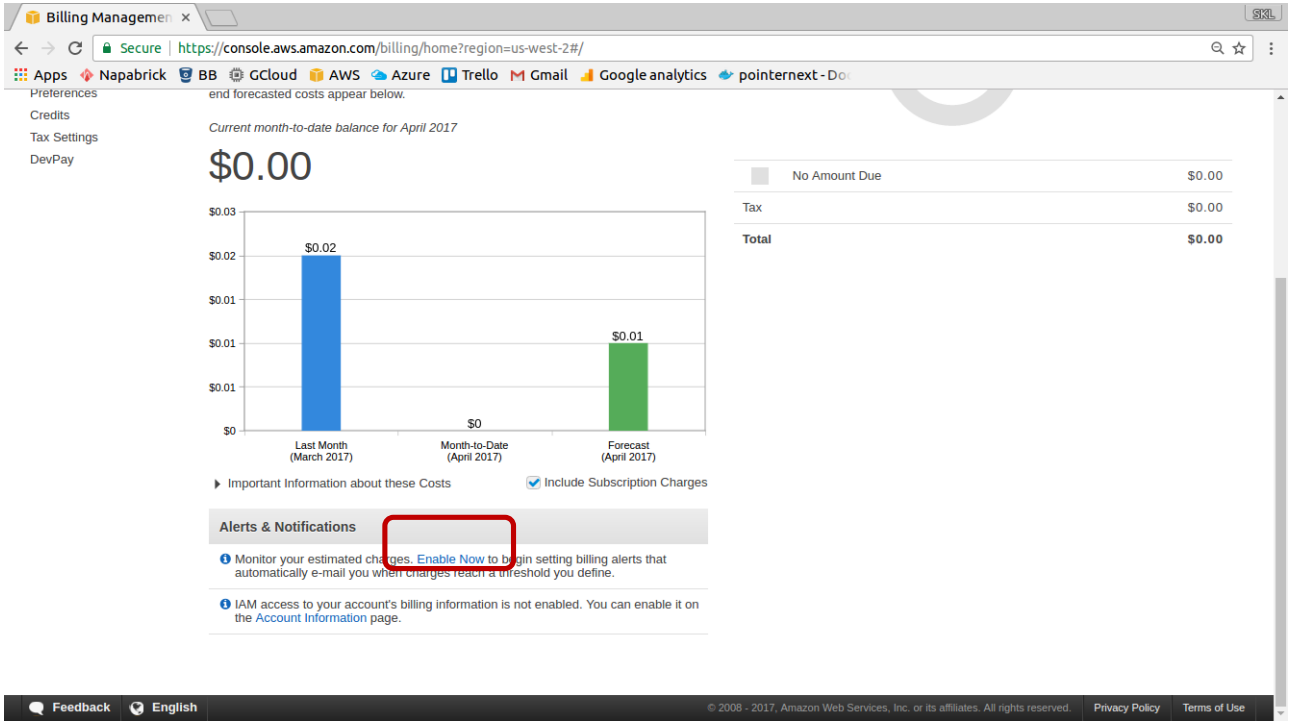
Introduction

Understanding billing and alerts

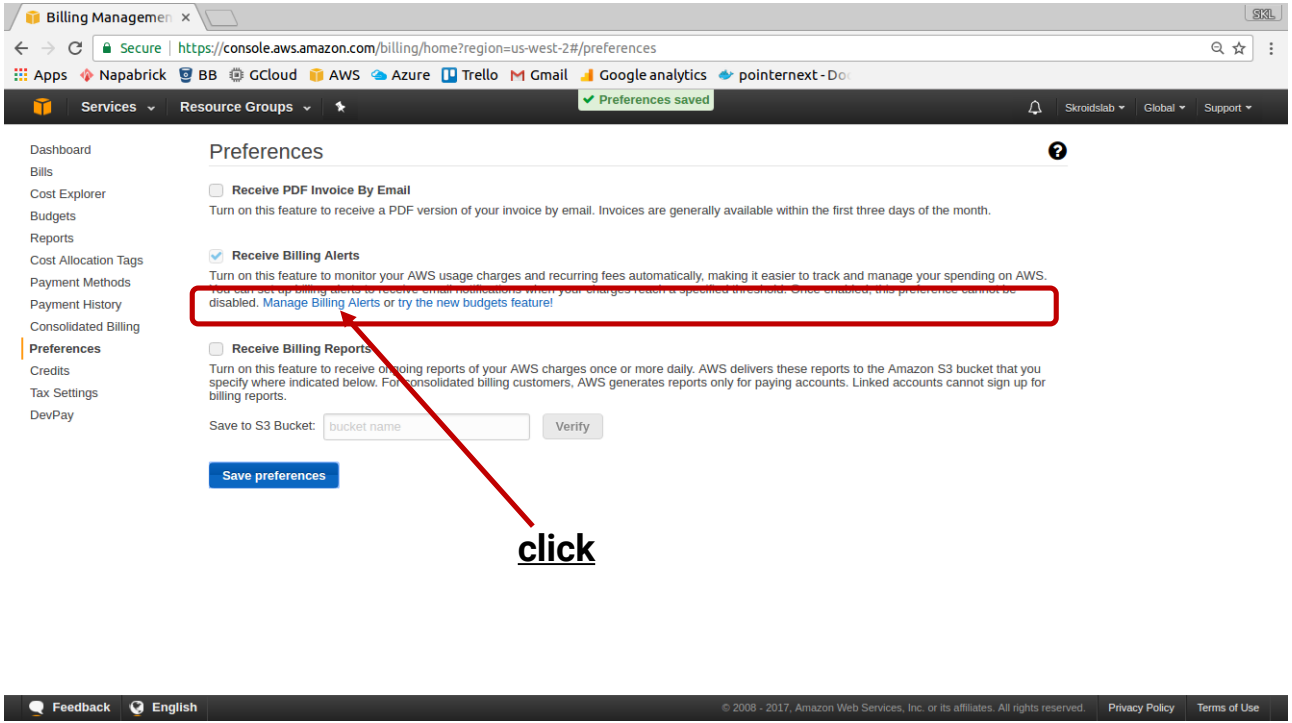
Billing - dashboard



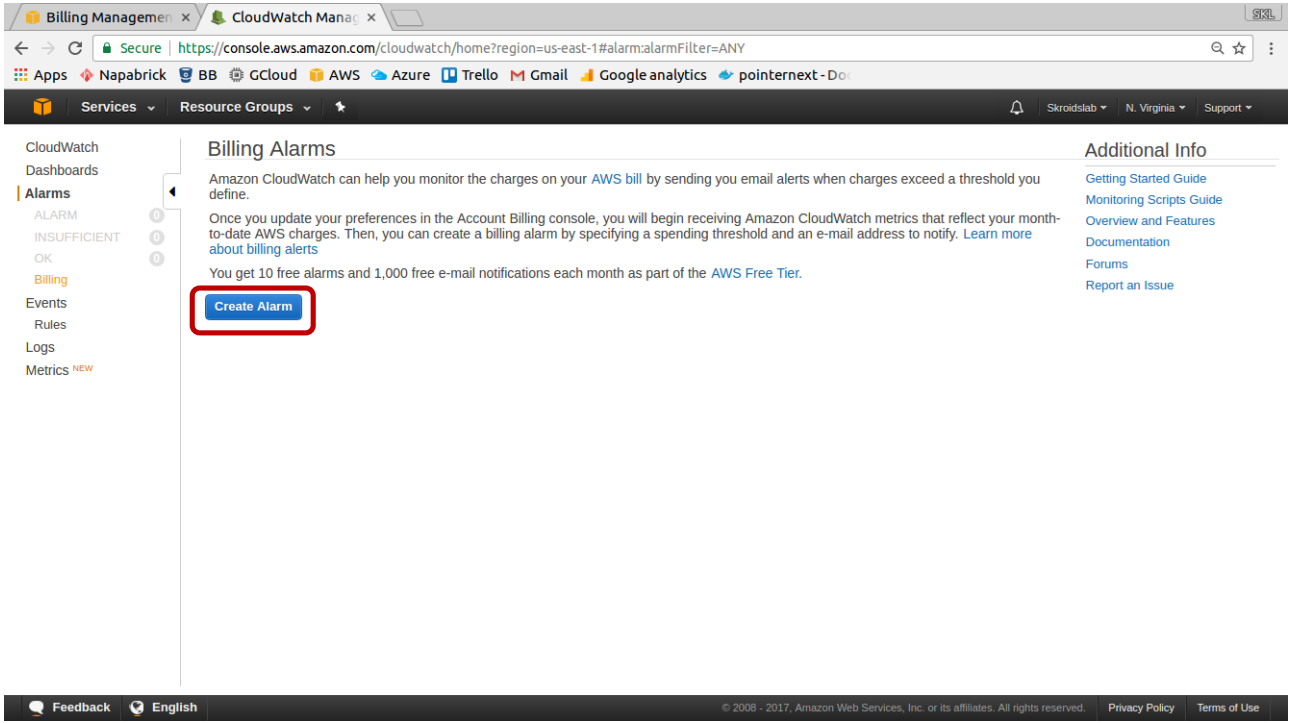
Billing - dashboard



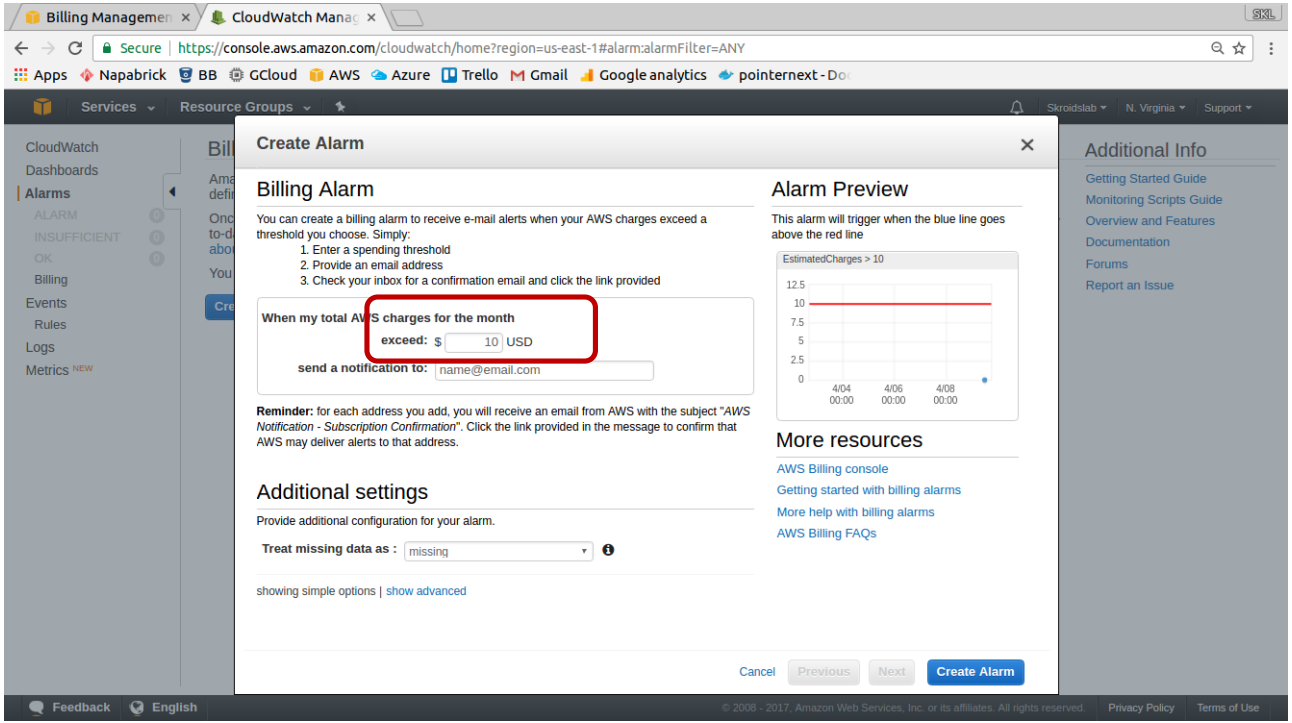
Billing - dashboard



Billing - dashboard

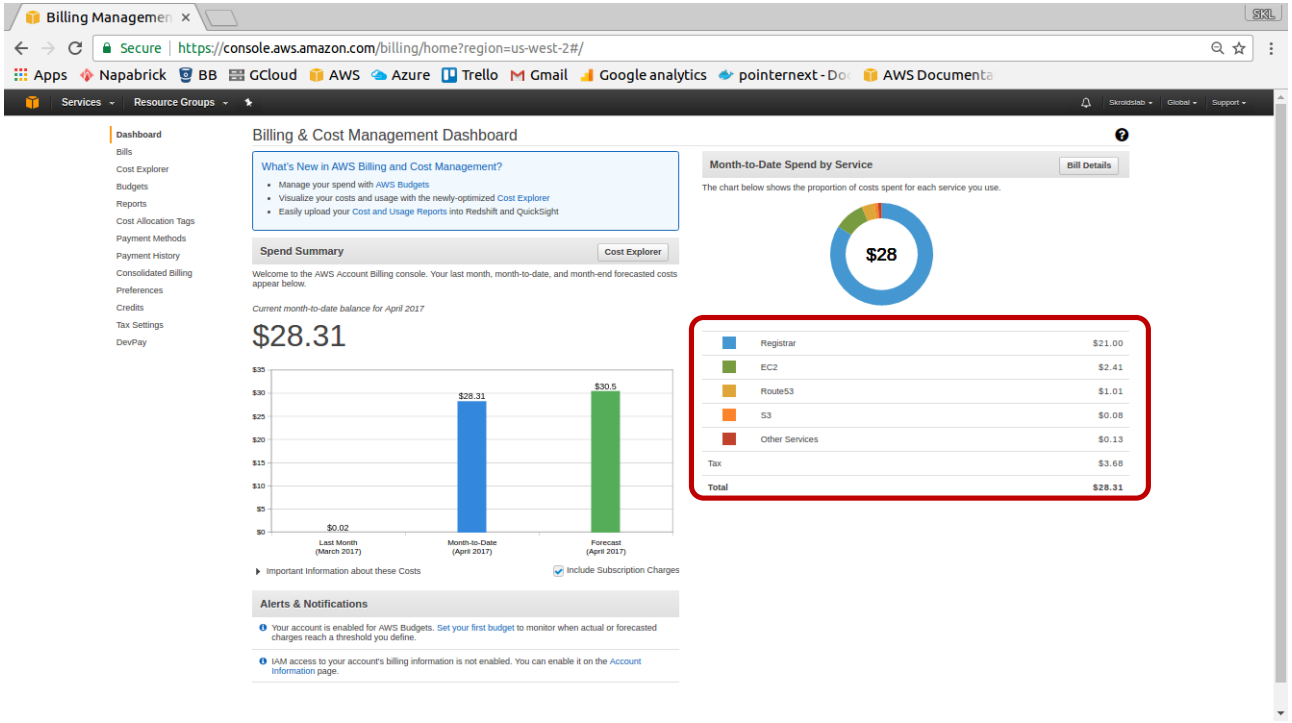


Billing - dashboard



The email needs to be verified in 72hrs.

Billing - dashboard, itemized view



How much are we talking about?

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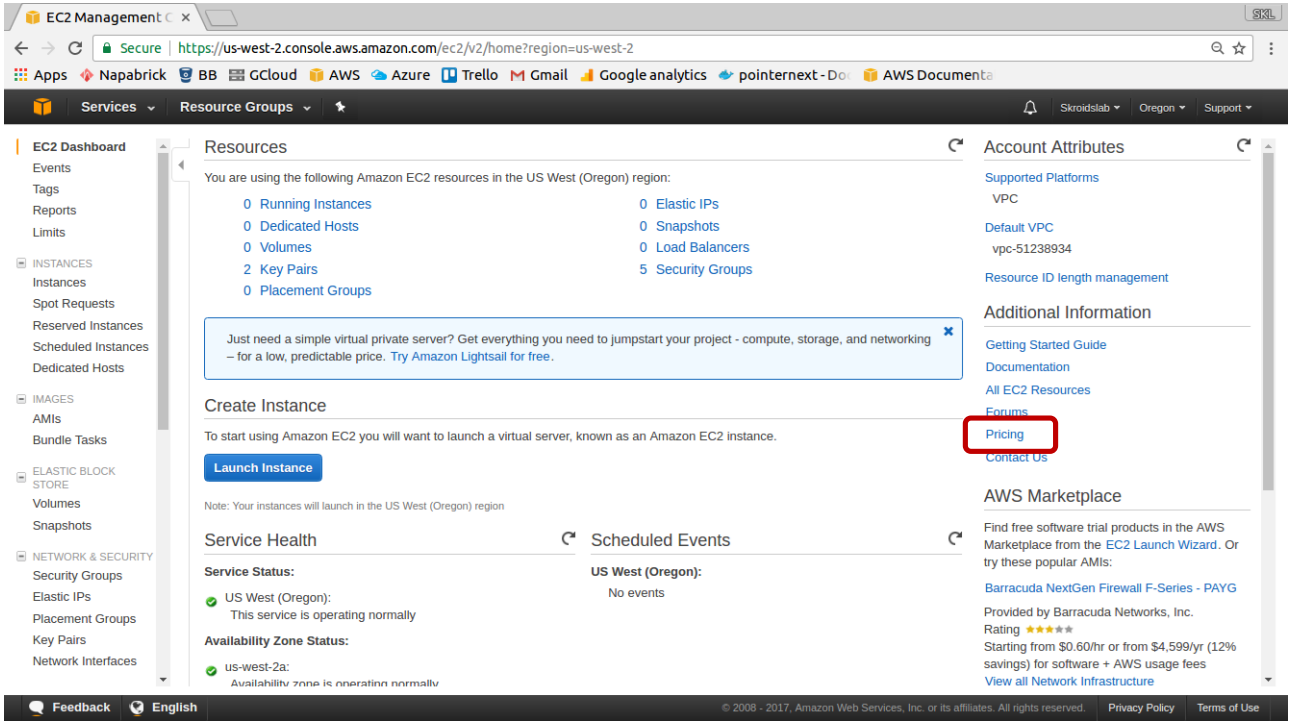

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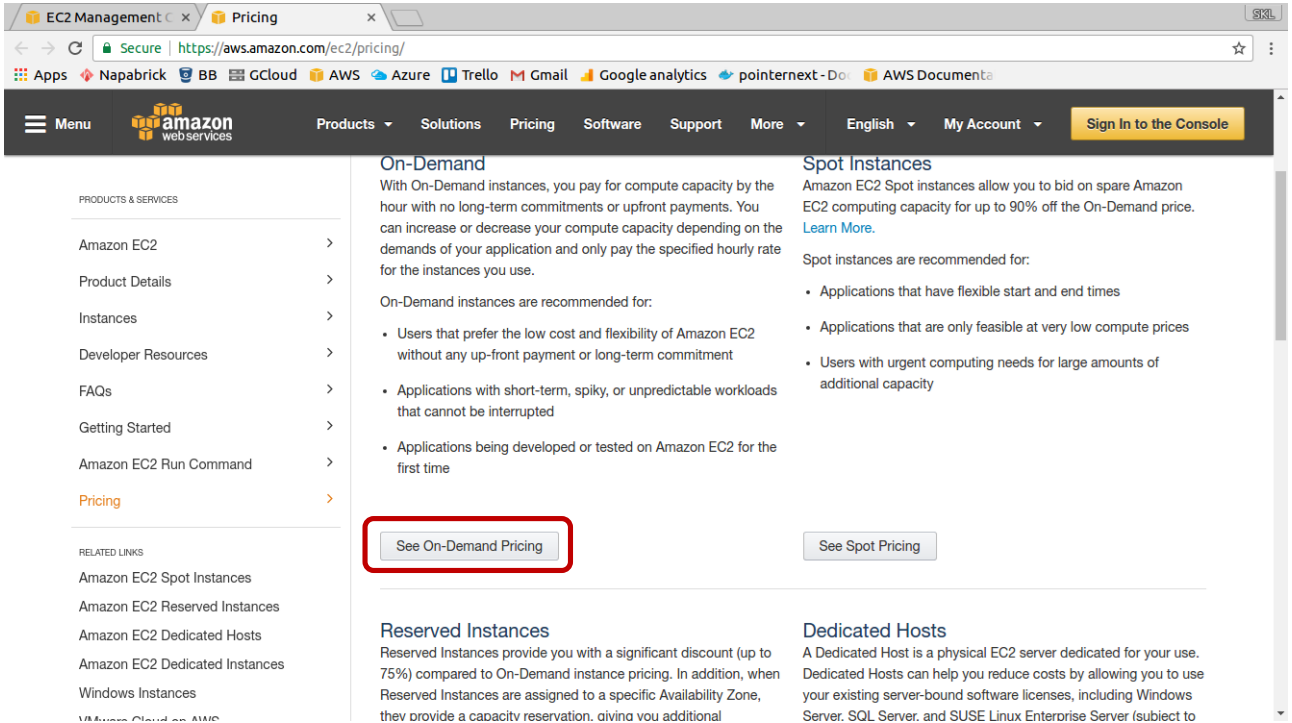

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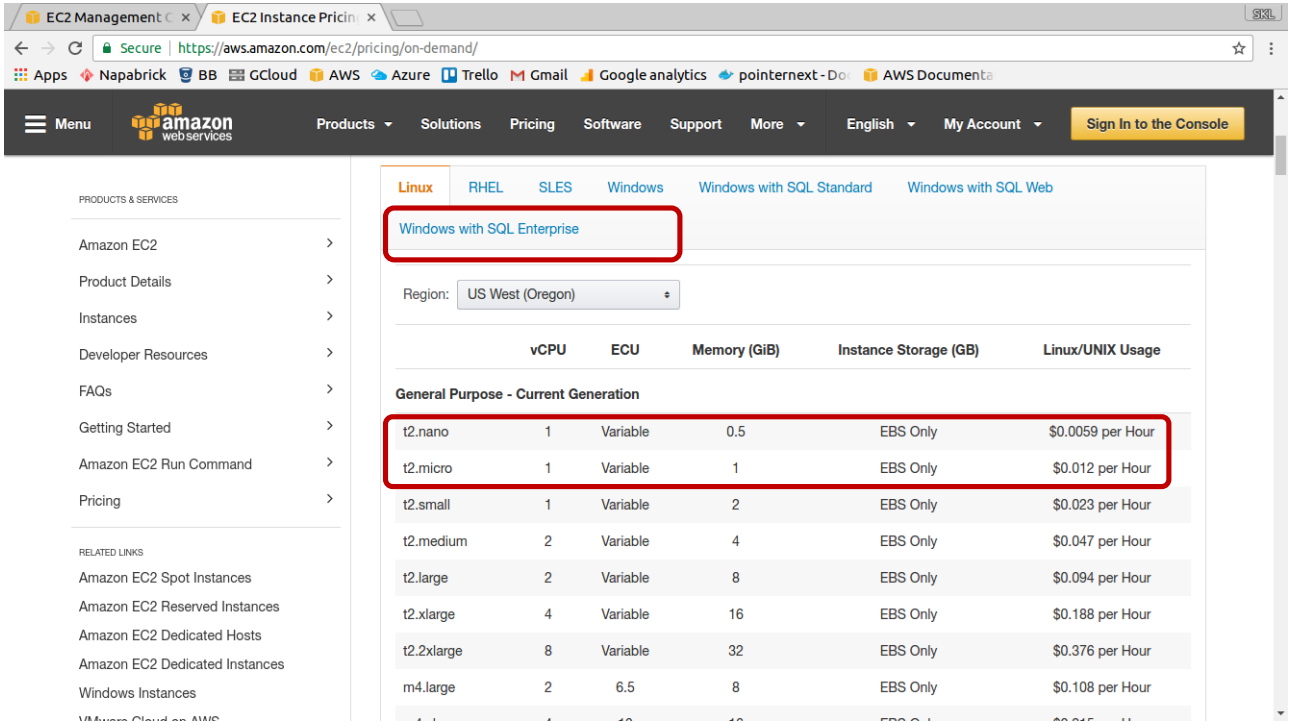

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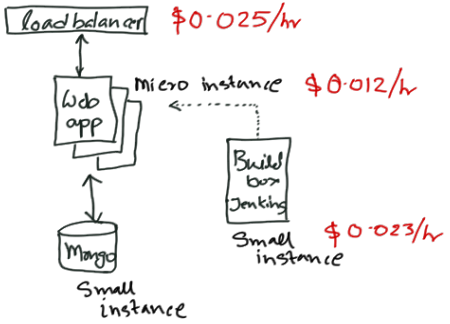
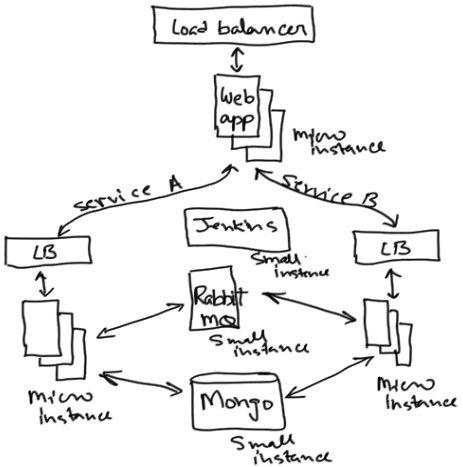


Component	Count	Unit Cost	Price
Load balancer	1	$0.025/hr	$0.025
Micro instance	3	$0.012/hr	$0.036
Small Instance	2	$0.023/hr	$0.046

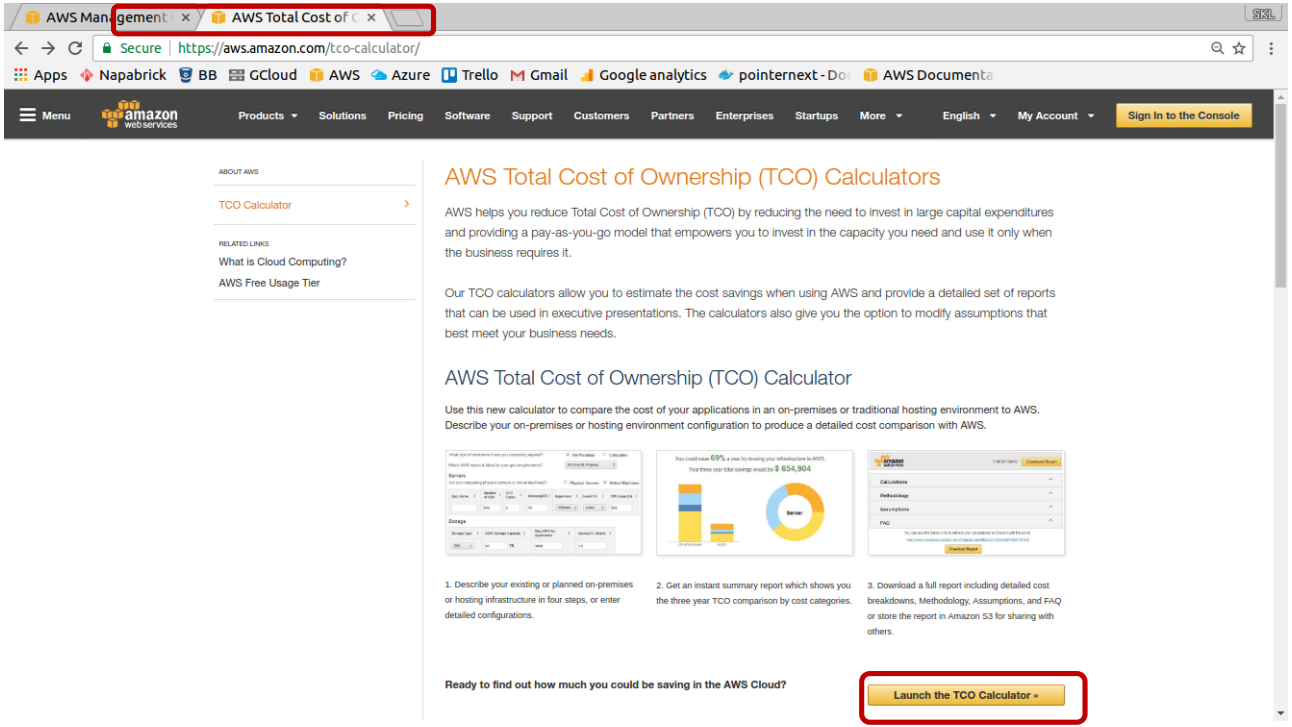
Per hour cost is ~ $0.11



Component	Count	Unit Cost	Price
Load balancer	3	$0.025/hr	$0.075
Micro instance	9	$0.012/hr	$0.108
Small Instance	3	$0.023/hr	$0.069

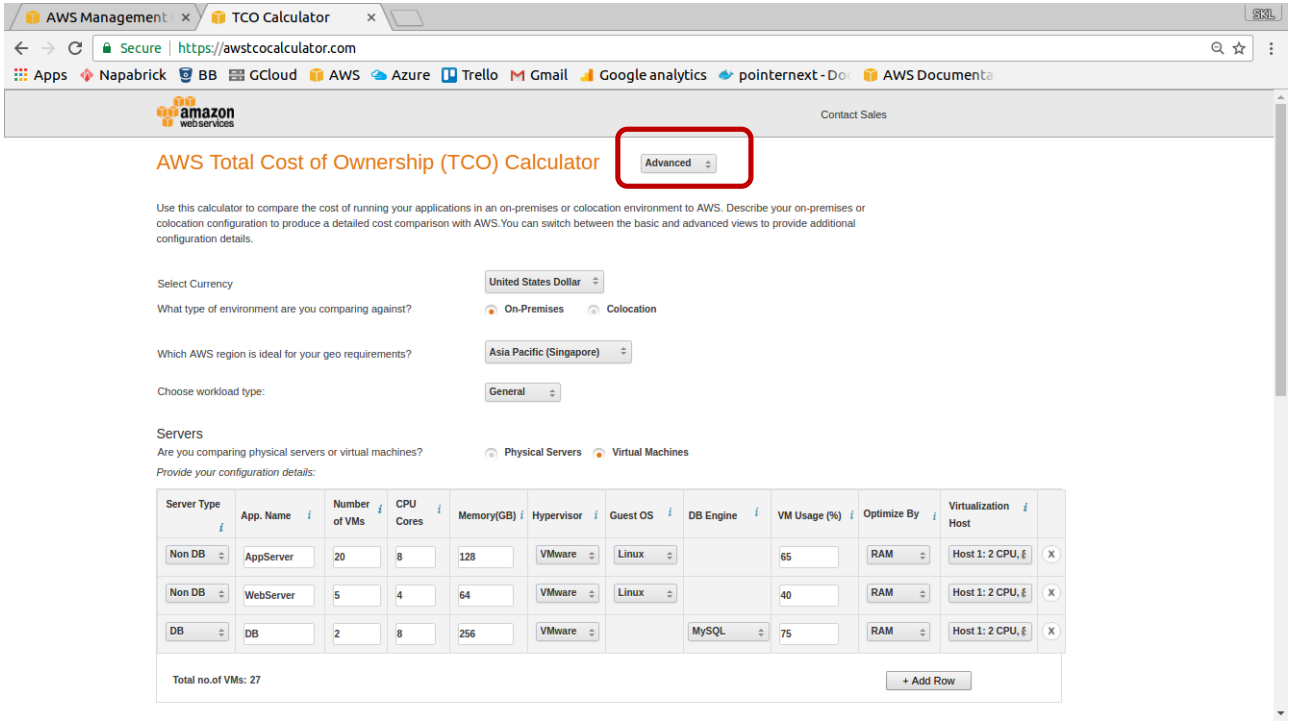
Per hour cost is ~ $0.26

Cost of Ownership

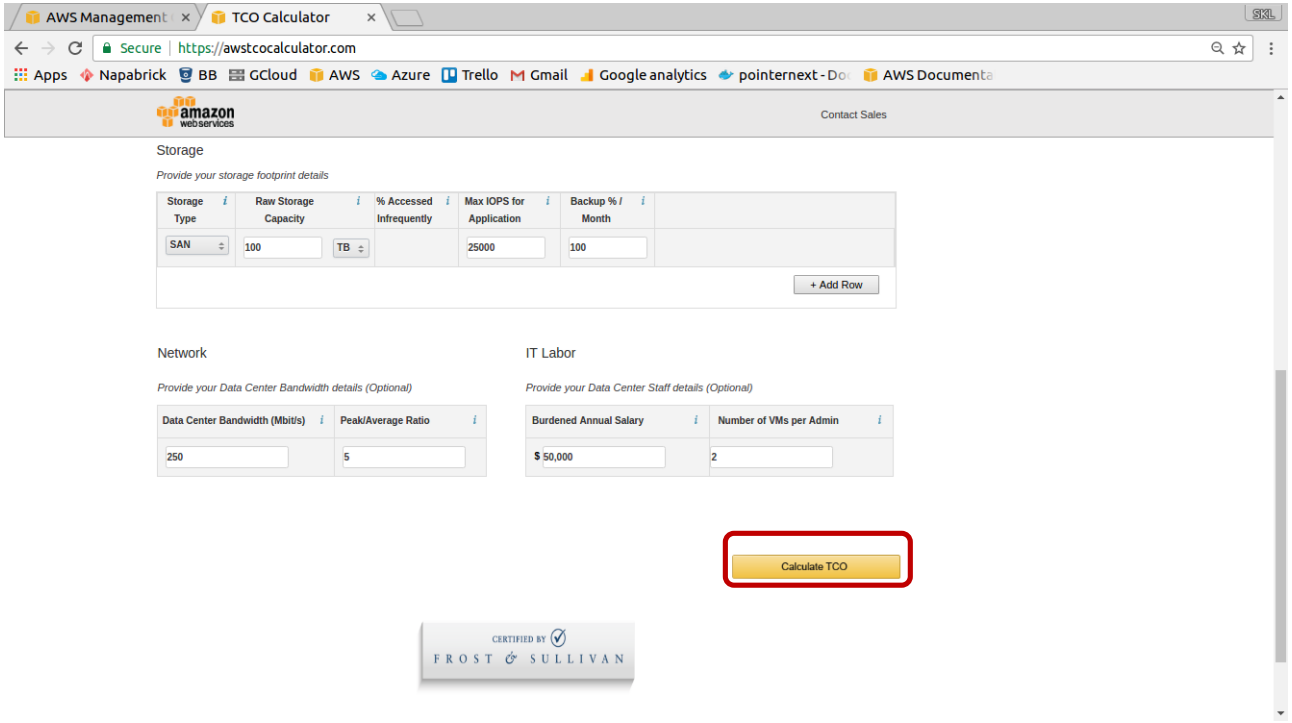


https://aws.amazon.com/tco-calculator/

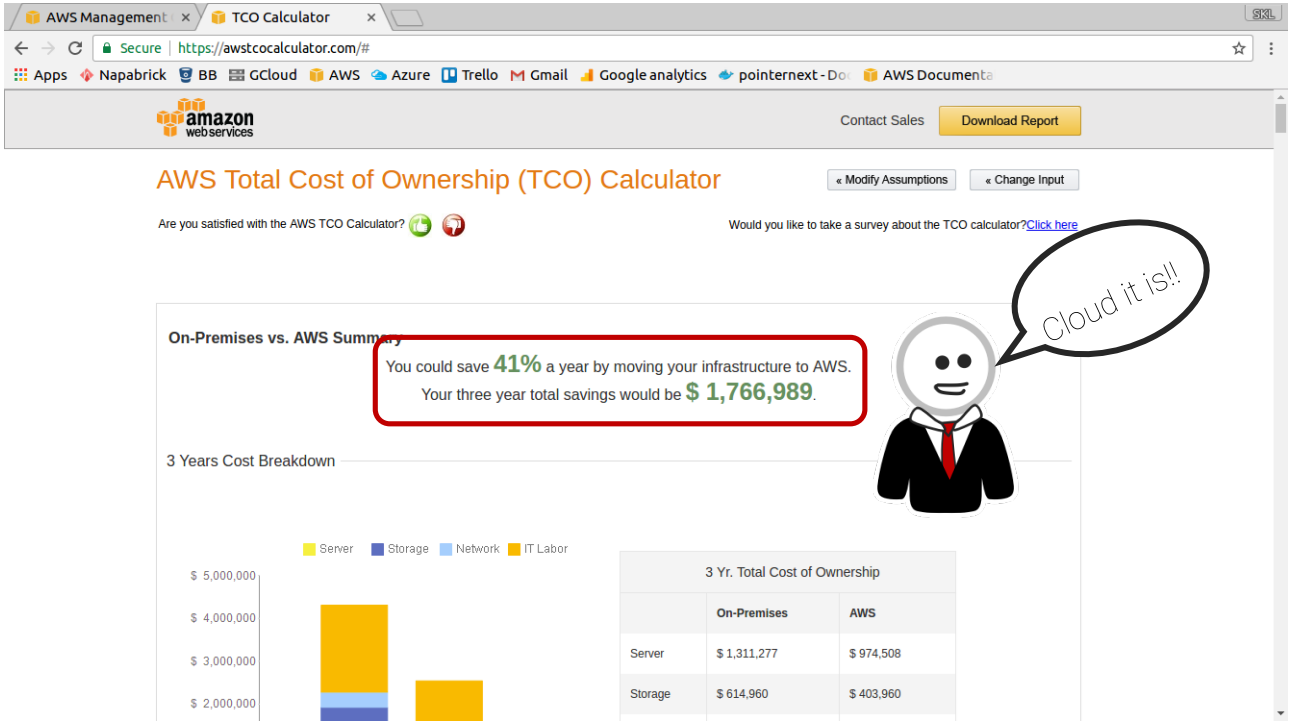
Cost of Ownership



Cost of Ownership



Cost of Ownership



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Identity and Access Management (IAM)

Fundamentals & Multi Factor Authentication setup

Overview - Security services

- This is an important service for maintaining AWS account
- Can integrate with existing active directory allowing SSO
- Federation includes LinkedIn or Facebook
- Fine grained access control for various resources
- Can define various roles
- Multifactor authentication (especially for the root account)
- Temporary access for users to certain areas of AWS
- Password management policies (e.g. rotation and rules)
- Core areas
    - Users - individuals
    - Groups - set of users under one set of permissions
    - Roles - access specifications (can be allocated to users, groups and resources such as EC2)
    - Policies - basically permissions assigned to a User/Group/Role

Activity - Custom AWS signin URL

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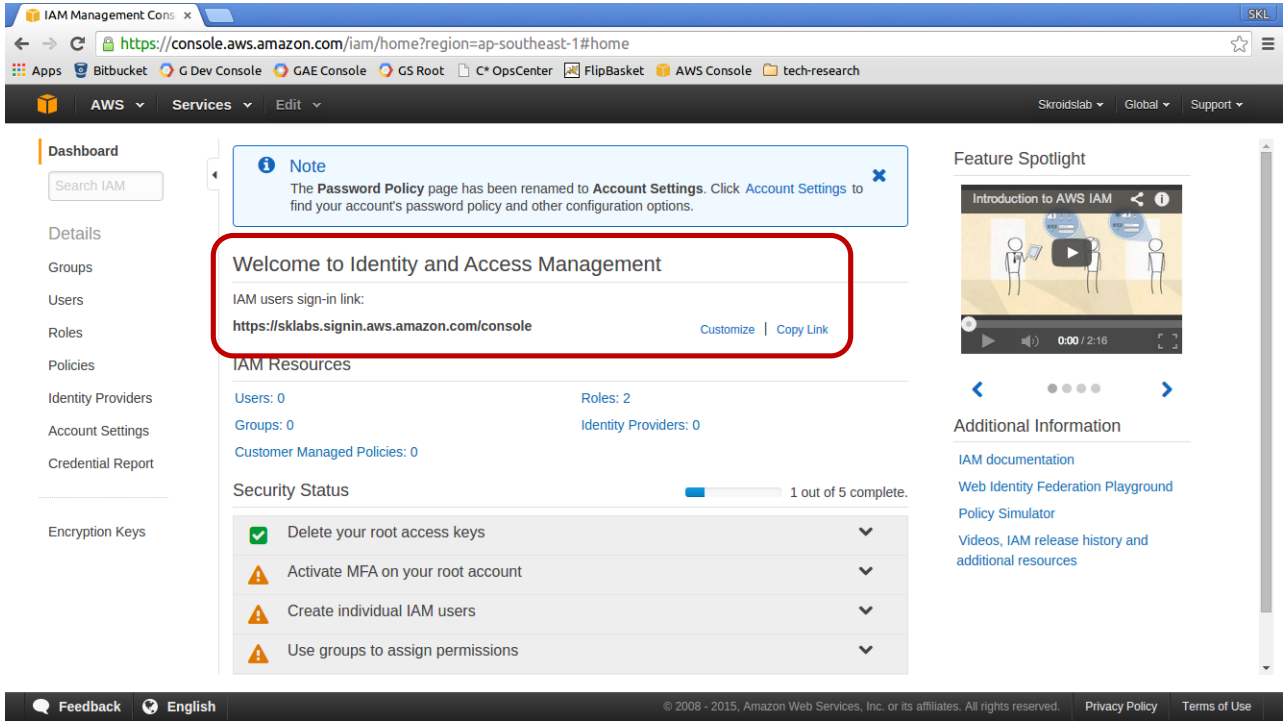

Change the IAM sign in link, send out to your team. Notice that the IAM settings do not need a region - it will be "Global"

Activity - MFA setup

- Good idea to enable on the root account
  - Root a/c is the email that you used to signup in AWS
  - Can be setup on all accounts

- Install the "AWS Virtual MFA" on your mobile device, choices are
  - Google authenticator app (install this)
  - AWS Virtual MFA app - provided by "AWS Mobile LLC"

Activity - MFA setup

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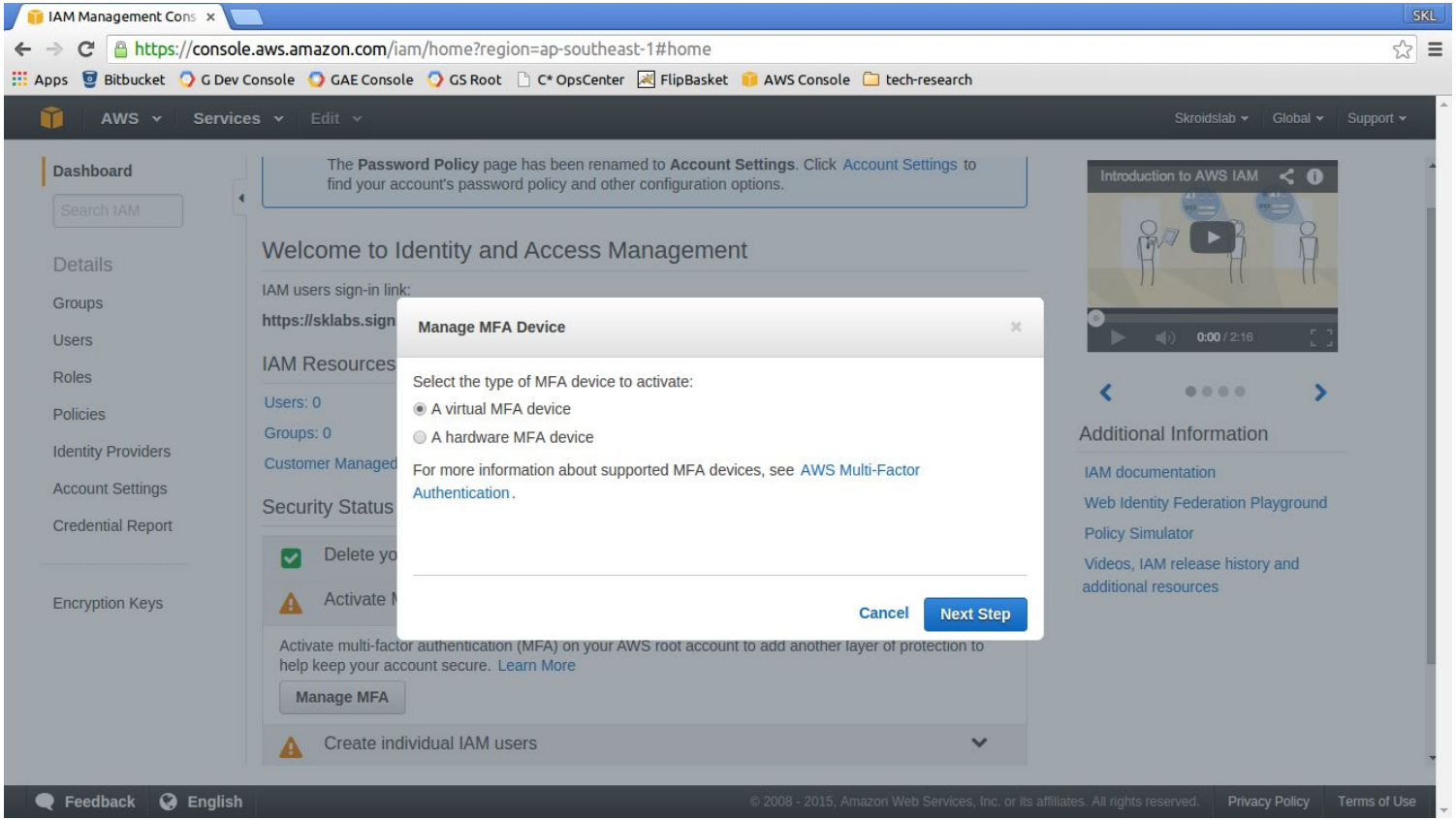

Activity - MFA setup

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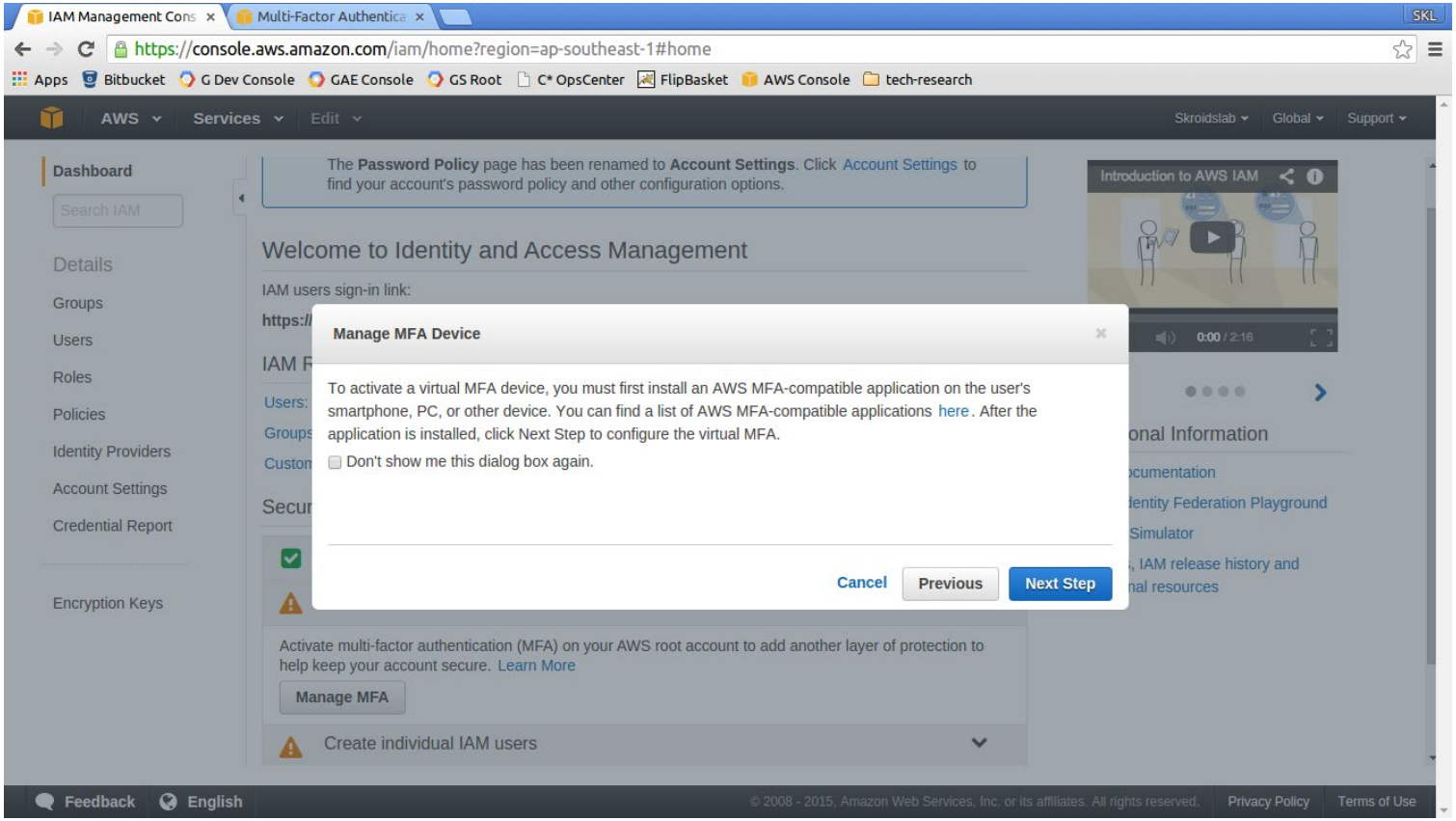
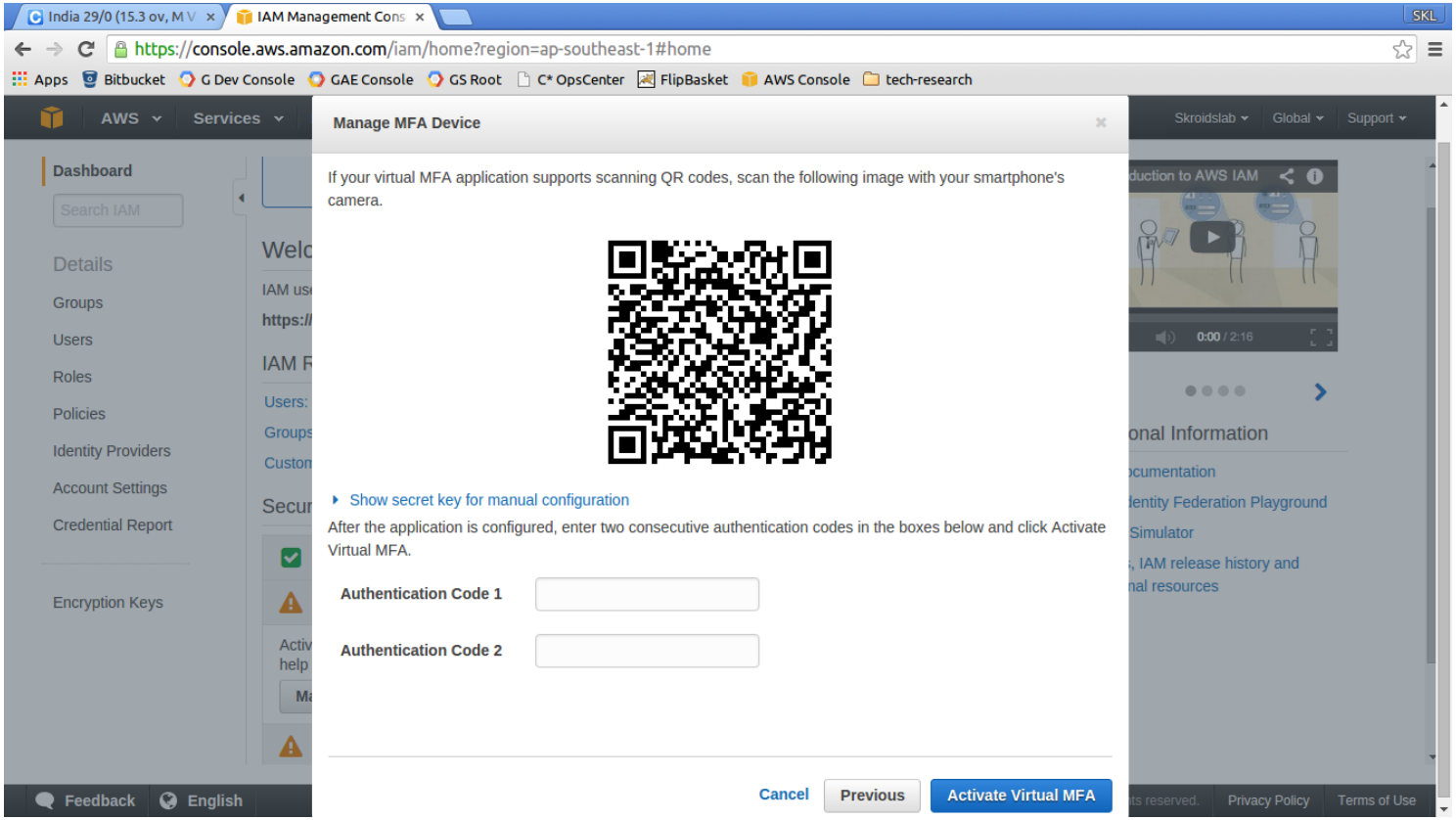


