**CS 310**
**Scalable Software Architectures**
**Spring 2023**

# Project #02 --- Part 02 (v1.3)

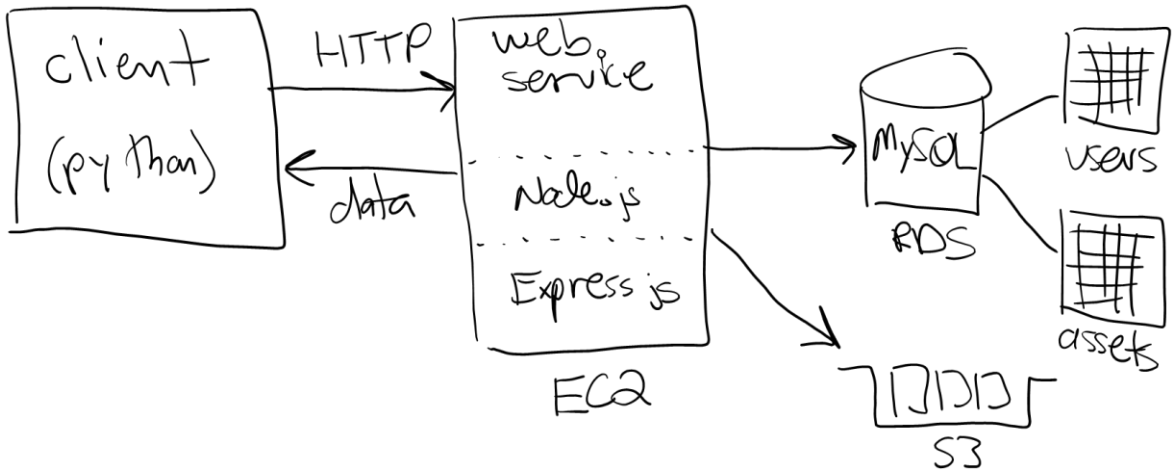
**Assignment:** Multi-tier PhotoApp with AWS EC2, S3 and RDS
**Submission:** via Gradescope (unlimited submissions)
**Policy:** individual work only, late work is accepted
**Complete By:** Friday May 12 @ 11:59pm CST

Late submissions: you can submit up to 3 days late (Monday May 15), no penalty using late days.
NO submissions accepted after Monday May 15.

**Pre-requisites:** Lecture 08 (Tues April 25). See Canvas for links to recording / PPT

## Overview

Here in project 02 we are building out the web service for our PhotoApp, and rewriting the client to interface with the web service API:




In part 02 we're going to complete the web service by adding two more functions to the API: **/user** and **/image/:userid**. Then we'll use AWS *Elastic Beanstalk* to help us provision an instance of EC2 to run our web service and expose our API to the outside world.

## Before we start…

Here in part 02 there are three main steps to perform:

1. *Implement the API function **/user**, which uses the PUT verb to either insert a new user into the database, or if the user already exists (based on the email address) then the user's lastname, firstname, and bucketfolder in the database are updated.*
2. *Implement the API function **/image/:userid**, which uses the POST verb to upload an image to S3, and then store information about this asset in the database.*
3. *Use AWS **Elastic Beanstalk** to deploy your web service on an instance of EC2.*

Gradescope will be used to collect your web service files, and your EC2 endpoint. We are not collecting your Python client, but you'll need to continue development for testing purposes.

## (1) /user

The **/user** function inserts a new user, or updates an existing user, in the database. The client will make a PUT request, passing the following data in the body of the request using JSON:

```
data = {
  "email":        "...",
  "lastname":     "...",
  "firstname":    "...",
  "bucketfolder": "..."
}
```

If the given email is not found in the **users** table, a new user is inserted and the web service returns the following response:

```
{
  "message": "inserted",
  "userid":  userid
}
```

Note that when you execute an SQL insert query, the MySQL library returns the auto-generated userid in **`result.insertId`** (capital I and lowercase d). If you want to double-check that the insert executed successfully, confirm that `result.affectedRows == 1`.