Activity - MFA setup



Activity - MFA setup

- Open "Google authenticator" in your mobile app
- Scan the QRCode as displayed on the console
- This will access the MFA
- Enter the digits in the first authentication code field, wait for it to change and add the second one
- Logout of the AWS console, log back in and now see it asks for the second authentication

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Compute - Part I

EC2 introduction

Overview - Elastic Compute Cloud

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- The "backbone"! AKA EC2
- Rent instances/machines/boxes/VMs (pick your choice)
  - https://aws.amazon.com/ec2/instance-types

The Amazon EC2 Service Level Agreement (SLA) commitment is 99.95% availability for each Region

Overview - Elastic Compute Cloud

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- Key design aspects
  - Have a few *reserved* instances (discounts are big!) + autoscale with *on-demand* instances
  - *Spot* instances for use-cases that can be interrupted unpredictably
  - Have mounted disks for app data
  - Think microservices
  - Create application feature zones (groups of microservices)
- Pricing tip about spot instance
  - If spot instance is terminated by AWS then you will not be charged for the partial hour of use
  - If you terminate the instance then the whole hour will be chargeable
- EBS which is storage, summary below
  - SSD General purpose - GP2 (upto 10k IOPS)
  - SSD Provisioned iops - IO1 (>10k IOPS)
  - HDD, Throughput optimized - ST1 (frequently accessed, e.g. sequentially updating data workloads), non bootable
  - HDD cold - SC1 - less frequently accessed, non bootable
  - HDD Magnetic - standard, really cheap, bootable
- Cannot mount EBS to multiple instances, use EFS instead
- EFS is like a shared store area

Activity - EC2 Dashboard

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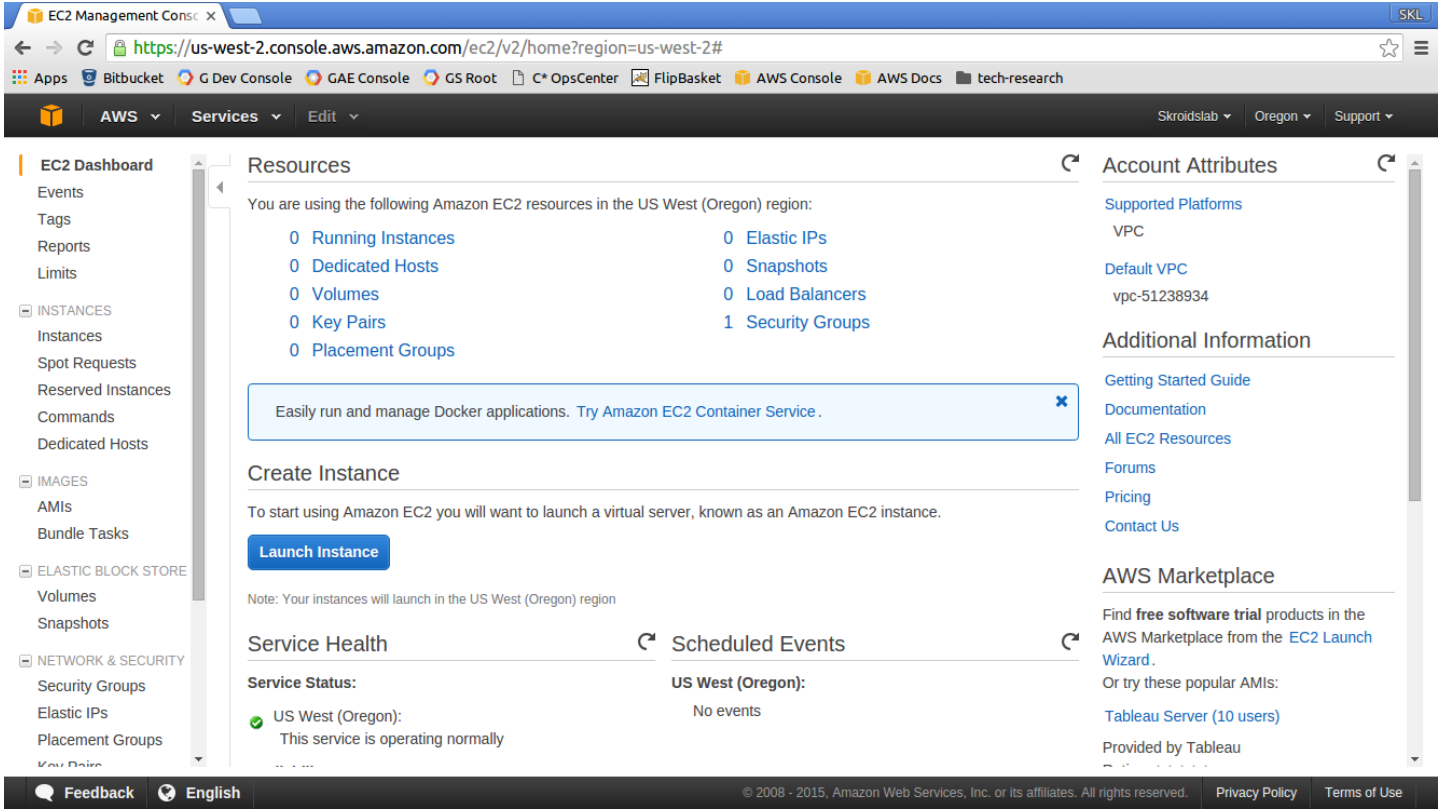

Activity - EC2 launch instance

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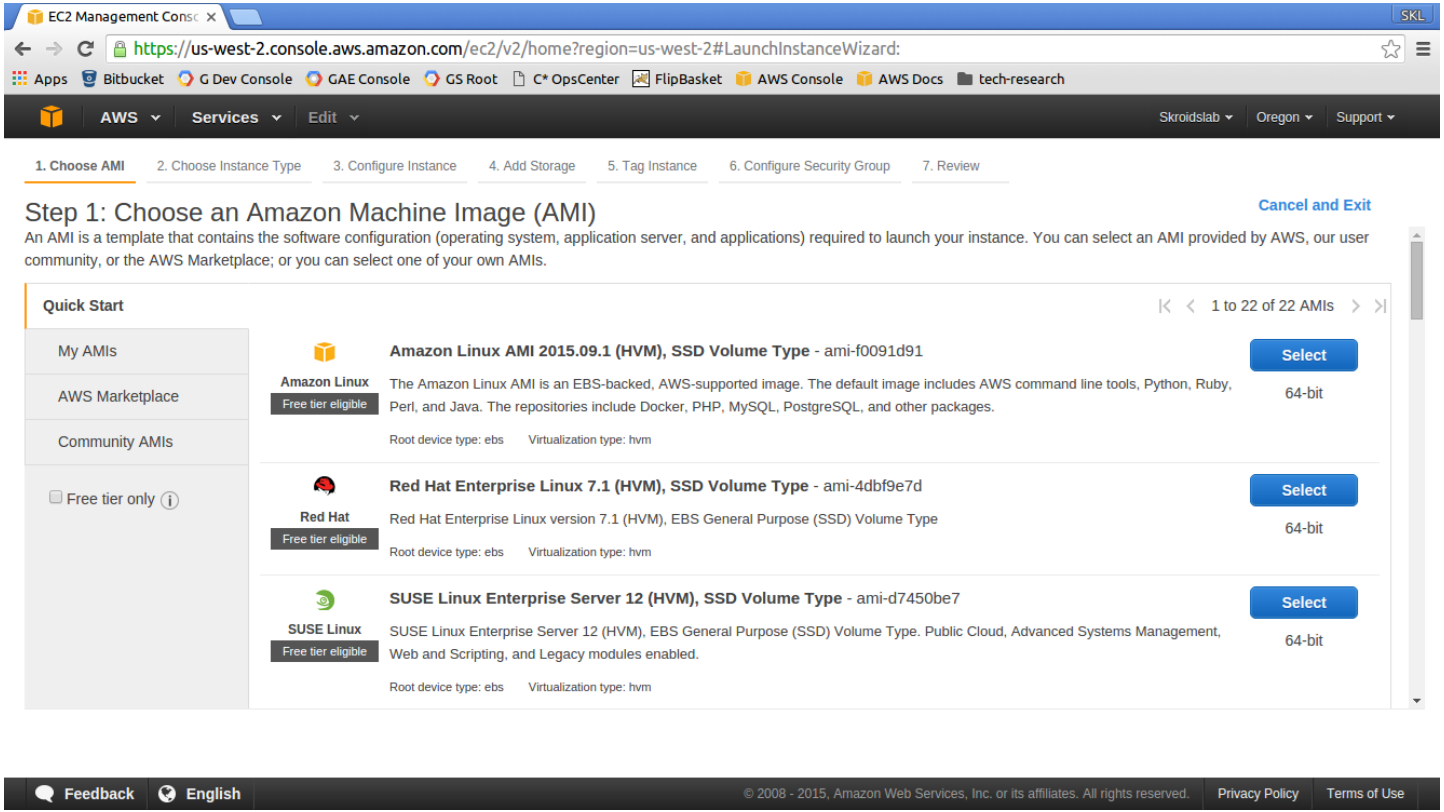

Activity - EC2 launch instance

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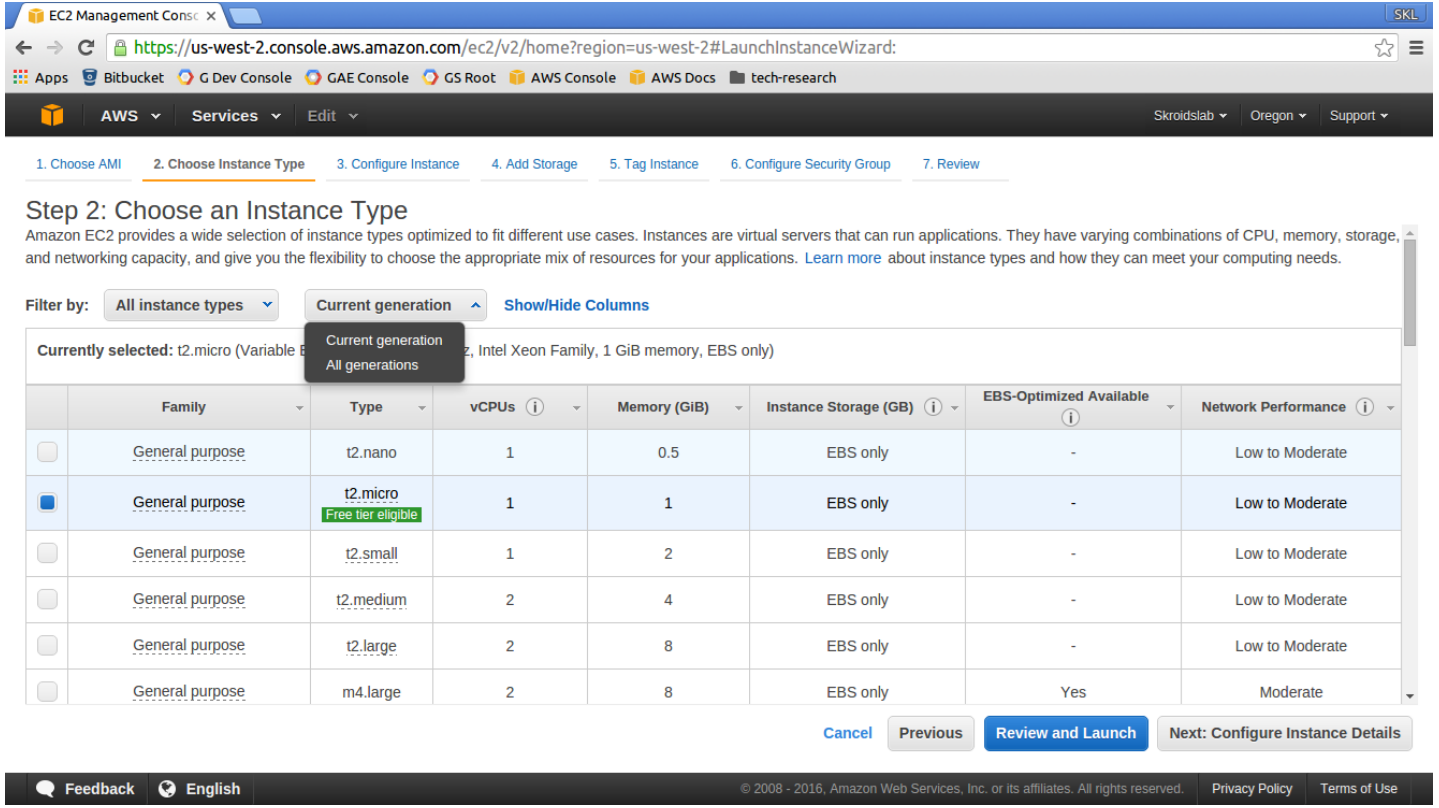
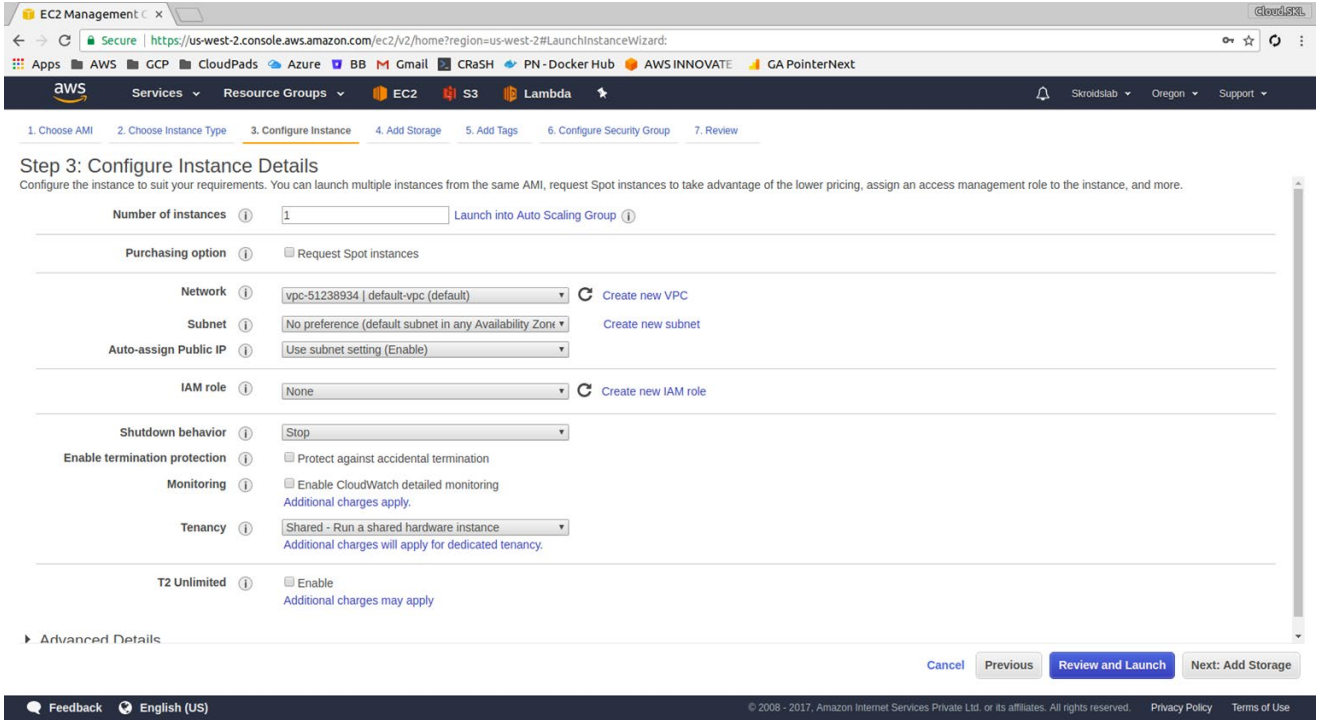
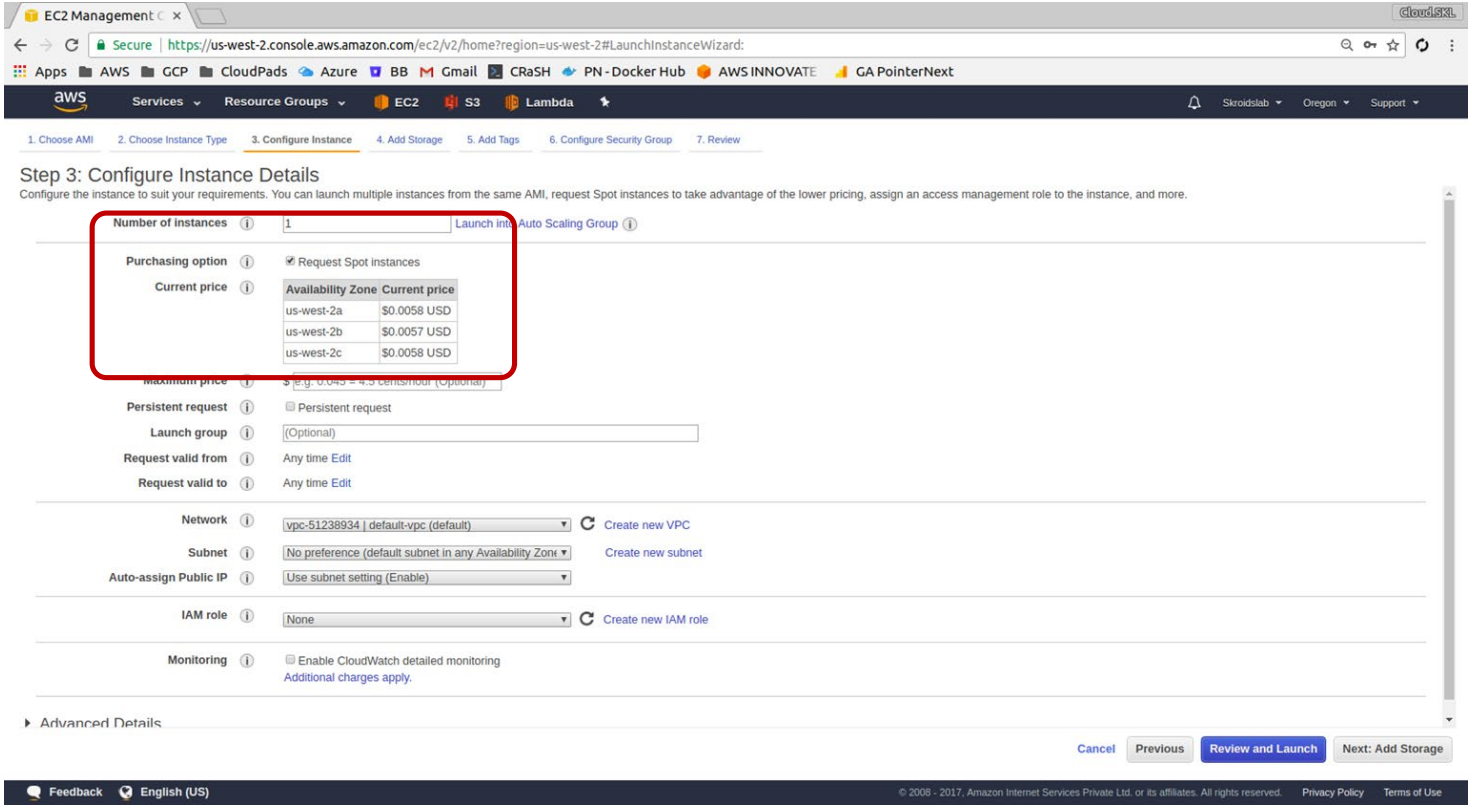


Activity - EC2 launch instance



https://aws.amazon.com/blogs/aws/new-t2-unlimited-going-beyond-the-burst-with-high-performance/

Activity - EC2 launch instance



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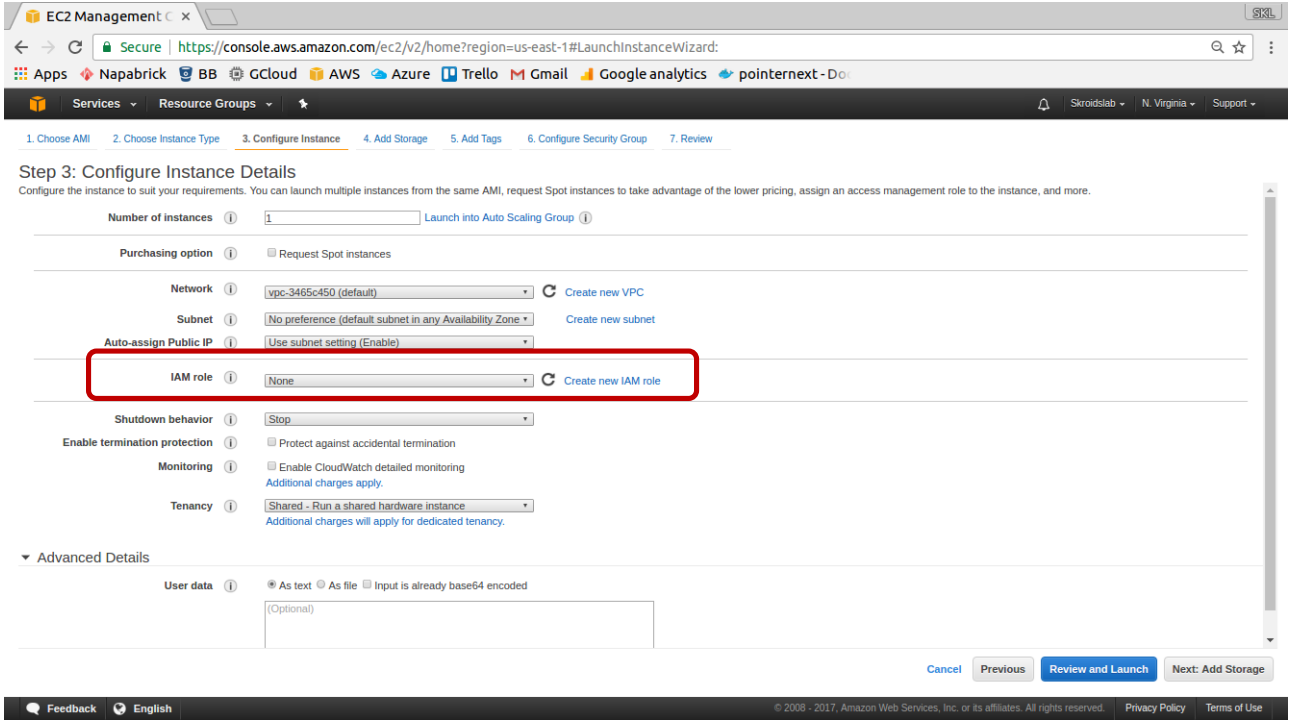

Important! What happens if you miss adding a role?

Activity - EC2 launch instance

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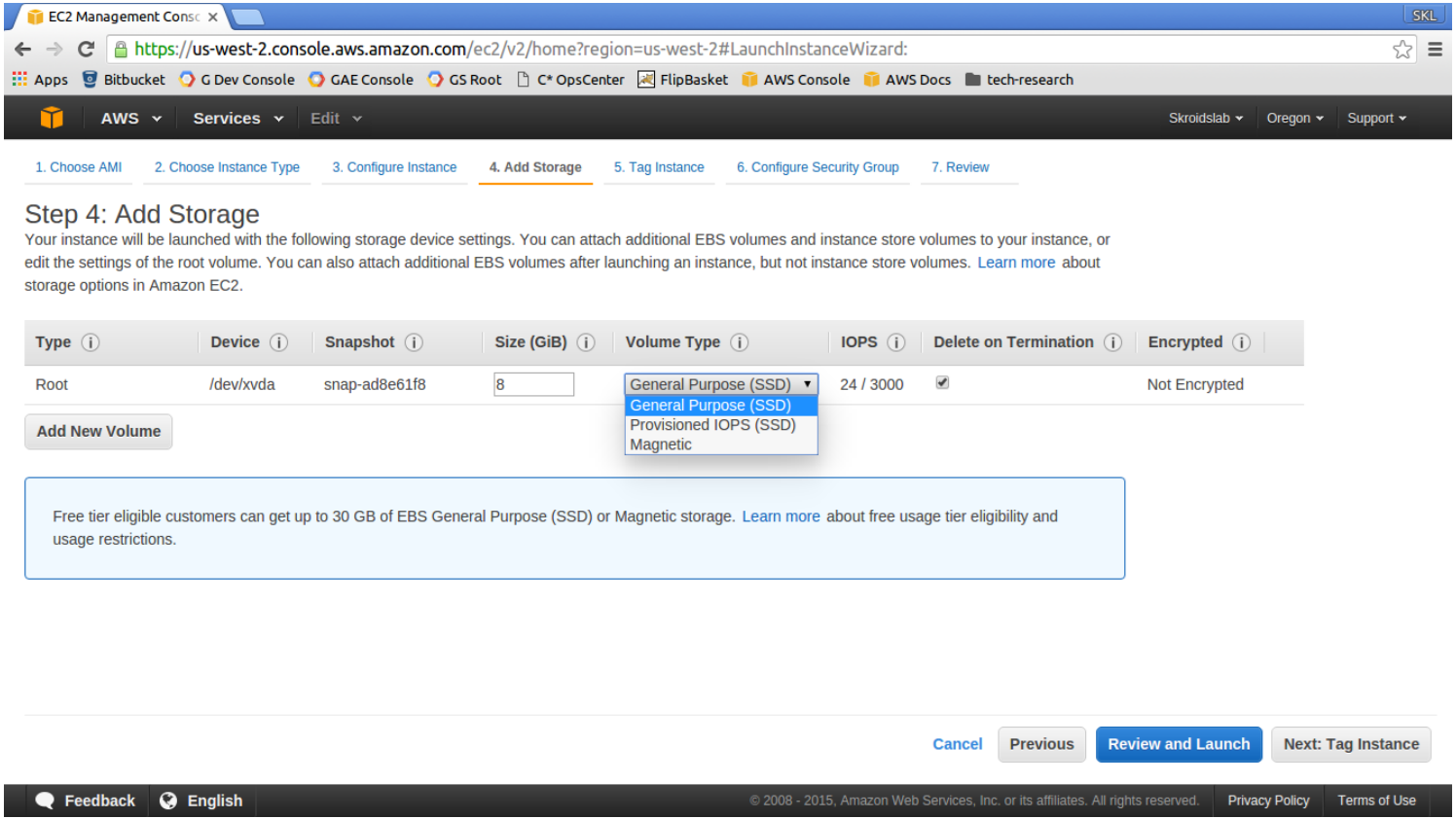
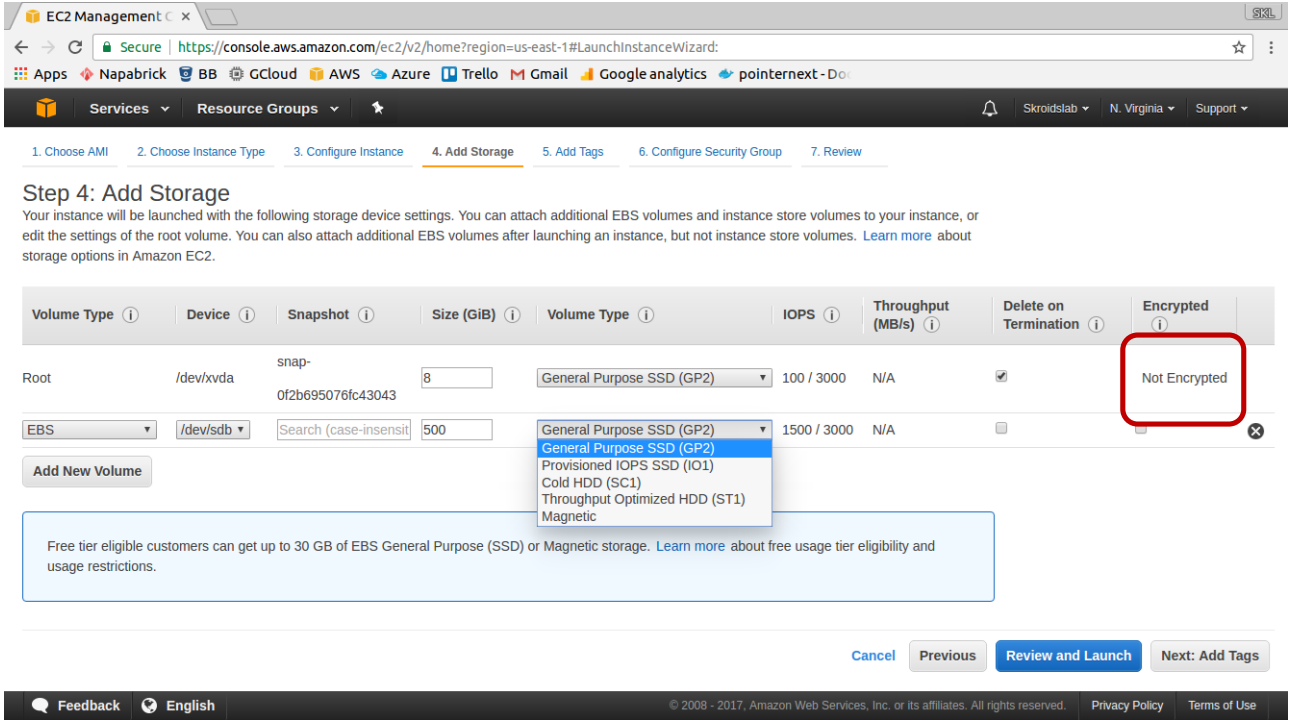


Activity - EC2 launch instance



Cannot encrypt the boot volume BUT any additional EBS you can.
Or create your own AMI and encrypt Or use 3rd party service

Activity - EC2 launch instance

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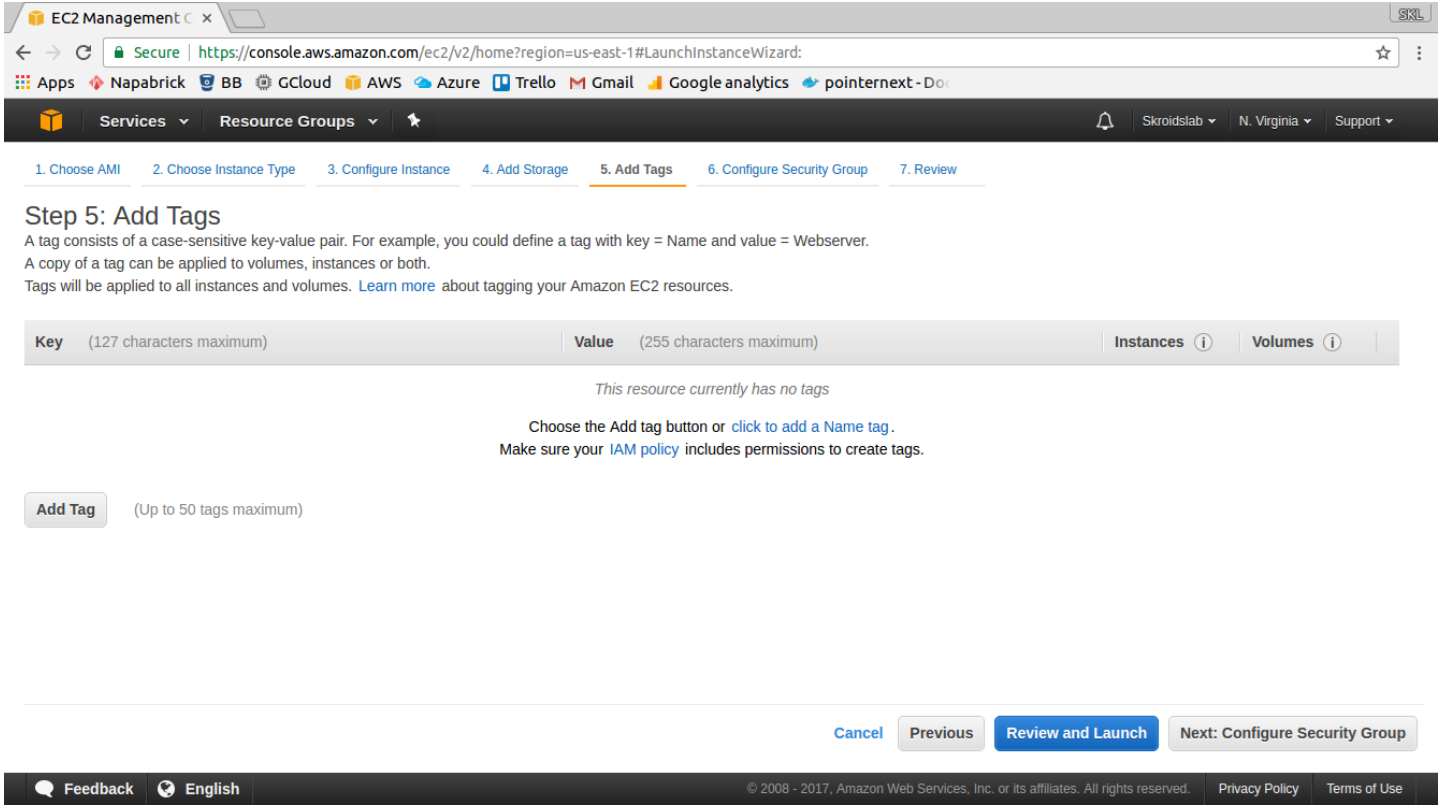

Activity - EC2 launch instance

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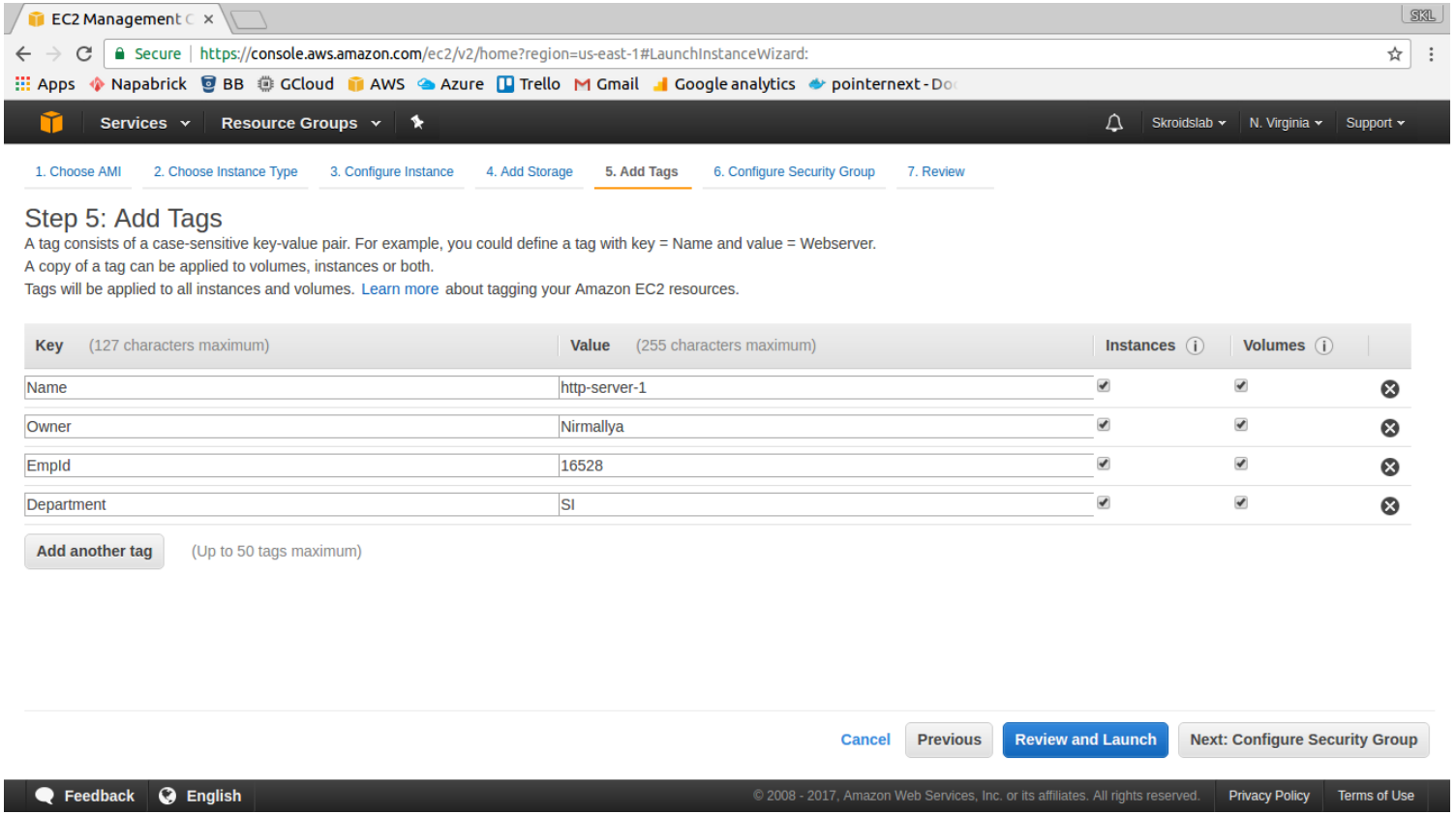

Activity - EC2 launch instance

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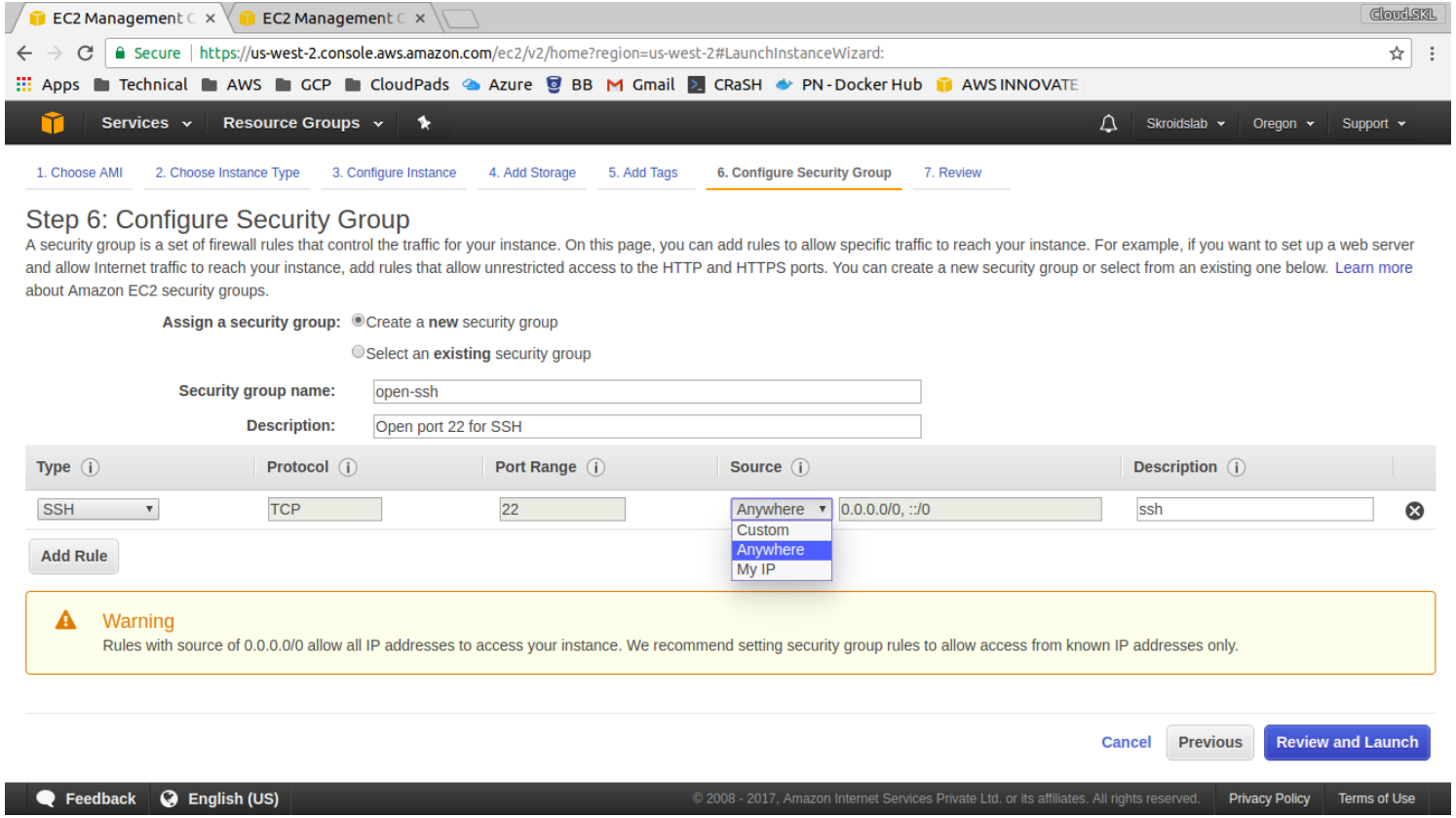

Activity - EC2 launch instance

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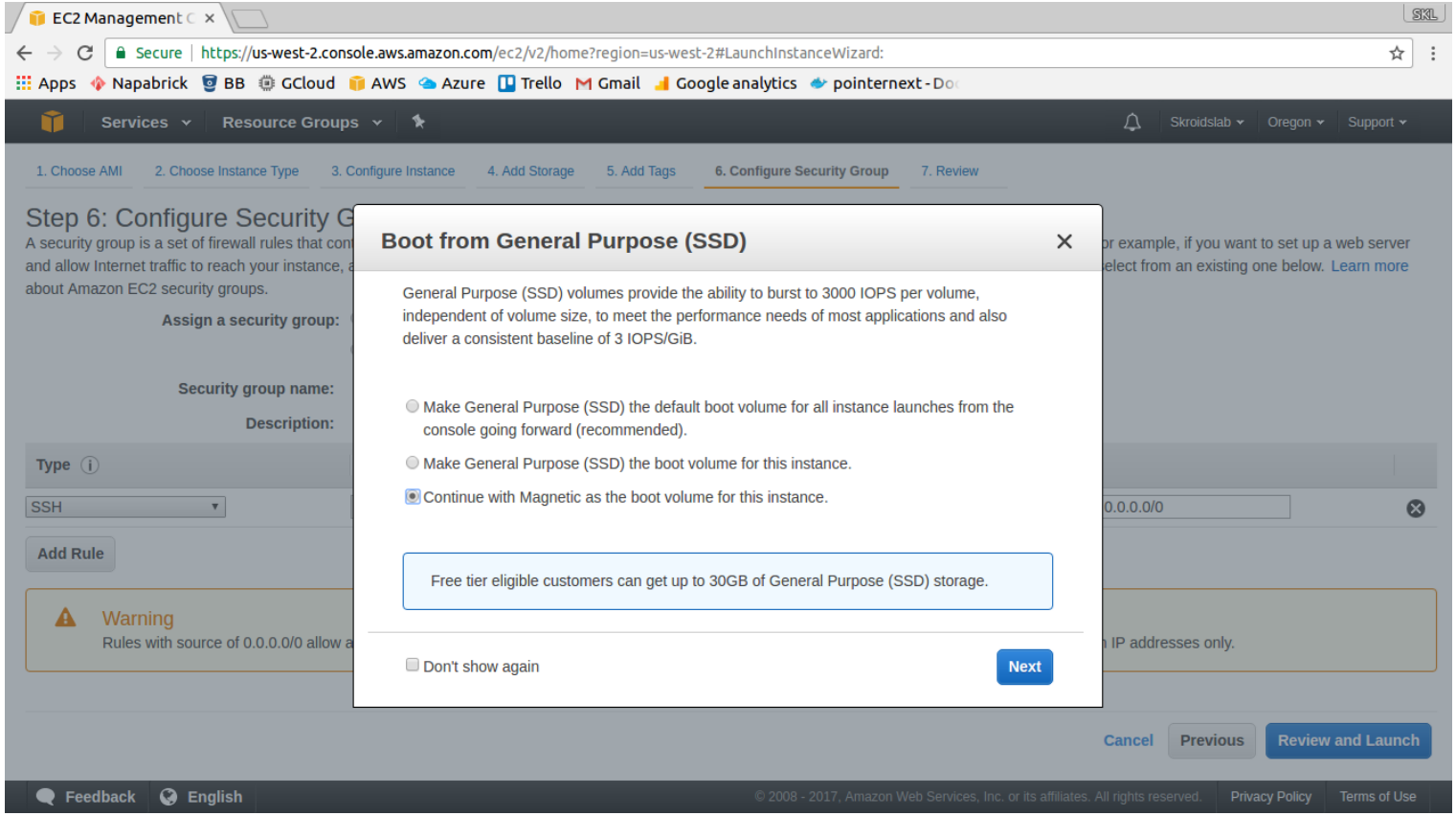

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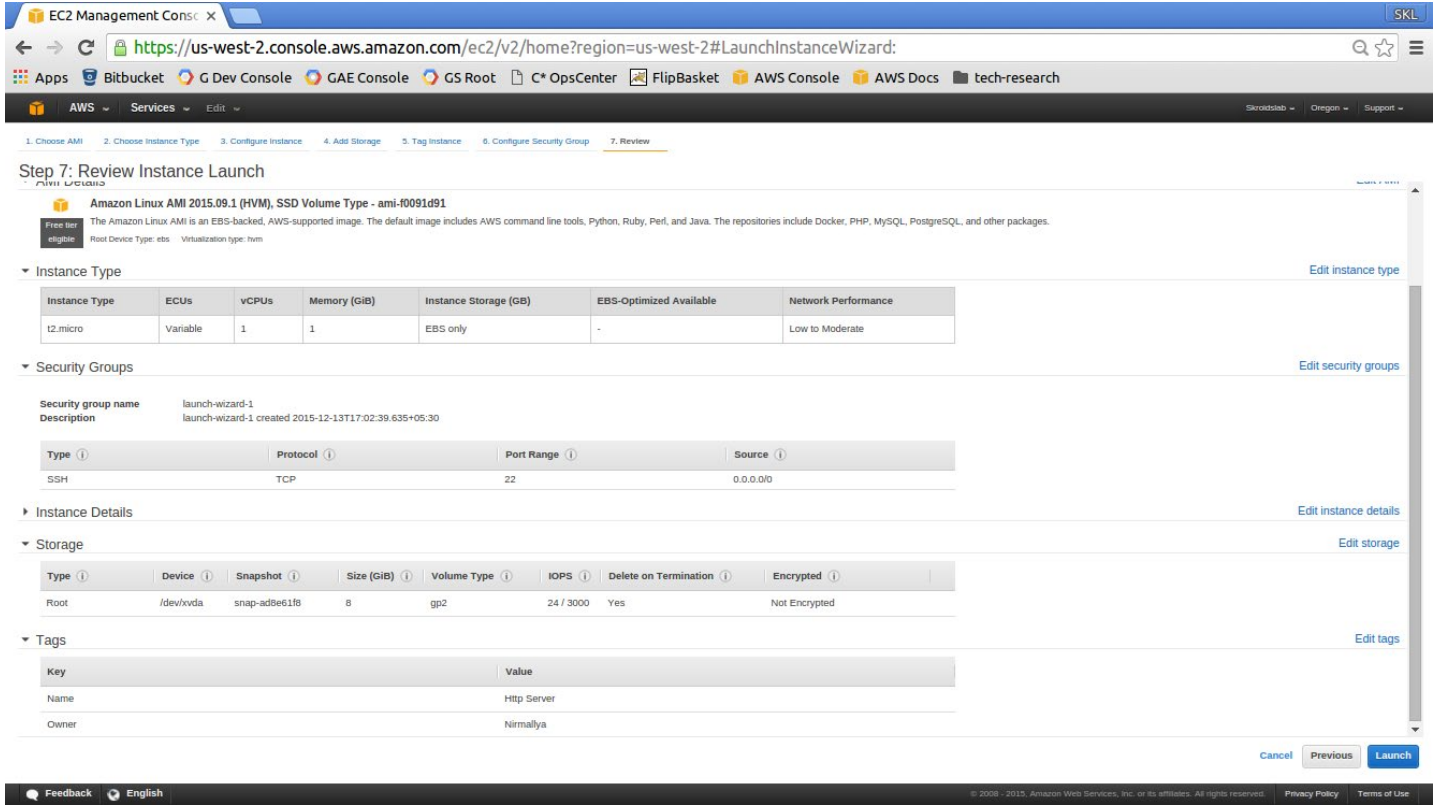

Activity - EC2 launch instance

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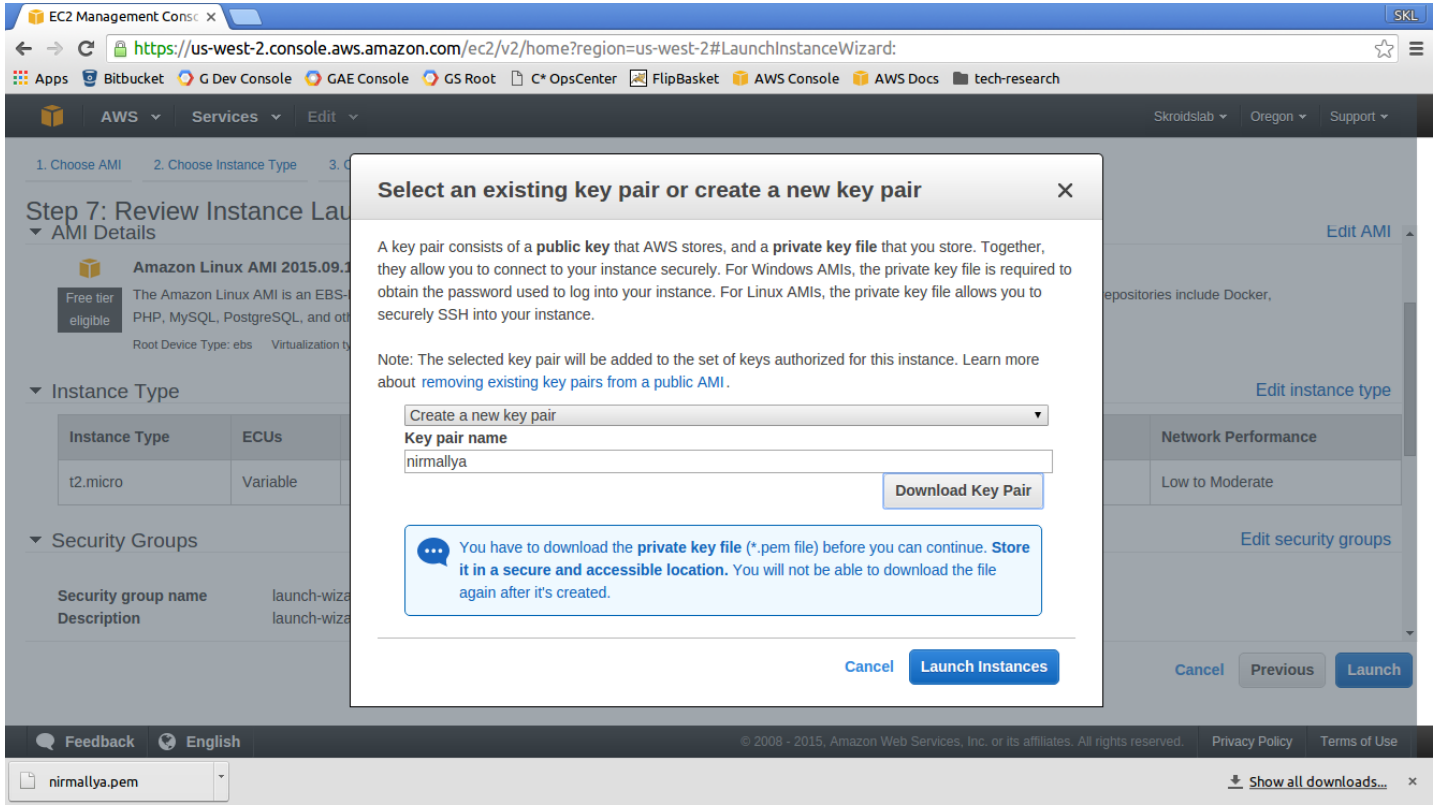

Activity - EC2 launch instance

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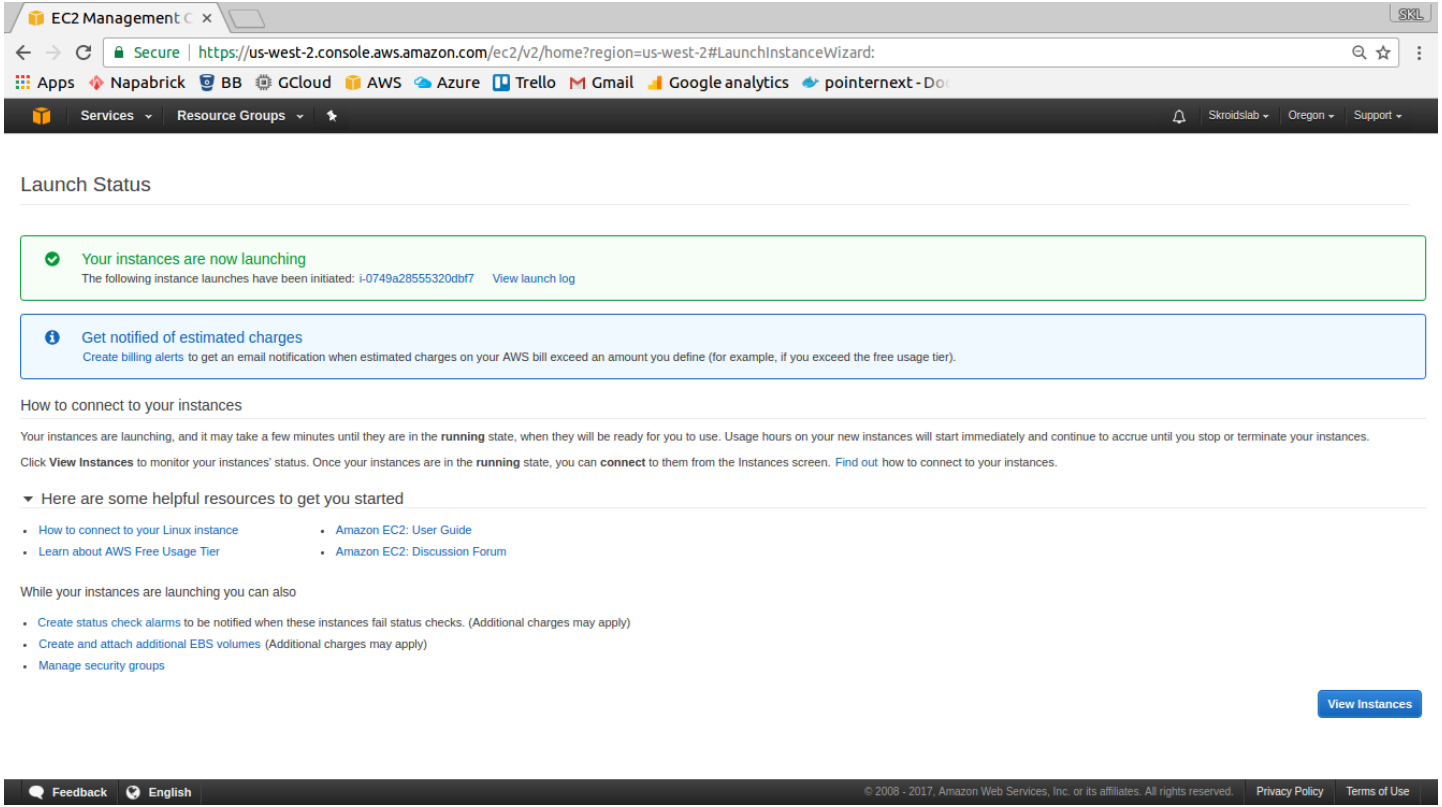

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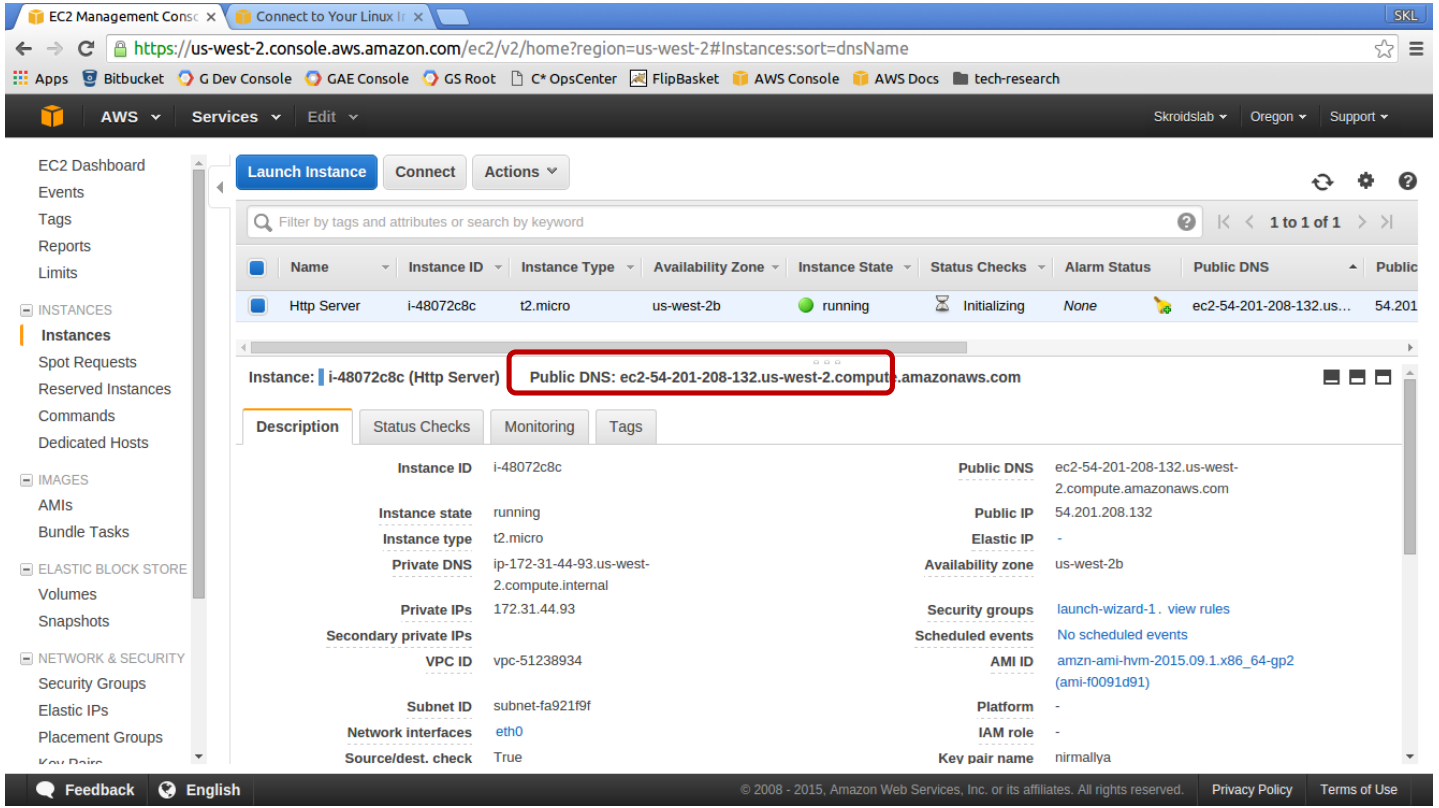

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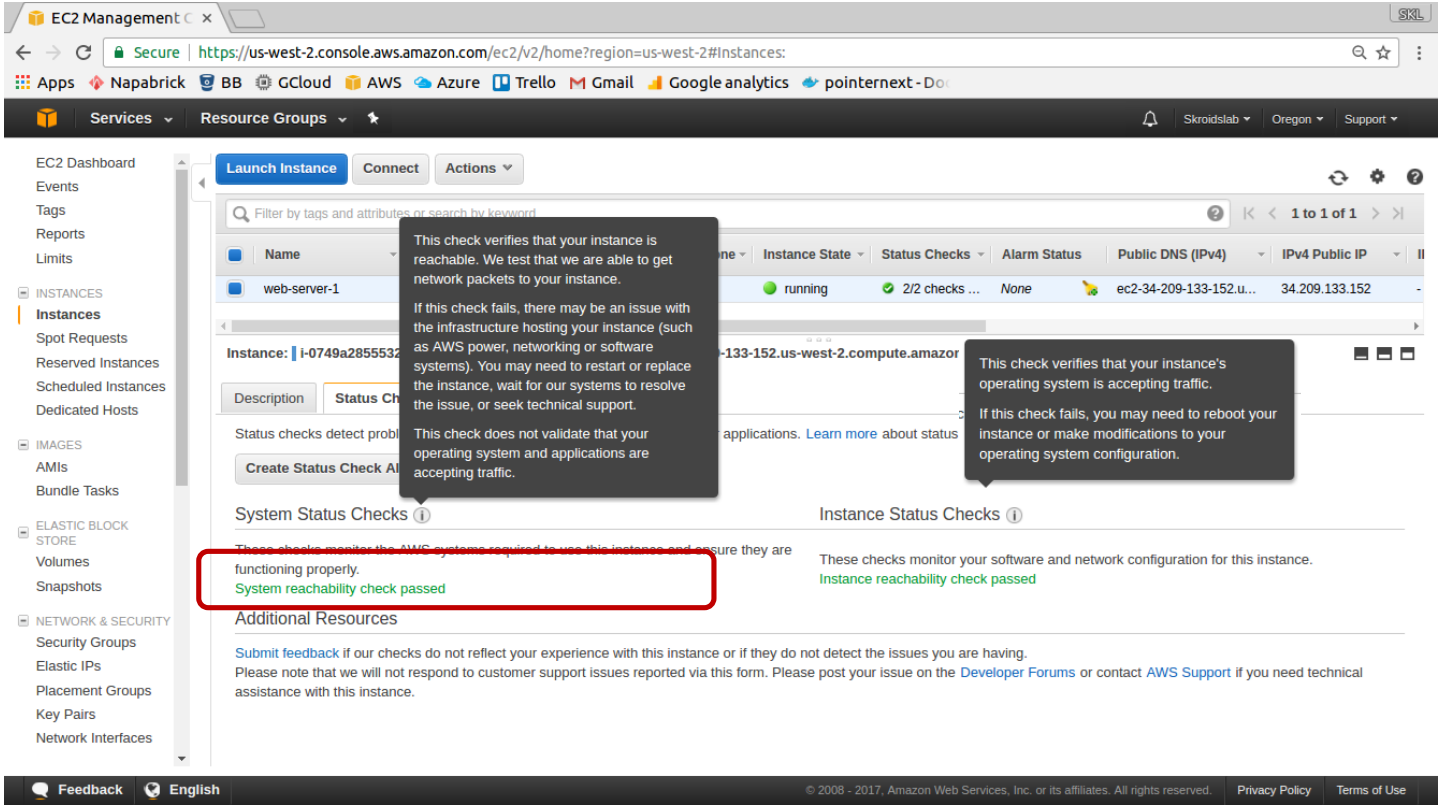

Activity - EC2 launch instance

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- When you launch an instance in EC2-Classic, we automatically assign a public IP address to the instance. You cannot modify this behavior. When you launch an instance into a VPC, your subnet has an attribute that determines whether instances launched into that subnet receive a public IP address.
- By default, we *don't automatically assign a public IP address* to an instance that you launch in a *non default subnet*.
- You can control whether your instance in a VPC receives a public IP address by doing the following:
    - Modifying the public IP addressing attribute of your subnet. For more information, see Modifying Your Subnet's Public IP Addressing Behavior in the Amazon VPC User Guide.
    - Enabling or disabling the public IP addressing feature during launch, which overrides the subnet's public IP addressing attribute. For more information, see Assigning a Public IP Address.

http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/using-instance-addressing.html

Activity - EC2 install http server

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- Connect to AWS using PUTTY [http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/putty.html]
- Protect your PEM file
  - chmod 400 <PEM>
- To login to the instance you can use public DNS or IP
  - ssh -i <PEM> ec2-user@<Public DNS>

  OR
  - ssh <Public IP> -l ec2-user -i <PEM>
- Once you are in, fire up the following commands
  - sudo yum update
  - sudo yum install httpd
  - sudo service httpd start
  - curl localhost
- Go to the browser and access the site using the public IP address
- Are you able to see the default page?

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Compute - Part I

Security groups

Activity - Security group

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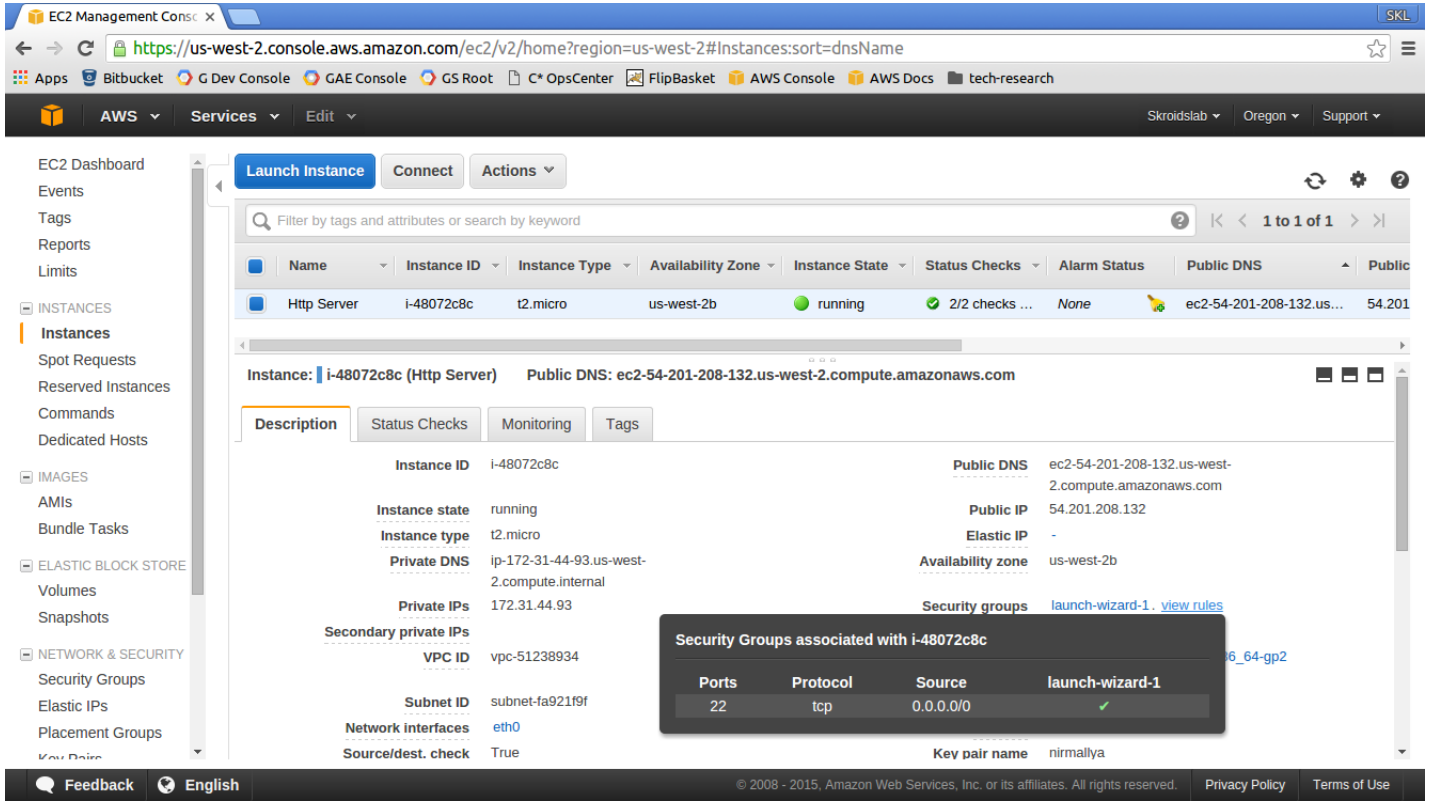

Activity - Security group

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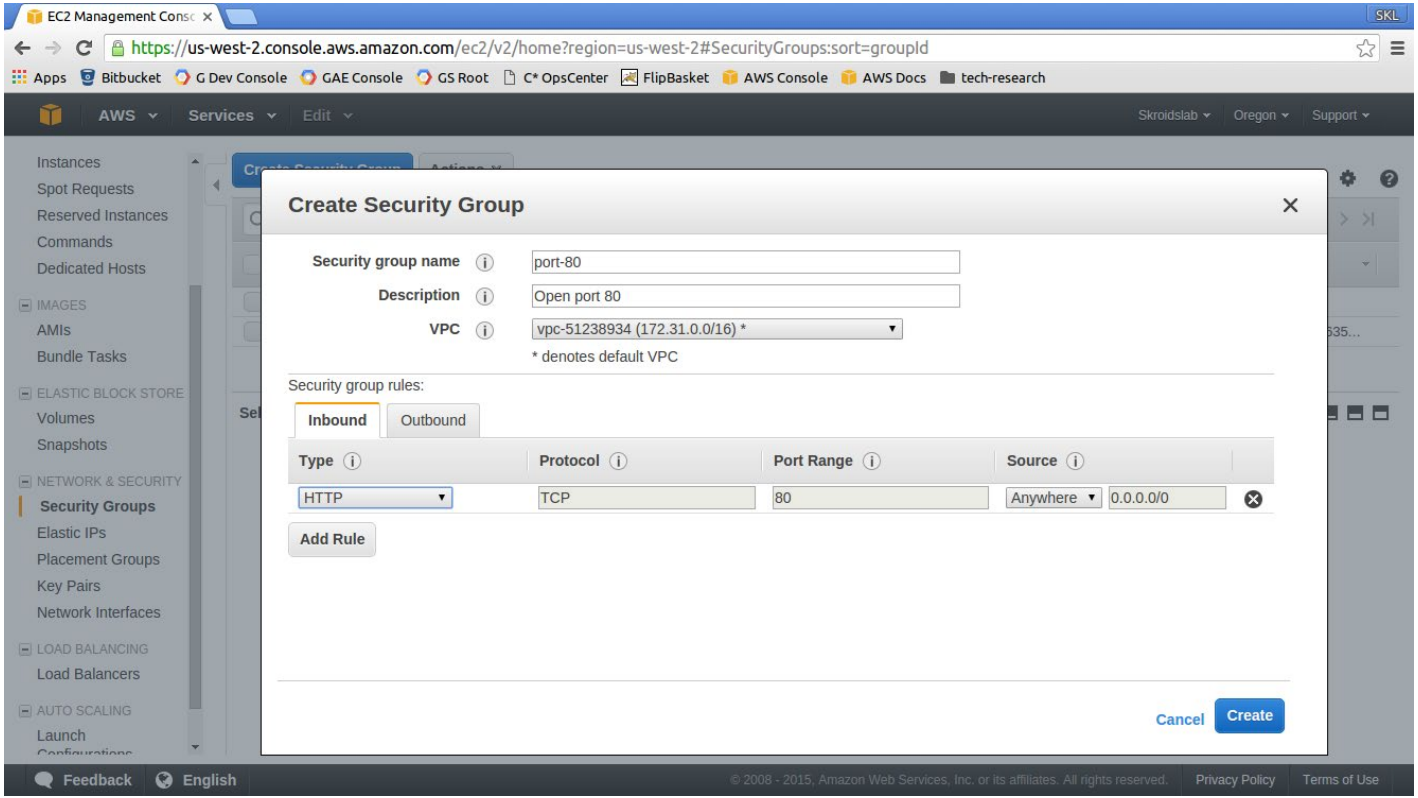

Activity - Security group

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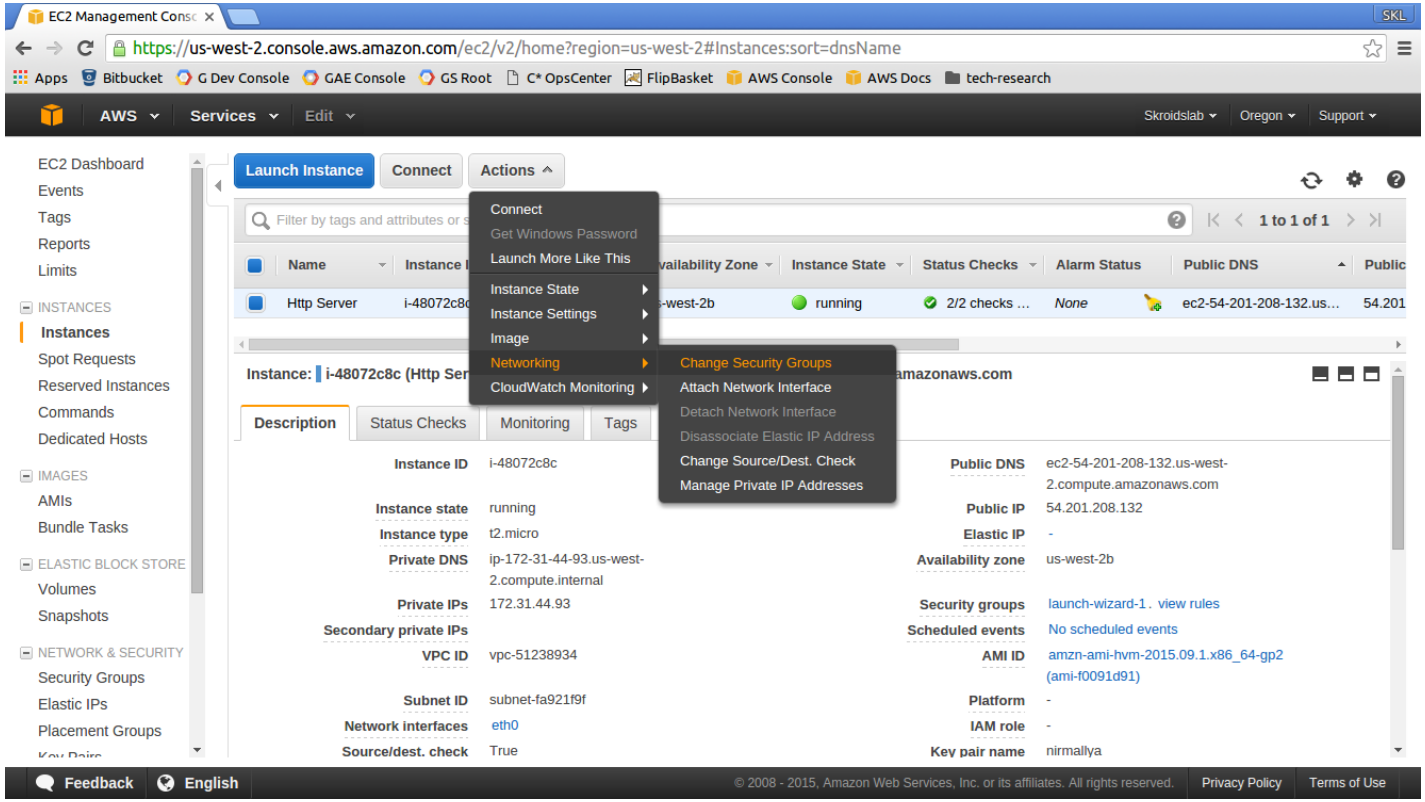
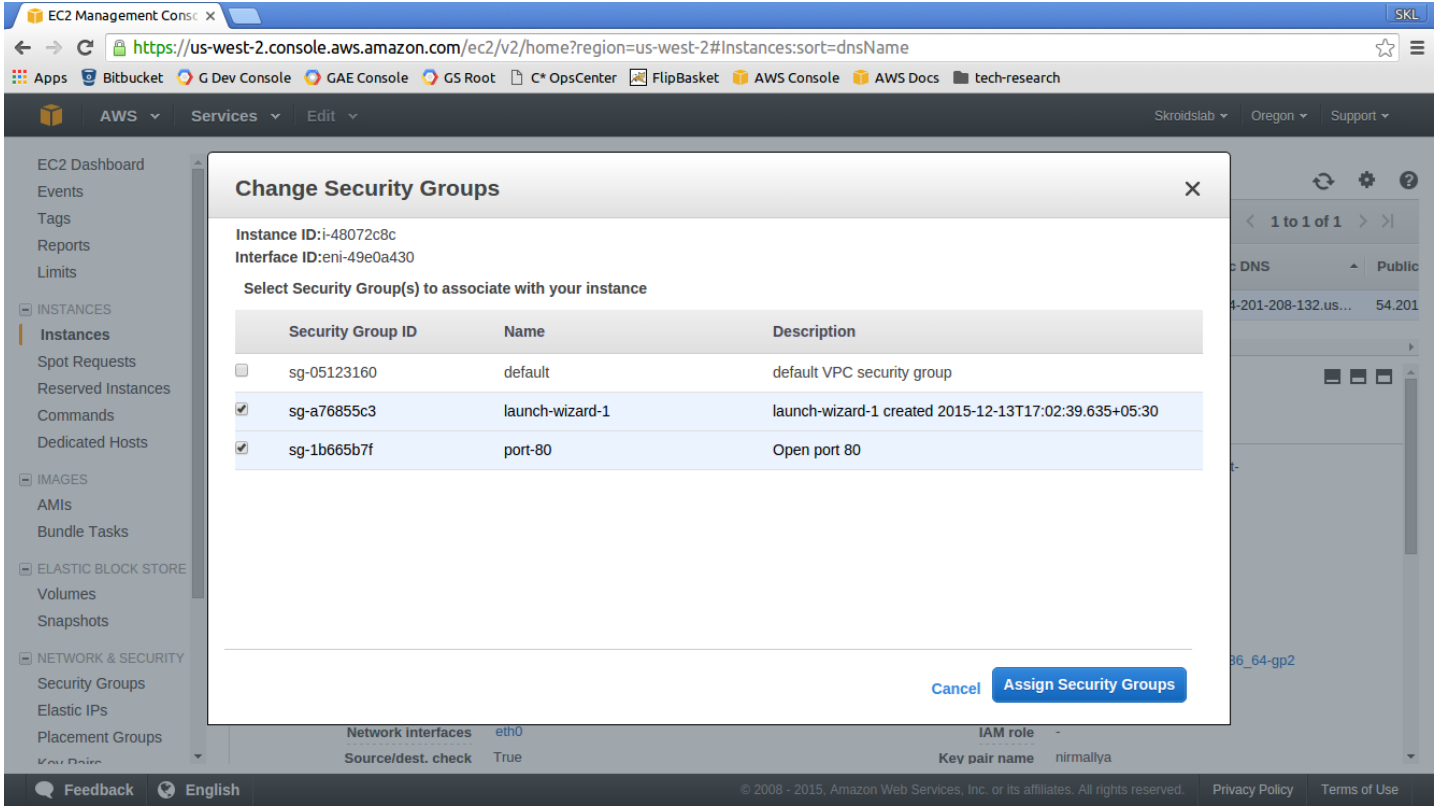


Activity - Security group

greatlearning



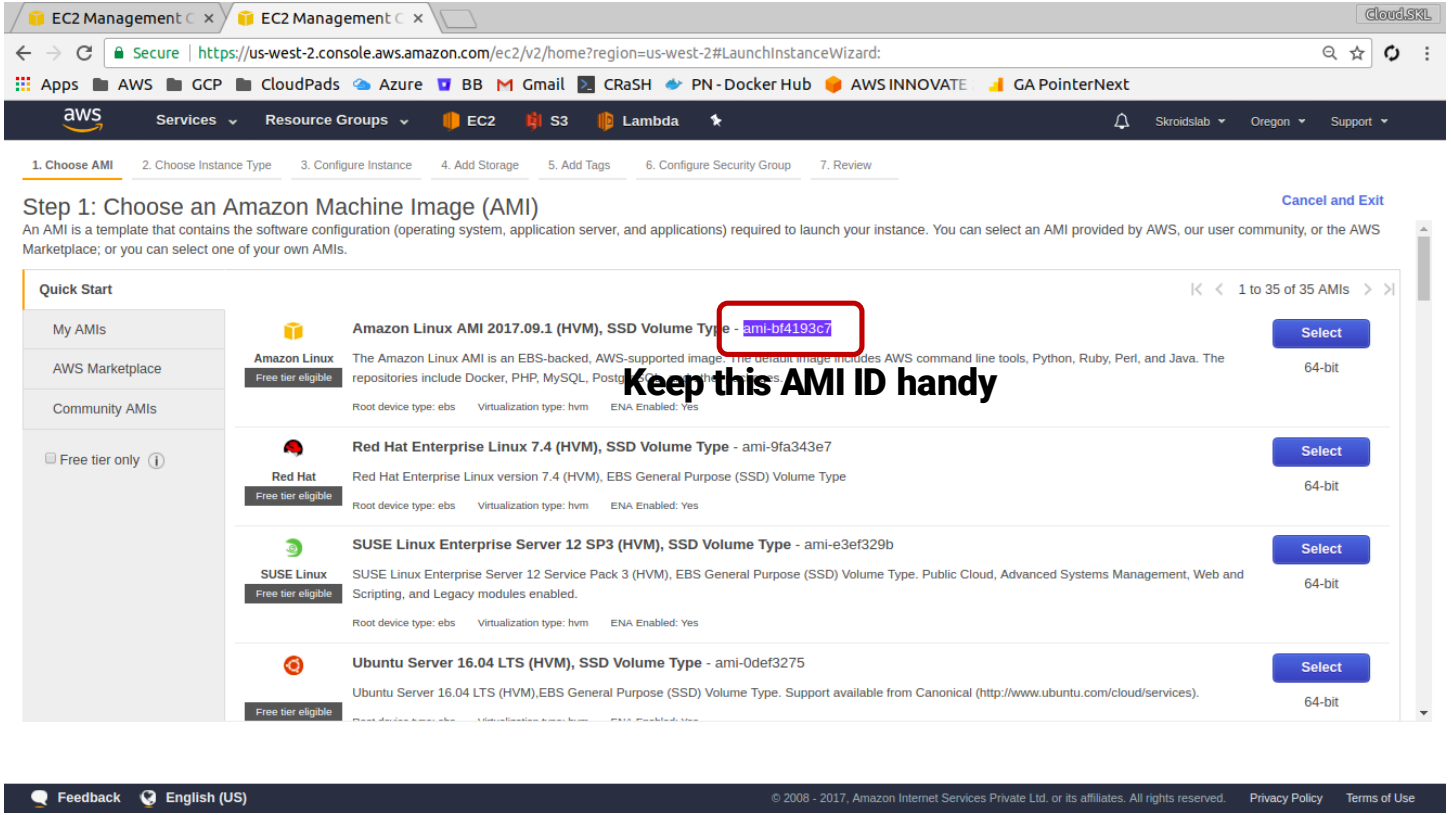
Fleet of EC2 instances

greatlearning

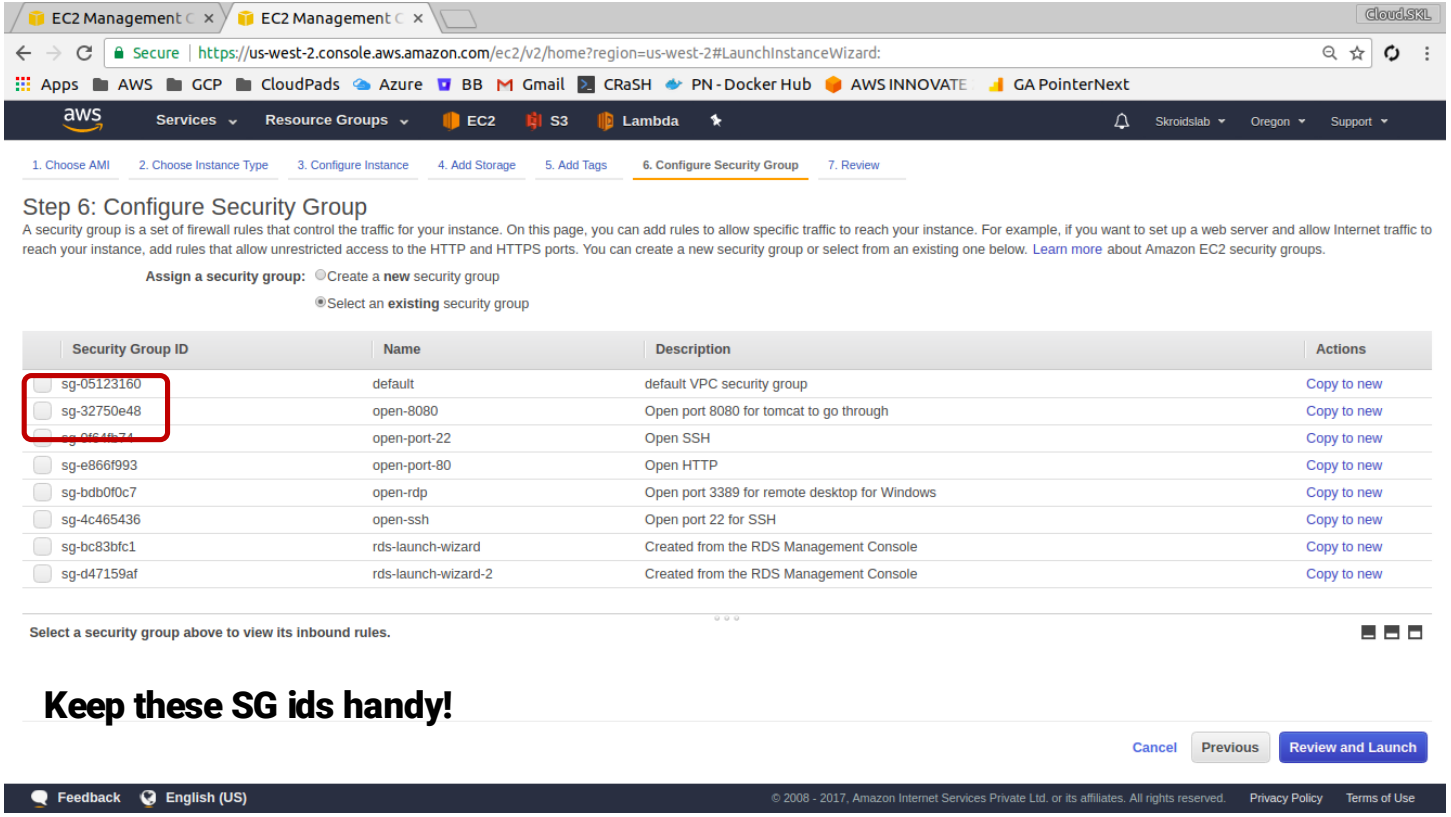
- We have one instance and are able to access the site with the direct IP address
- However, we would like to have a design where we have more than 1 server hiding behind a load balancer(LB)
- Concept
  - Create multiple instances in availability regions defined by the subnets
  - Point the LB to these multiple instances
- Exercise
  - We will use EC2 instance "Launch Templates"
  - Create 2 more EC2 instance in the same VPC but use a different subnet