If the given email is found in the users table, the user's row in the database is updated with the provided data, and the web service returns the following response:

```
{
  "message": "updated",
  "userid":  userid
}
```

No changes are made to S3, even though the user's bucketfolder may have changed in the database. If an

error occurs, return the following response with a status code of 400:

```
{
  "message": "some sort of error message",
  "userid":  -1
}
```

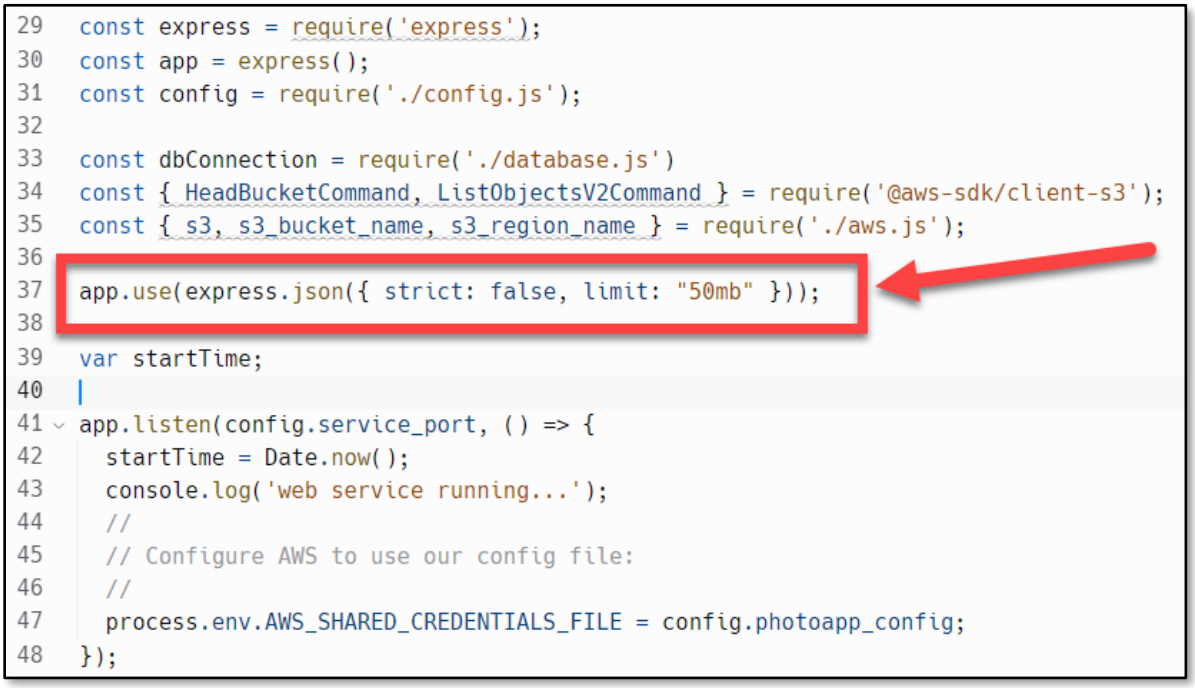
To get started, download the JS file "api_user.js" from dropbox. This file exports the function **put_user**:

```
exports.put_user = async (req, res) => {

  console.log("call to /user...");

  try {
    .
    .
    .
  }
  catch (err) {
    res.status(400).json({
      "message": err.message,
      "userid": -1
    });
  }
}
```

You'll need to update your main "app.js" file to call this function when a PUT request is made for /user. First, add the following app.use( ) call to enable JSON deserialization of incoming JSON data (and support for large image files):



```
29  const express = require('express');
30  const app = express();
31  const config = require('./config.js');
32
33  const dbConnection = require('./database.js')
34  const { HeadBucketCommand, ListObjectsV2Command } = require('@aws-sdk/client-s3');
35  const { s3, s3_bucket_name, s3_region_name } = require('./aws.js');
36
37  app.use(express.json({ strict: false, limit: "50mb" }));
38
39  var startTime;
40
41  app.listen(config.service_port, () => {
42    startTime = Date.now();
43    console.log('web service running...');
44    //
45    // Configure AWS to use our config file:
46    //
47    process.env.AWS_SHARED_CREDENTIALS_FILE = config.photoapp_config;
48  });
```