Activity - Instance template

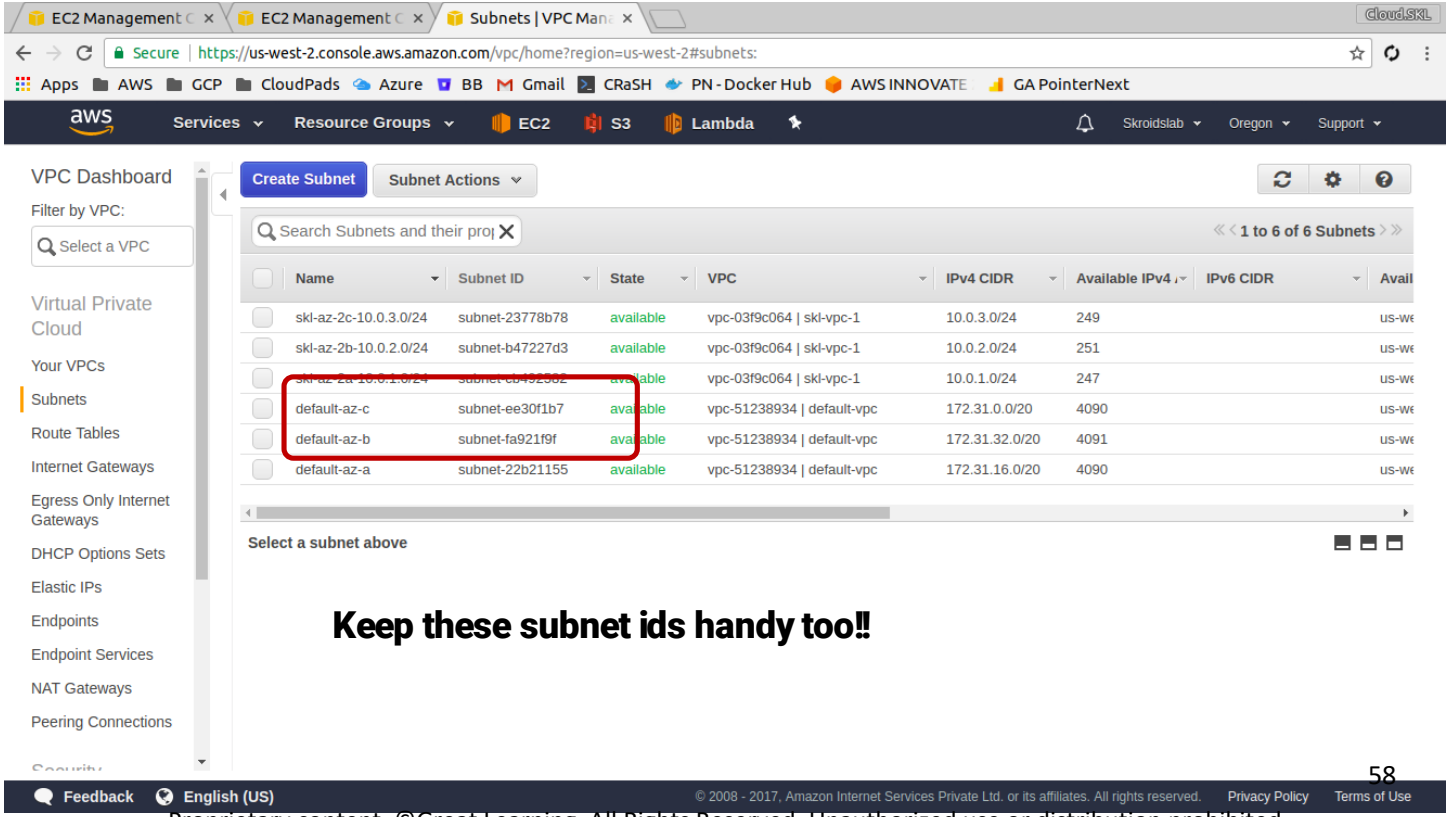
greatlearning



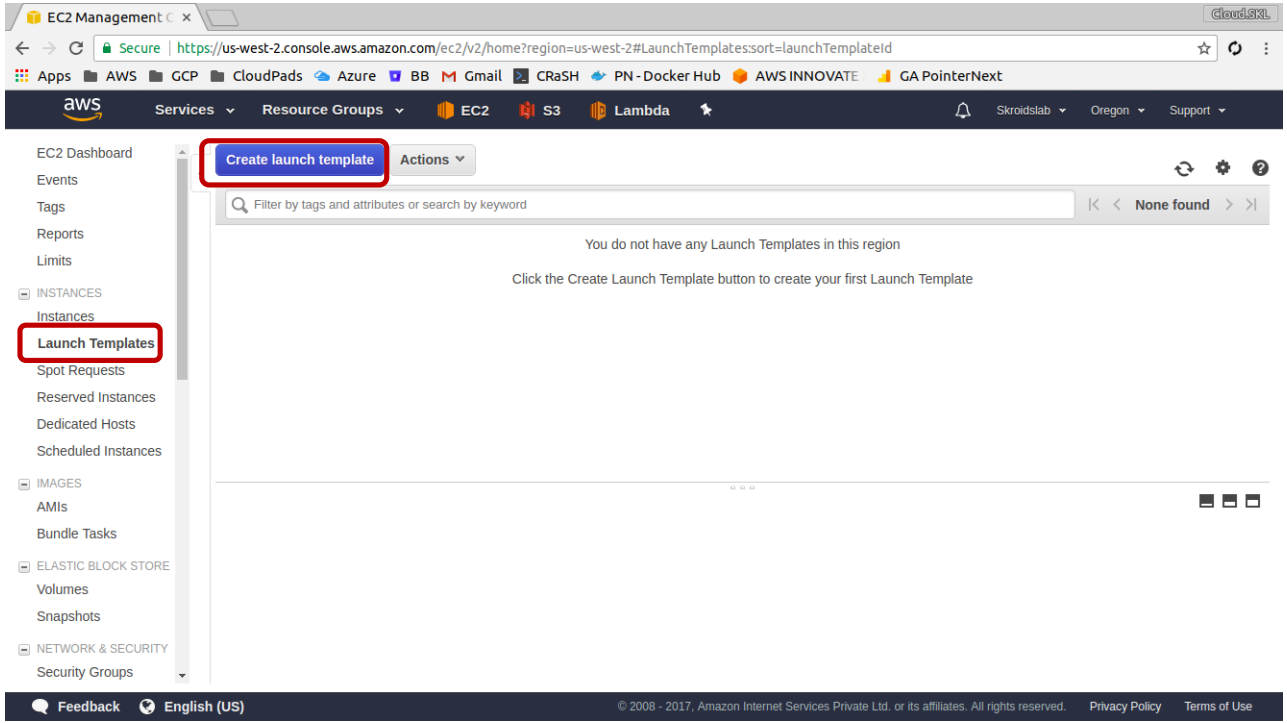
Activity - Instance template



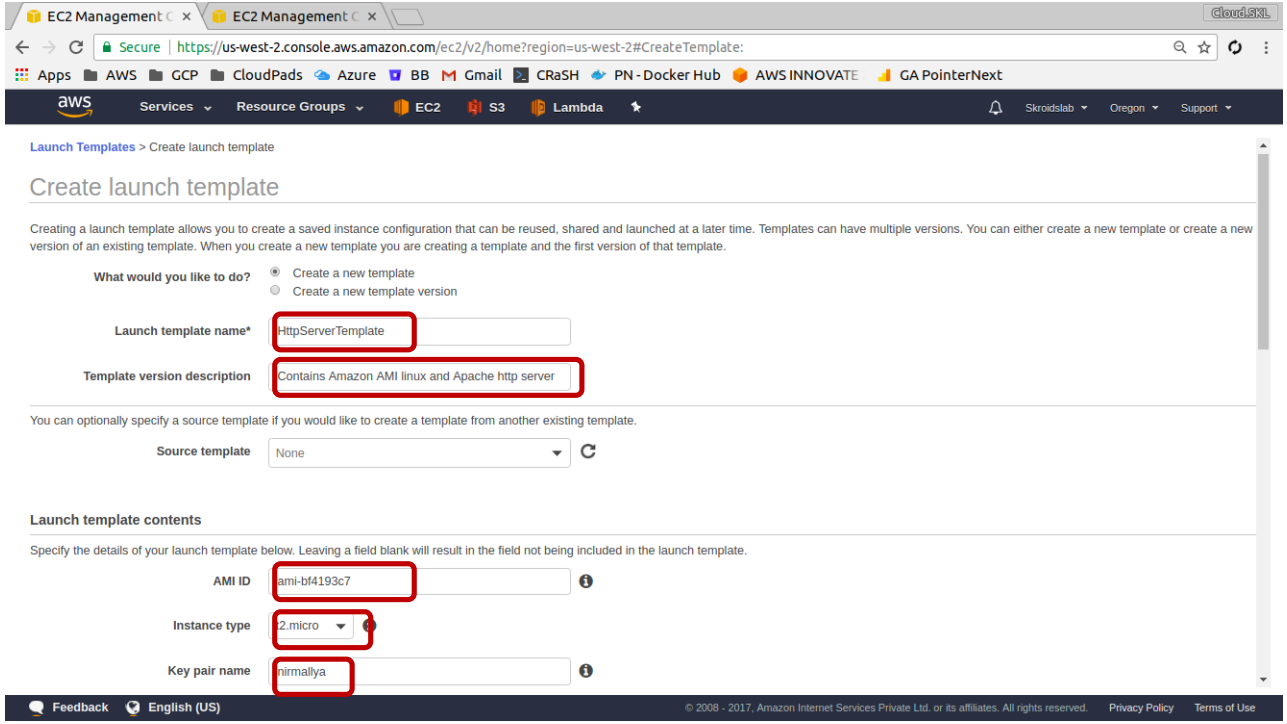
Activity - Instance template



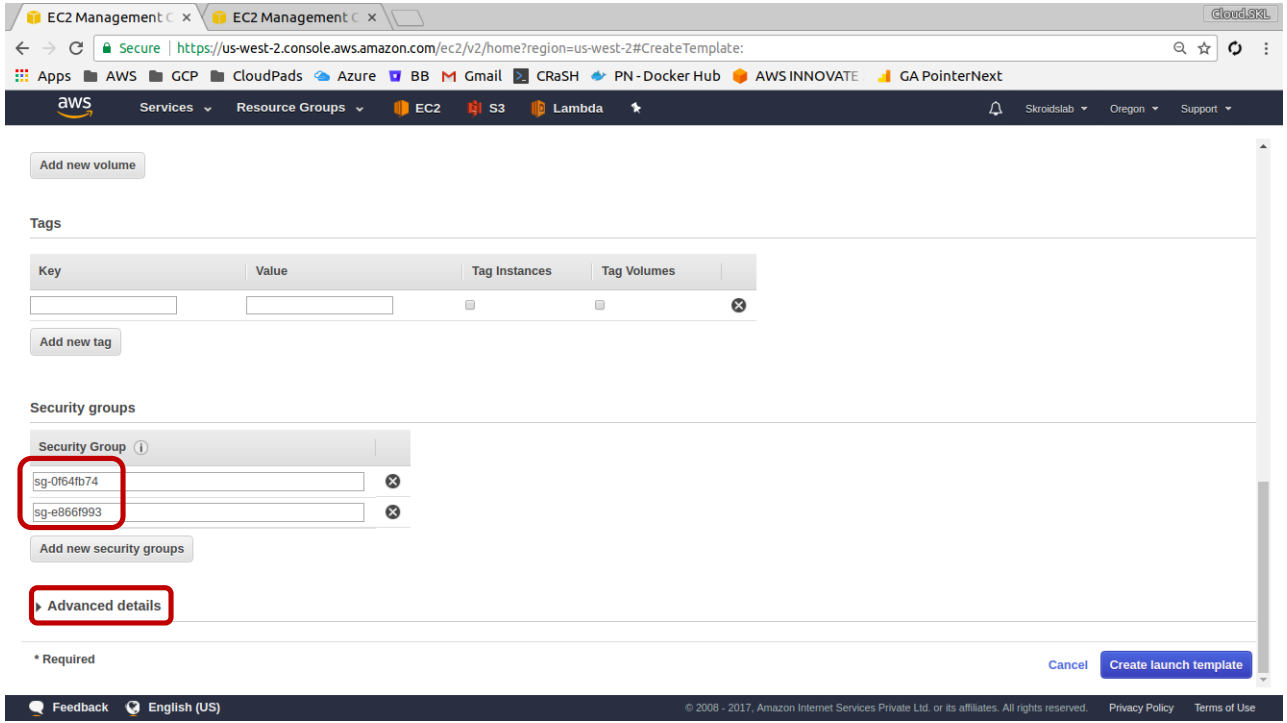
Activity - Instance template



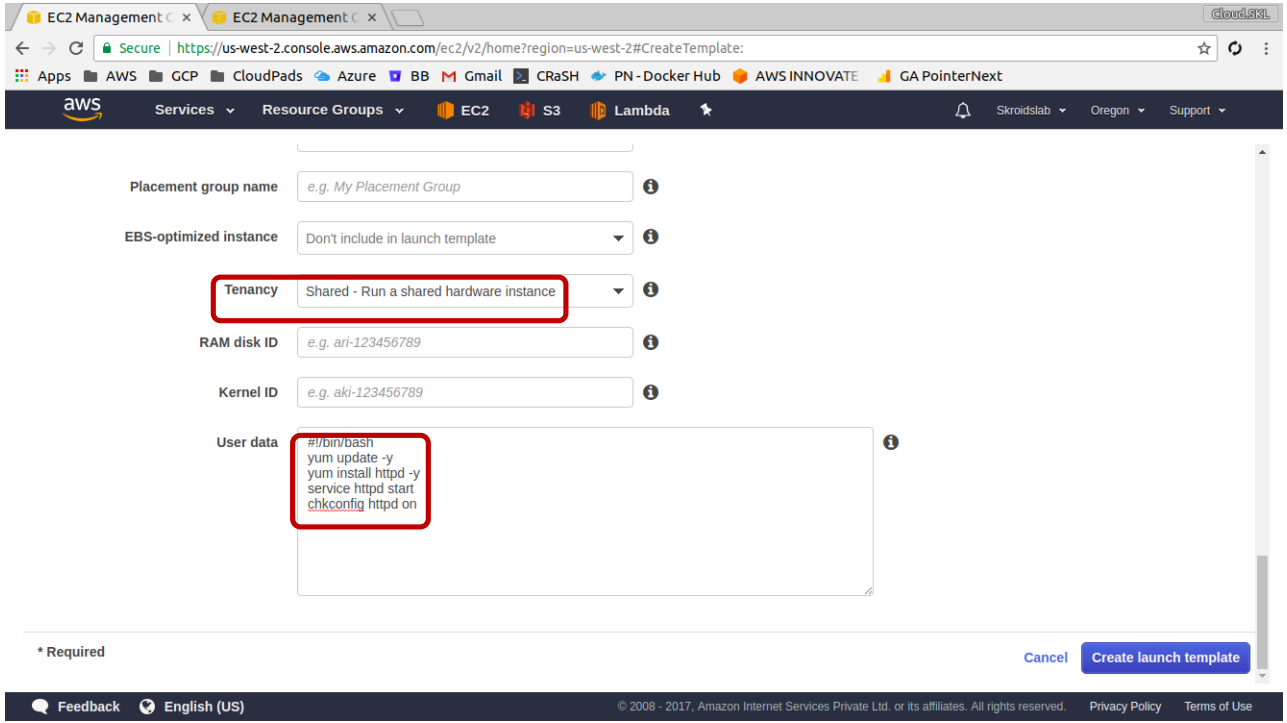
Activity - Instance template



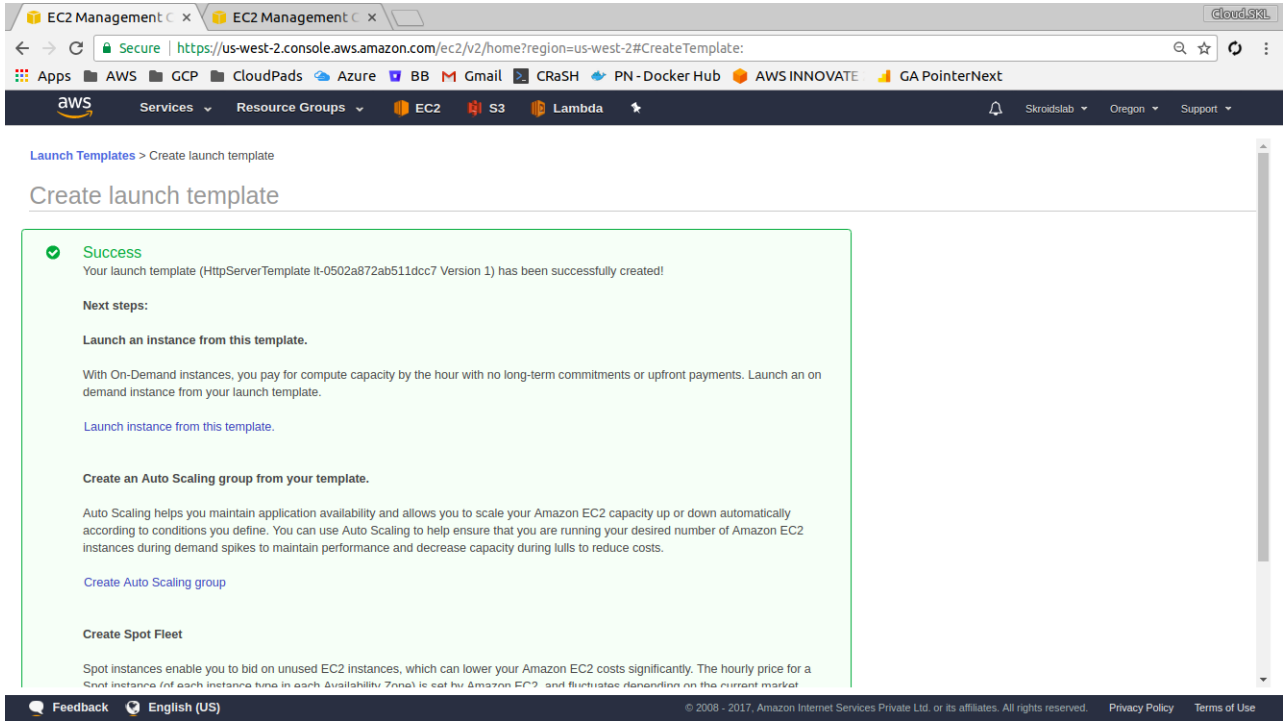
Activity - Instance template



Activity - Instance template

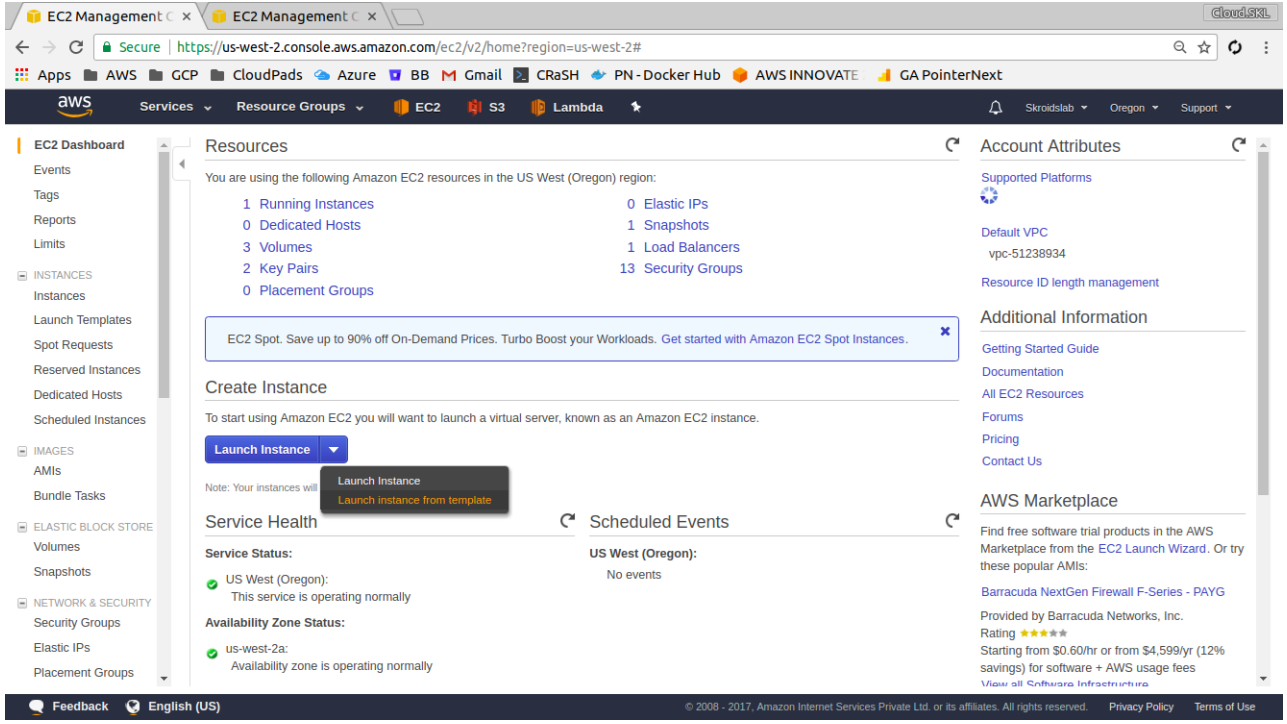


Activity - Instance template



Activity - Instance template

Launch 2 more instances using the instance template



Activity - Instance template

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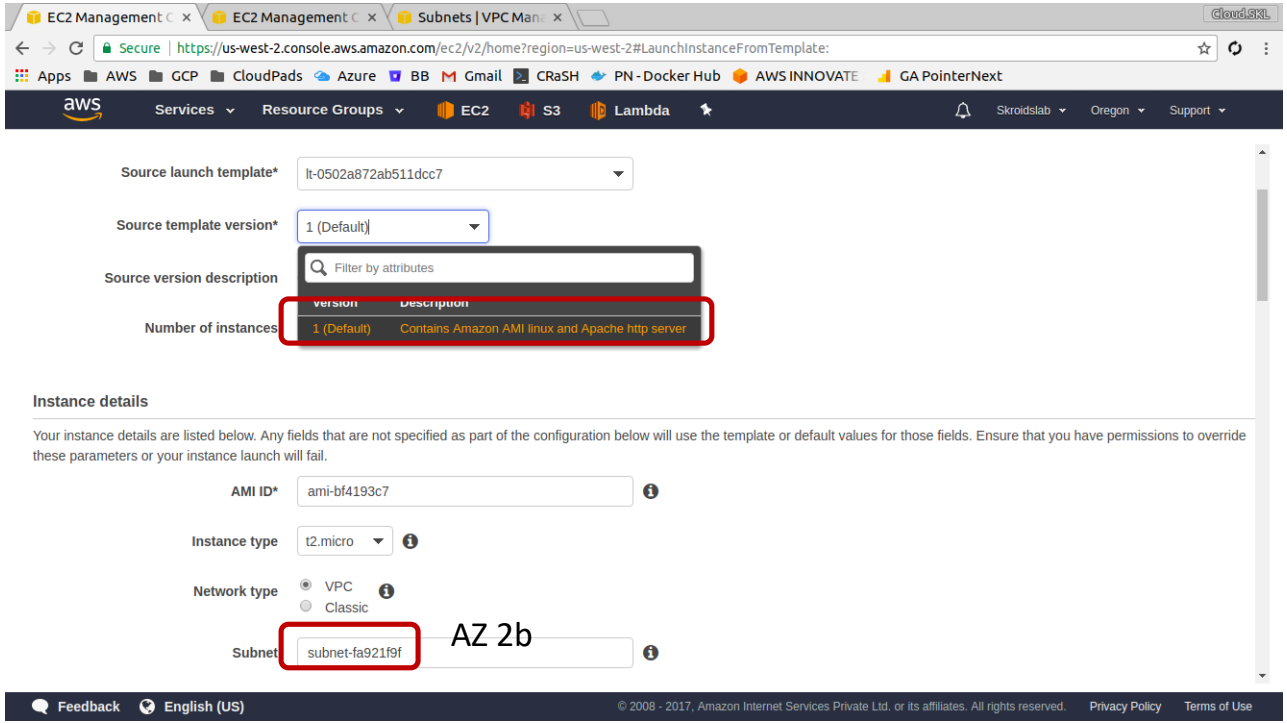
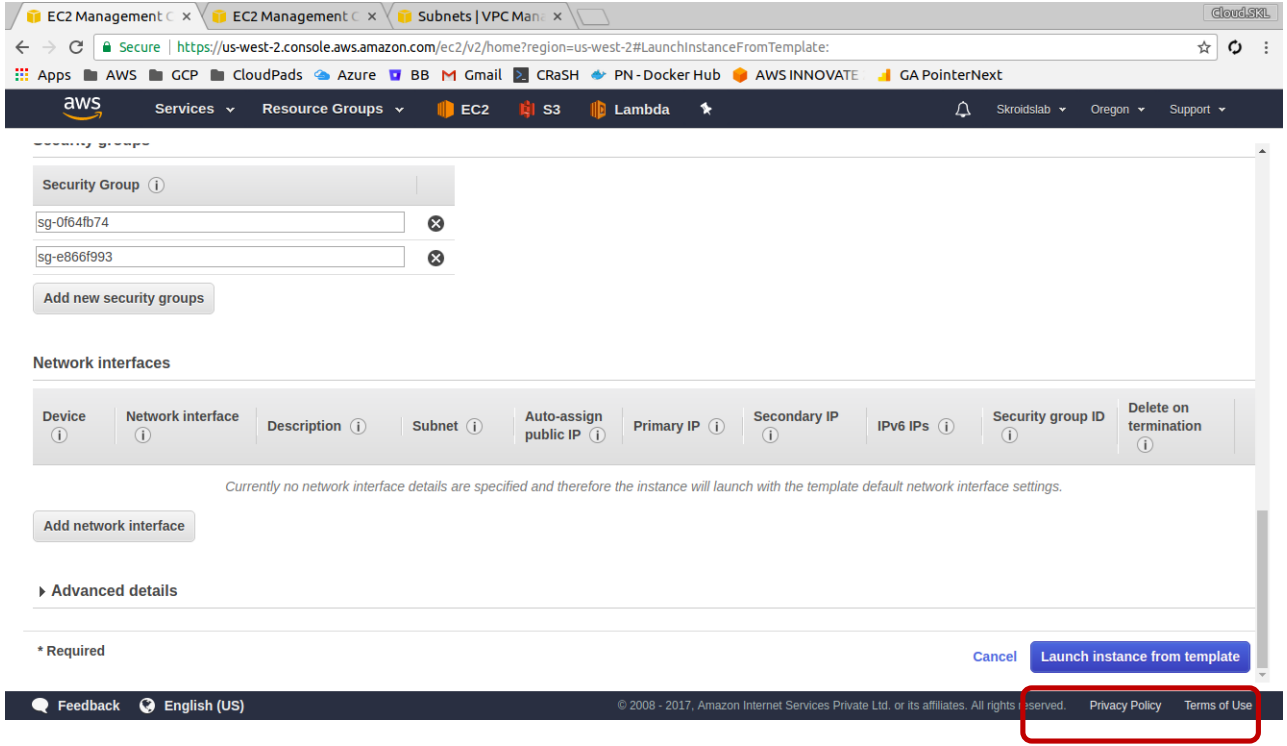


After this add the "tag"

Activity - Instance template



And it says "User Data" needs to be base64 encoded!!!

Activity - Instance template

- Goto https://www.base64encode.org/
  - Click on the "Encode" tab
  - Paste the full user data in the text area
- The encoded string will look like this
  - IyEvYmluL2Jhc2gNCnl1bSB1cGRhdGUgLXkNCnl1bSBpbnN0YWxsIGh0dHBkIC15DQpzZXJ2aWNlIGh0dHBkIHN0YXJ0DQpjaGtjb25maWcgaHR0cGQgb24=

Fleet of EC2 instances

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- Install the apache http server
    - $ sudo yum update
    - $ sudo yum install httpd
    - $ sudo service httpd start
    - $ curl localhost
  - Also create files called index.html & health.html
    - $ sudo su [For root access]
    - # cd /var/www/html
    - # echo "Web server 1" > index.html
    - # echo "ok" > health.html
  - Do this in both instances

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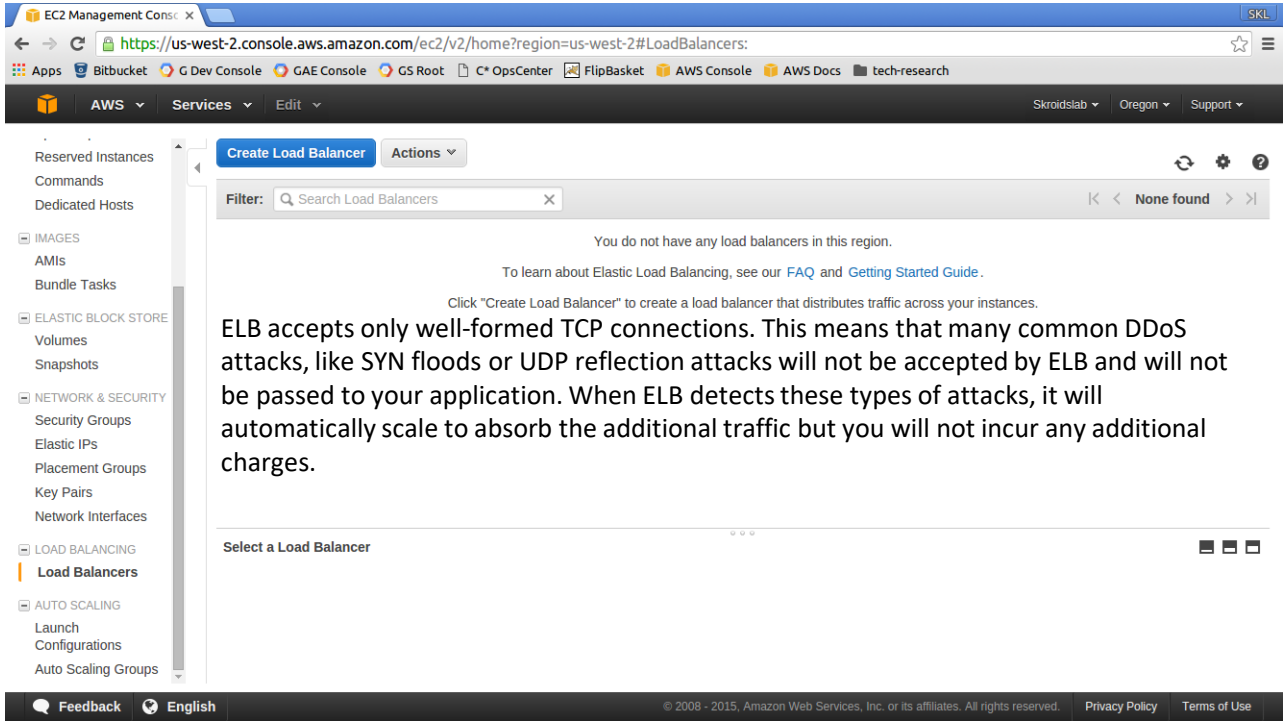
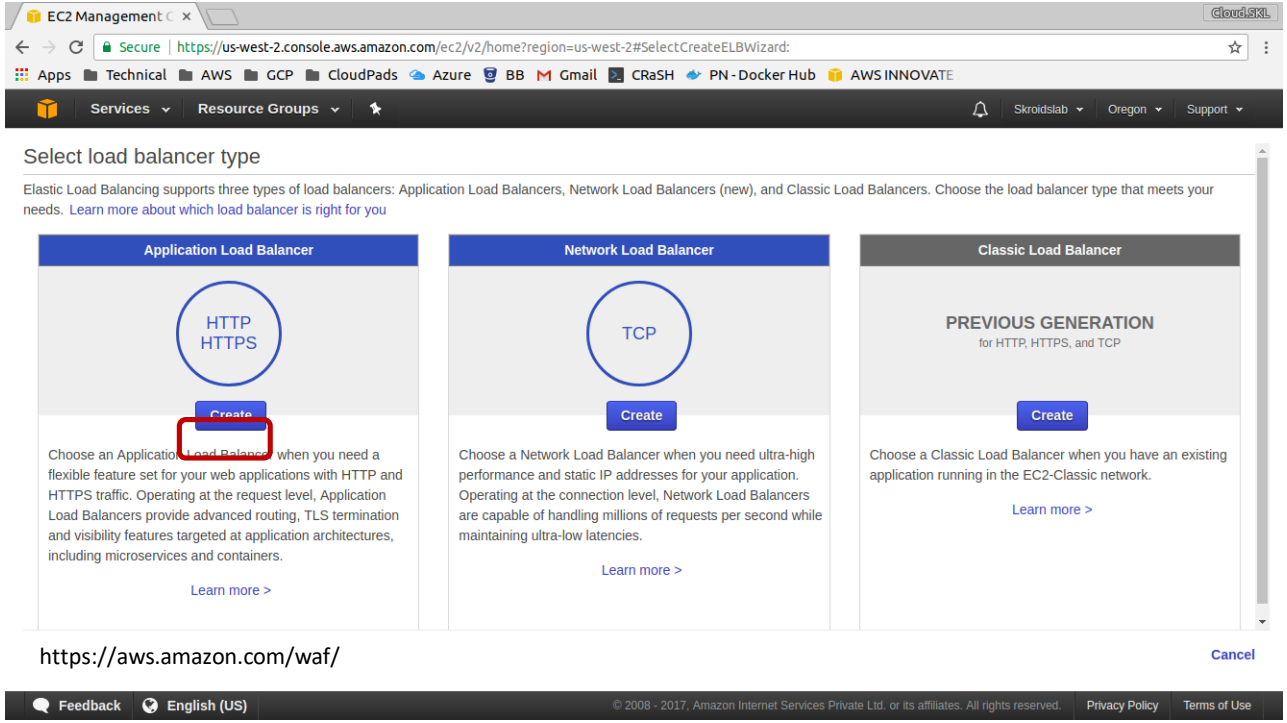
Compute - Part I

Load balancing

Activity - load balancer



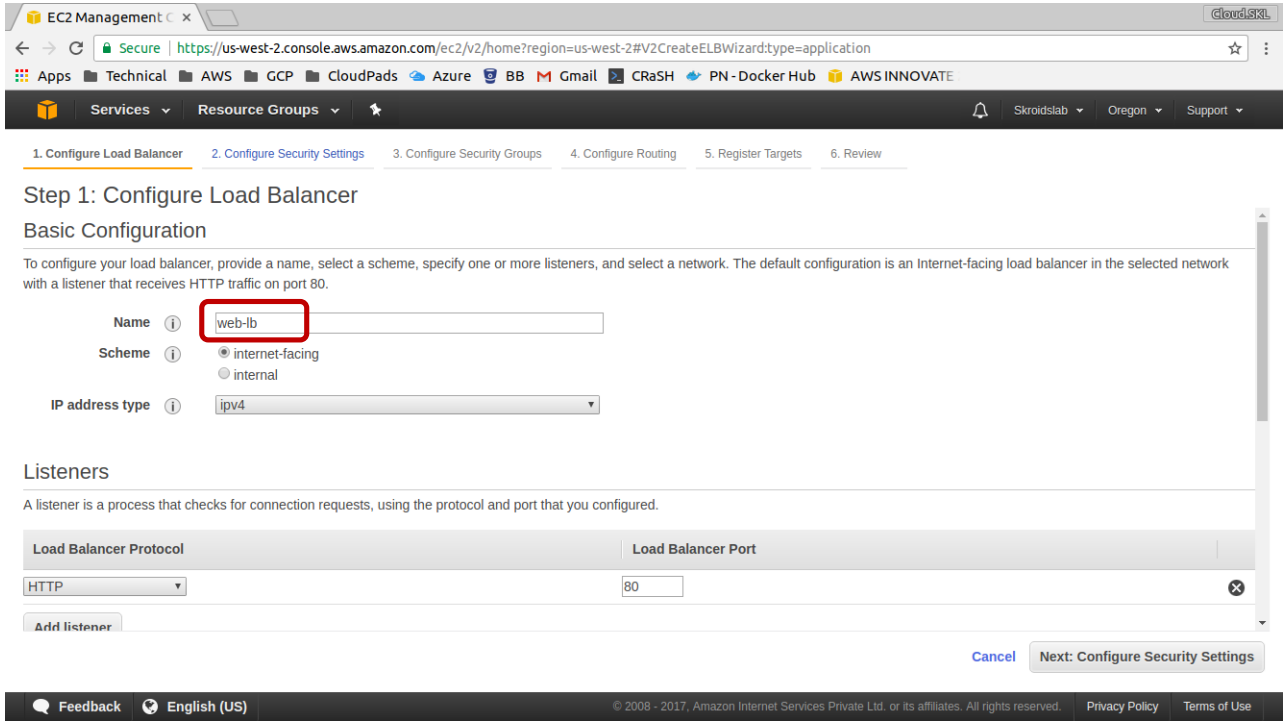
Activity - load balancer



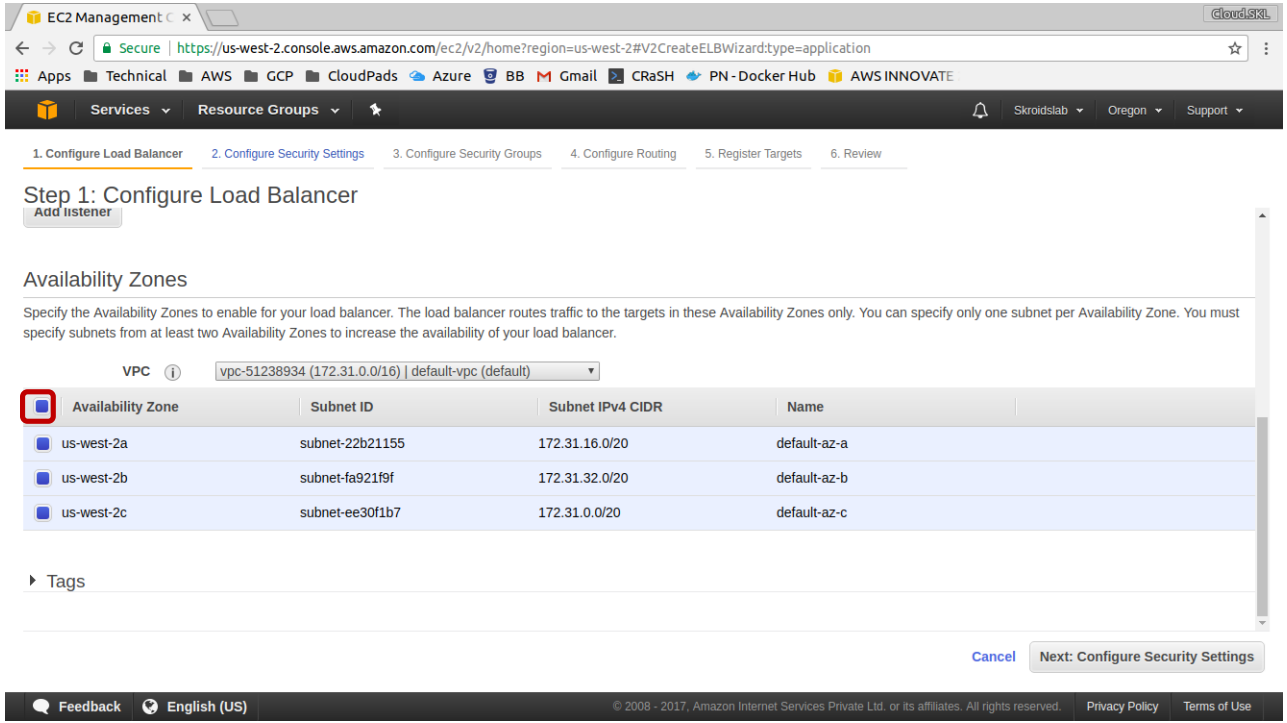
https://aws.amazon.com/waf/

https://aws.amazon.com/blogs/aws/new-application-load-balancing-via-ip-address-to-aws-on-premises-resources

Activity - http load balancer

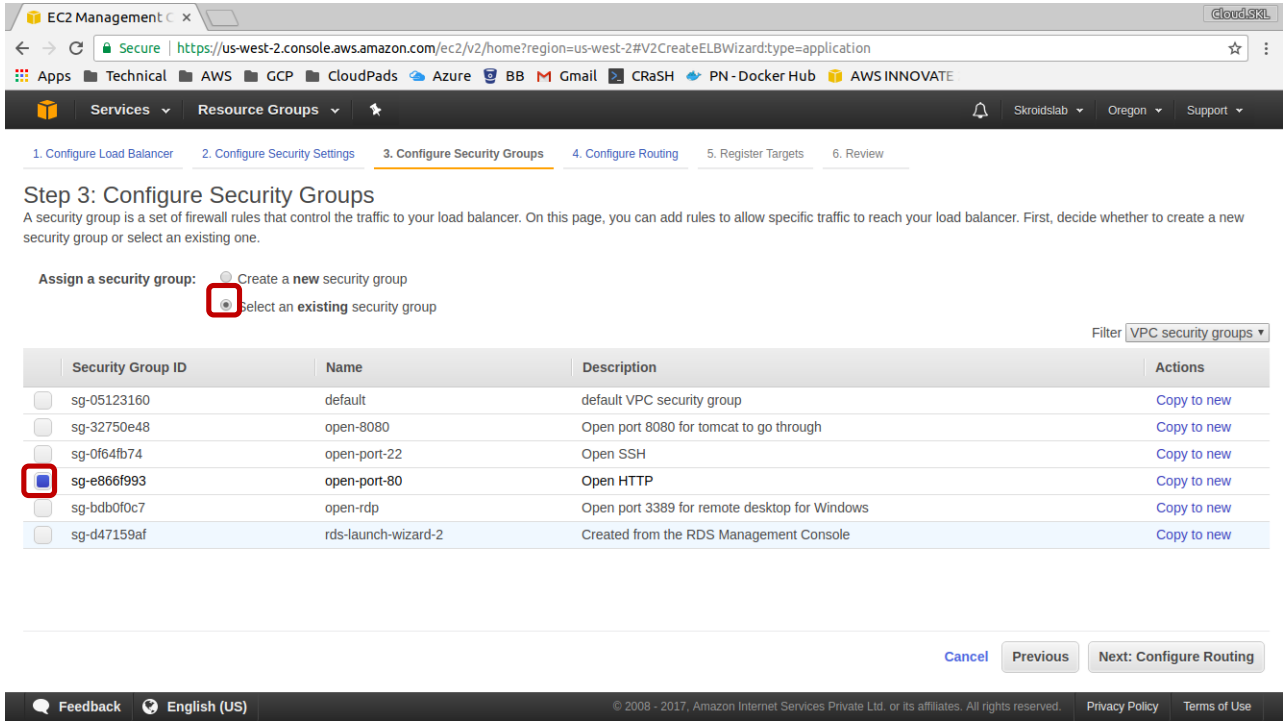


Activity - http load balancer

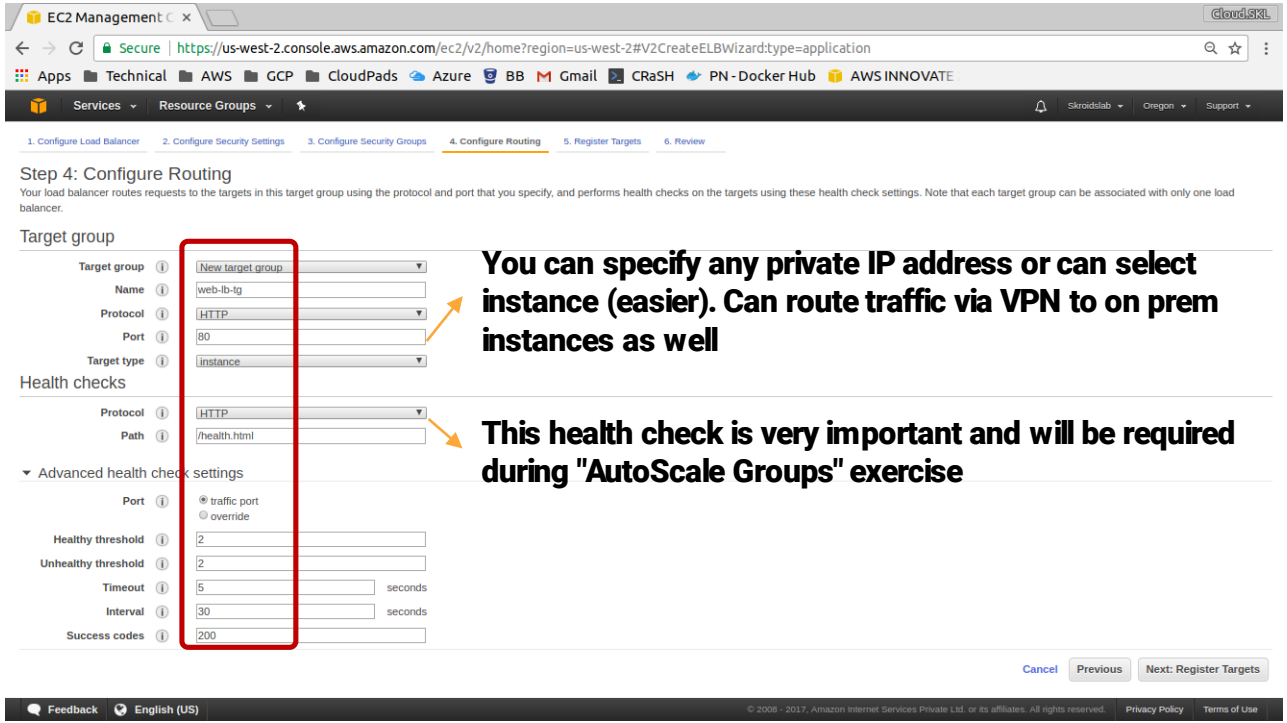


Activity - http load balancer

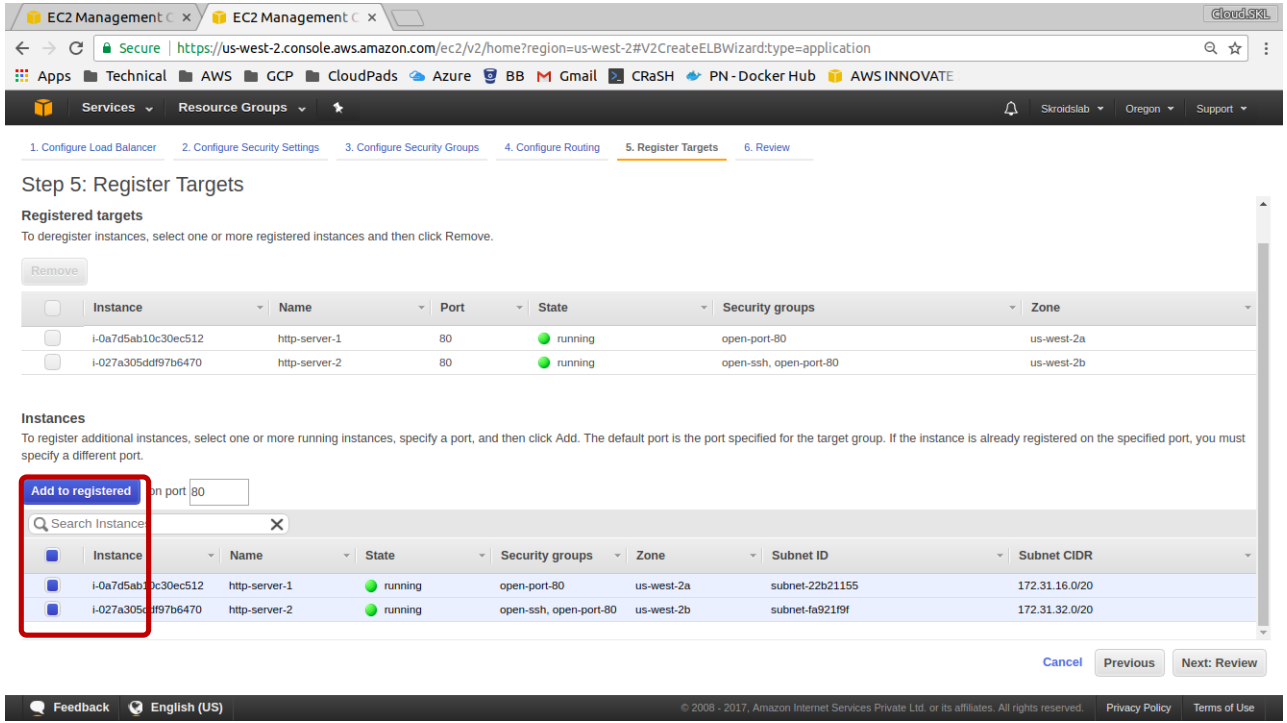
Activity - http load balancer



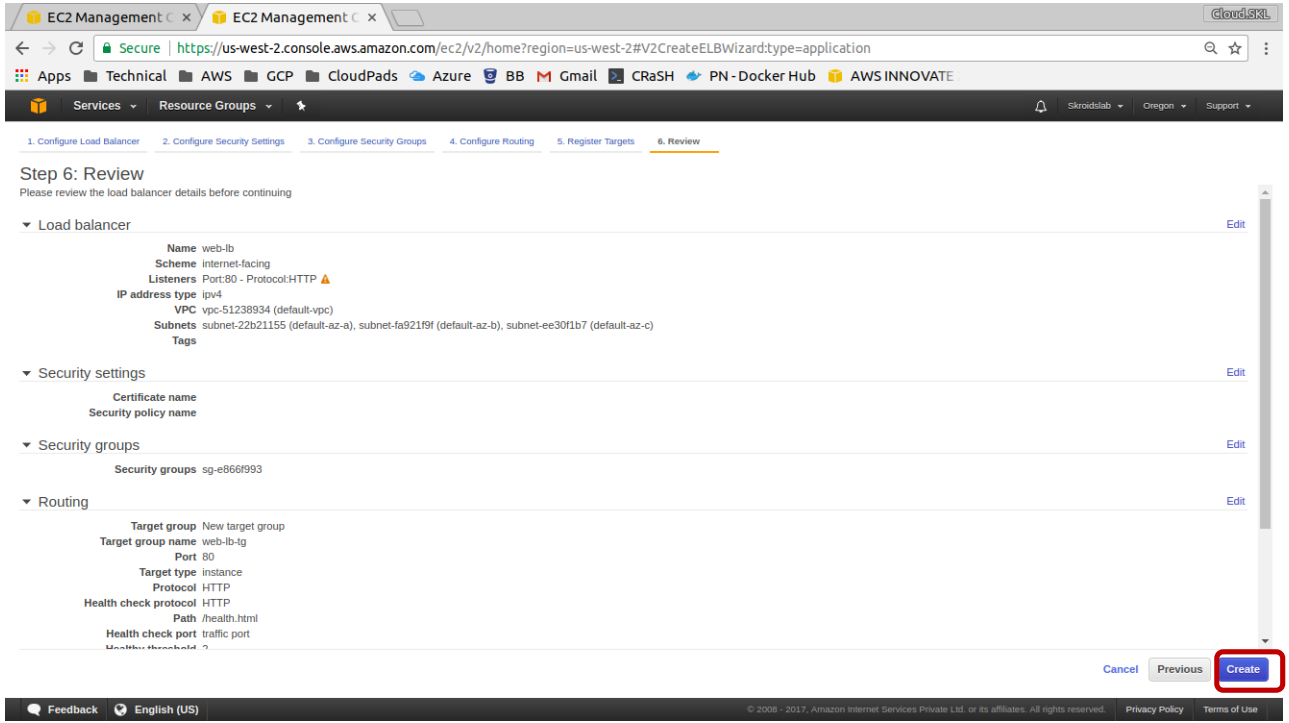
Activity - http load balancer



Activity - http load balancer



Activity - http load balancer



Activity - http load balancer

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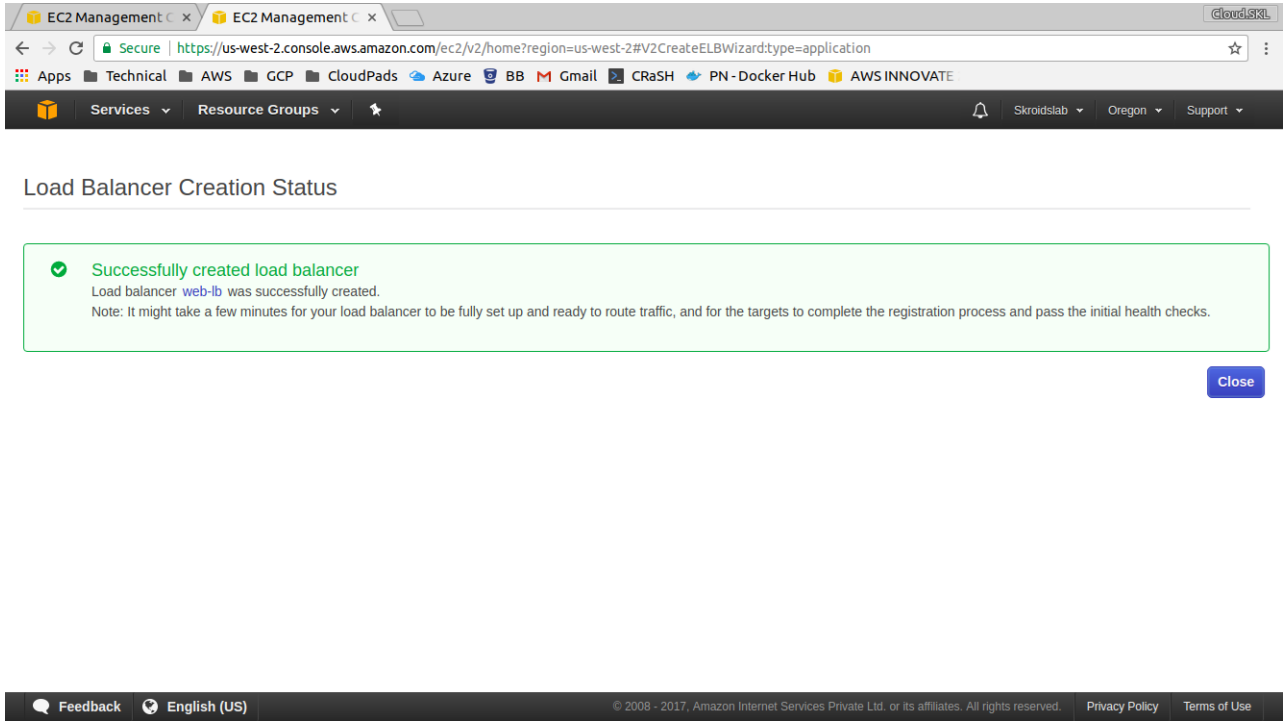
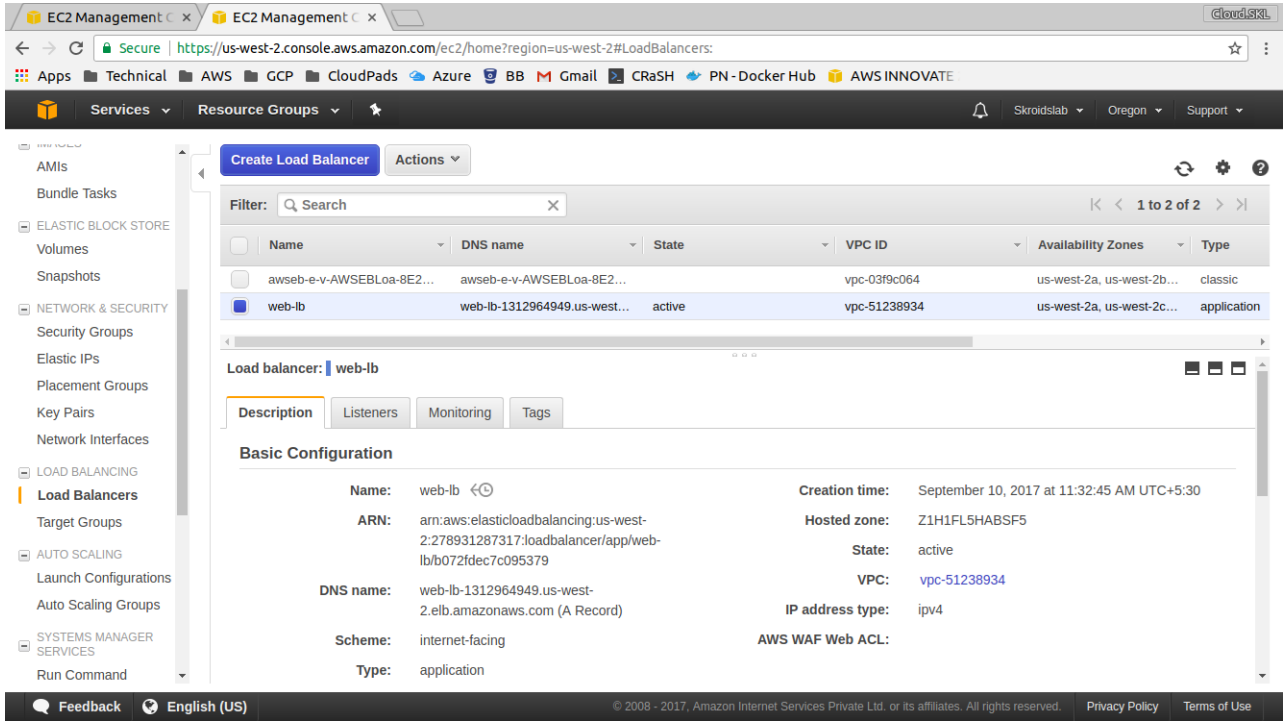
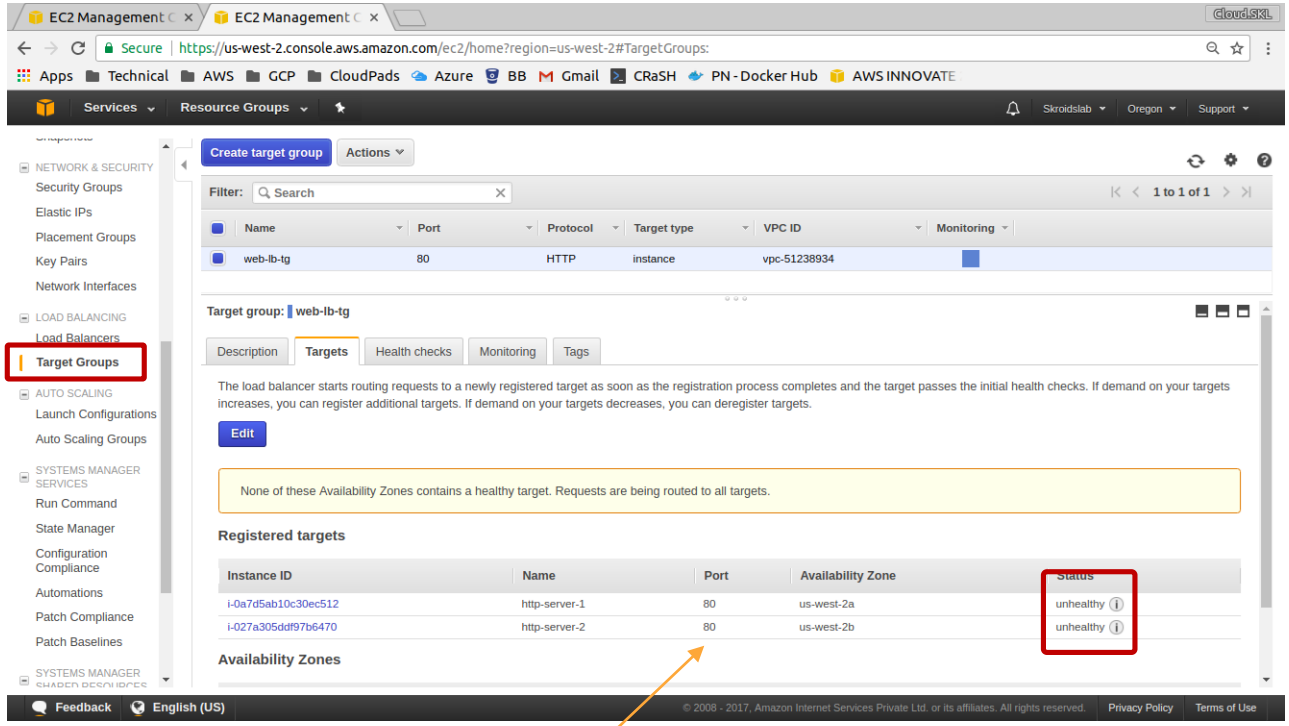


Activity - http load balancer



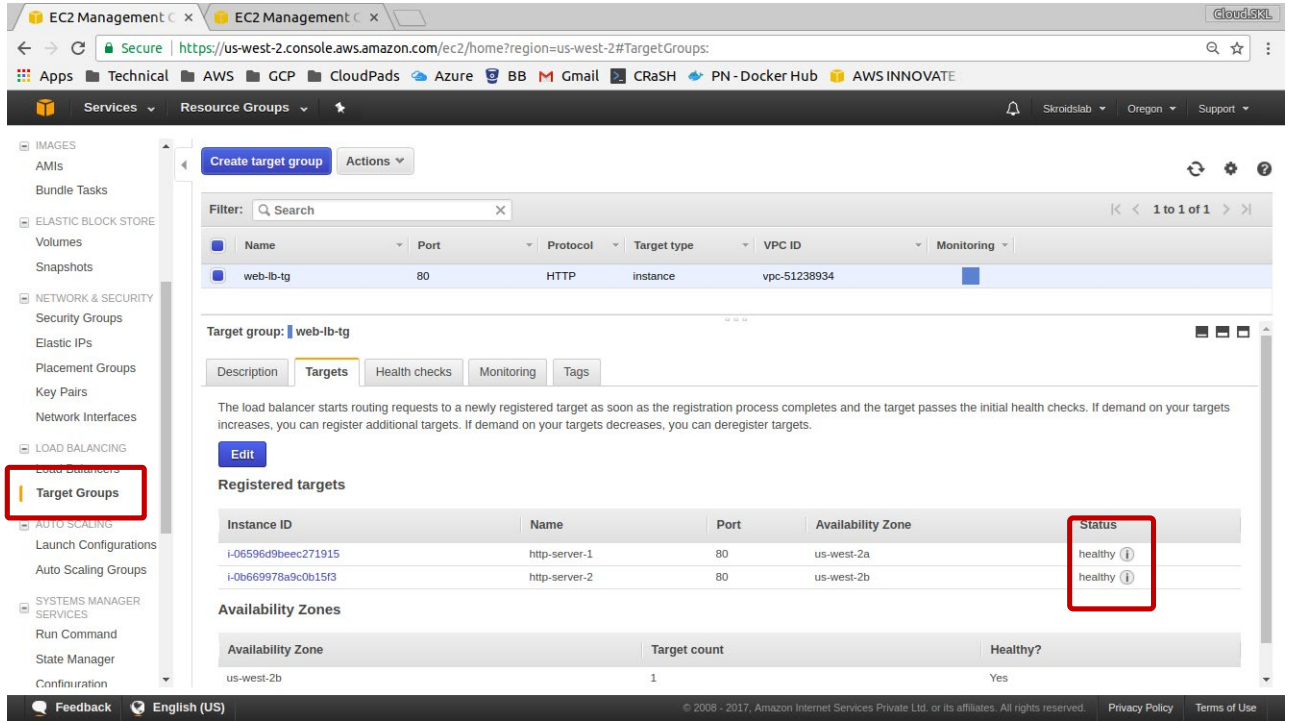
Activity - http load balancer

greatlearning



Port from the http LB is automatically mapped

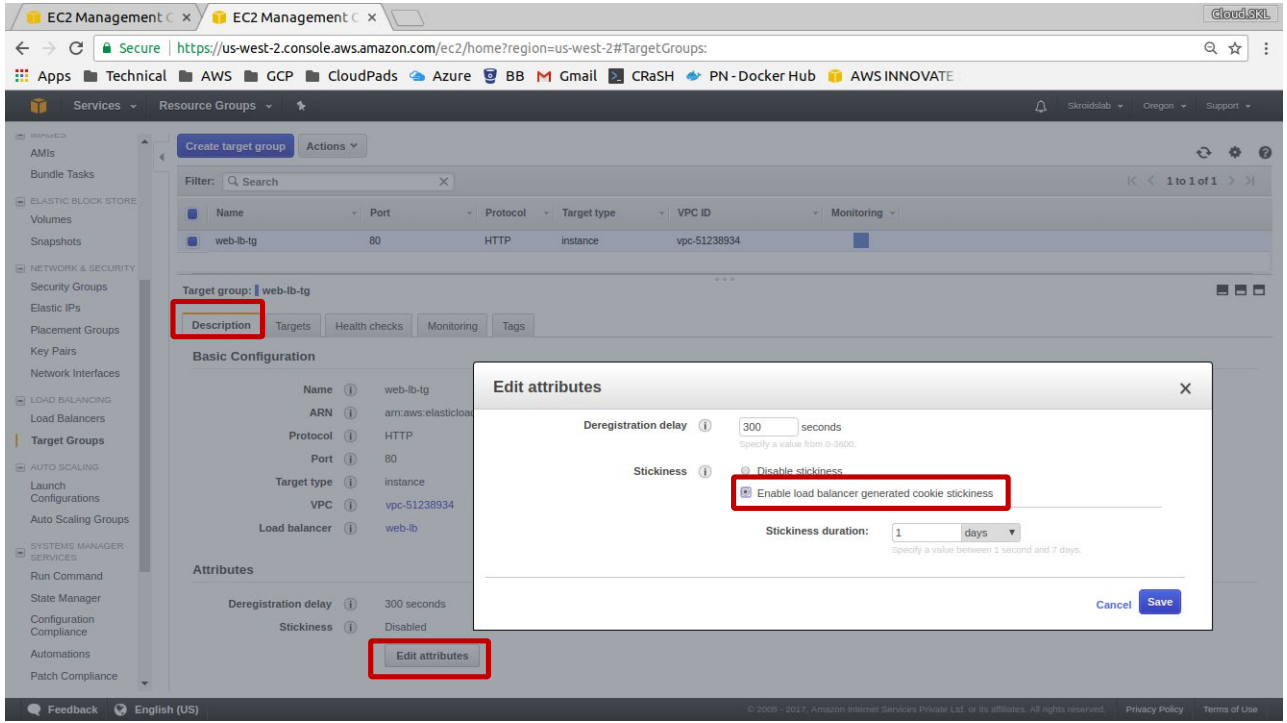
Activity - http load balancer



Activity - load balancer

- Hit the load balancer using the DNS name
- No IP address will be provided, it may be changed by AWS
- Not a best practice of accessing LB using IP address
- Hit the DNS a few times and see the content change as the request shifts from one server to the other
- You can configure alarms
- LB always gives you a public DNS and not a public IP
- ACTIVITY -> Simulate a failure by shutting down an instance
- DEBATE -> You can enable LB to "instance stickiness" (next...)

Activity - load balancer



Reference - classic load balancer

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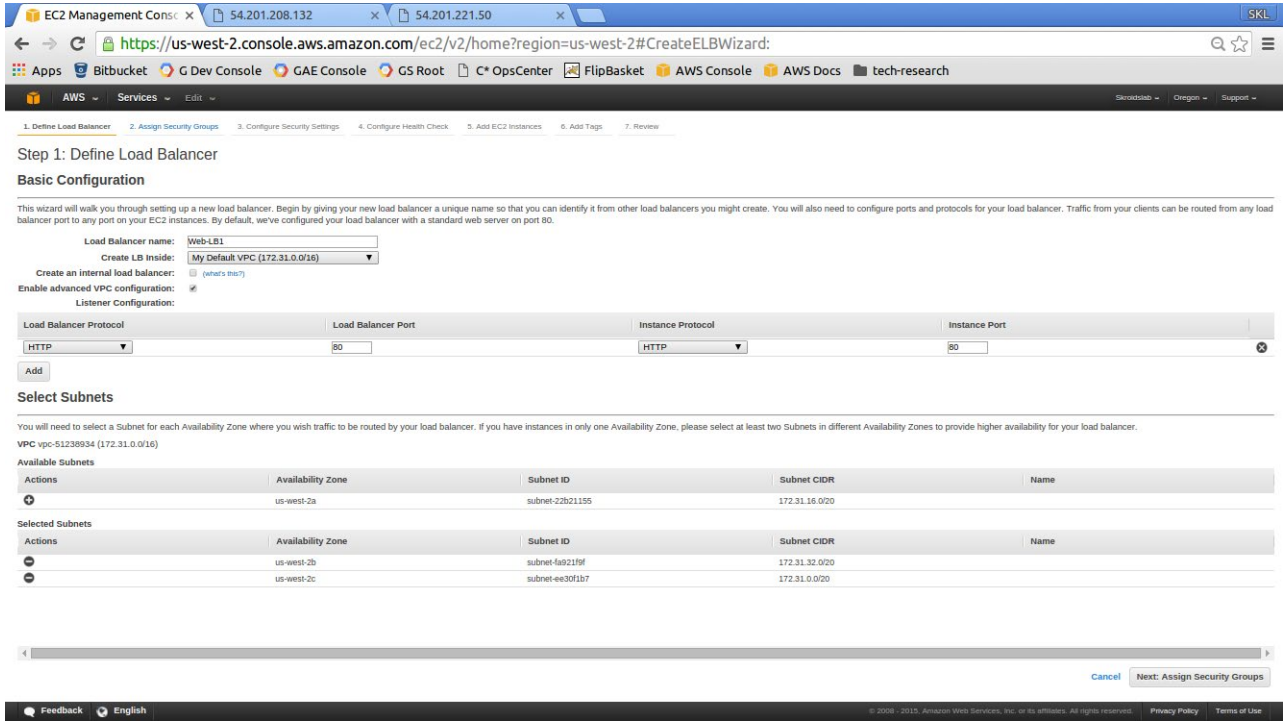
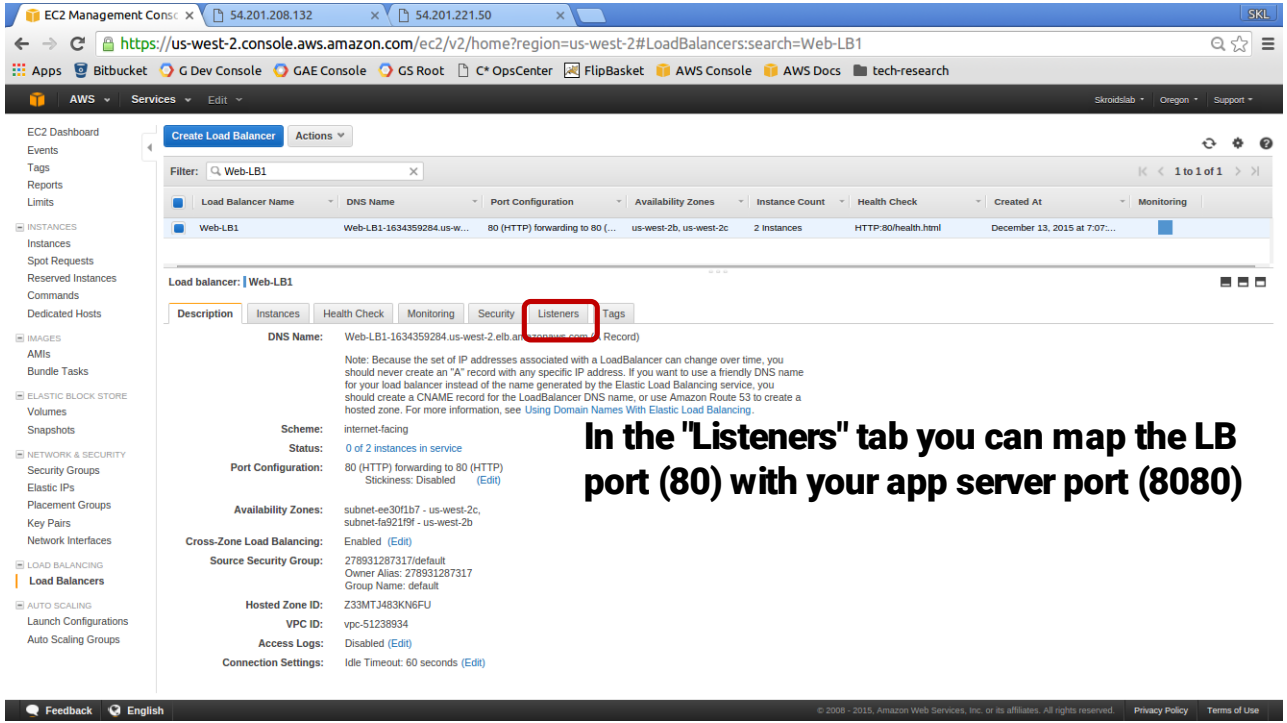


Reference - classic load balancer



In the "Listeners" tab you can map the LB port (80) with your app server port (8080)

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Compute - Part I

Web Application Firewall (WAF)

Shield - discussion

WAF exercise prerequisites

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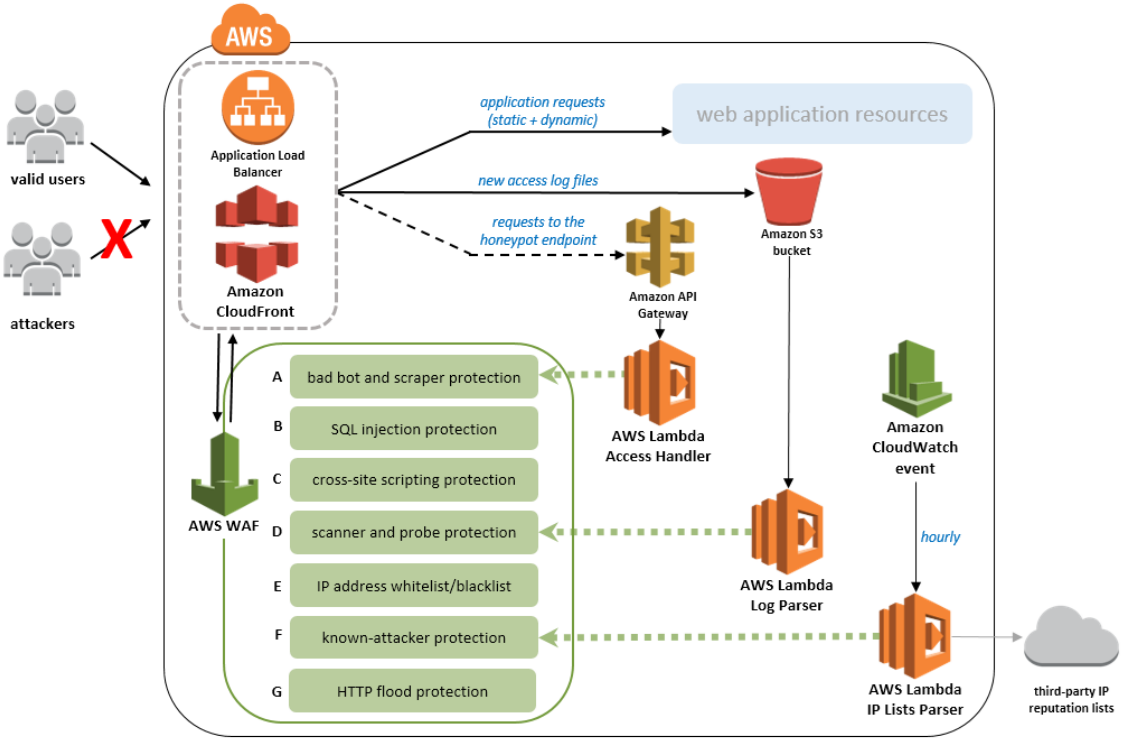
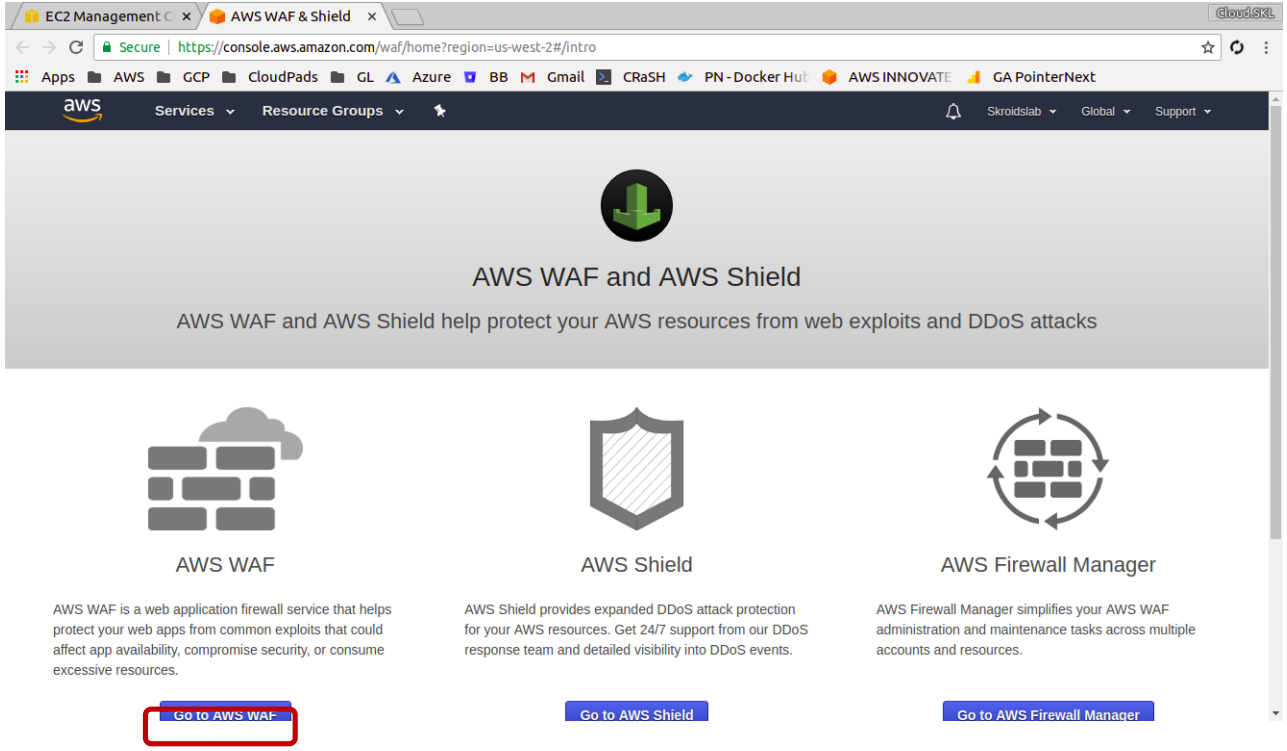
- Any web application hosted on EC2
- Serving traffic on port 80
- Application load balancer with a target group having the EC2 instance
- WAF pricing: https://aws.amazon.com/waf/pricing/
  - $5 per web ACL per month
  - $1 per rule per web ACL per month
  - $0.60 per million web requests
- Shield standard and advanced https://docs.aws.amazon.com/waf/latest/developerguide/ddos-overview.html
- Tutorials: https://docs.aws.amazon.com/waf/latest/developerguide/tutorials.html
- Popular rules: https://github.com/aws-samples/aws-waf-sample

LB and WAF & other components



WAF can sit in front of LB or CDN

WAF



WAF

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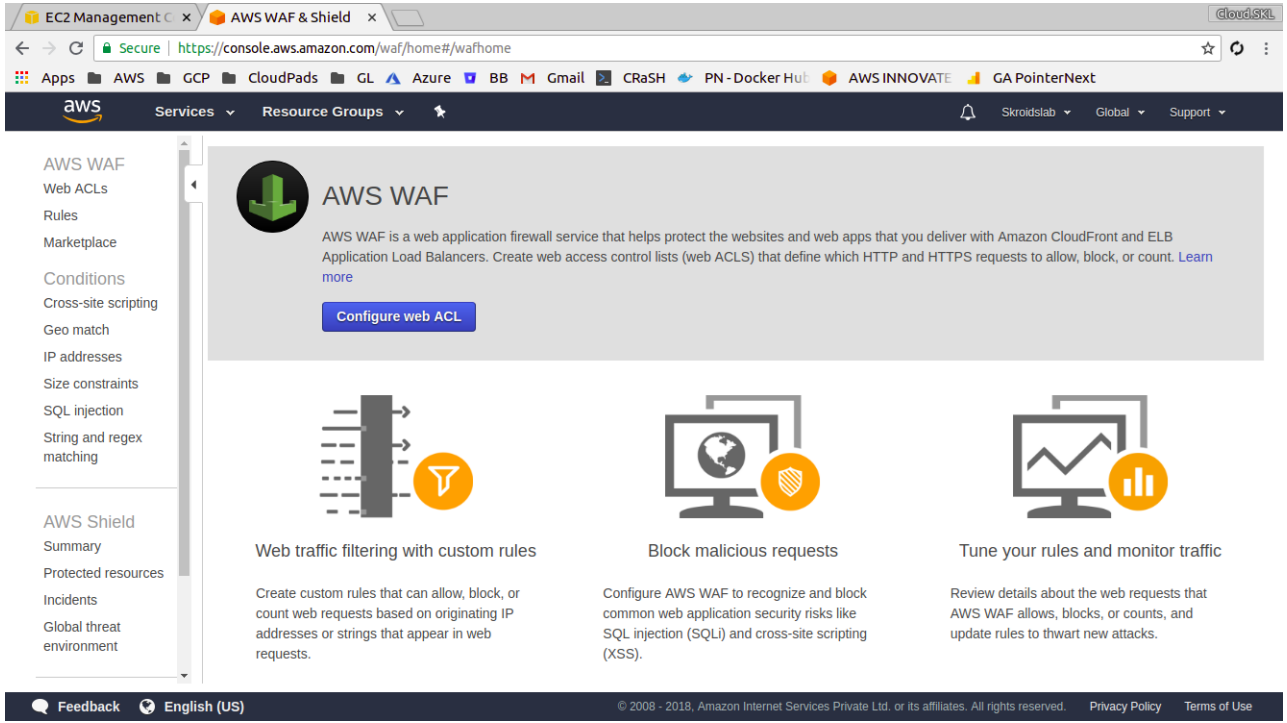
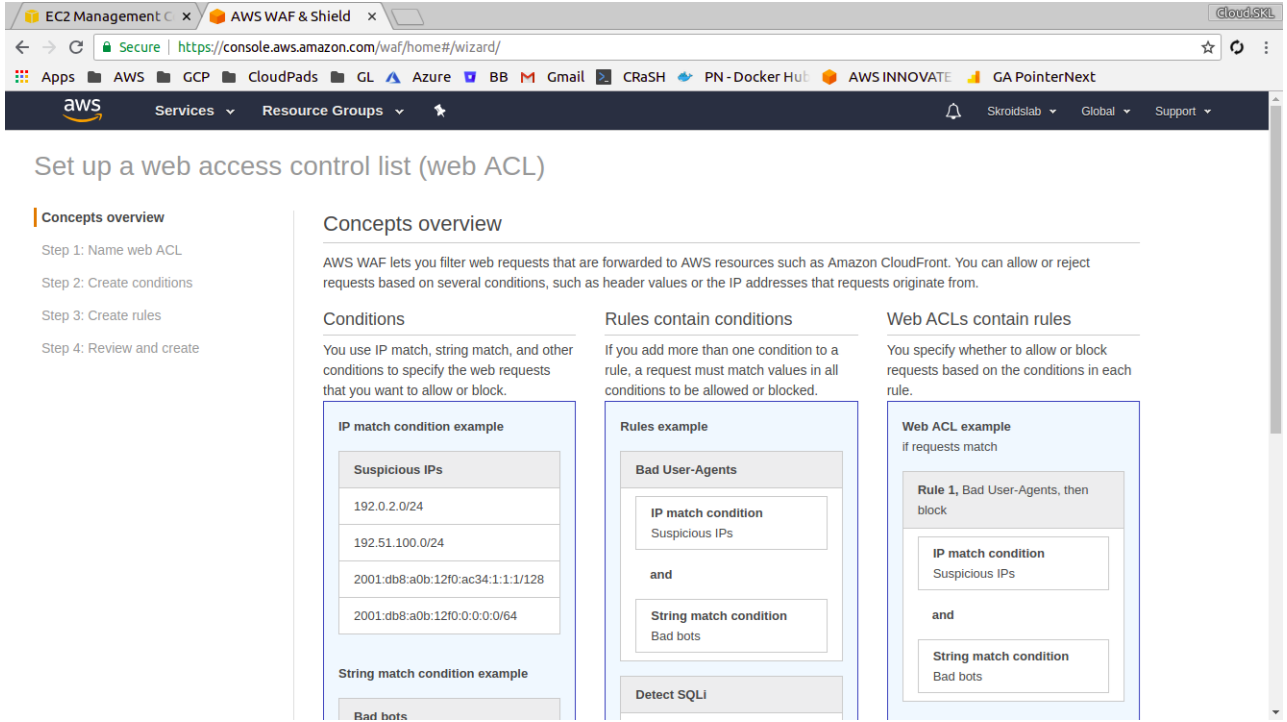


WAF - ACL



Scroll down and click "Next"

WAF - ACL

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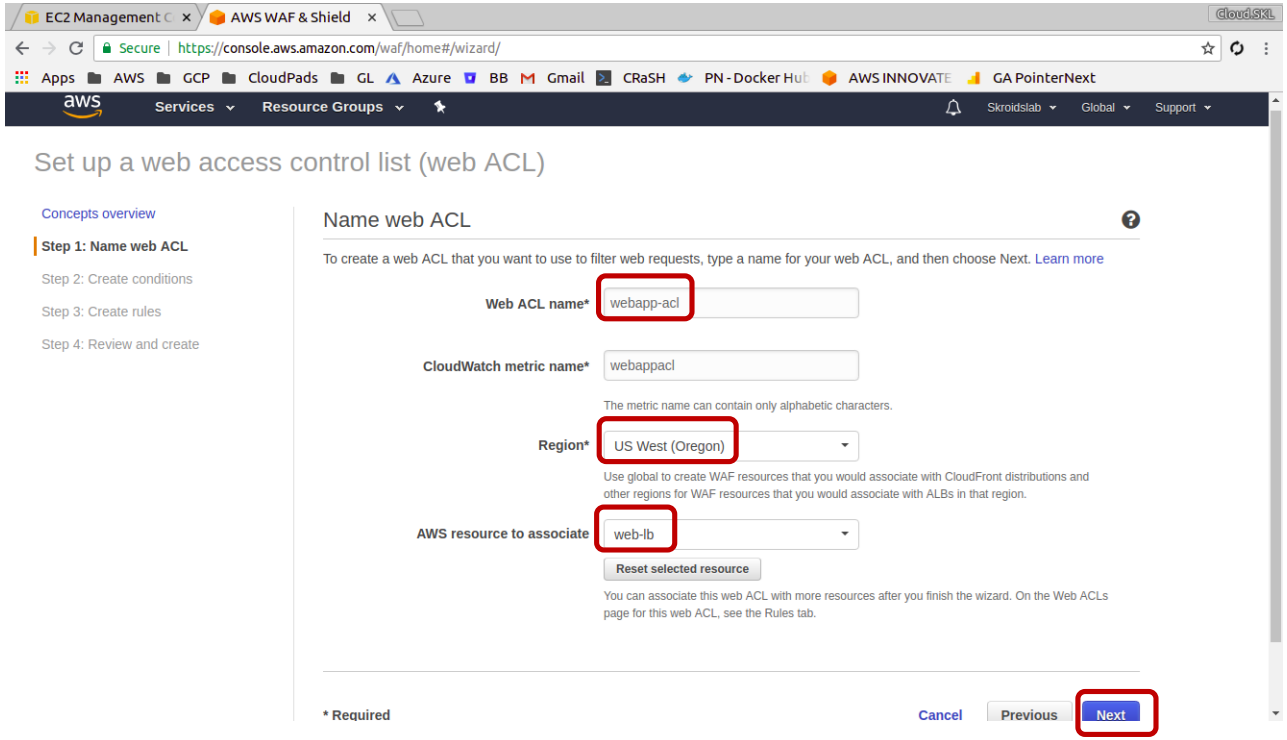
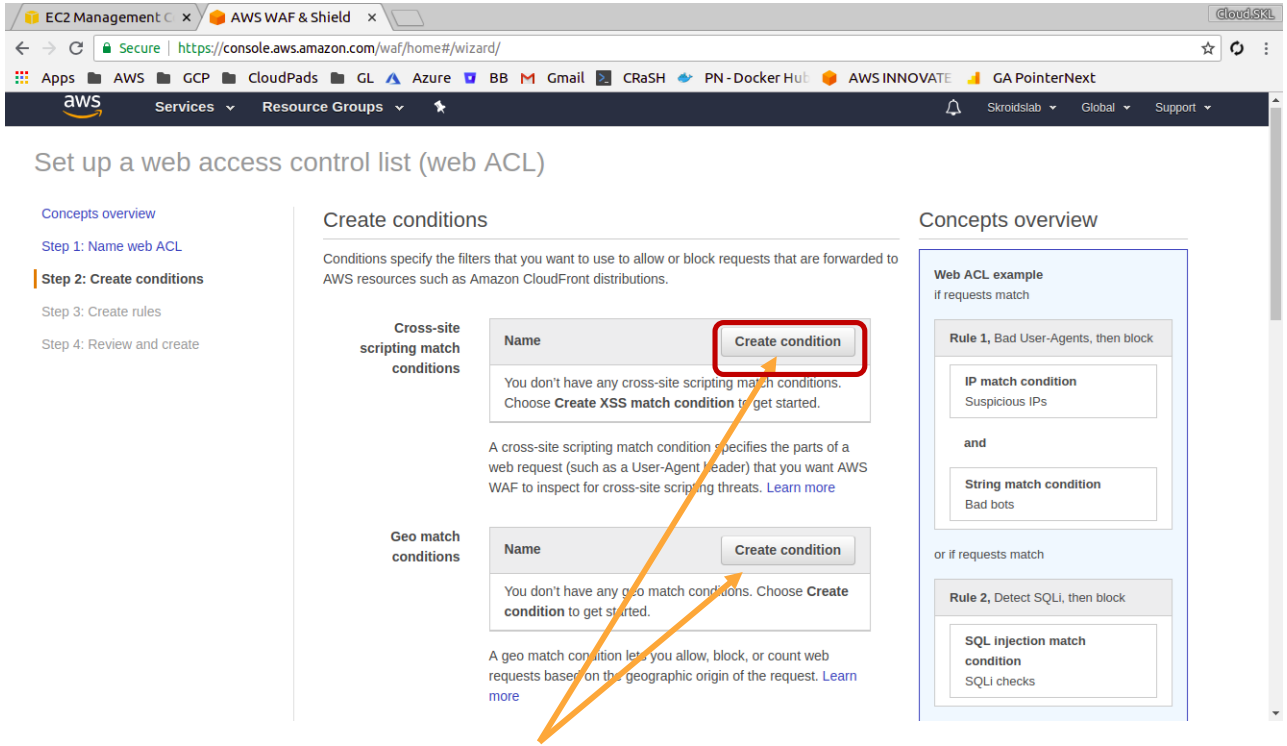


WAF - Conditions



Create multiple conditions by clicking on the appropriate "Create condition" button which will show an "overlay" window

WAF - CORS condition

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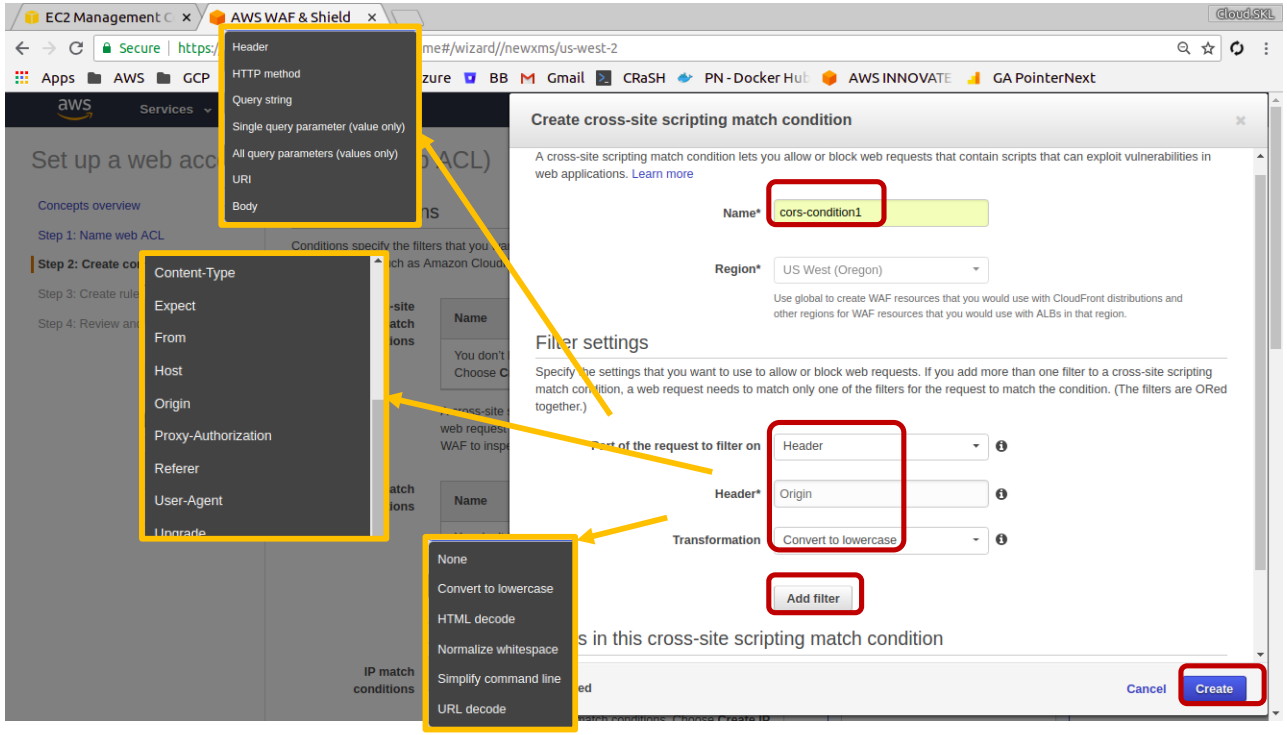

This flow remains the same for all conditions. Multiple filters are ORed together

WAF - Geo/country condition

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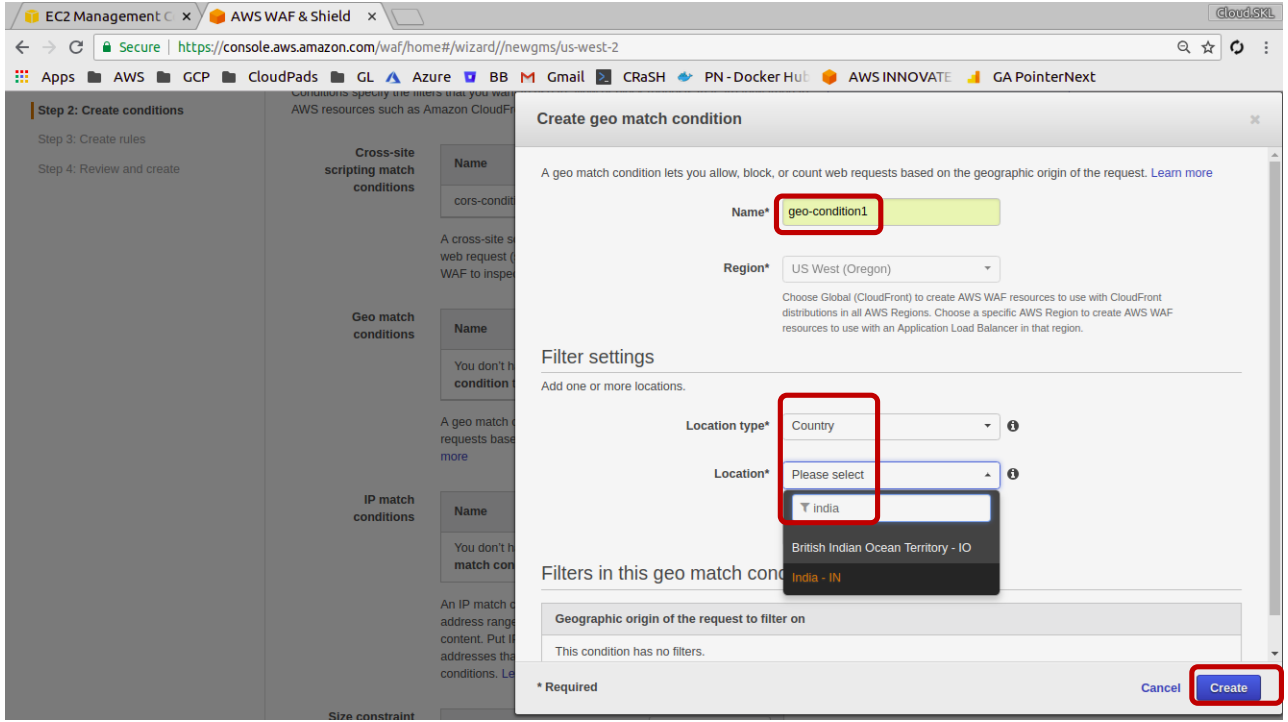

WAF - IP match condition

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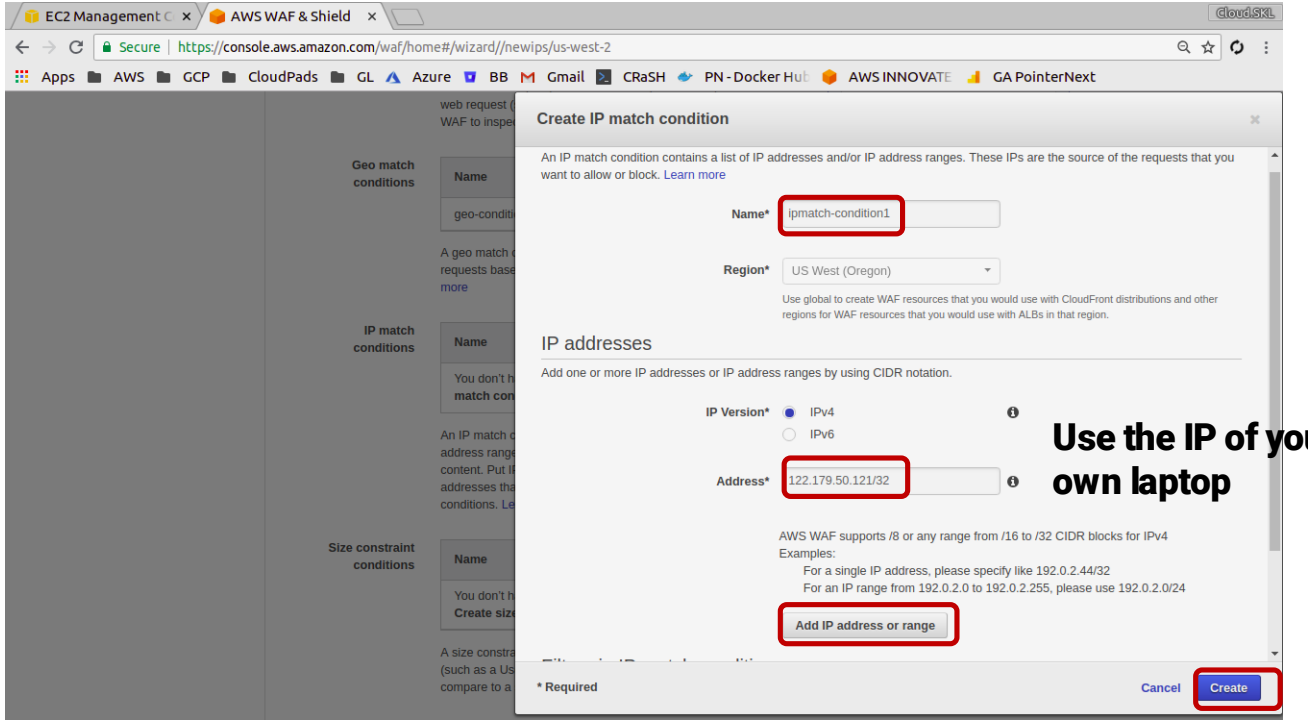
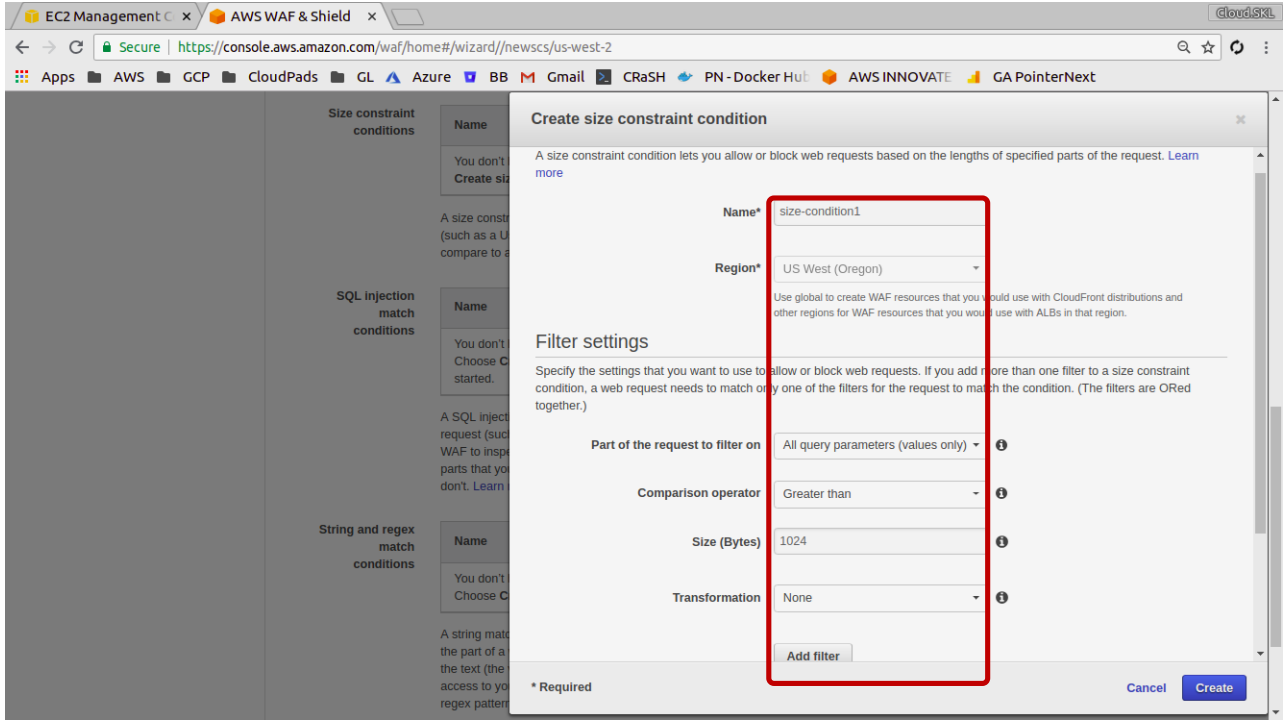


Use the IP of your own laptop

We will use this condition to allow traffic only from this IP

WAF - Size check condition



WAF - SQL injection condition

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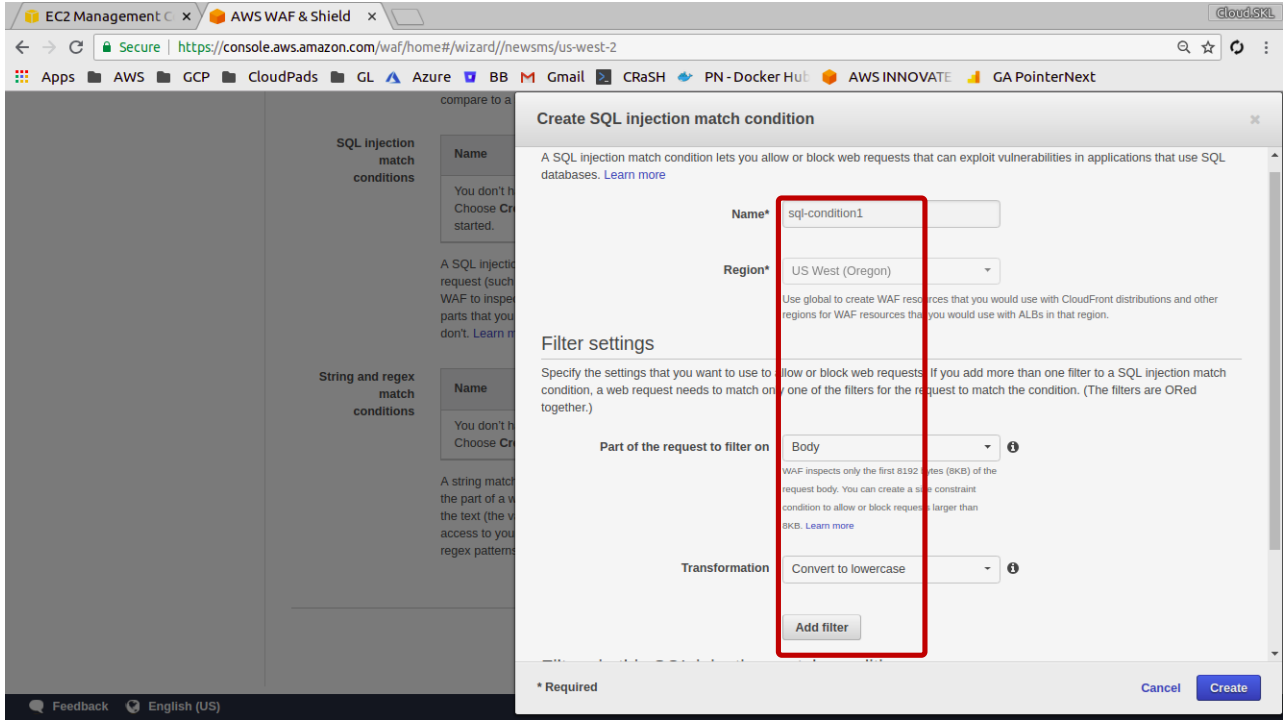
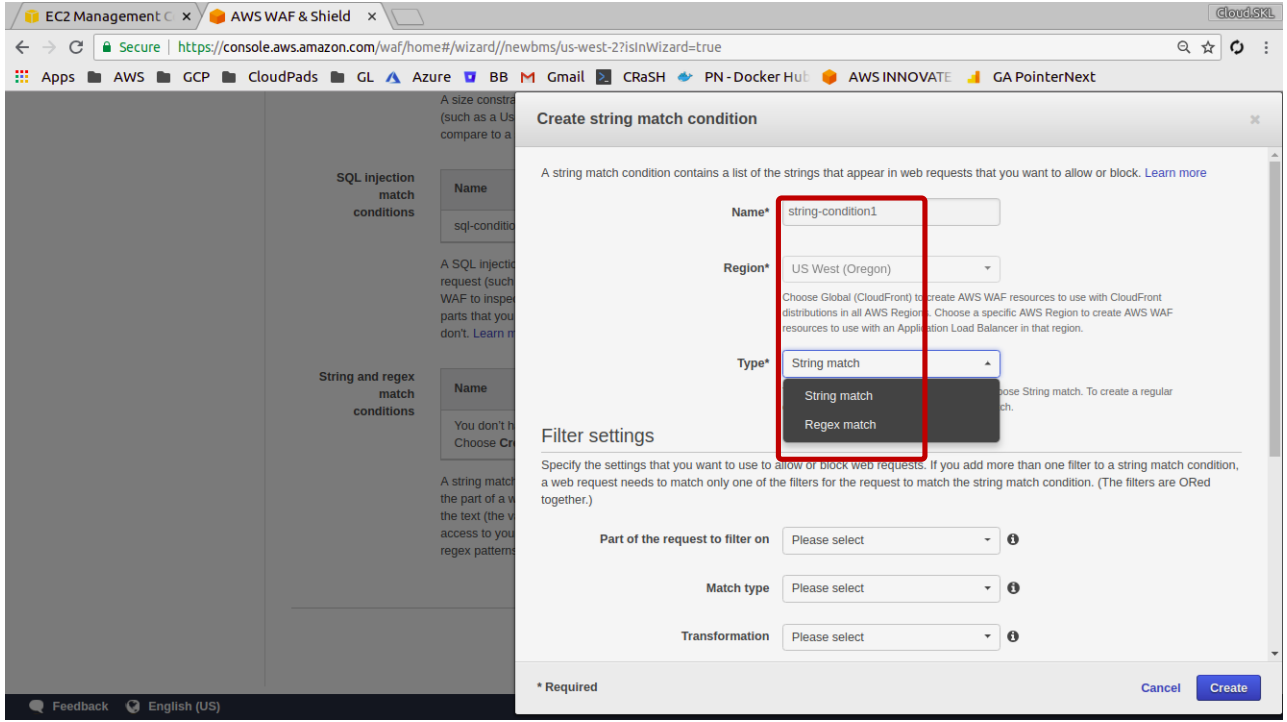
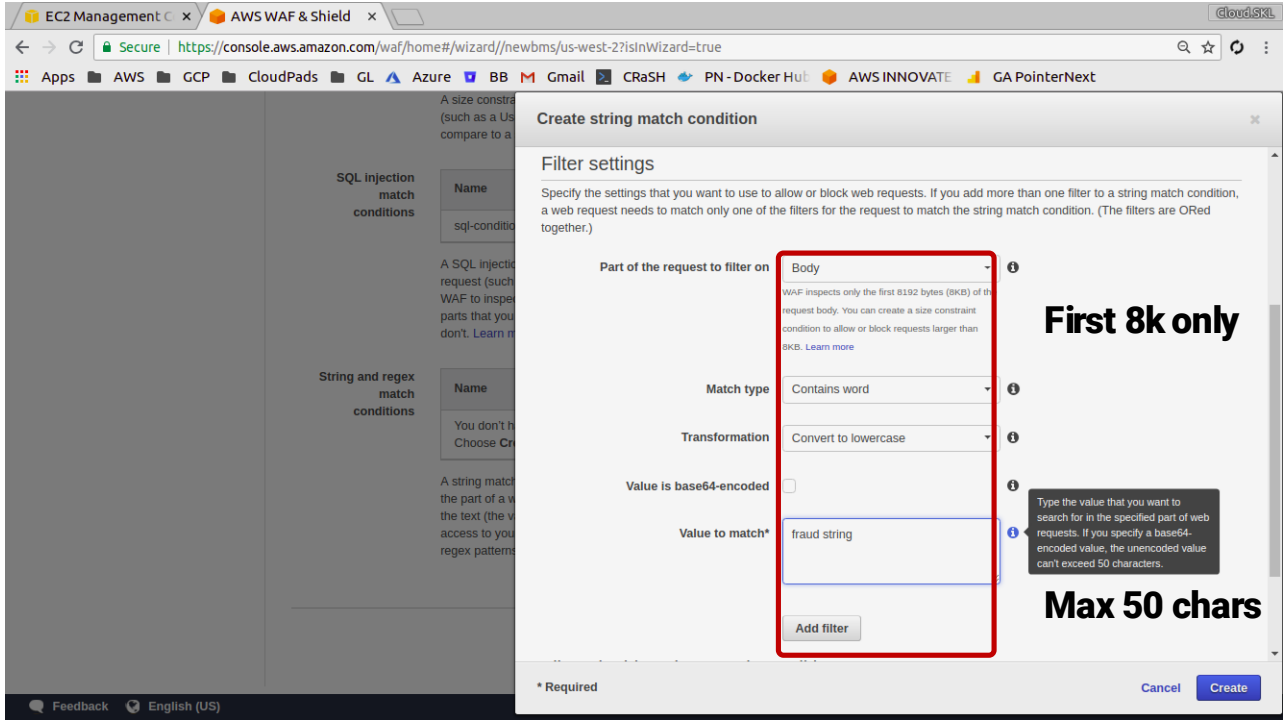