Now load the "api_user.js" file (step 1) and associate a PUT request for /user to call put_user (step 2):

```
61  //
62  // service functions:
63  //
64  var stats = require('./api_stats.js');
65  var users = require('./api_users.js');
66  var assets = require('./api_assets.js');
67  var bucket = require('./api_bucket.js');
68  var download = require('./api_download.js');
69
70  var user = require('./api_user.js');
71
72  app.get('/stats', stats.get_stats);  //app.get('/stats', (req, res) => {...});
73  app.get('/users', users.get_users);  //app.get('/users', (req, res) => {...});
74  app.get('/assets', assets.get_assets);  //app.get('/assets', (req, res) => {...});
75  app.get('/bucket', bucket.get_bucket);  //app.get('/bucket?startafter=bucketkey', (req,
76  app.get('/download/:assetid', download.get_download); //app.get('/download/:assetid', (
77
78  app.put('/user', user.put_user); // app.put('/user', (req, res) => {...});
79
```

1

2

The web service is now configured and runnable. This would be a good time to setup a testing infrastructure, and confirm that the web service returns an error when /user is called:

```
{
  "message": "TODO: /user",
  "userid":  -1
}
```

How to test? You have at least two options. Option #1 is to extend your Python-based client with another command to update/insert a user. See Lecture 08 (slide 13) for an example of how to code the client. Option #2 is to use a tool such as https://postman.com to generate a PUT request and supply test data; see lecture 08 for an example of this as well. [ *Note that we are *not* collecting the Python client here in part 02, so you are free to implement client-side testing however you want.* ]

**SUGGESTION**: when working with a new language and framework, it's generally a good idea to write just a few lines of code, add some print debugging with console.log( ), run and test. Then write a few more lines, more console.log( ), run, test. Repeat. Your function needs to respond, so at the bottom of your try block have this:

```
console.log("/user done, sending response...");

res.json({
  "message": "so far so good",
  "userid": 123
});
```

Slowly evolve the function step by step until it's working.

## (2) /image/:userid

The **/image/:userid** function uploads an image to S3 and updates the database accordingly. The client will make a POST request, passing the user id as part the path and the following data in the body of the request using JSON:

```
data = {
  "assetname": "...",
  "data":      "..."
}
```

The **assetname** element is the local filename, and **data** element is the image as a base64-encoded string. If the user id does not exist in the database, the web service returns normally (status code 200) with the following response:

```
{
  "message": "no such user...",
  "assetid": -1
}
```

If the user id exists, the image is uploaded to S3 and stored in the user's folder with a unique key; generate the key using UUID v4 as we have in the past. Also insert a new row into the **assets** table of the database, and respond with the auto-generated asset id as follows:

```
{
  "message": "success",
  "assetid": assetid
}
```

If an error occurs, return the following response with a status code of 400:

```
{
  "message": "some sort of error message",
  "assetid": -1
}
```

To get started, download the JS file "api_image.js" from dropbox. This file exports the function **post_image**:

```
const uuid = require('uuid');

exports.post_image = async (req, res) => {

  console.log("call to /image...");

  try {
    .
    .
    .
  }
  catch (err) {
```

```
      res.status(400).json({
        "message": err.message,
        "assetid": -1
      });
    }
}
```