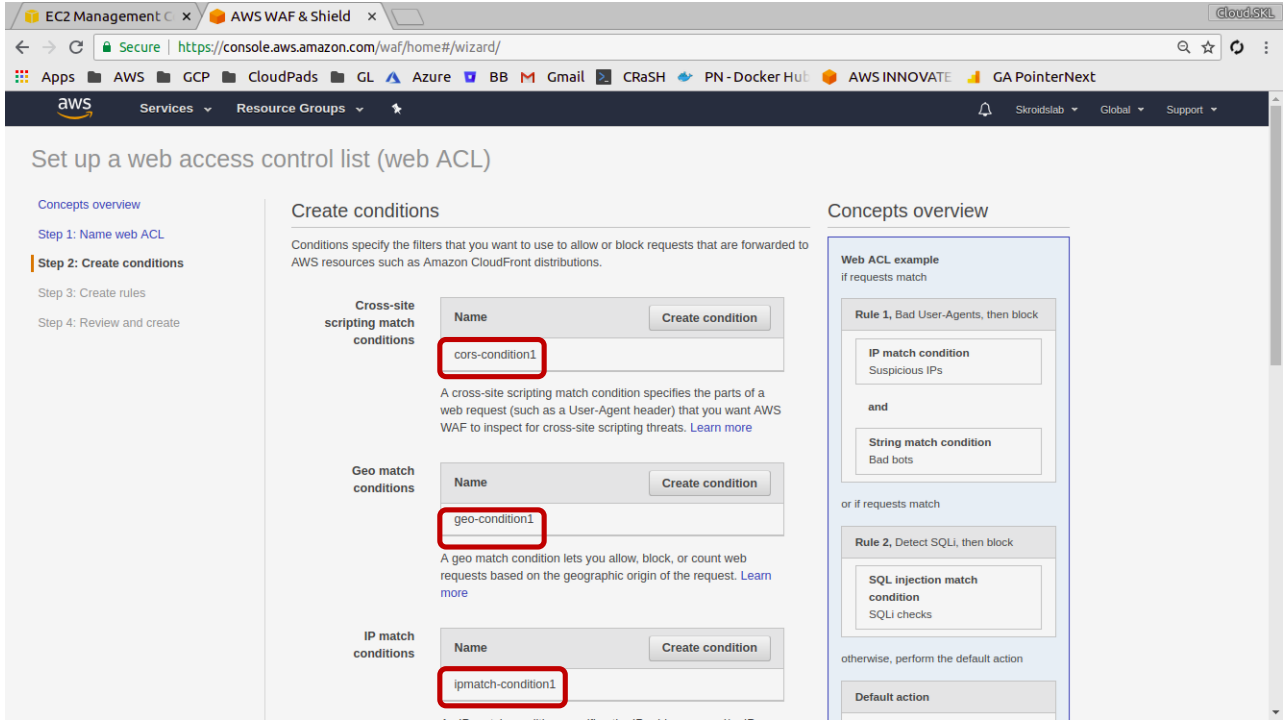
WAF - String match condition



WAF - String match condition

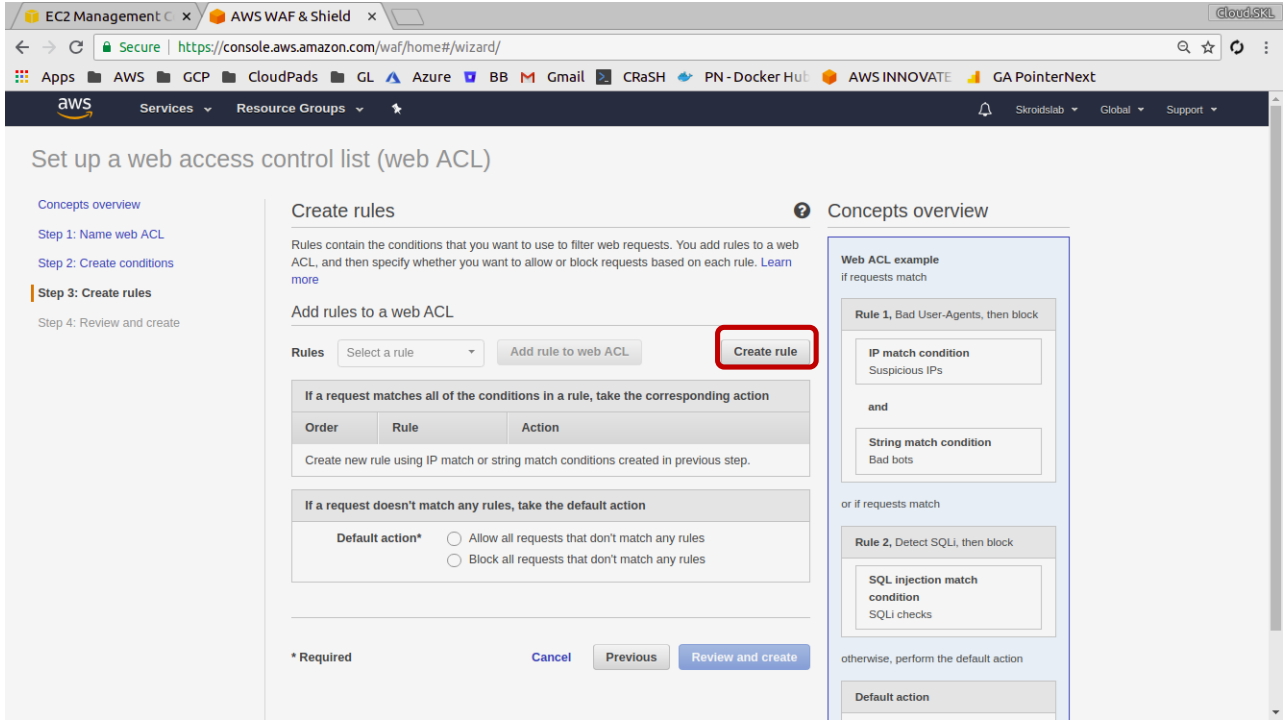


WAF - condition summary



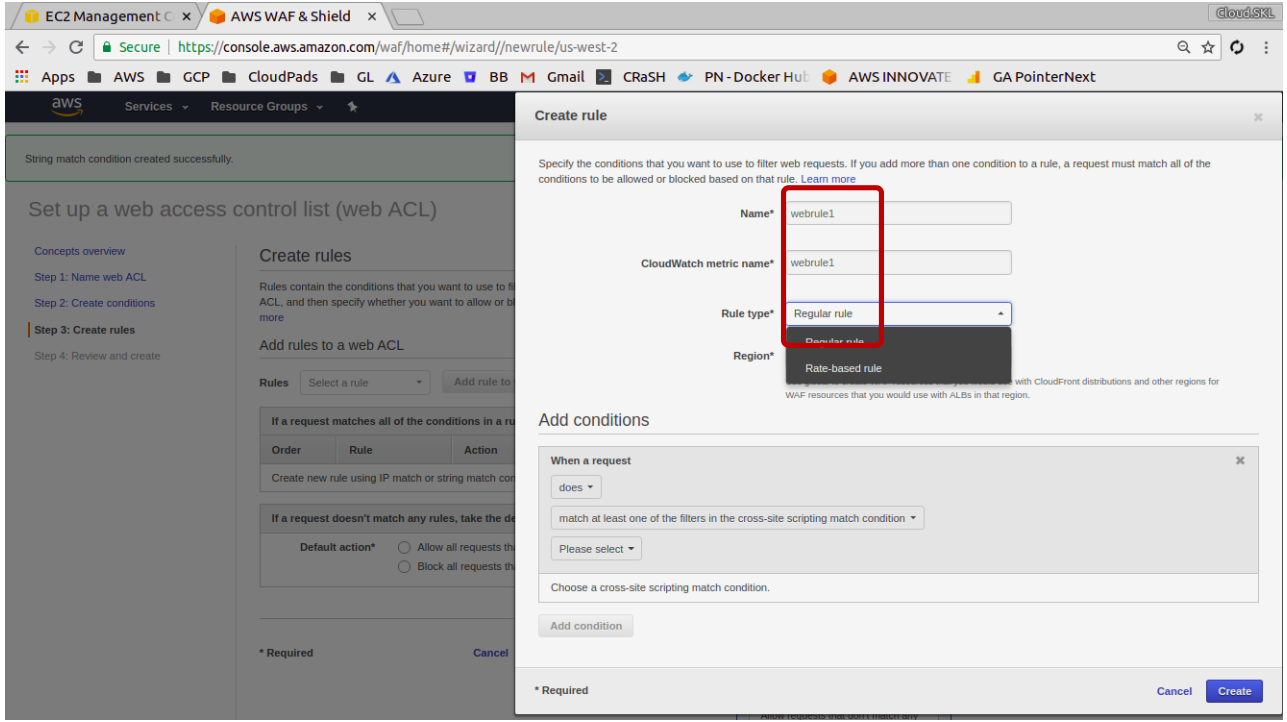
and other conditions. Scroll down and click "Next"

WAF - Rules

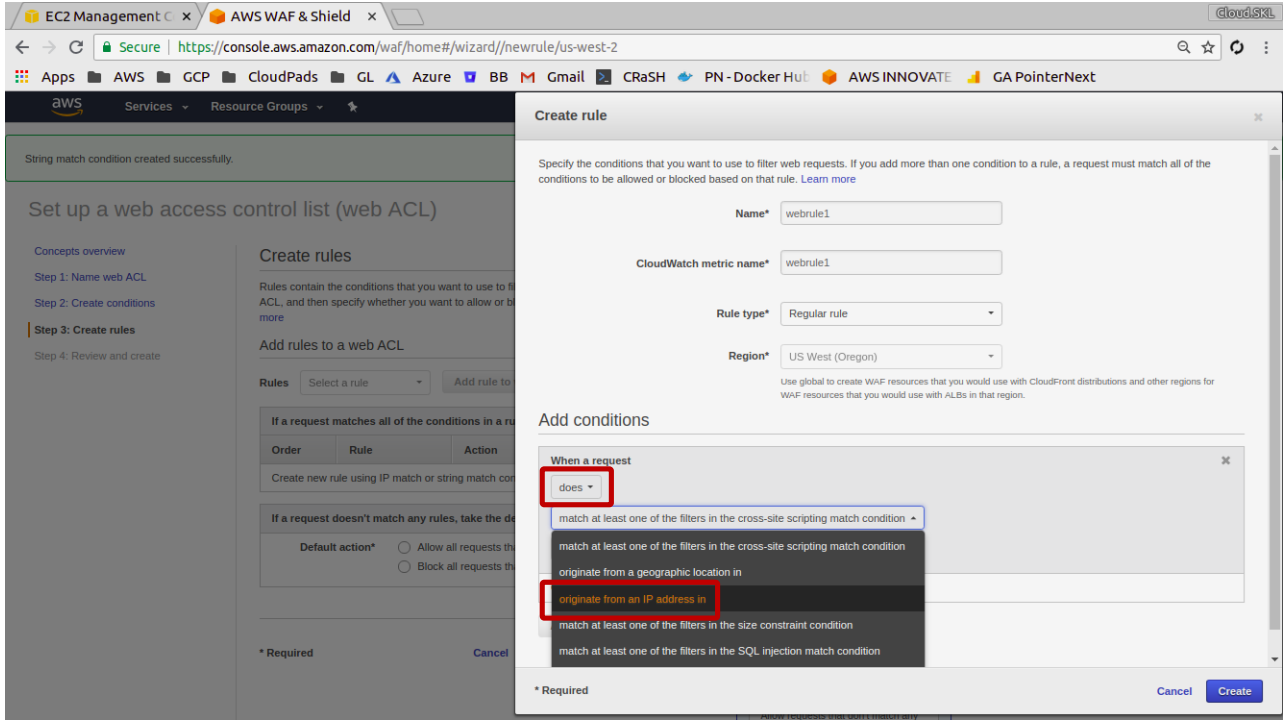


Rules will use the conditions defined earlier

WAF - Rules



WAF - Rules



WAF - Rules

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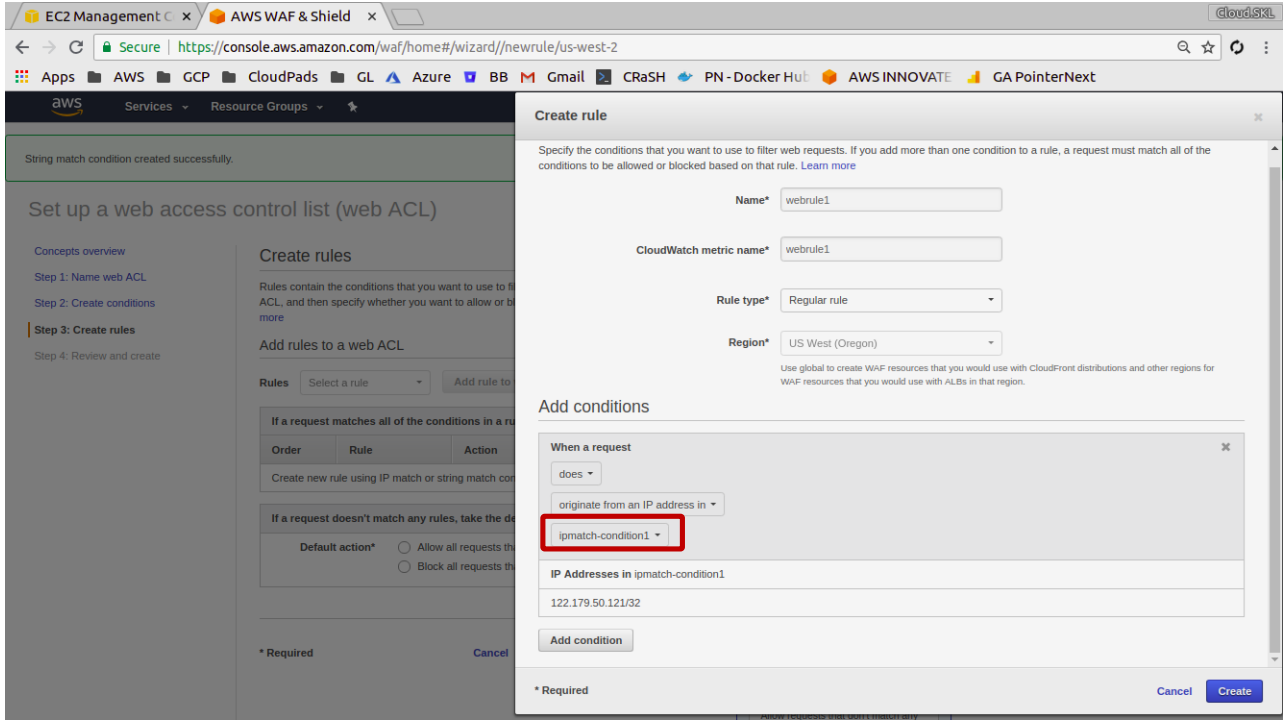
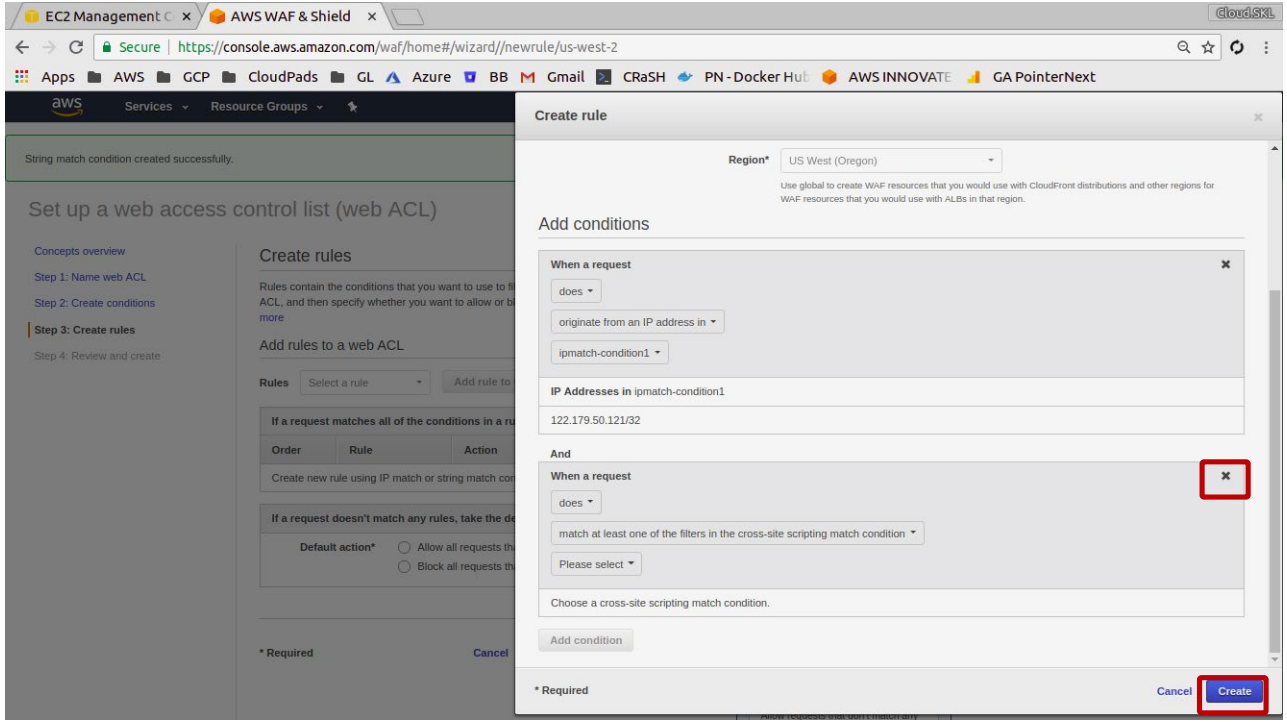
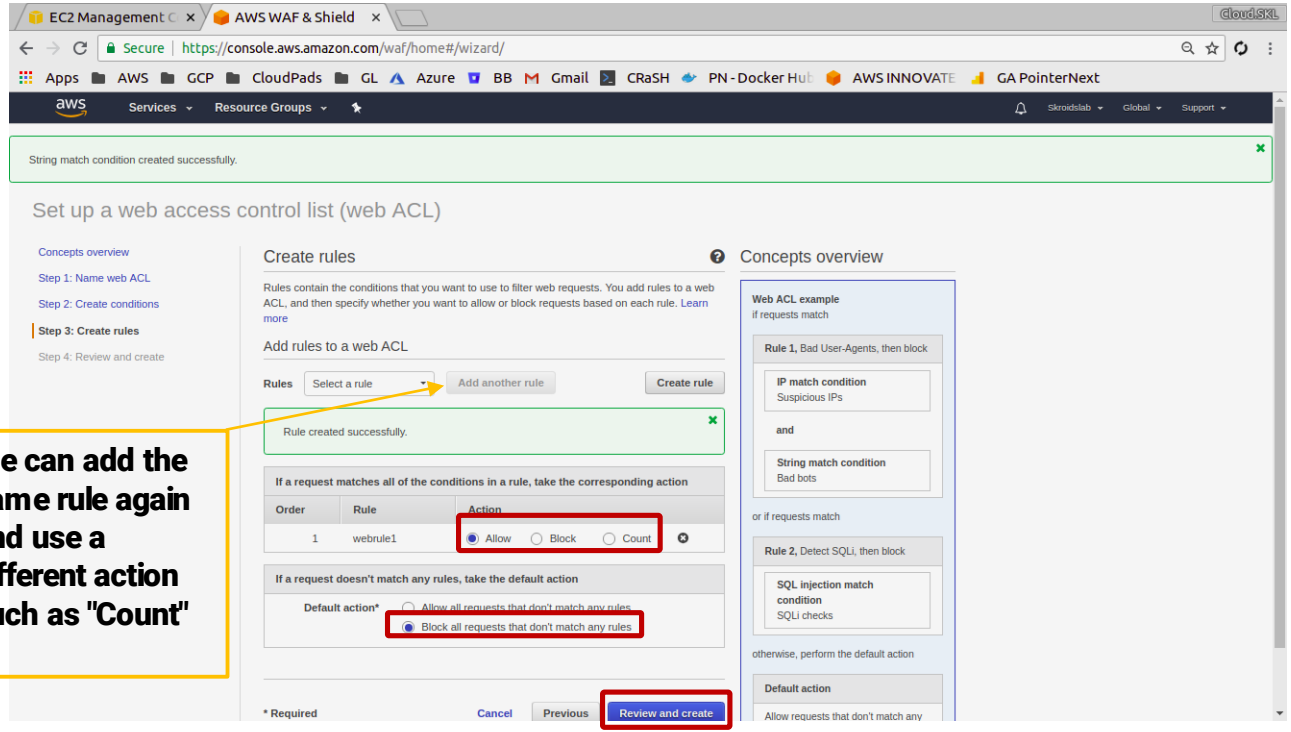


WAF - Rules



Another condition will be ANDed together
Remove the newly added condition!

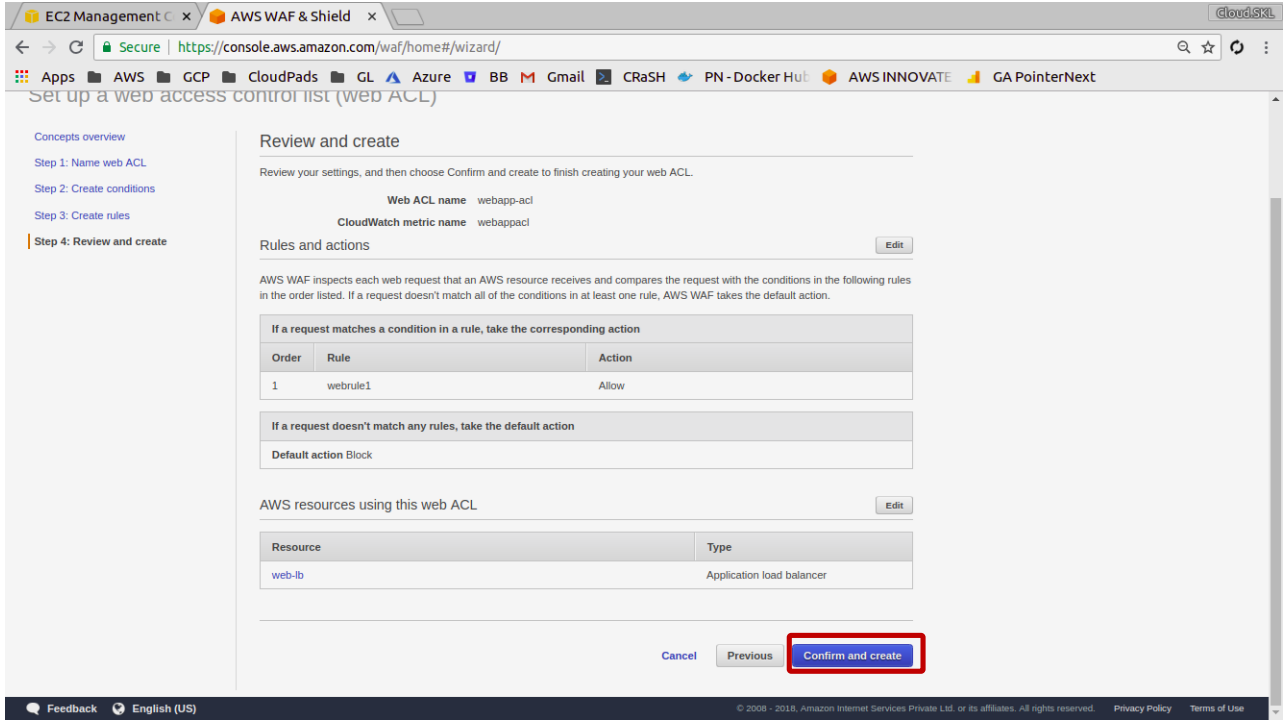
WAF - Rules summary



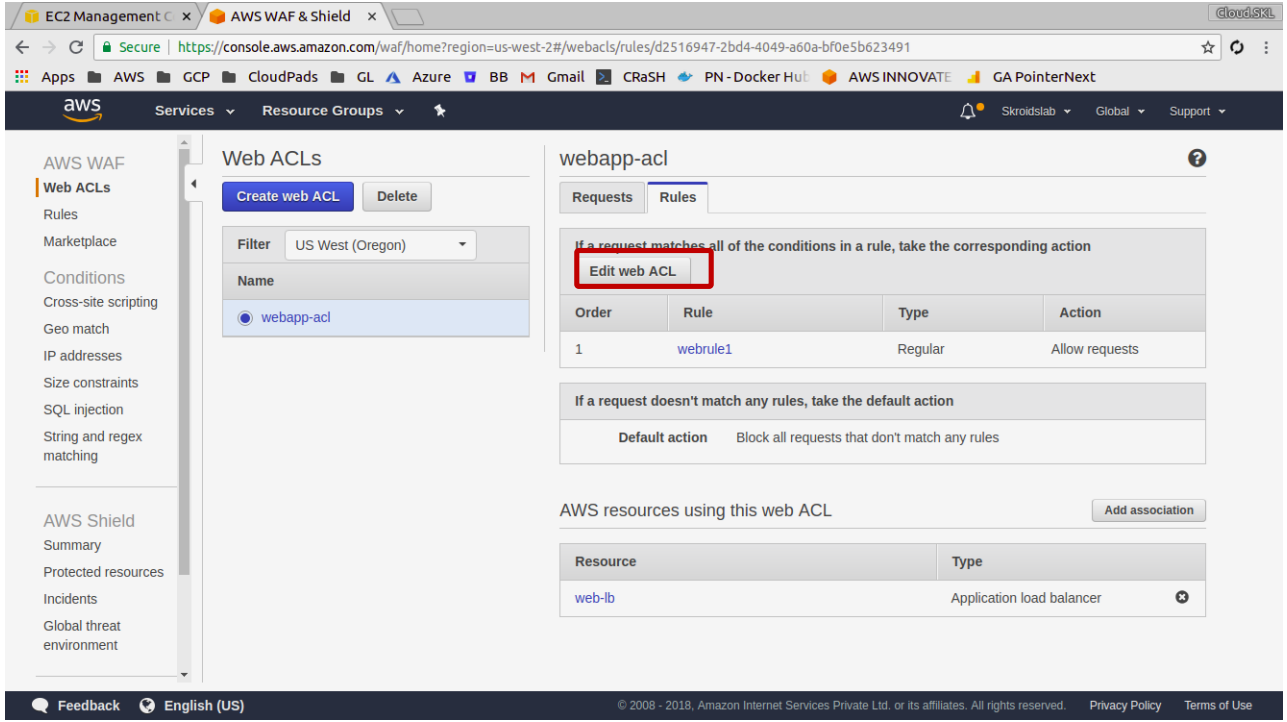
We can add the same rule again and use a different action such as "Count"

Change the action to "Allow" and default action to "Block". This will allow traffic ONLY from your laptop IP

WAF - ACL creation final step



WAF - ACL summary



WAF

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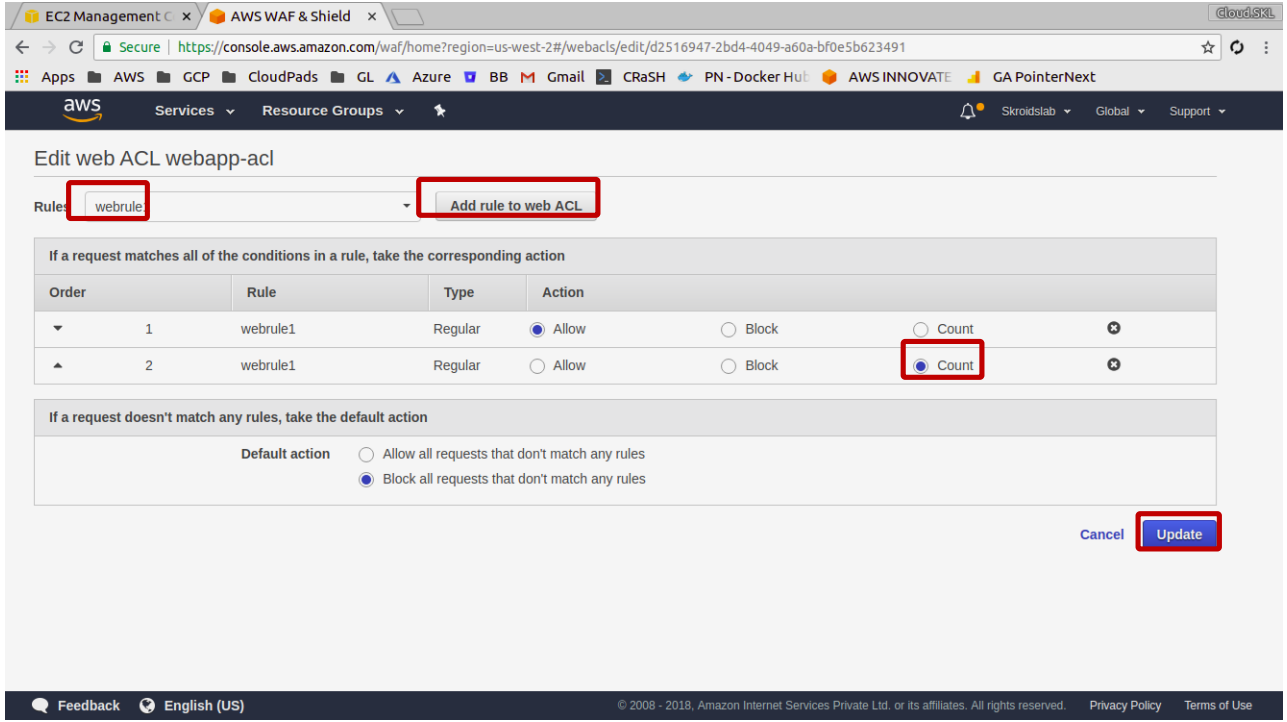

WAF

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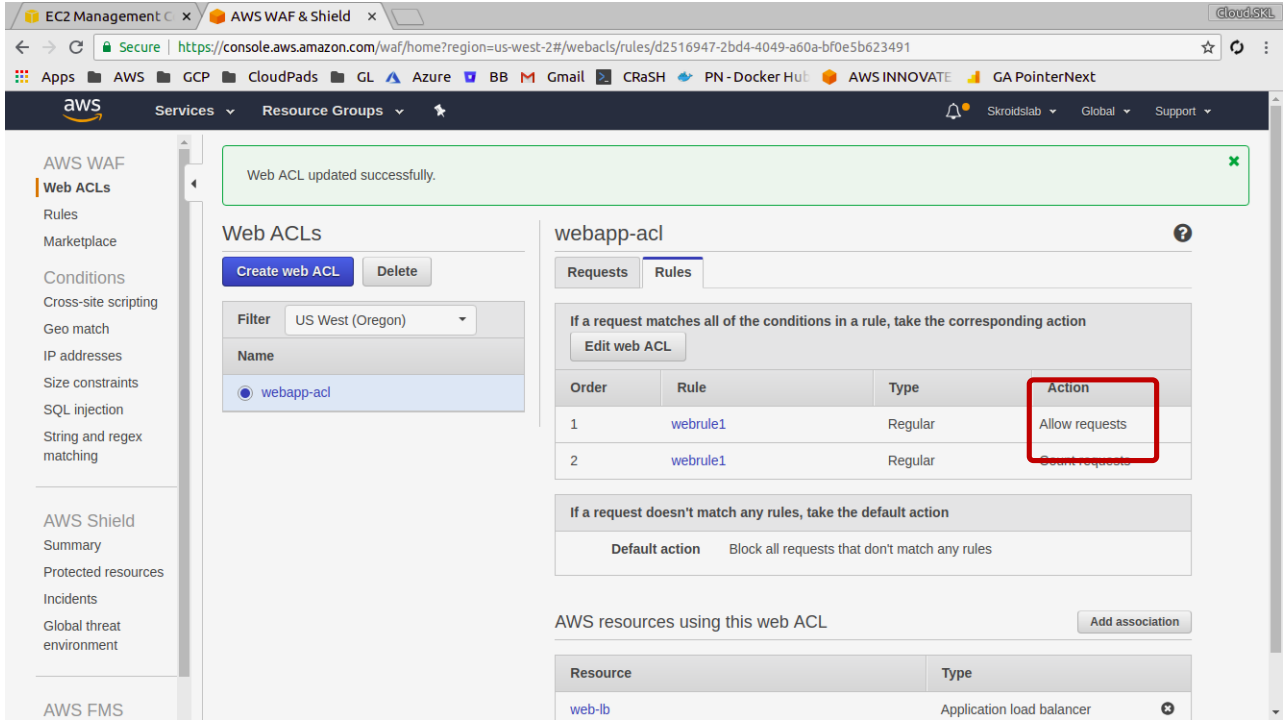
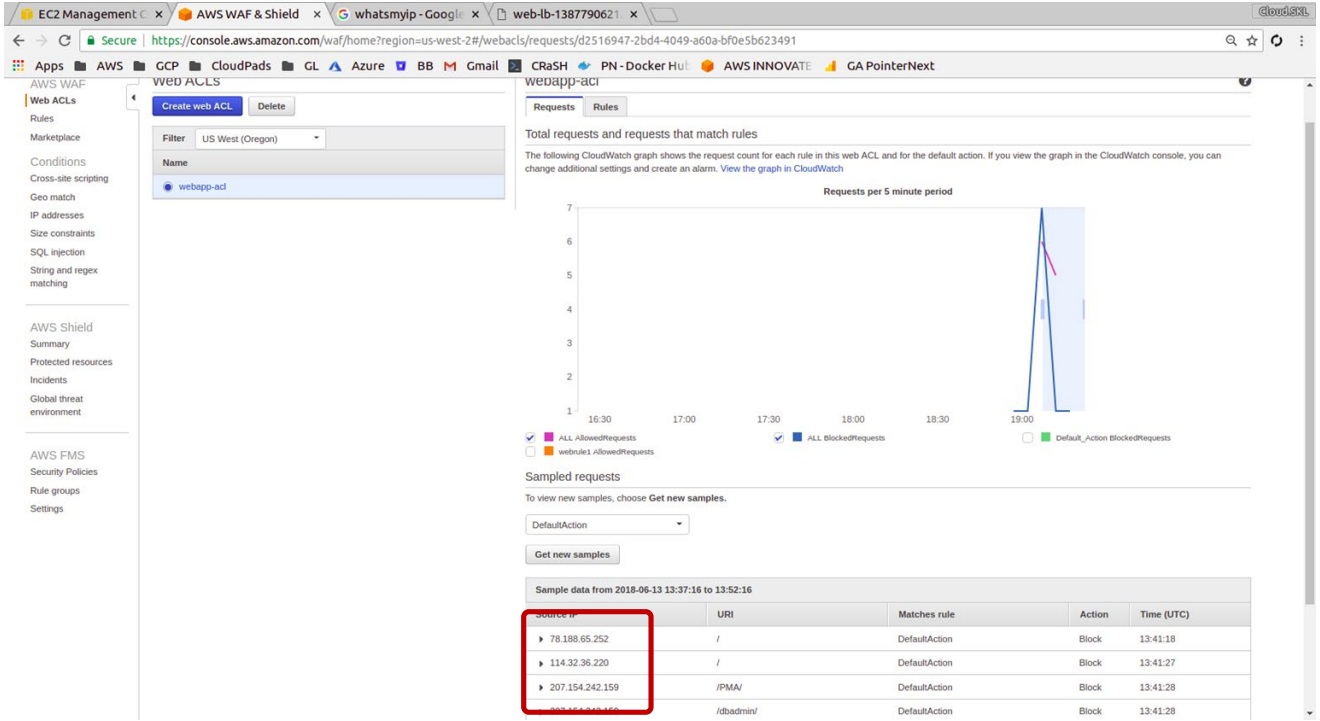


$5 per web ACL per month
$1 per rule per web ACL per month

WAF - Testing

- Hit the LB DNS and you will be able to access the site
- Refresh a few times to increase the count of hits
- Go back to WAF and see the graph and "Get new samples"
- If the screen is not refreshing with data then wait for 10 mins
- Update the rule and change it to block the requests from YOUR laptop IP and see the samples show blocked requests!

WAF



In a matter of minutes you can see sites being blocked!!!
See next ...

WAF

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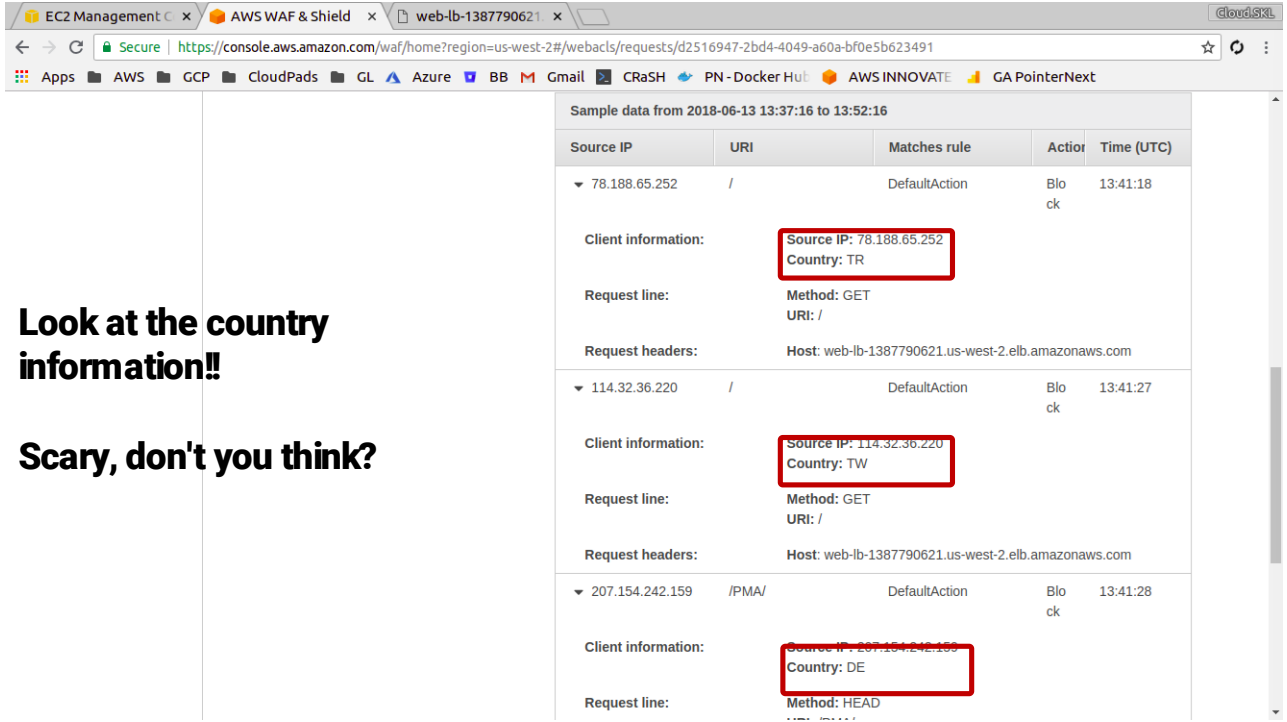

Look at the country information!!

Scary, don't you think?

WAF - Cleanup

- We have to remove all rules
- Remove conditions
- Delete rules
- Remove the LB association
- Delete the ACL
- Delete the rule condition(s)
- Delete the rule
- Delete the conditions
- Remove the LB,TG and EC2 instance

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Compute - Part I

Boot volume and Instance types

EC2 - Boot volume types

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- Type 1 - Backed by EBS (common choice)
  - Can be attached at the time of launching or after launching
  - Can stop the instance
  - Snapshot the disk
  - In case of any AWS failure, stop the instance and start it again, EBS survives and the instance is created on a different VM
  - Can detach and attach to another instance
  - Termination protection is available (delete host retain boot volume)
- Type 2 - Instance store (Ephemeral store)
  - Can attach instance store ONLY at the time of launching
  - Can only reboot or terminate the instance
  - If there is an instance problem then you lose the instance store based volume (less durability than EBS)
  - Cannot detach and attach to another instance
  - No termination protection

EC2 - Boot volume types

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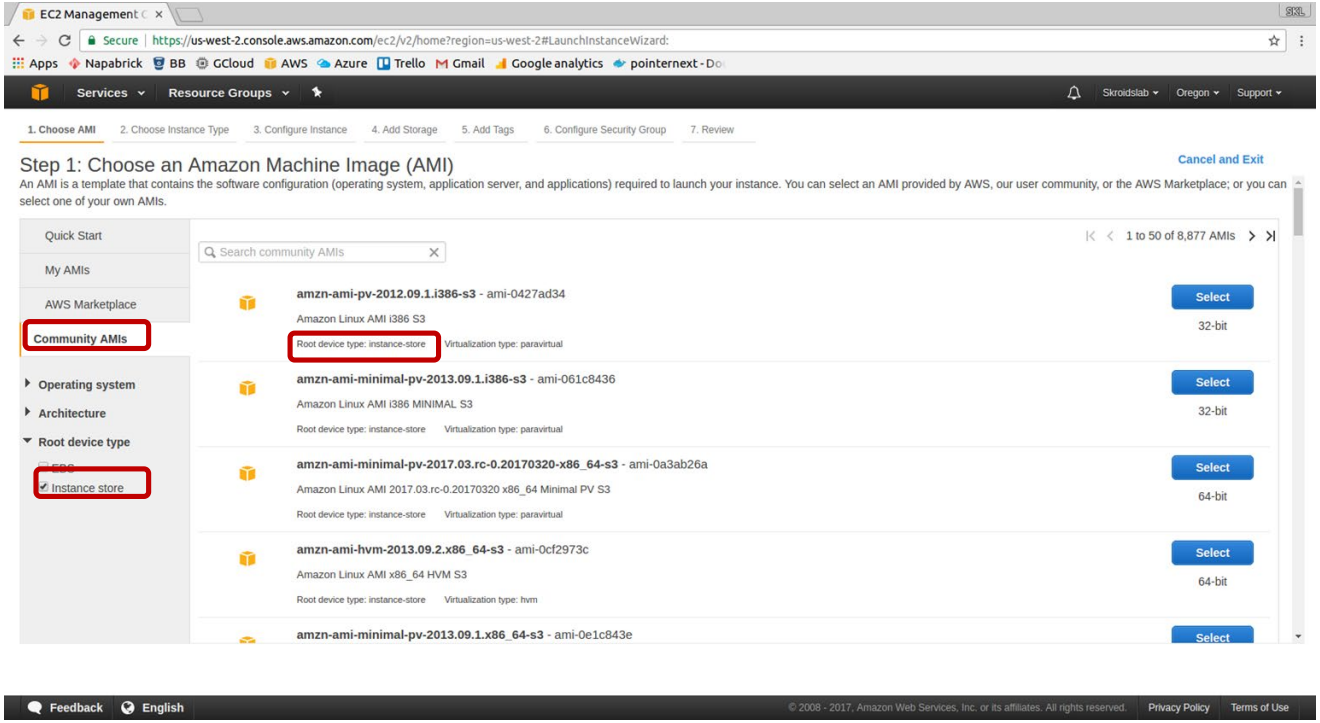

Get an instance store based EC2 instance

EC2 - Other types of instances

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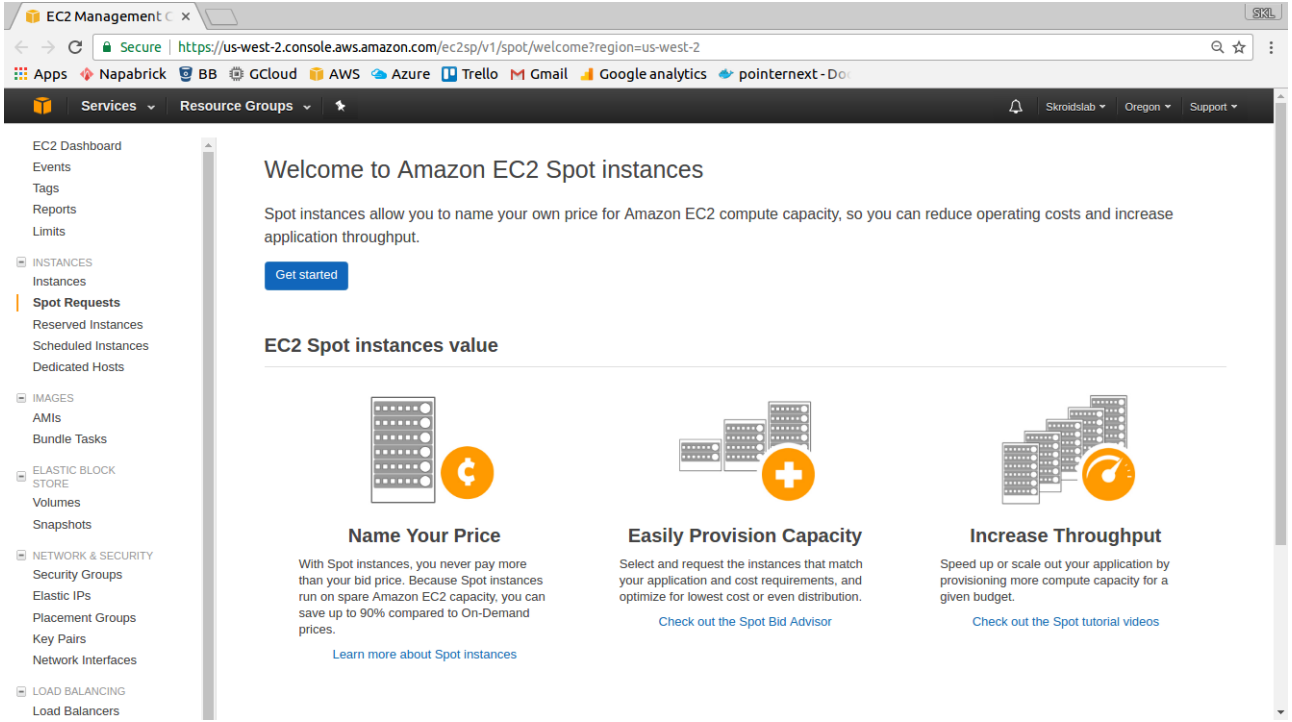
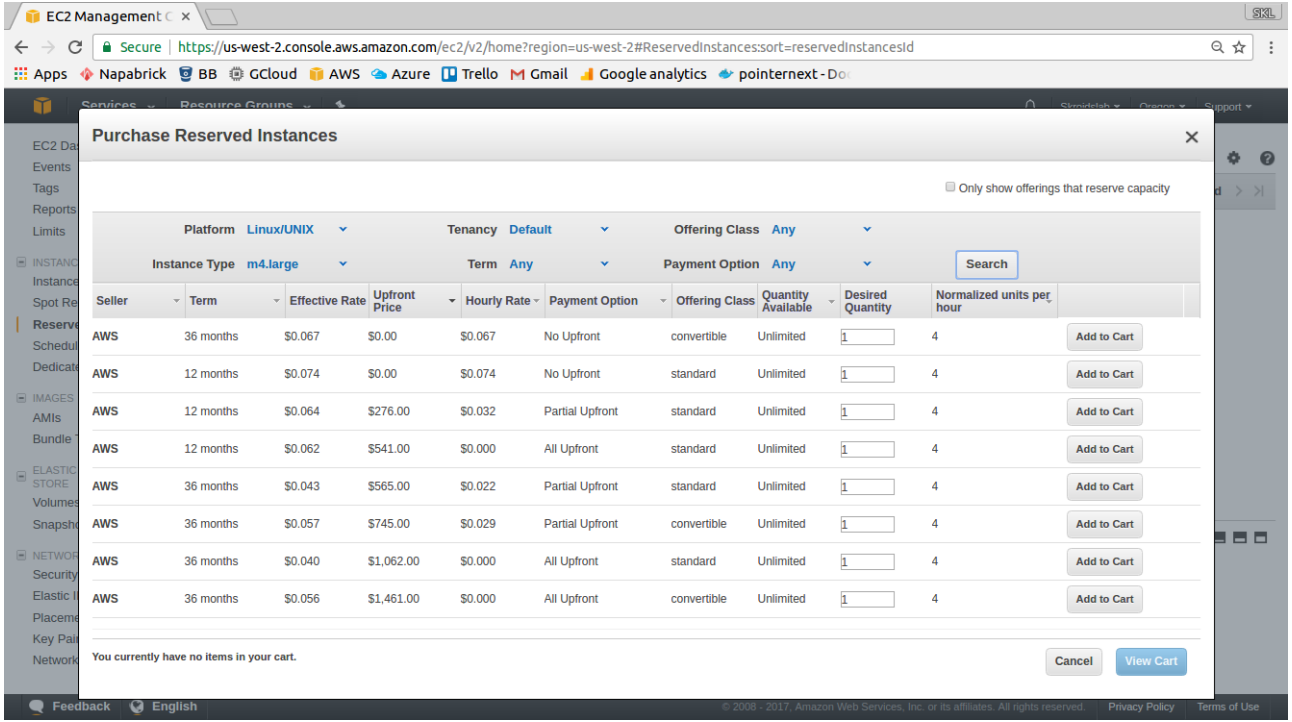


EC2 - Other types of instances



EC2 - Other types of instances

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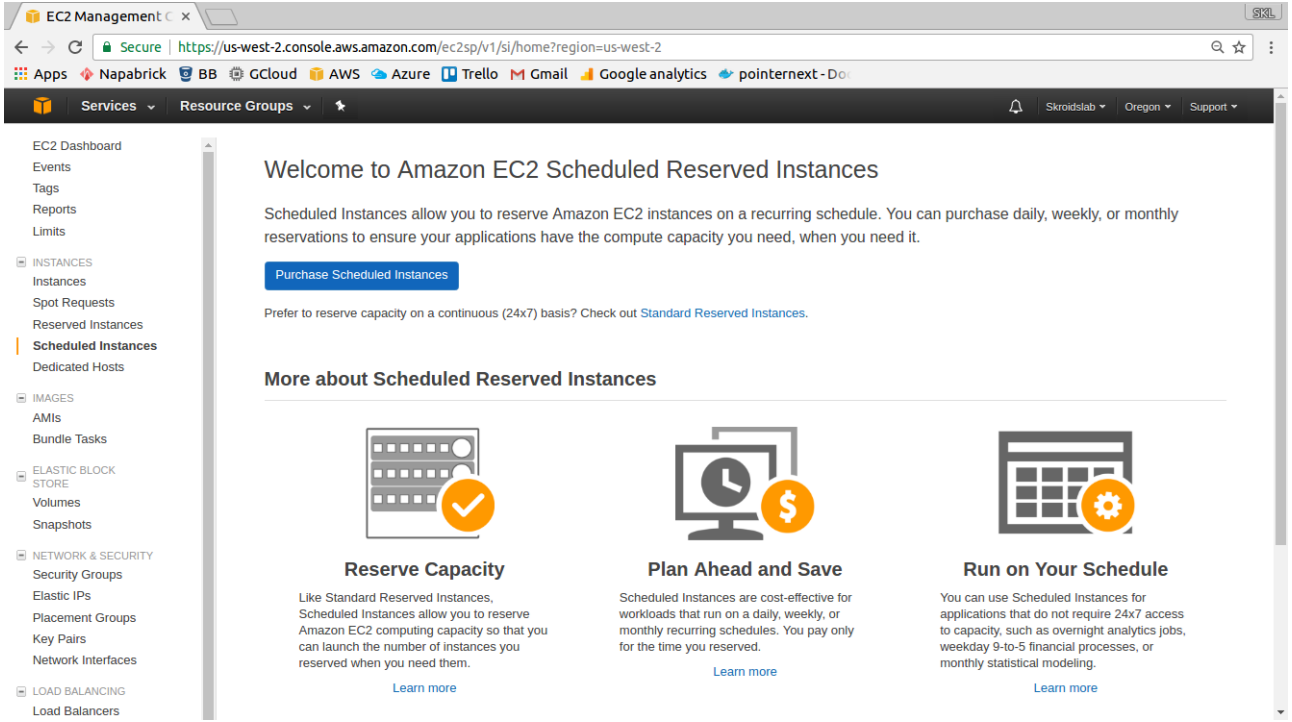
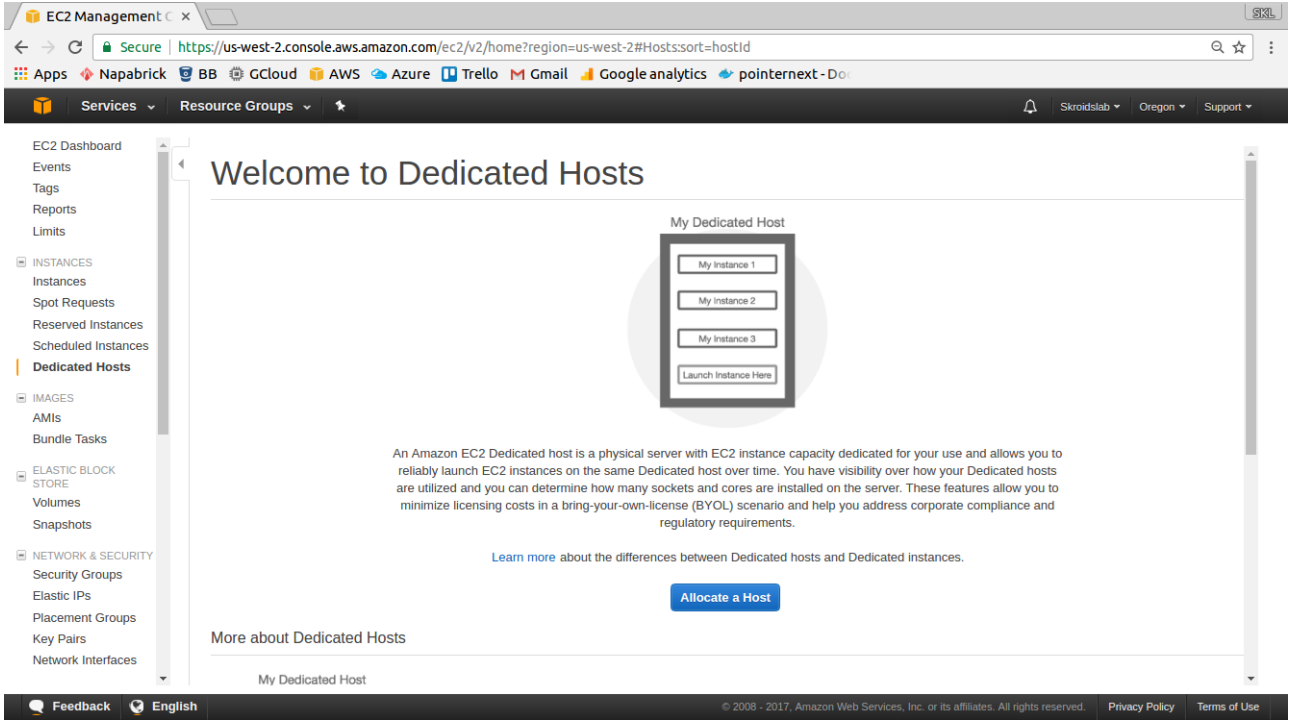