You'll need to update your main "app.js" file to call this function when a POST request is made for /image. Load "api_image.js" file (step 1) and associate a POST request for /image/:userid to call post_image (step 2):

```
61  //
62  // service functions:
63  //
64  var stats = require('./api_stats.js');
65  var users = require('./api_users.js');
66  var assets = require('./api_assets.js');
67  var bucket = require('./api_bucket.js');
68  var download = require('./api_download.js');
69  var user = require('./api_user.js');
70
71  var image = require('./api_image.js');
72
73  app.get('/stats', stats.get_stats);  //app.get('/stats', (req, res) => {...});
74  app.get('/users', users.get_users);  //app.get('/users', (req, res) => {...});
75  app.get('/assets', assets.get_assets);  //app.get('/assets', (req, res) => {...});
76  app.get('/bucket', bucket.get_bucket);  //app.get('/bucket?startafter=bucketkey', (req, res) => {...});
77  app.get('/download/:assetid', download.get_download); //app.get('/download/:assetid', (req, res) => {...});
78  app.put('/user', user.put_user); // app.put('/user', (req, res) => {...});
79
80  app.post('/image/:userid', image.post_image); // app.post('/image/:userid',  (req, res) => {...});
81
```

1

2

The web service is now configured and runnable. This would be a good time to setup a testing infrastructure, and confirm that the web service returns an error when for example **/image/123** is called:

```
{
  "message": "TODO: /image",
  "assetid": -1
}
```

In this case I would recommend testing via your Python-based client, since you'll want to upload the file, and then download and display to confirm it was uploaded properly. You can also use the "users" and "assets" commands to ensure the database is being updated correctly.

**Some programming hints…** On the client, you need to pass the image as a base64-encoded string. This requires the following steps in Python:

1. *Open the file for binary read using open(filename, 'rb'), read the contents, and close the file. The result is an array of bytes we'll call B.*
2. *Encode as base64: E = base64.b64encode(B)*

3. *Interestingly, E is an array of type byte, which JSON doesn't like. So convert E to a string S using S = E.decode( )*

S is your image as a base64-encoded string. Pass S as your data element to the web service. On the server, you'll receive the base64-encoded string and will need to decode so you can send the raw bytes to S3. Use the **Buffer** functionality in node.js to decode:

```
var S = req.body.data;
var bytes = Buffer.from(S, 'base64');
```

You'll send bytes to S3 using the **PutObjectCommand**; see this reference for how to call S3 using this command (scroll down and expand the example "*Upload an object to a bucket*"). Finally, remember to use UUID to generate a unique bucket key for the image:

```
// generate a unique name for the asset:
var name = uuid.v4();
```

Don't forget to prefix the key with the user's bucket folder and "/"; you may assume the file extension is ".jpg".

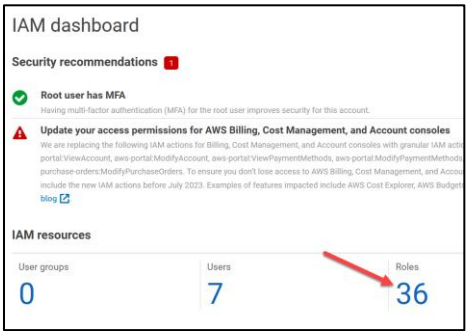
**SAME SUGGESTION**: build the web service function one small step at a time. Use console.log( ) to confirm your steps.

## (3) AWS IAM Roles

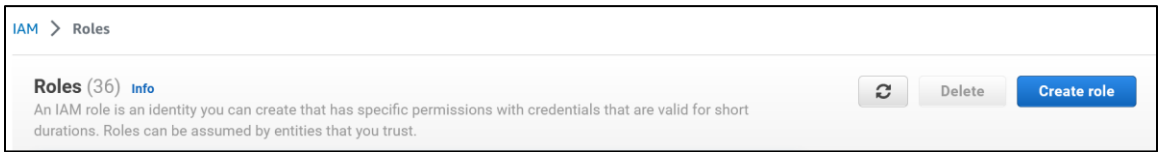
Congratulations, you have built a non-trivial web service using JavaScript, Node.js, and Express js! Well done. The programming is over, the last two steps are to configure AWS to run your web service using **EC2**, Amazon's *Elastic Compute* service. Since we are using a well-known framework, AWS makes it even easier by providing a service on top of EC2 called *Elastic Beanstalk* (EB) that makes setup even easier.

The first step is to setup two security roles in AWS IAM (identity access management), which are needed to control EB and EC2. Steps:

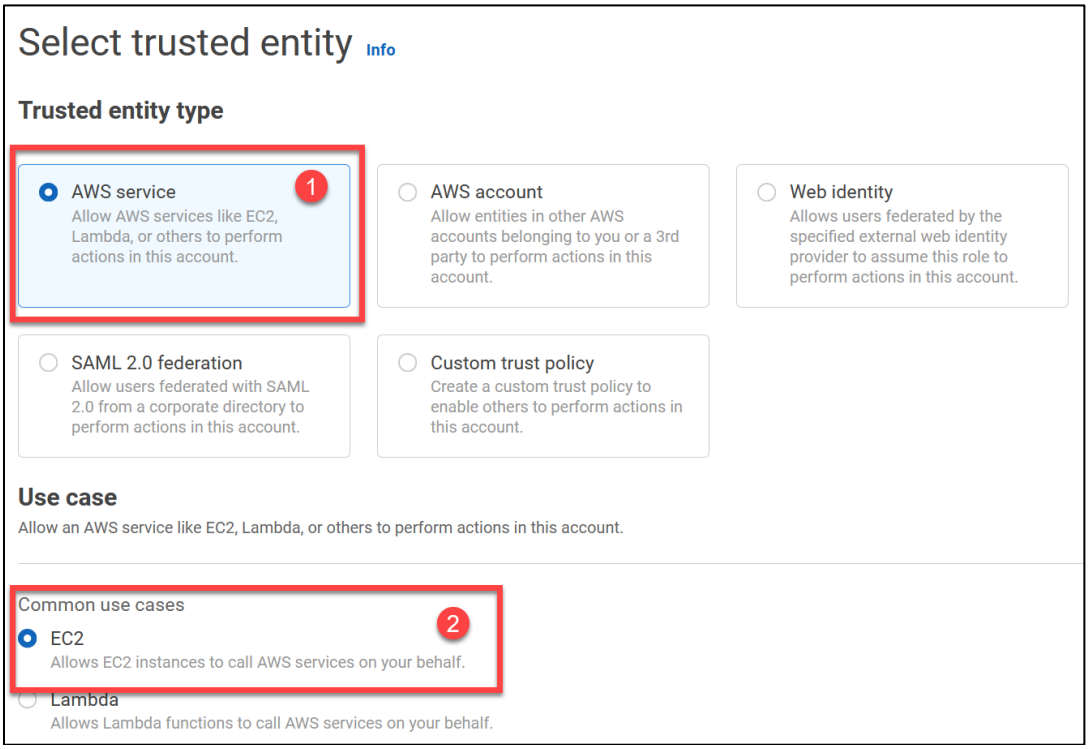
1. Login to AWS and open the Management Console. Search for "IAM".
2. You'll see 1 or more roles --- click on the number (36 in our case):