EC2 - Other types of instances



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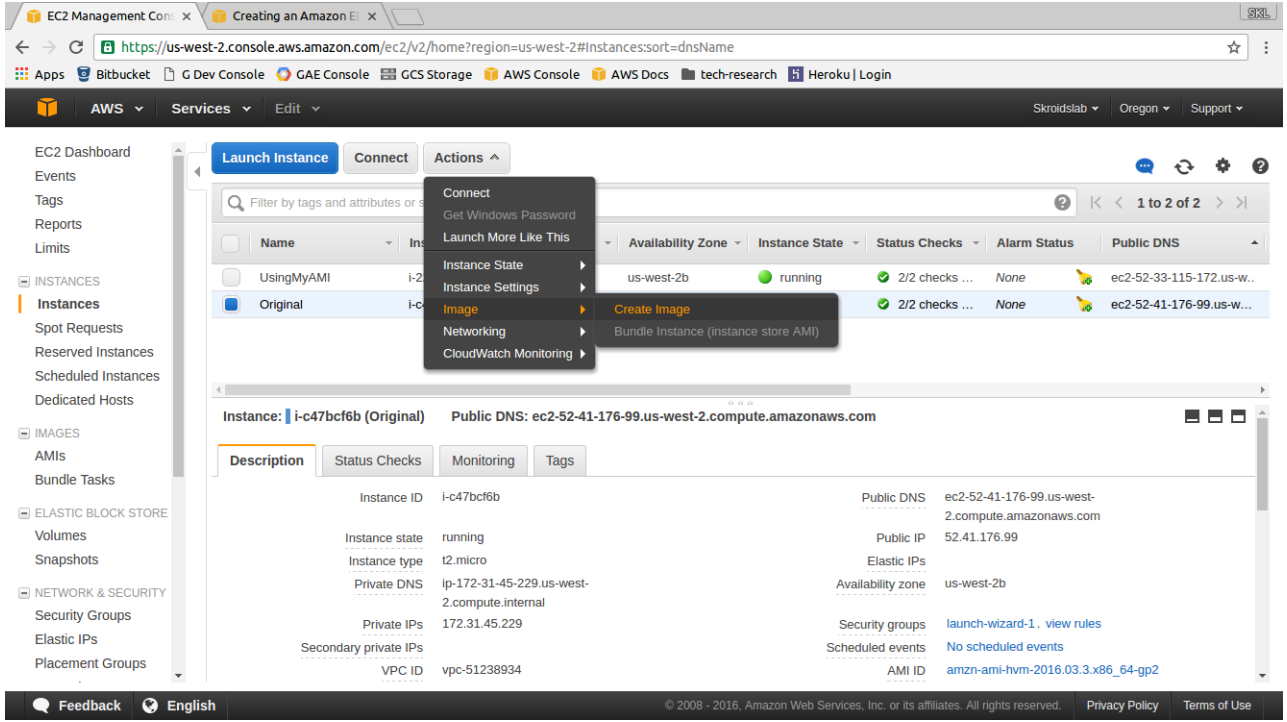
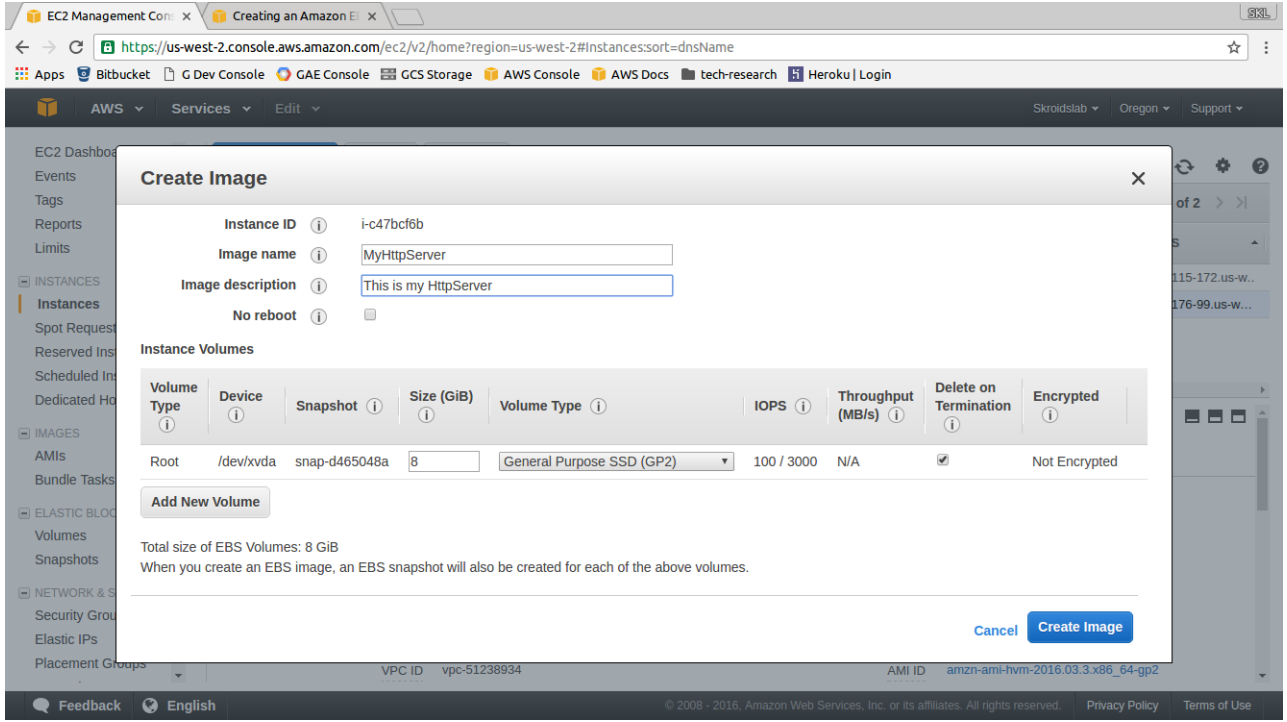
Compute - Part II

AMI

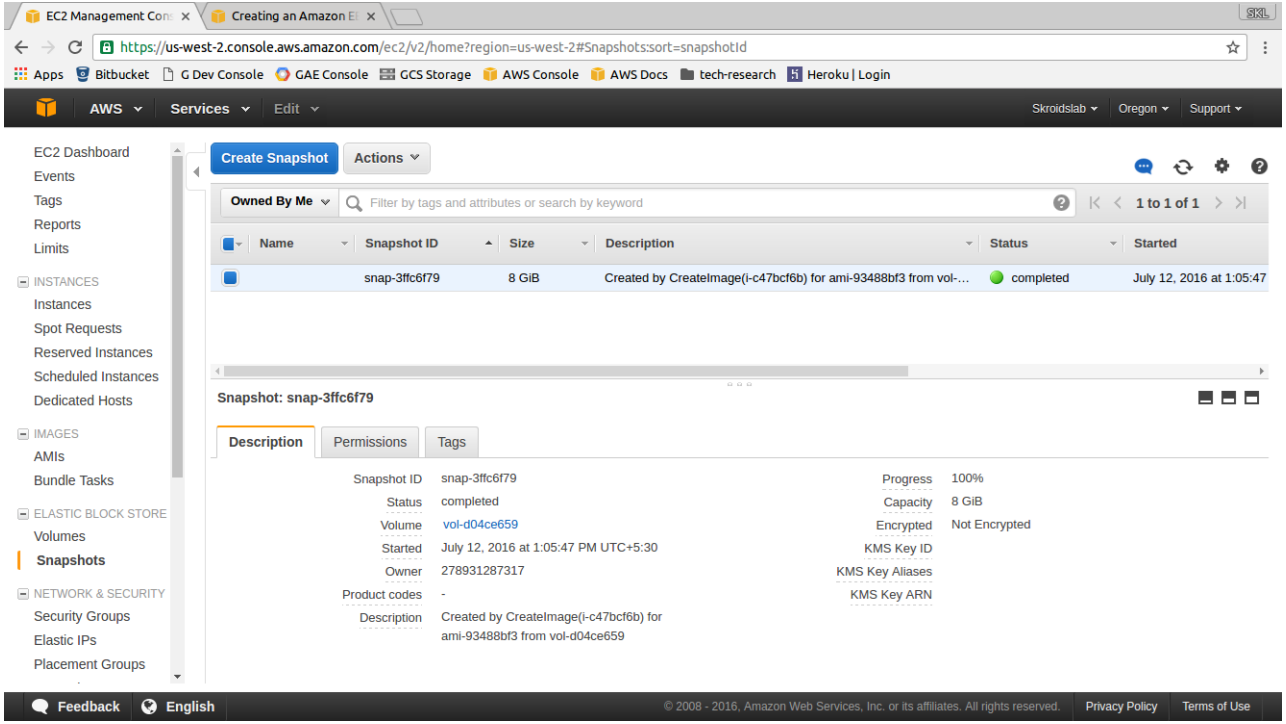
Activity - AMI from an existing instance



Activity - AMI



Activity - AMI (auto snapshot created)



Activity - AMI

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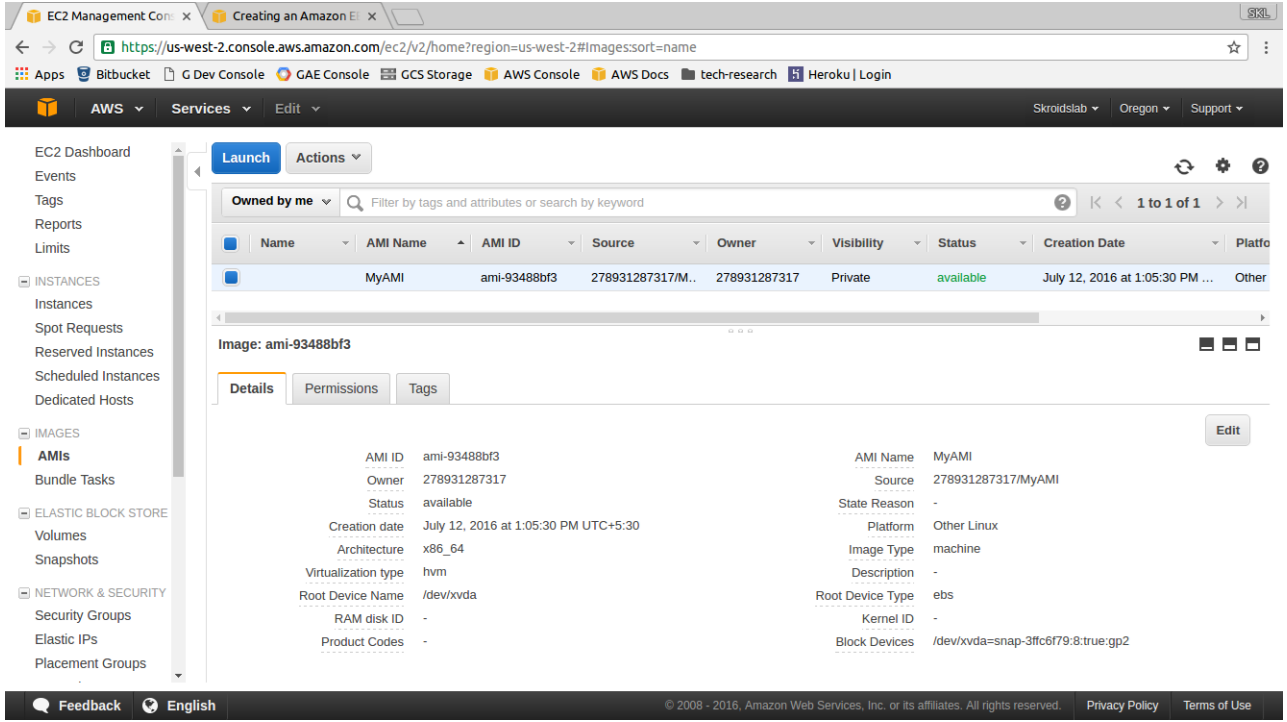

Activity - AMI

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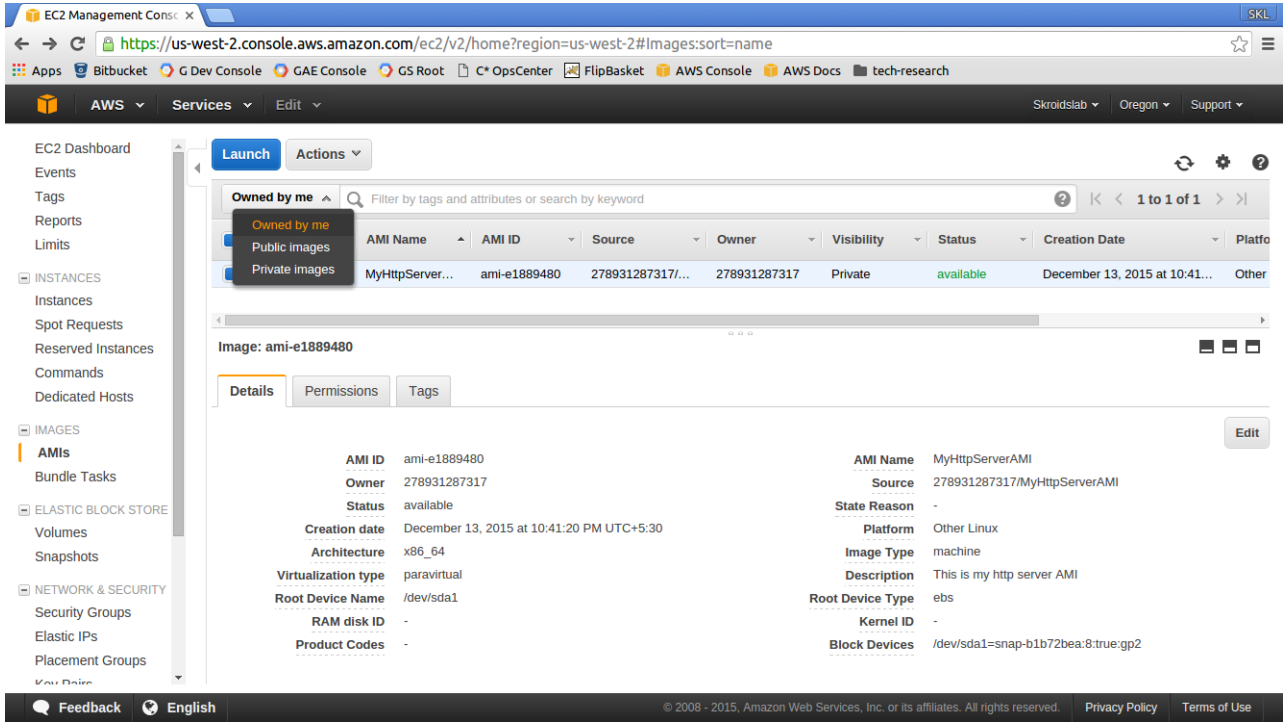

Activity - AMI

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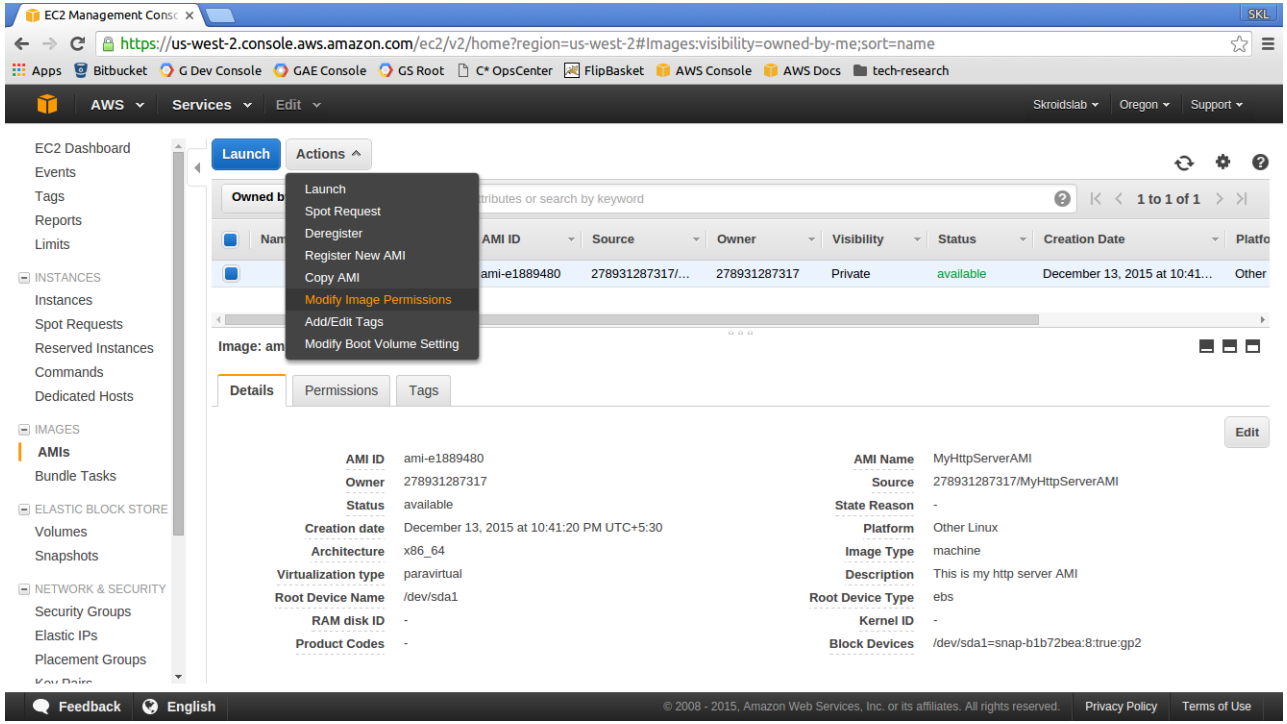

Activity - AMI

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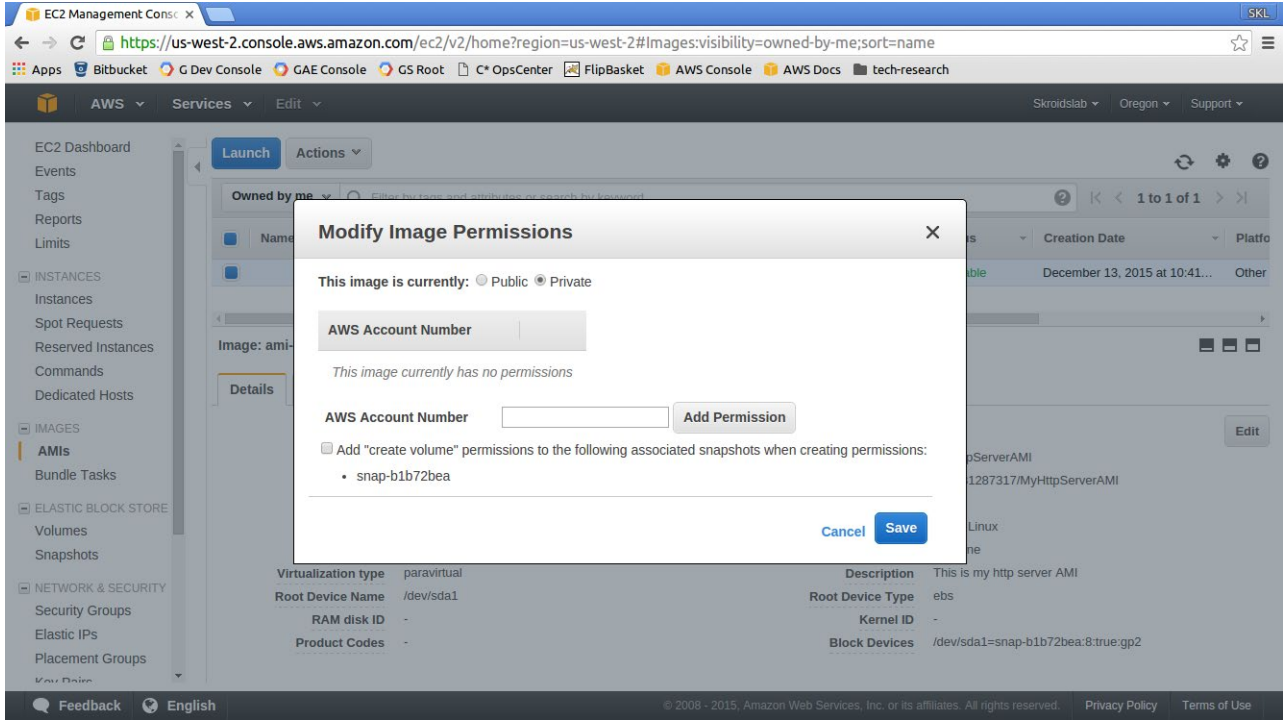

Activity - AMI

- AMIs are region specific, can only launch instances in the region where the AMI is stored
- Can copy AMIs to other regions via the console
- Can upload your own AMI built from other options such as a virtualization software
    - Have to convert to AMI manually using CLI
- Security precautions in case of public AMIs
- https://aws.amazon.com/articles/public-ami-publishing-hardening-and-clean-up-requirements/
- This for the main part falls in the devops section

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Compute - Part II

CLI and bootstrap scripts

Activity - CLI setup

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- The CLI works OOB in an instance that has the Amazon Linux AMI OR can be installed on the local machine as follows
  - $ sudo apt update
  - $ sudo apt install python-pip (or python-pip3 optional in case pip is not there)
  - $ sudo pip install awscli *
  - (Mac->) $ sudo easy_install pip
  - (Mac->) $ sudo pip install awscli –upgrade –ignore-installed six
- Login to the instance (ssh -i <pem> ec2-user@<dns>) and

  $ sudo su

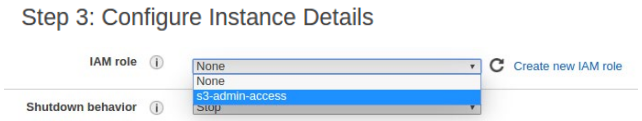
  # aws s3 ls
- The instance will not be able to access the bucket
- Do the following to setup the access (possible on your laptop as well)
  - $ aws configure
  - Create & enter the key etc of the user "CloudRoot" (Administrative policy attached)
  - Use the region as "us-west-2"
  - Inspect the files in the ~ folder under .aws subfolder (created because of aws configure)
  - The file "config" contains the region (In case the region was specified)
  - The file "credentials" contains the keys (huge security risk, also have to change in case the pwd is changed, solution is to use roles)

Activity - CLI

- "$ **aws s3 ls**" and you will be able to see the buckets
- To see the contents of the bucket type "# aws s3 ls s3://<bucket>/folder"
- "$ **aws ec2 describe-instances**" to see the list of instances in your account
- "$ **aws ec2 describe-instances | grep InstanceId**"
- "$ **aws ec2 terminate-instances –instance-ids i-0749a28555320dbf7**" - ec2 instance will be terminated
- "$ **aws rds describe-db-instances**" - will list all the databases in the account

Activity - CLI

- In the previous activity we saw how to set up a user with access using the access key and secret
- If someone hacks into the account then these keys are exposed
- Let's now create a new instance but this time assign a role
- Remember the role comment from the EC2 activity? "What happens if you miss assigning a role?"
  - At the time of launching a new instance select the IAM role that you want to associate in step 3 e.g. "s3-admin-access" that we created during IAM role activity



  - Proceed with the rest of the steps to launch the instance as usual
- Once the instance is launched you now configure the CLI but leave the access key and secret as blank
- You can execute the list commands of S3 as before without the access keys etc. This is more secure!
- You can remove the role all access is revoked immediately

Activity - Bootstrap script

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- It is a set of commands that are executed when an instance goes online (provisioned for the first time and at every reboot) as root.
- This is also known as "User Data" (as seen on the AWS EC2 instance creation screen)
- Ex 1: Regular shell script & here's a sample to install http server

```
#!/bin/bash
yum update -y
yum install httpd -y
service httpd start
chkconfig httpd on
IP_ADDR=$(curl http://169.254.169.254/latest/meta-data/public-ipv4)
echo "This is auto scale server $IP_ADDR" > /var/www/html/index.html
echo "ok" > /var/www/html/health.html
mkdir /opt/efs
```

- Ex 2: Copy files from S3
  - aws s3 cp s3://<bucket>/<subfolder>/filelist <target folder in the instance>
- Ex 3: Mount an EFS for file share
- This is very useful during autoscale where a server is provisioned with the software components without manual effort
- Note - it can take several minutes for the script to run
- Exercise - where can this be specified?

User data gets added to the cloud-init which is execute at the time of booting.
Must read -> http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/AmazonLinuxAMIBasics.html#CloudInit

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Compute - Part II

EC2 Autoscaling

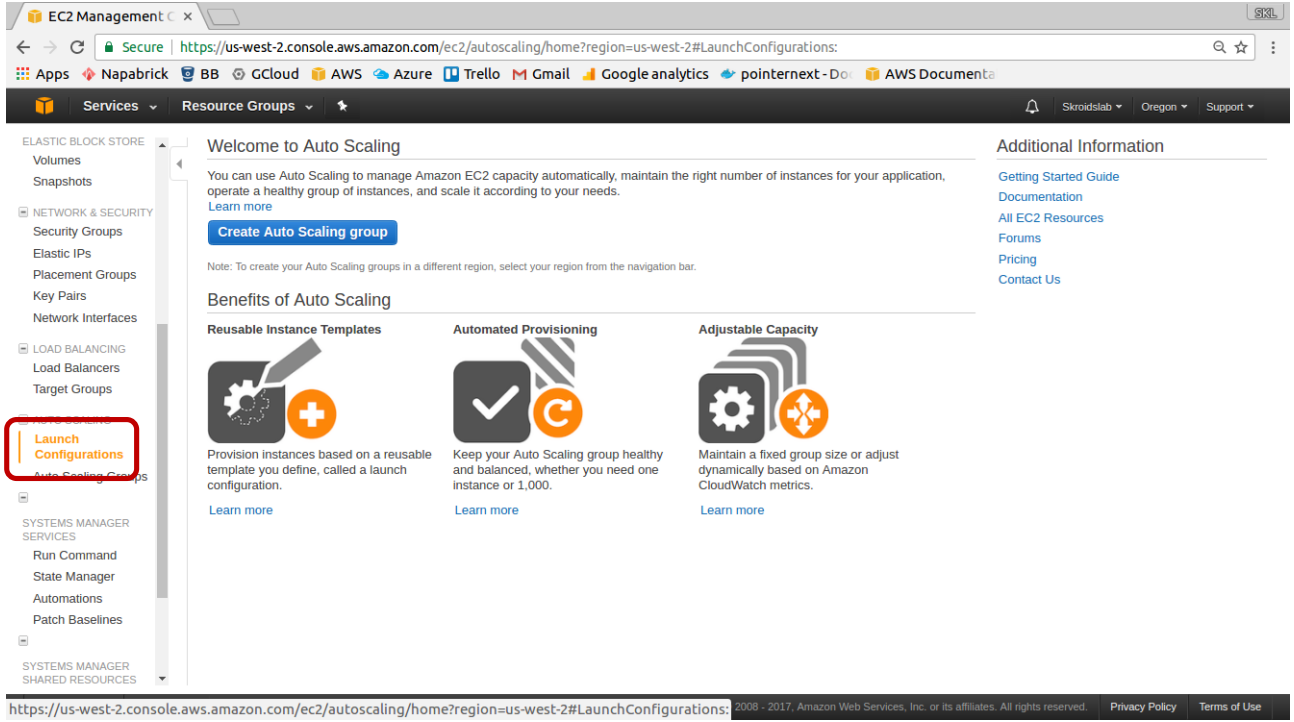
Activity - Config group & Autoscale

- Important to know "Elasticity"
- Core concept is to expand with load and shrink otherwise
- Cost varies accordingly - demand based cost of operations (OPEX)
- IaaS providers will let us configure rules based on which it scales either way
- Good idea for the application tier
- Debate such a model for the data tier and state your observations

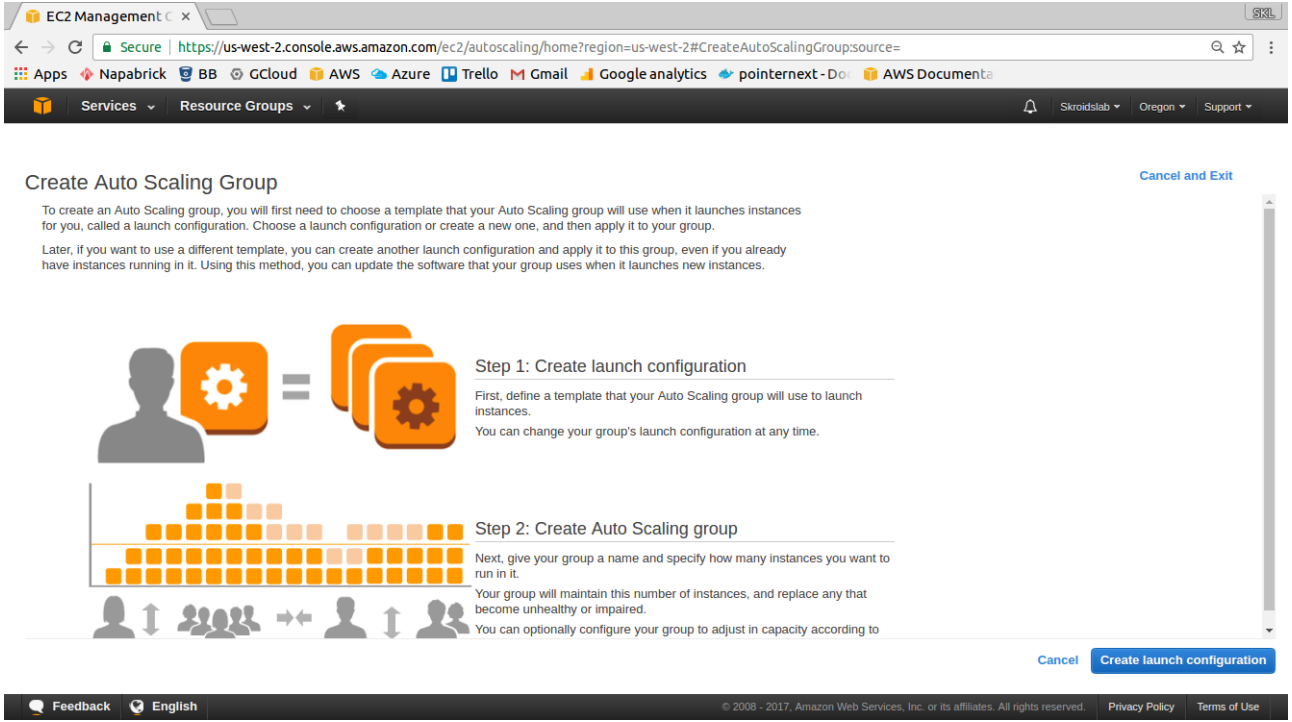
Question

Are you sure the capacity graph will be smooth and as parallel to the utilization graph?

Activity - Launch configuration



Activity - Launch configuration



Activity - Launch configuration

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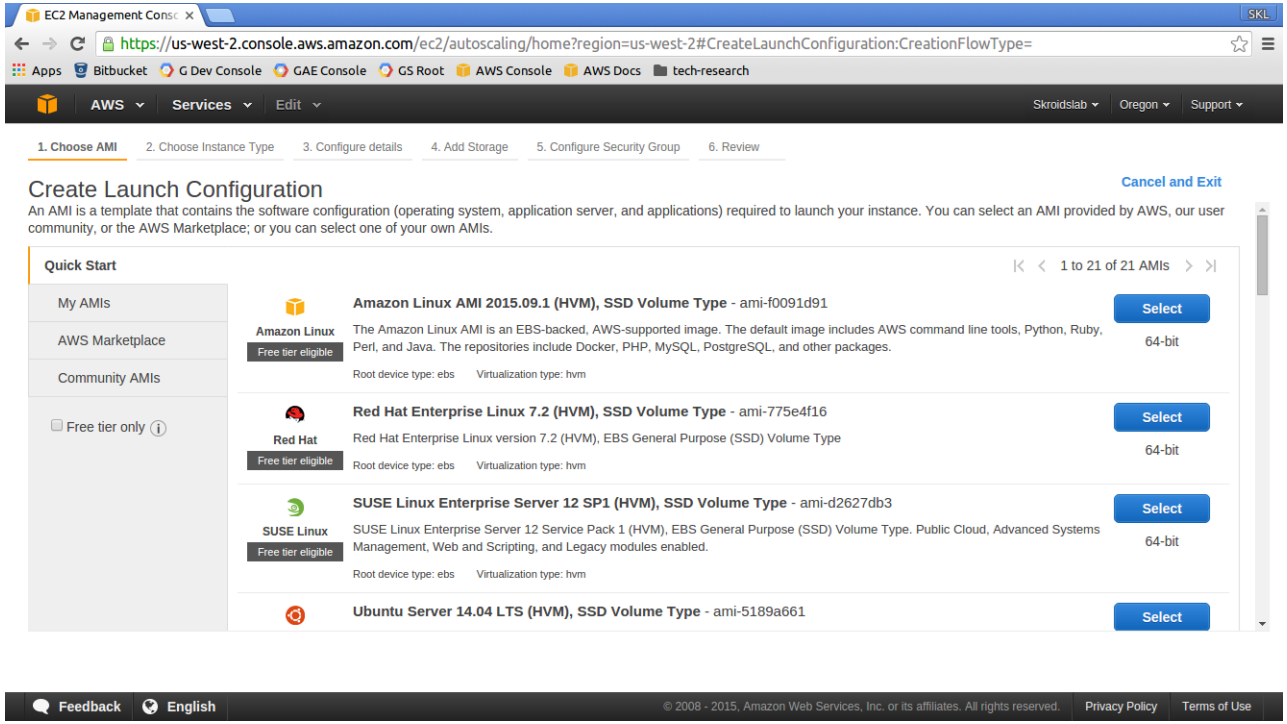

Activity - Launch configuration

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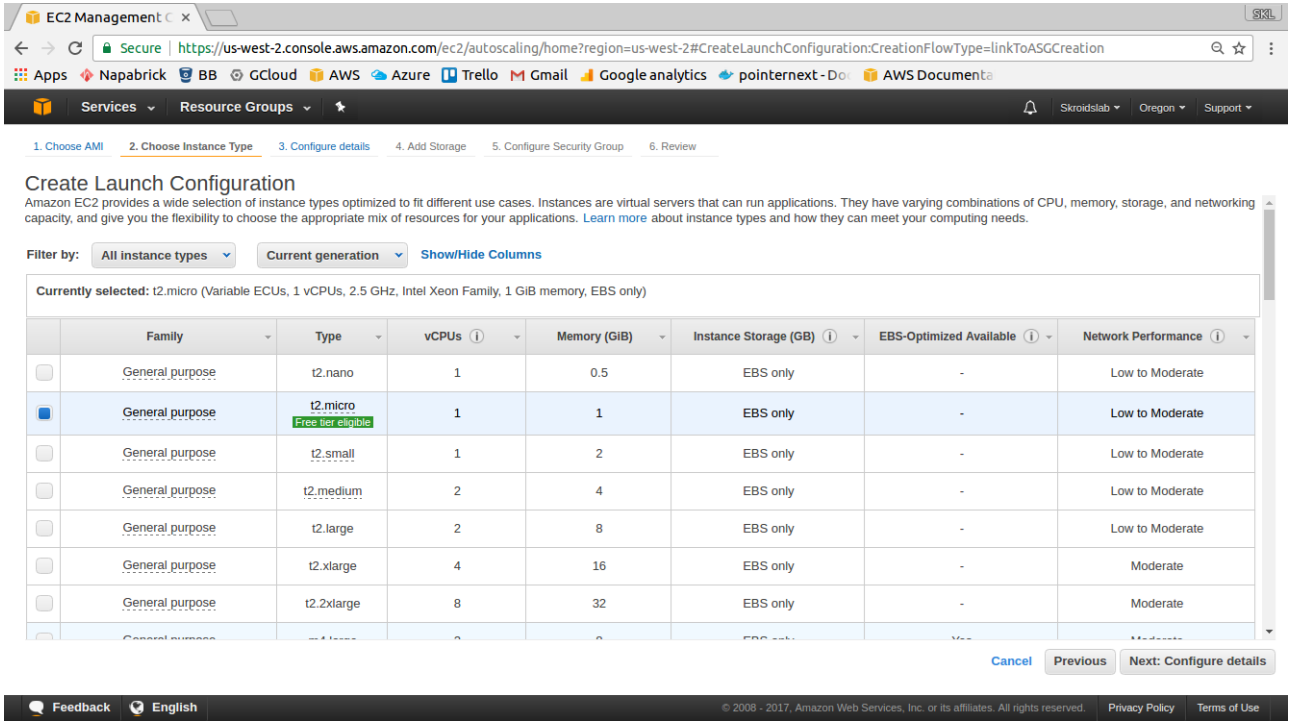

Activity - Launch configuration

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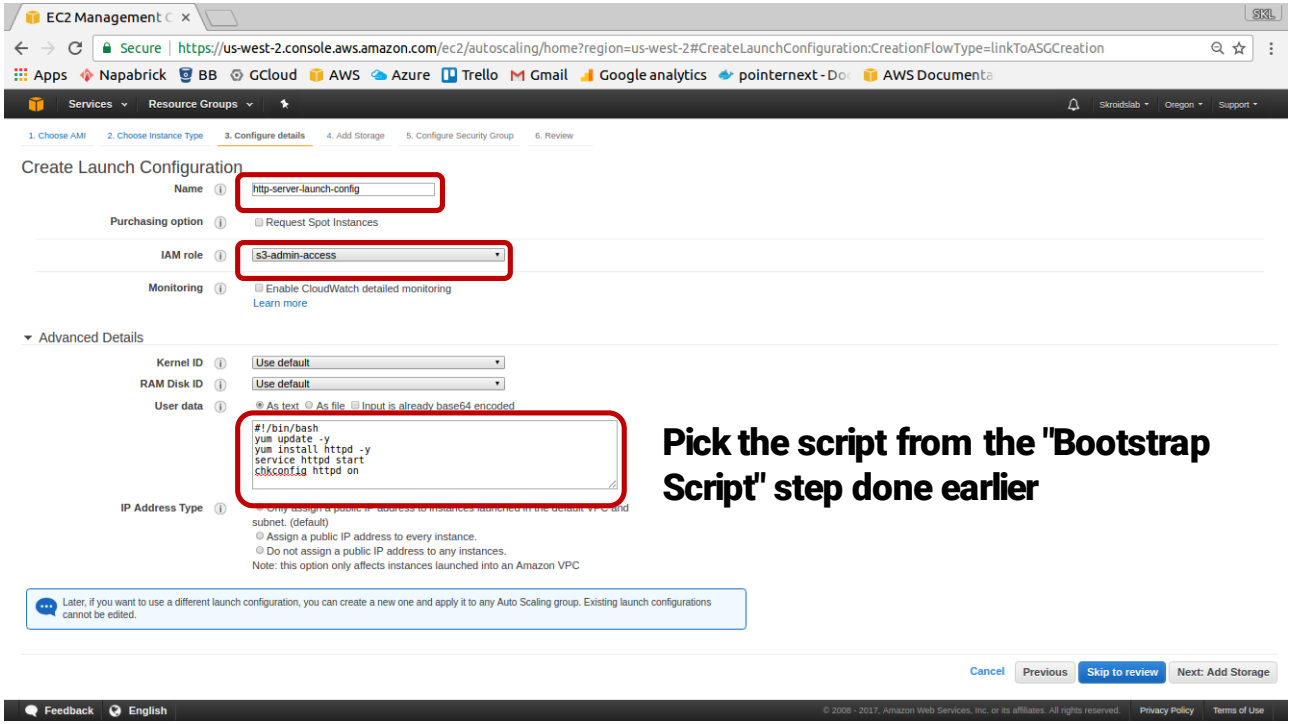
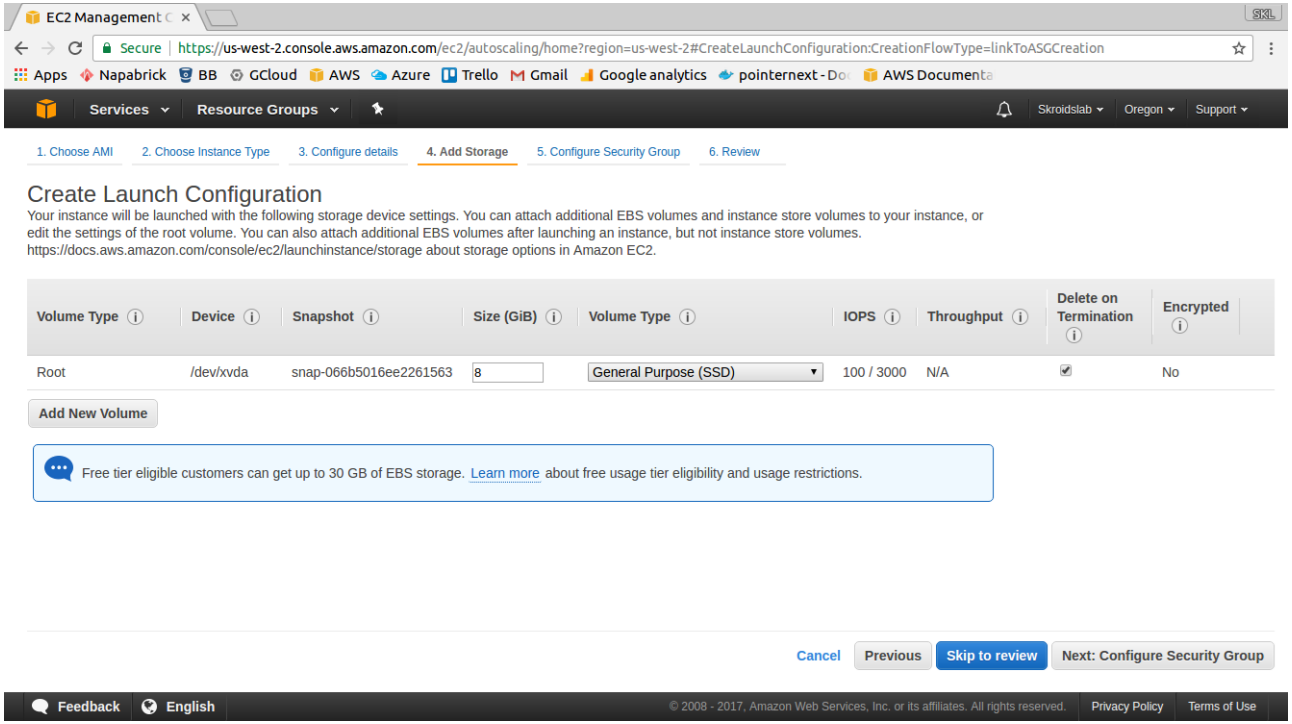


Pick the script from the "Bootstrap Script" step done earlier

Activity - Launch configuration



Activity - Launch configuration

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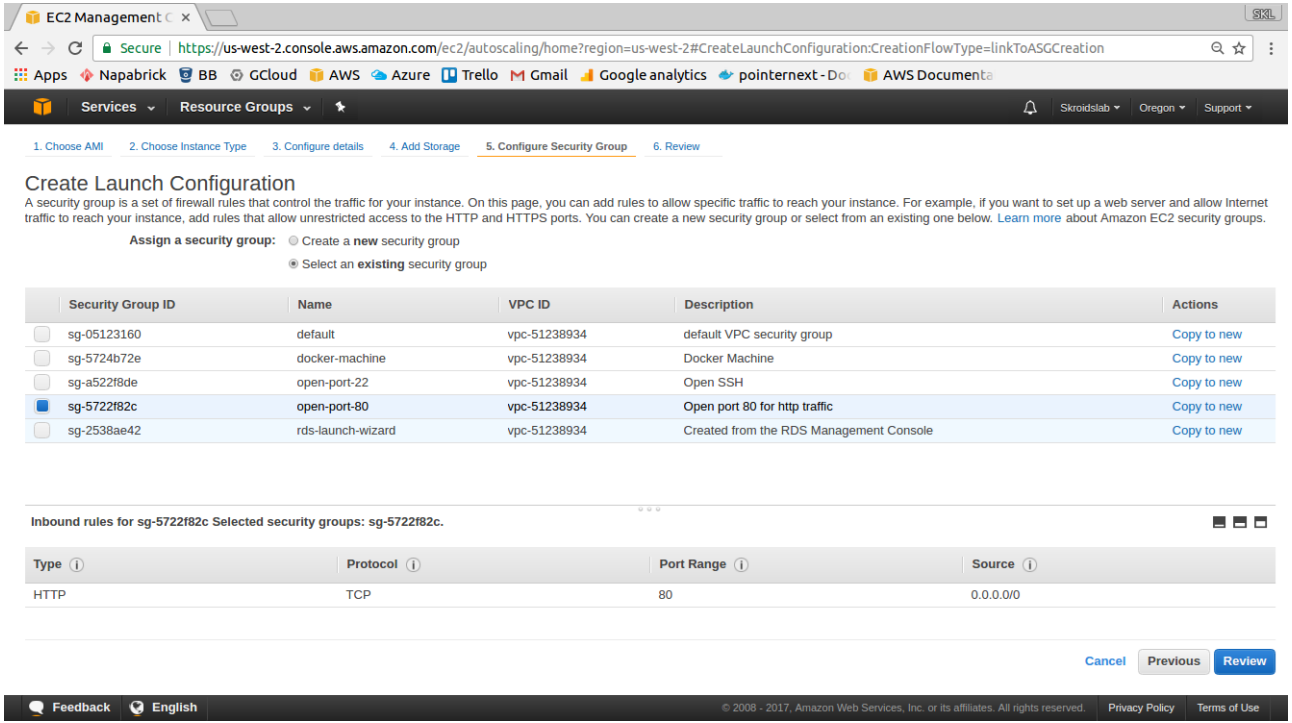
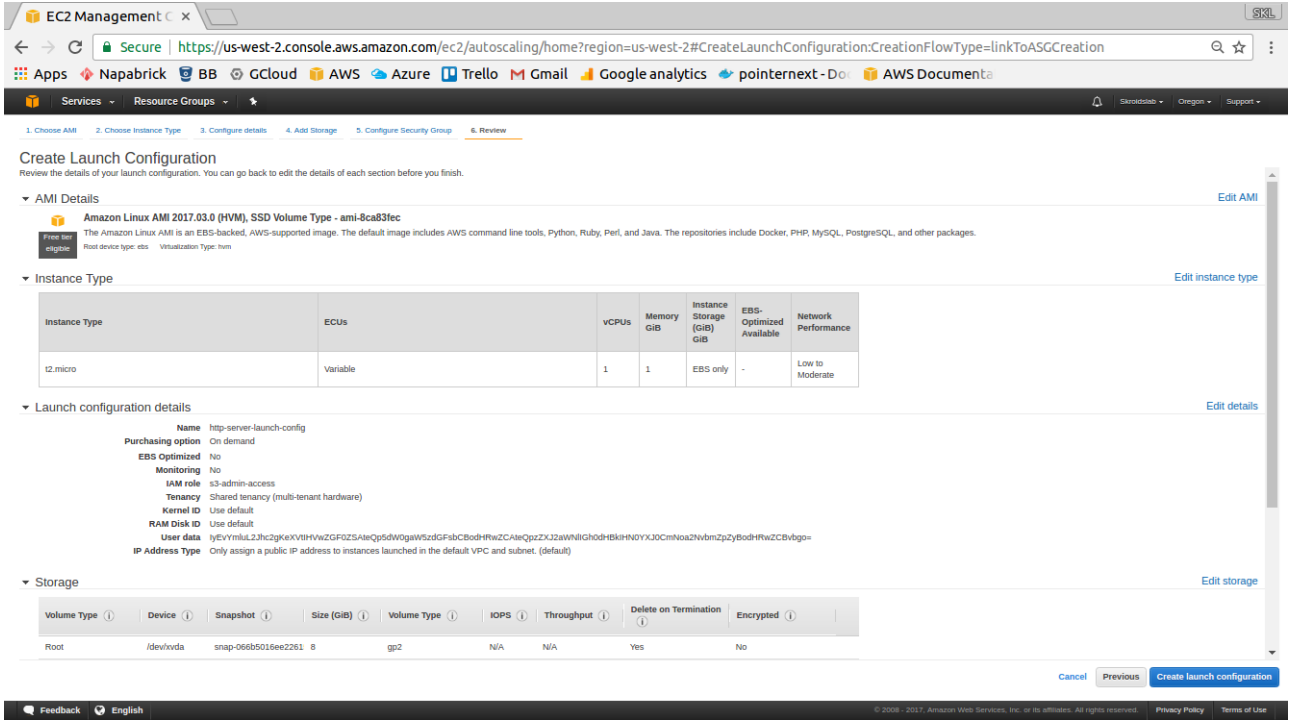
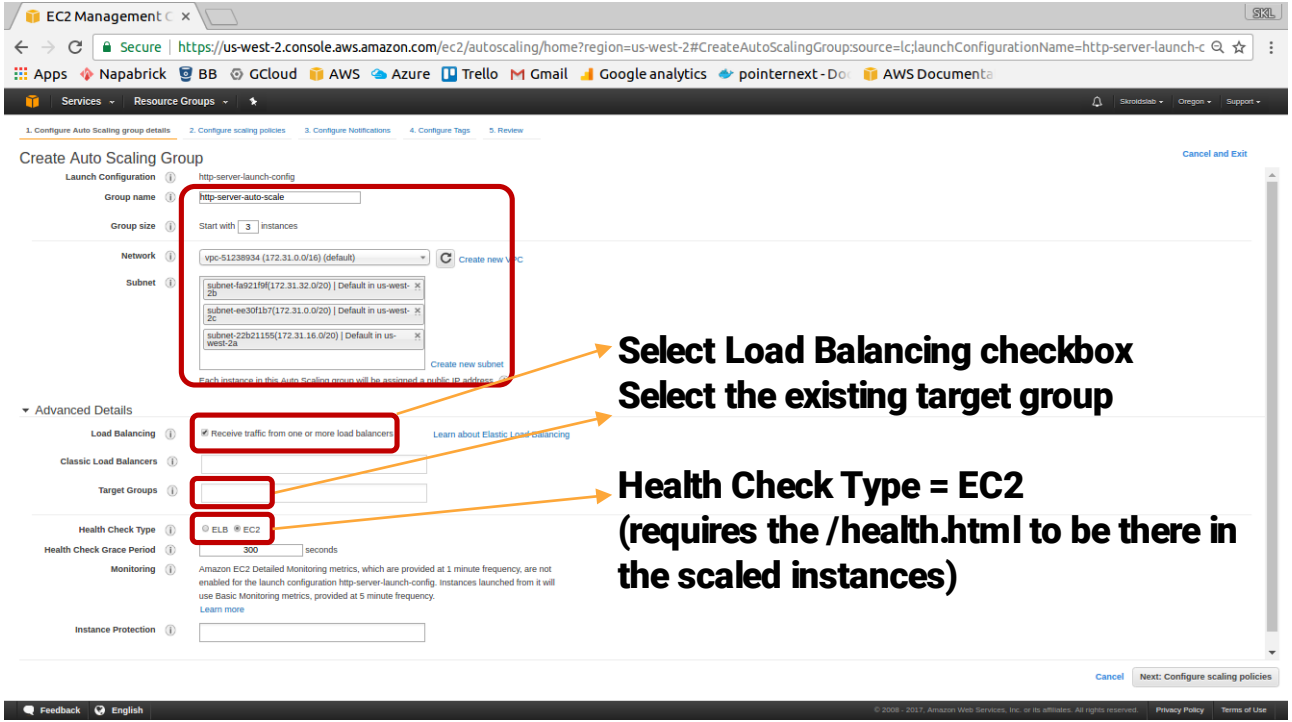


Activity - Launch configuration

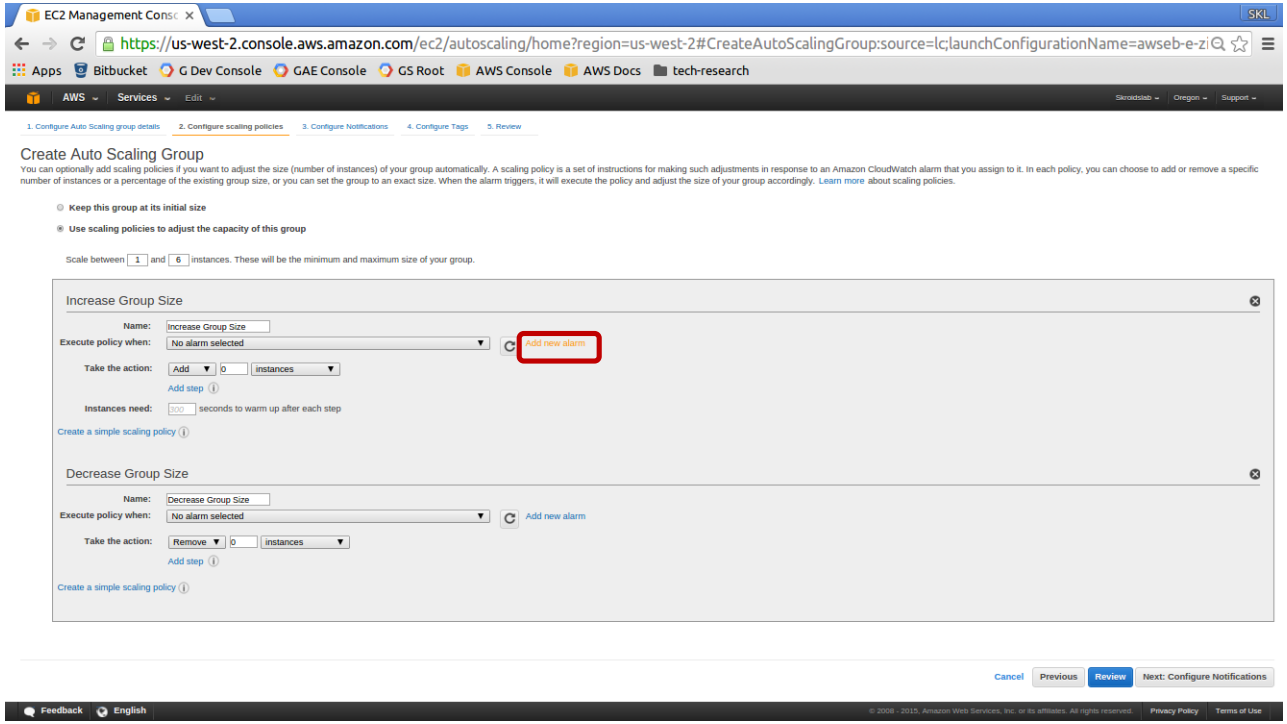


Pick the existing PEM and acknowledge in the next step

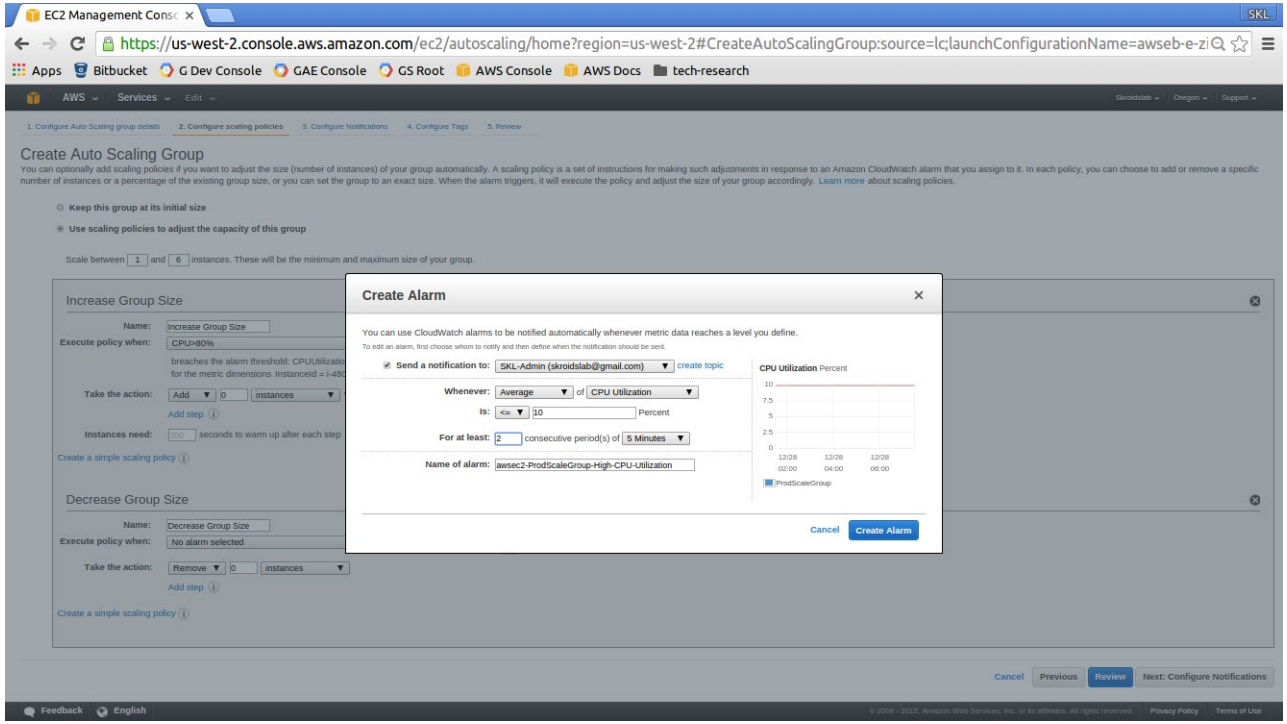
Activity - Auto scale group



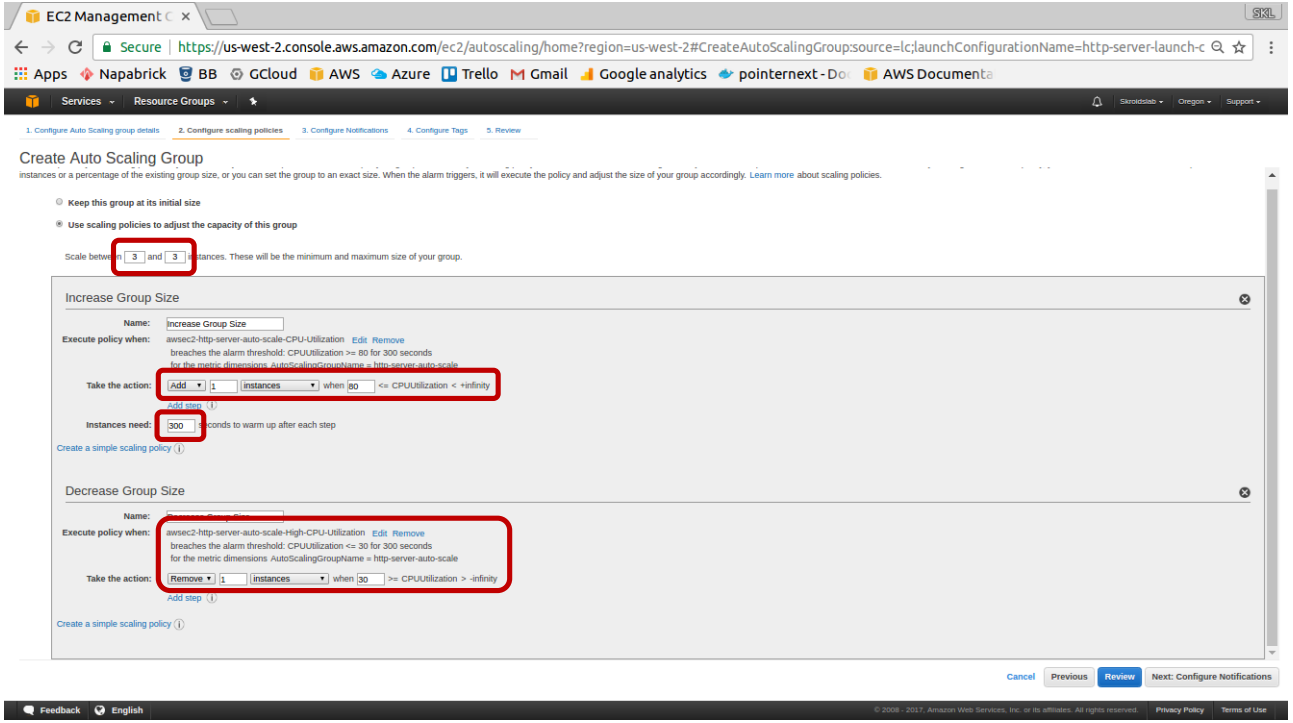
Activity - Auto scale group



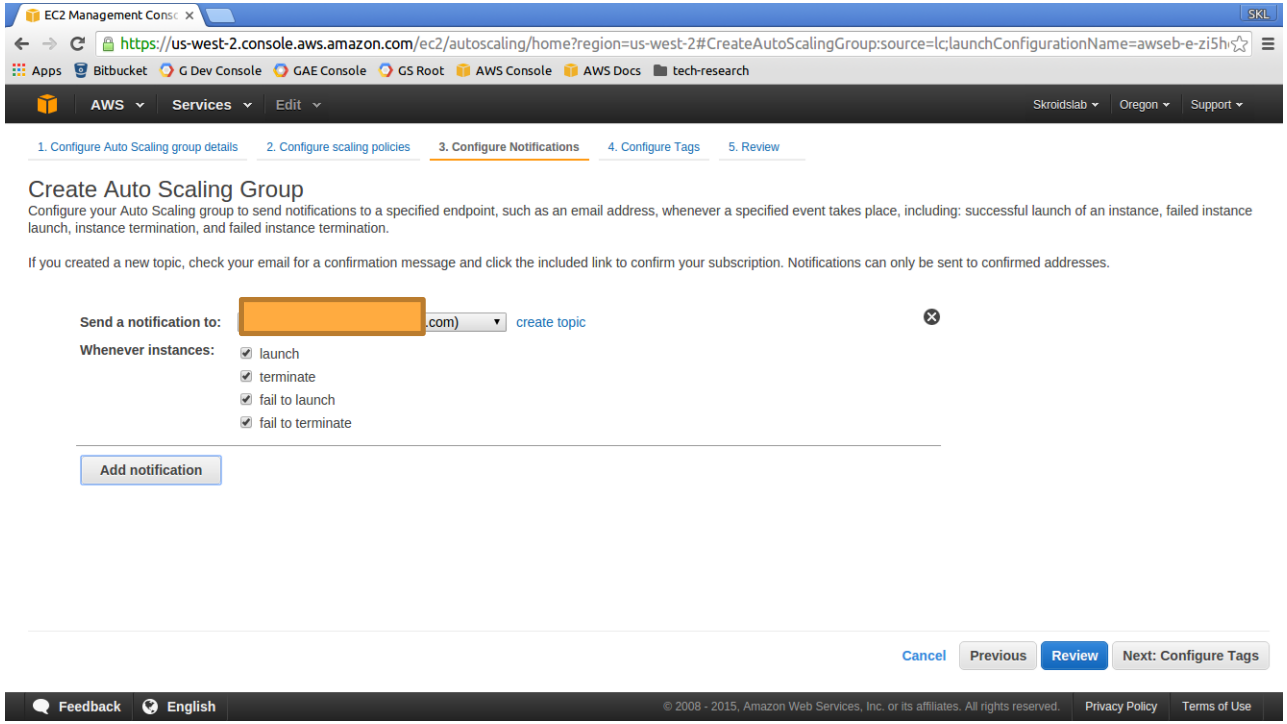
Activity - Auto scale group



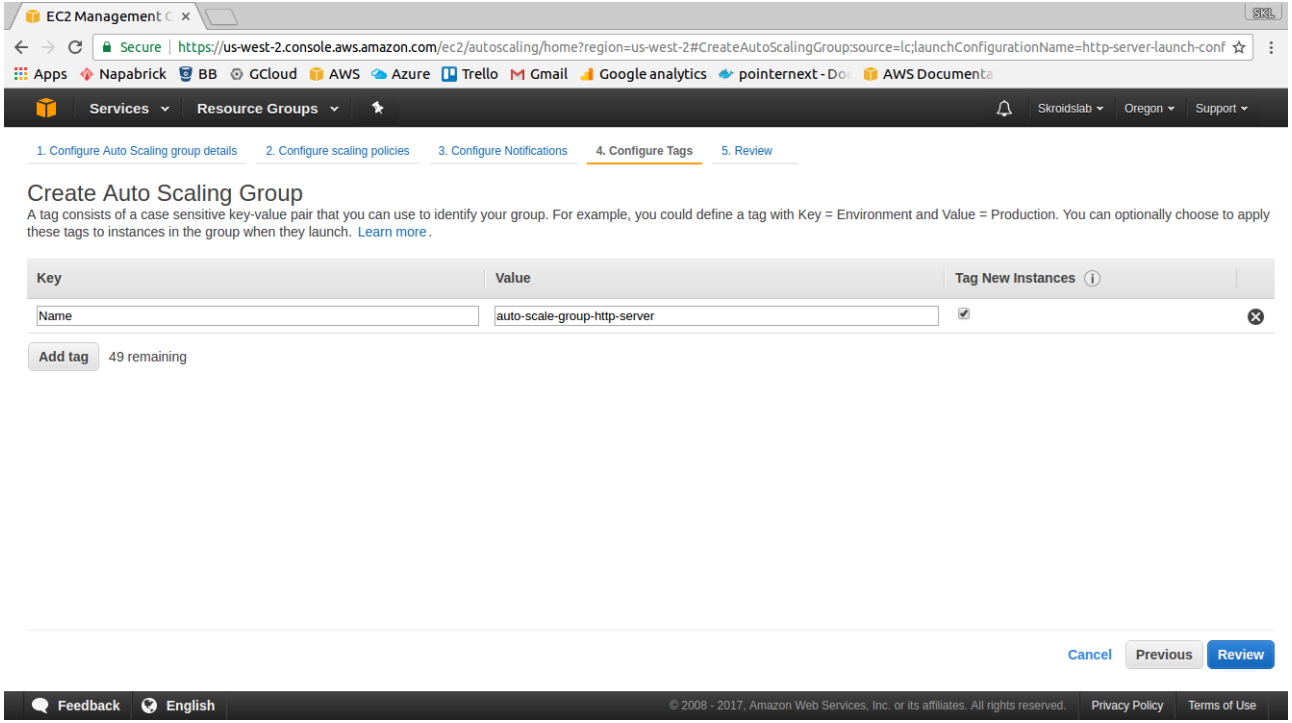
Activity - Auto scale group



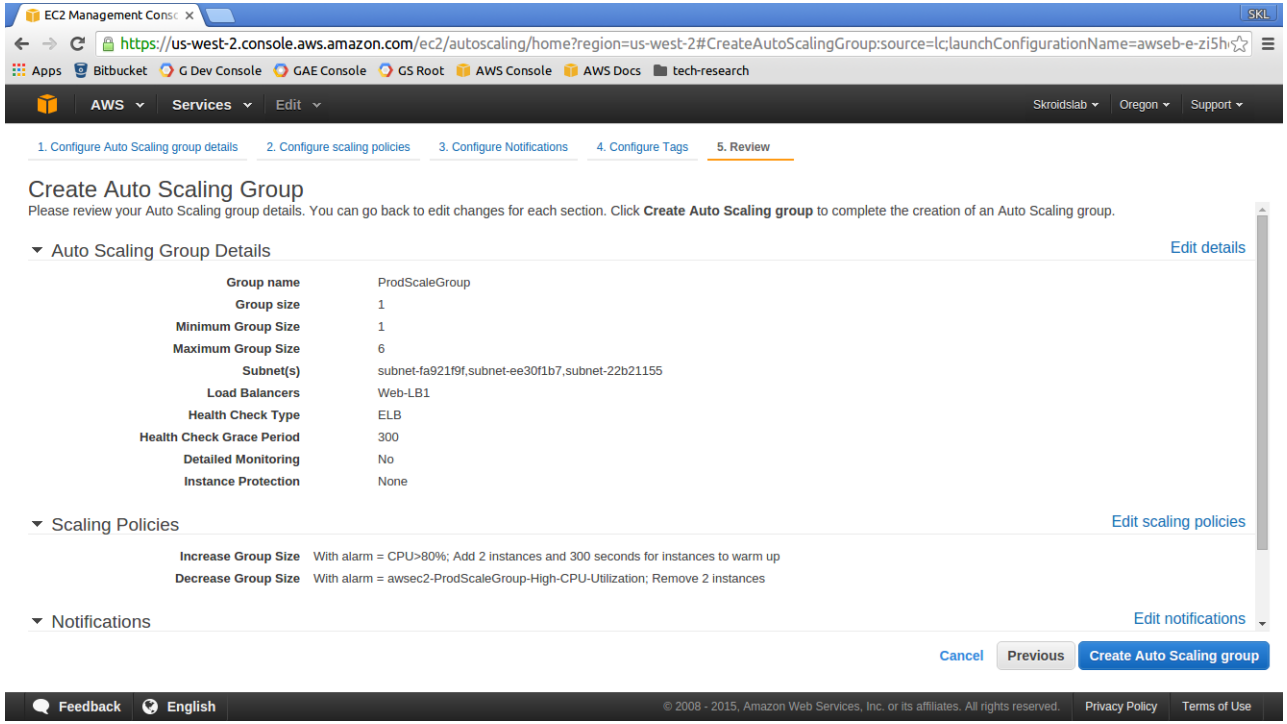
Activity - Auto scale group



Activity - Auto scale group



Activity - Auto scale group



Activity - Auto scale group

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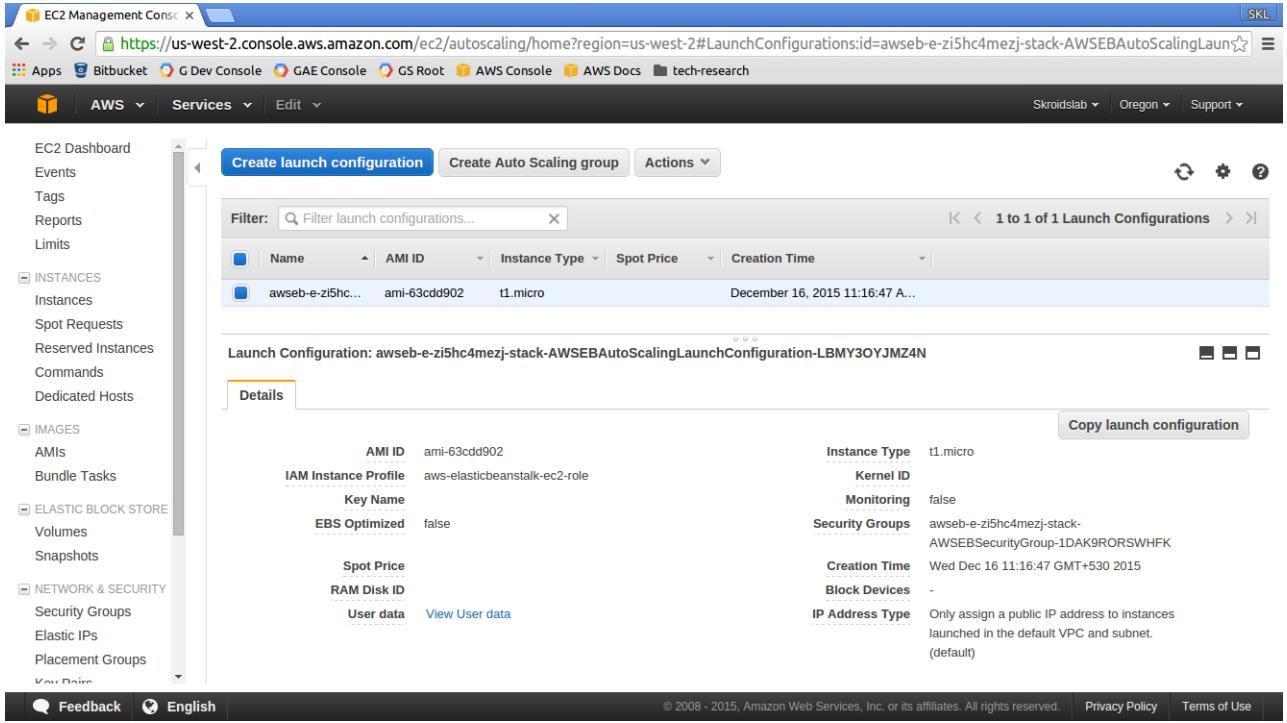
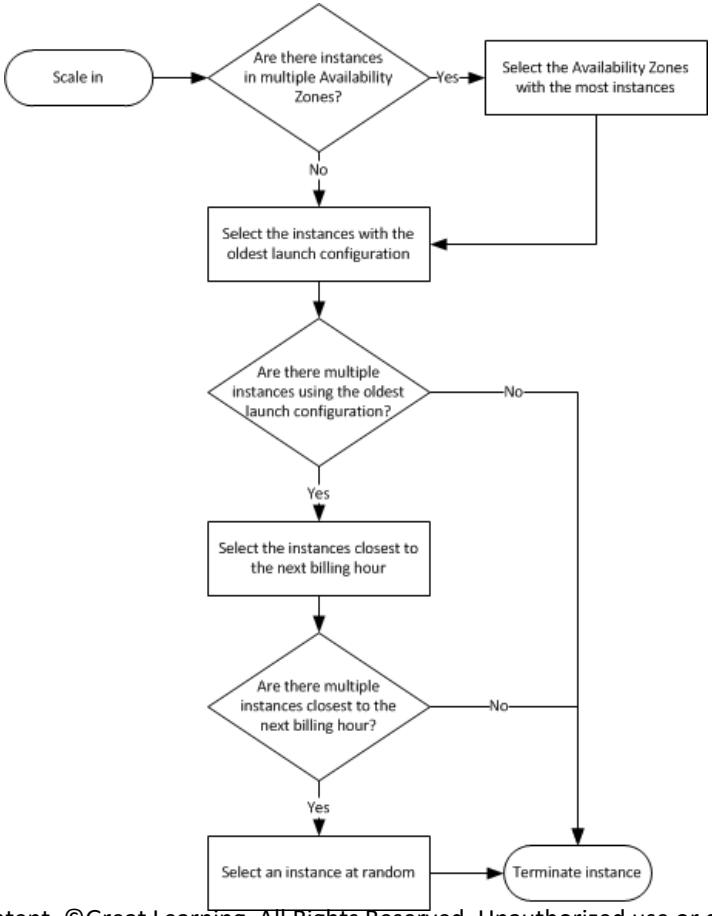


Go to the Load Balancer section and see the instances! Kill this newly created instance and state your observations!

Auto scale instance termination



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Compute - Part II

Instance metadata & Placement groups

Activity - Instance metadata

- On any instance using the following URL, gets the metadata
  - curl http://169.254.169.254/latest/meta-data/
  - Above command gives a bunch of options
  - Use any of these options at the end of the URL to get the metadata e.g.
  - curl http://169.254.169.254/latest/meta-data/public-ipv4
  - Notice the output in the following line just before the prompt
  - This URL is not about user data

Activity - Placement groups

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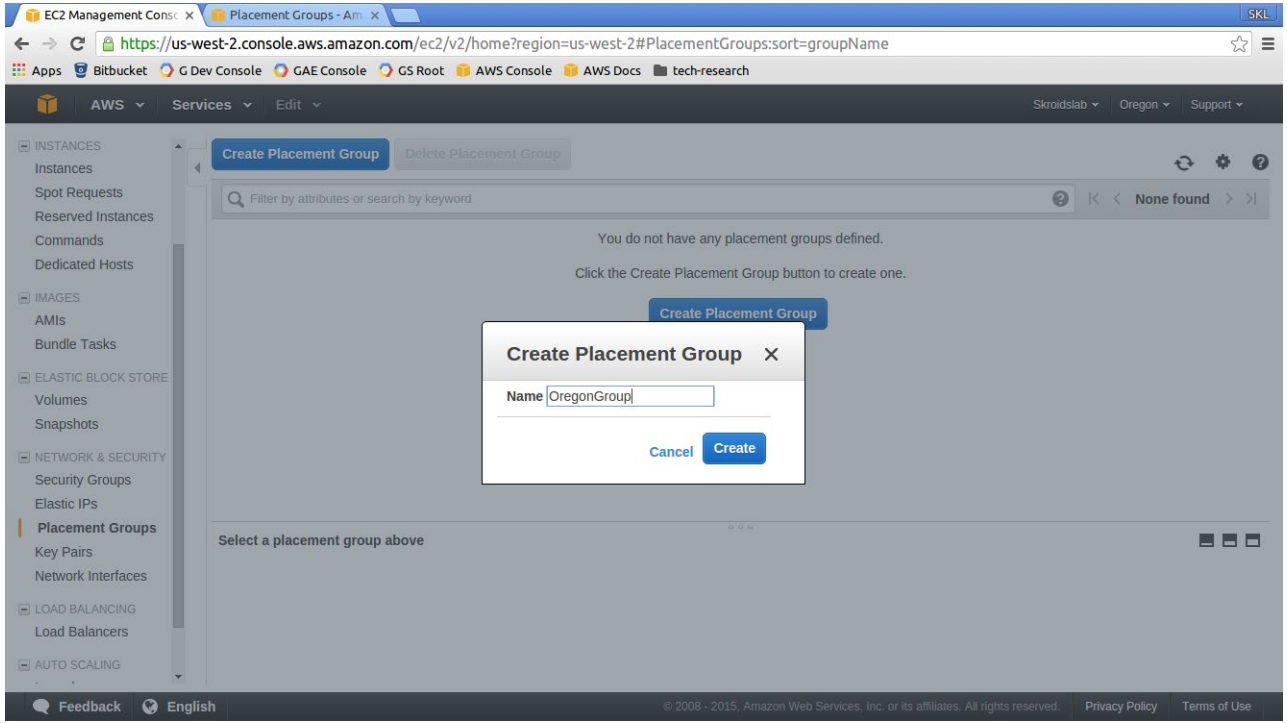
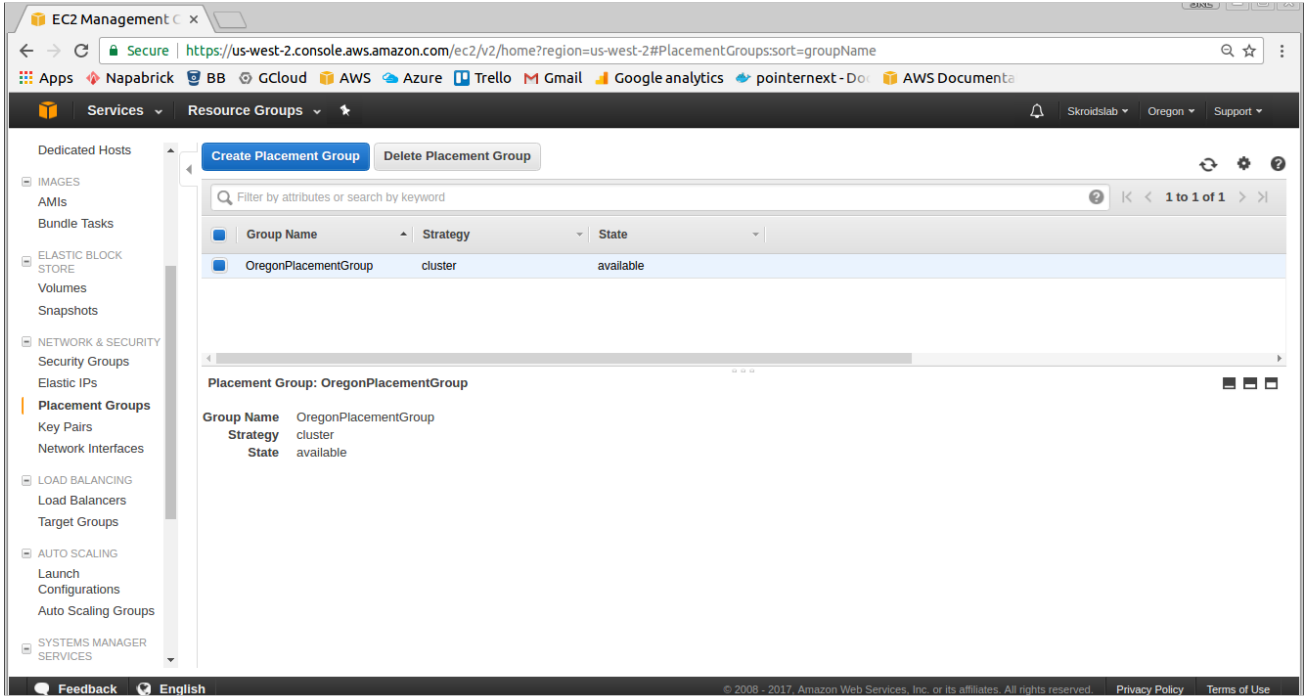
- A placement group is a logical group of EC2 instances in a "single availability zone"
- The objective is to have very high speed connectivity (10gbps) among the instances giving:
  - Low network latency
  - High network throughput
  - Or Both
- Name must be unique within the account
- Only certain type of instances can be launched (optimized for Compute, GPU, Mem, Storage)
- Recommended to have the same type of machines within a given placement group
- Cannot merge 2 placement groups
- Cannot move a placement group from one region to other either in part or full
- Cannot move an existing instance into a placement group

Activity - Placement groups



Activity - Placement groups

greatlearning



Activity - Placement groups

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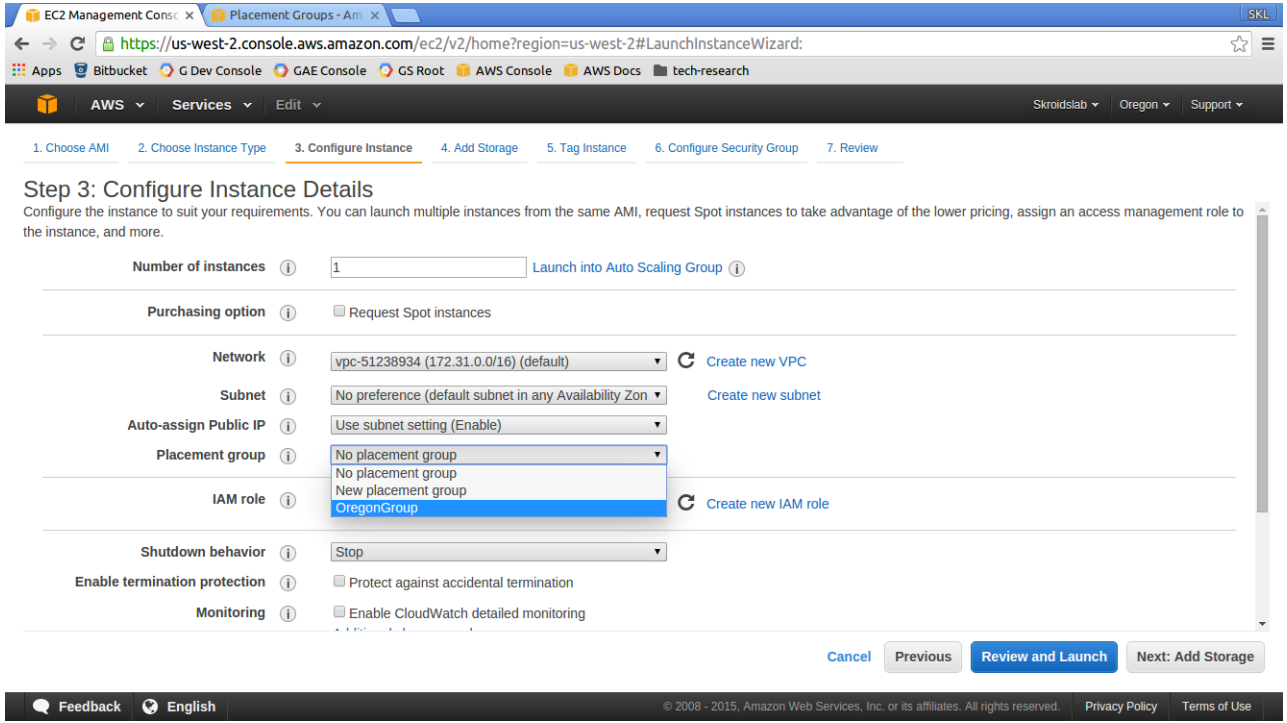

Compute - Part II

Windows on EC2

Windows EC2 instance

- Let's launch a windows instance
  - "Microsoft Windows Server 2016 Base"
  - m4.xlarge
  - Volume needs to be 30GB minimum
  - Add the RDP (remote desktop protocol) in the security group
  - Create a new PEM file
- Launch the instance (takes slightly longer as compared to linux)
- Next steps are a bit different in windows ...

Activity - Windows EC2 instance

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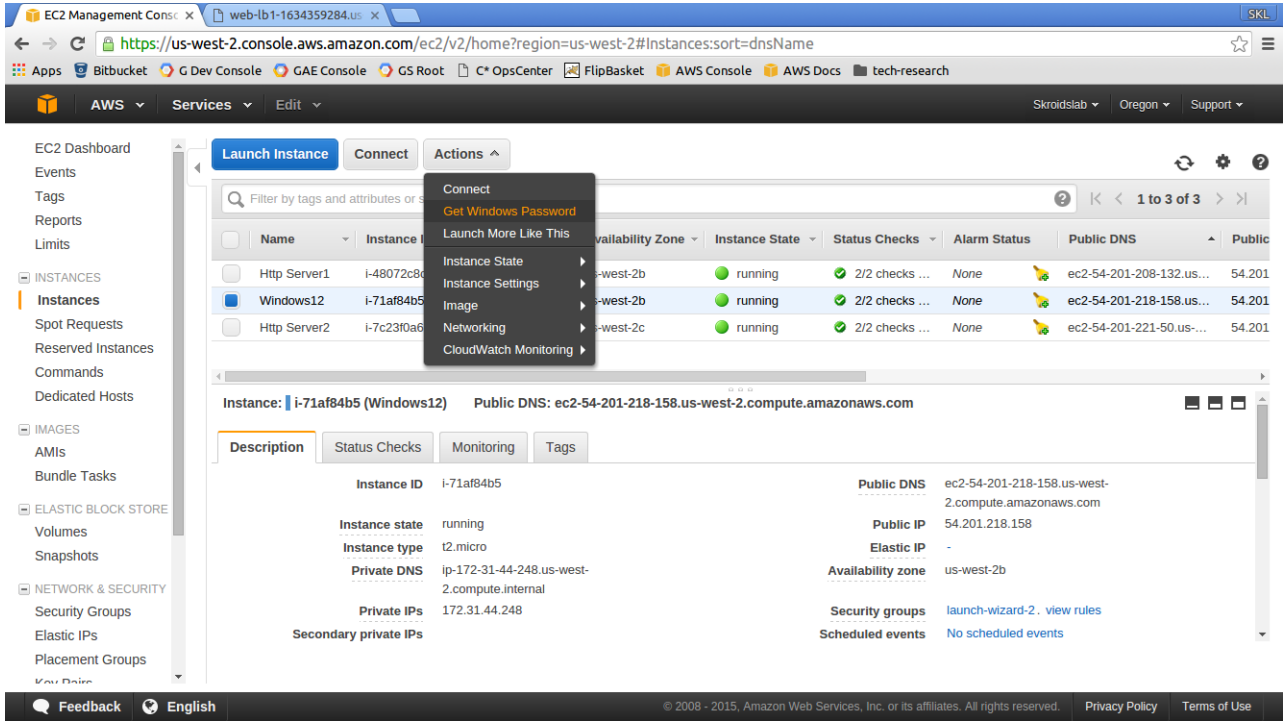

Activity - Windows EC2 instance

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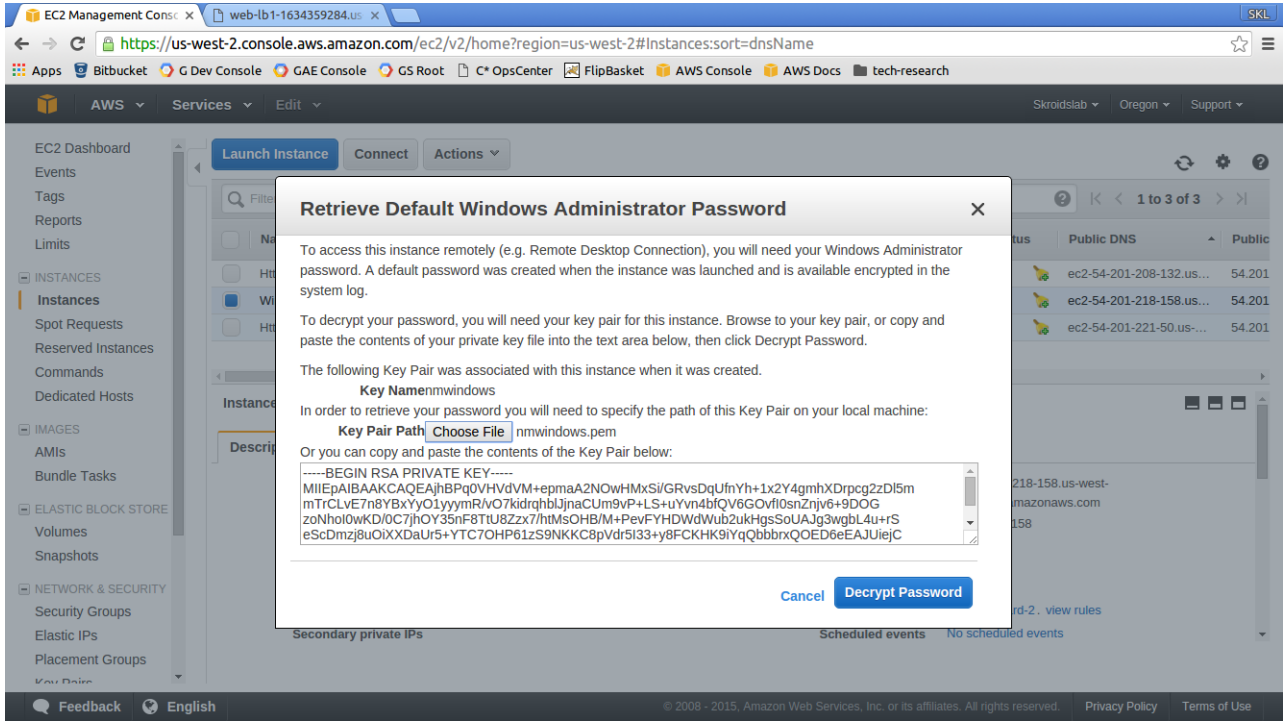
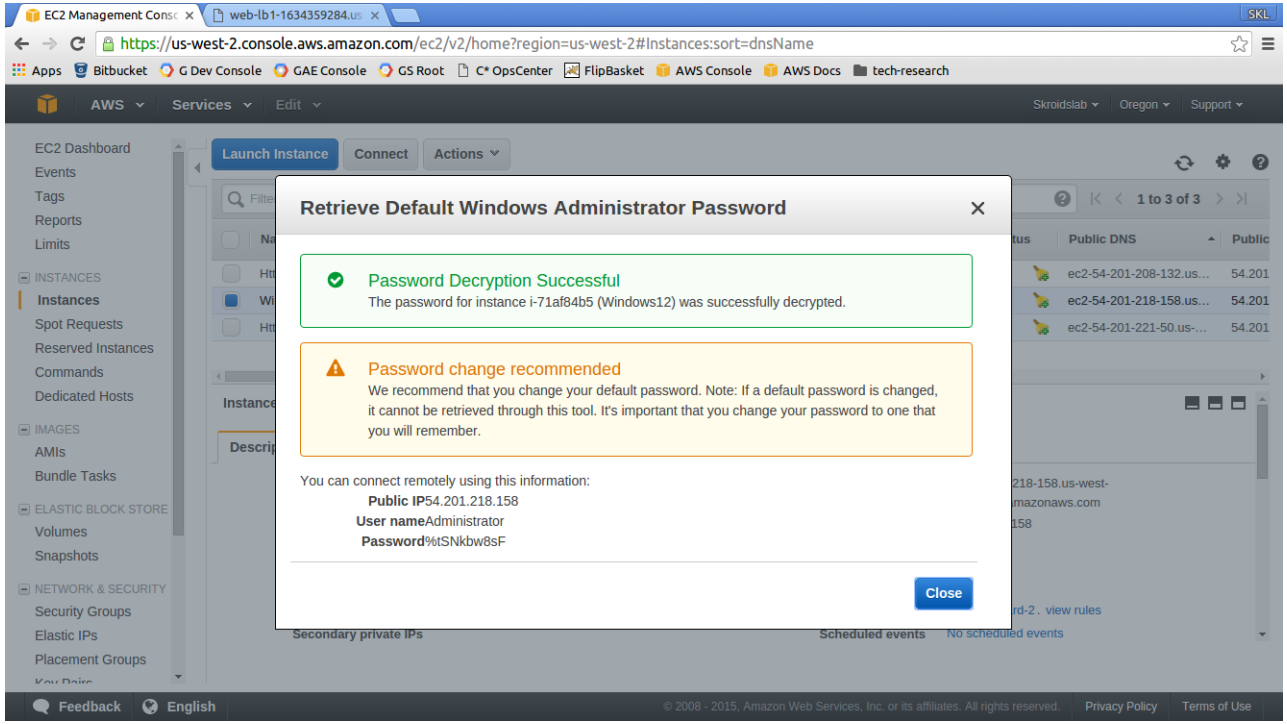
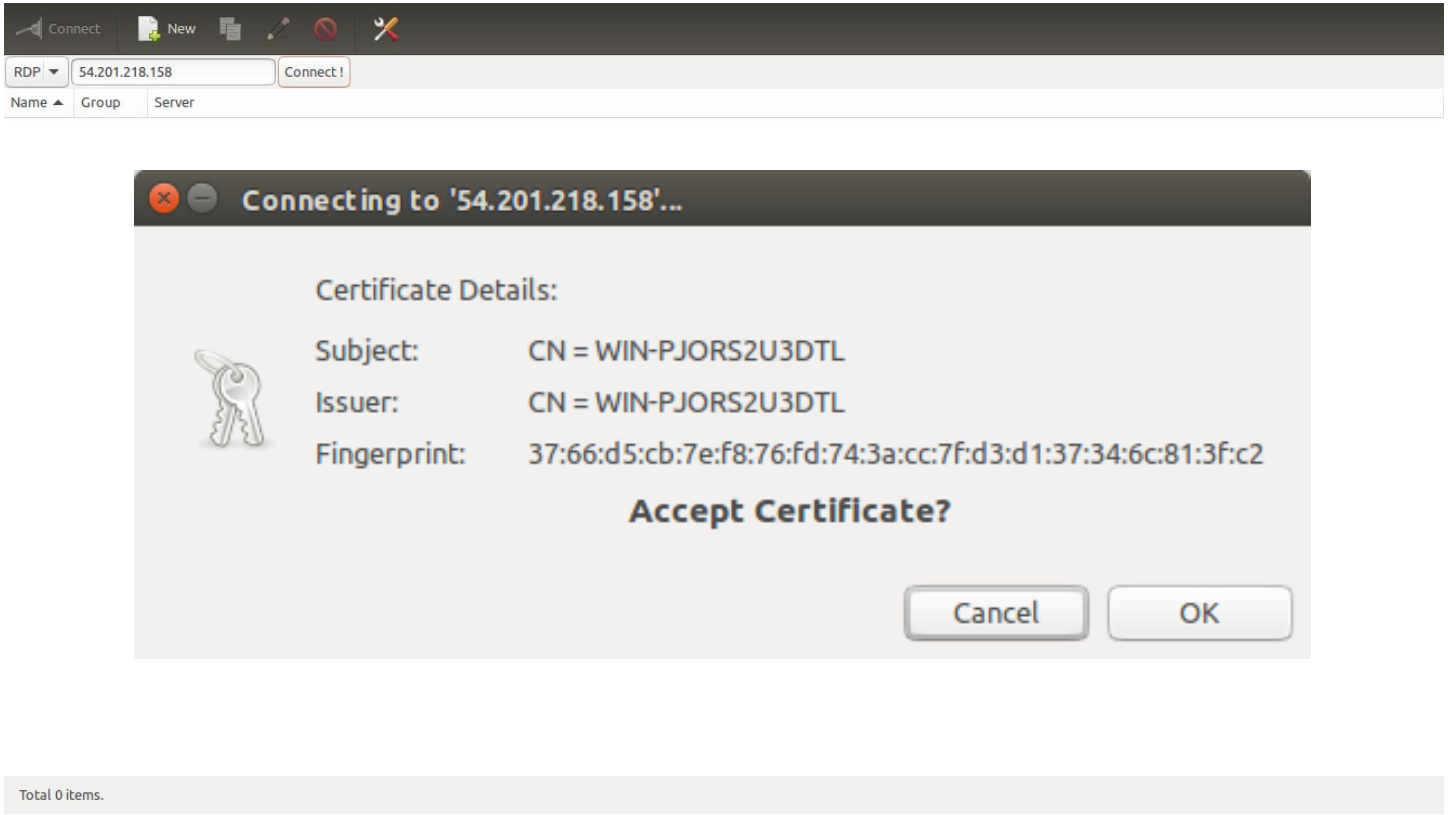


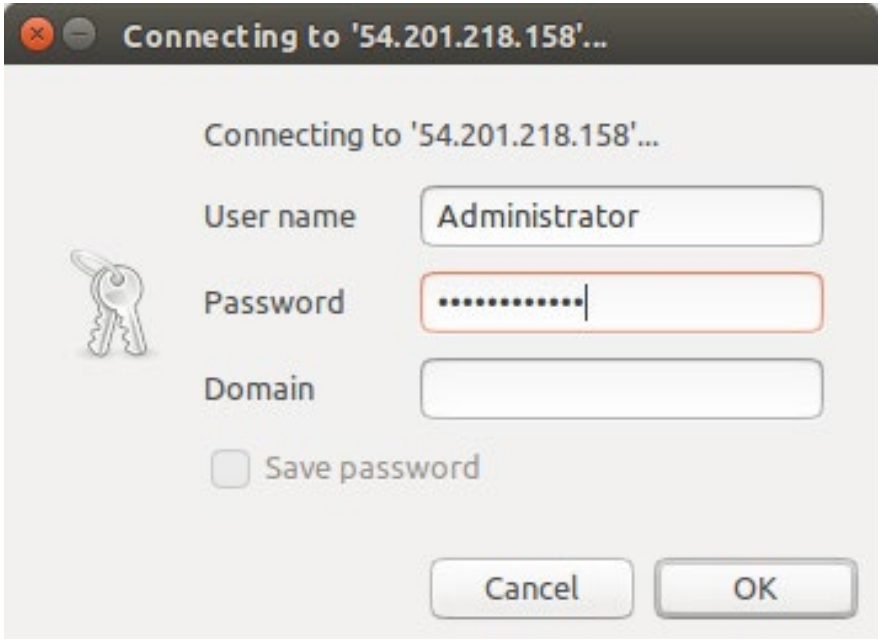
Activity - Windows EC2 instance



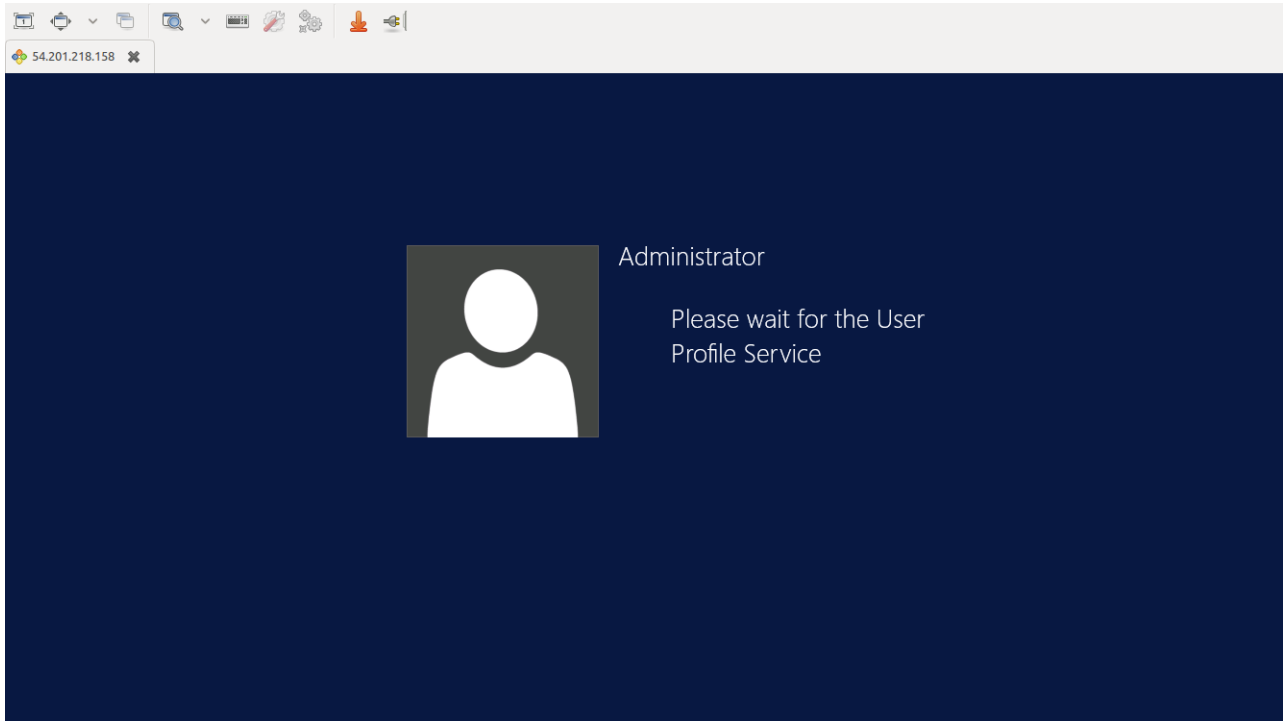
Activity - Windows EC2 instance



Activity - Windows EC2 instance



Activity - Windows EC2 instance



Activity - Windows EC2 instance