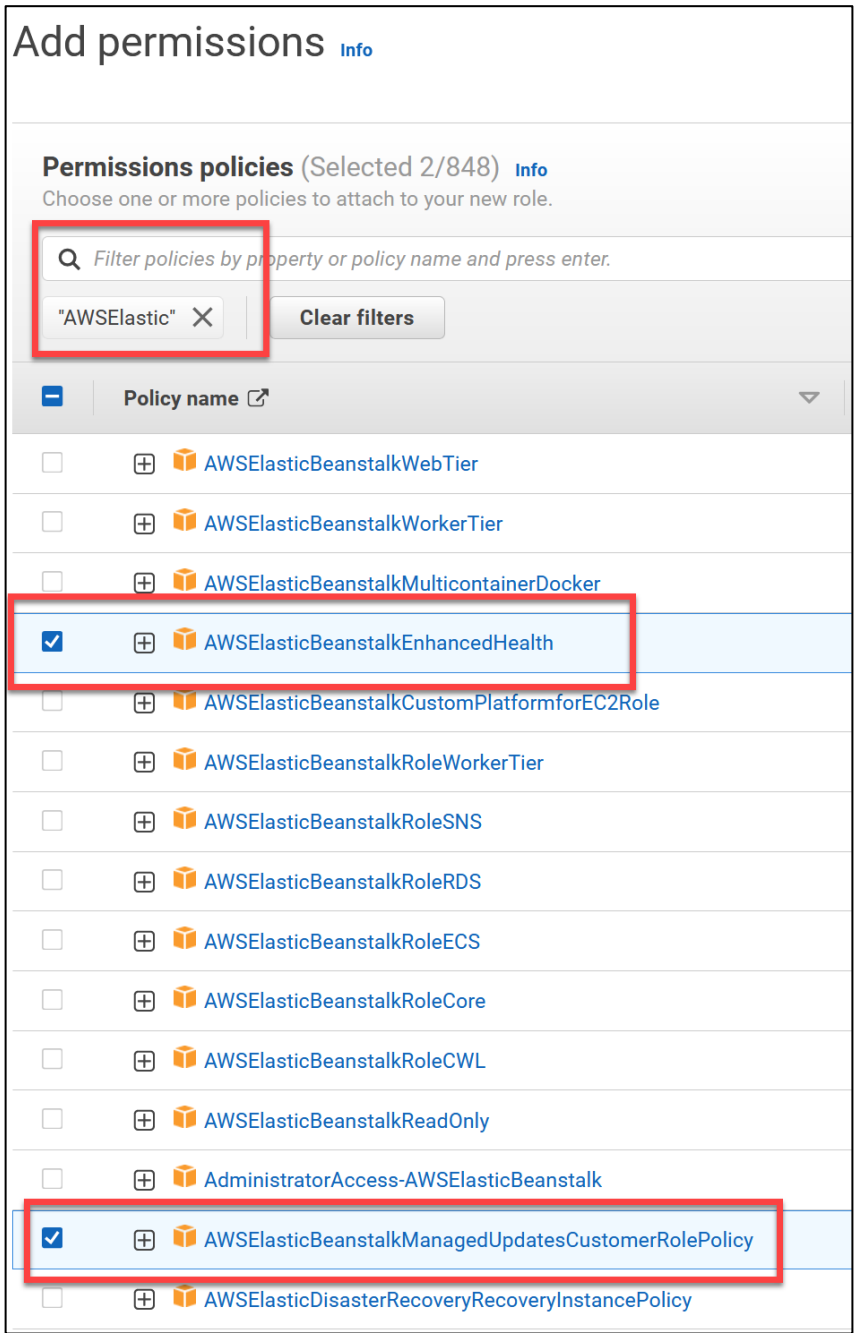
3. Click “Create role” to create a new role:



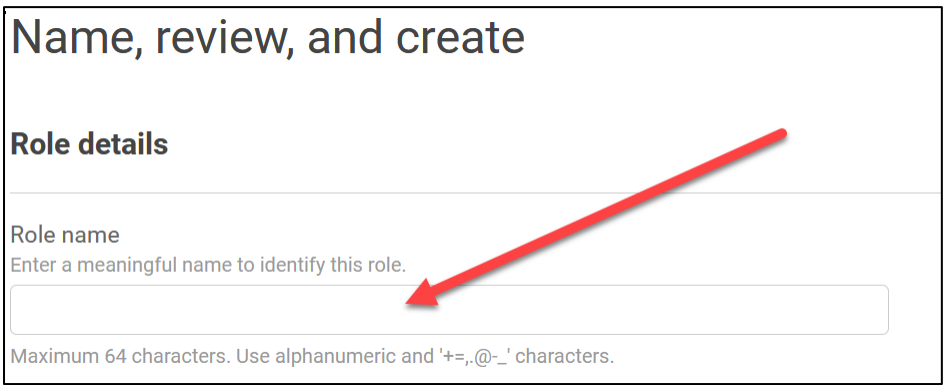

4. On the next screen, select “AWS service” and “EC2” as common use case:



5. The next screen is for adding additional permissions --- narrow down the search by entering "AWSElastic" in the search field and pressing ENTER. Then select the two roles shown and click "Next":

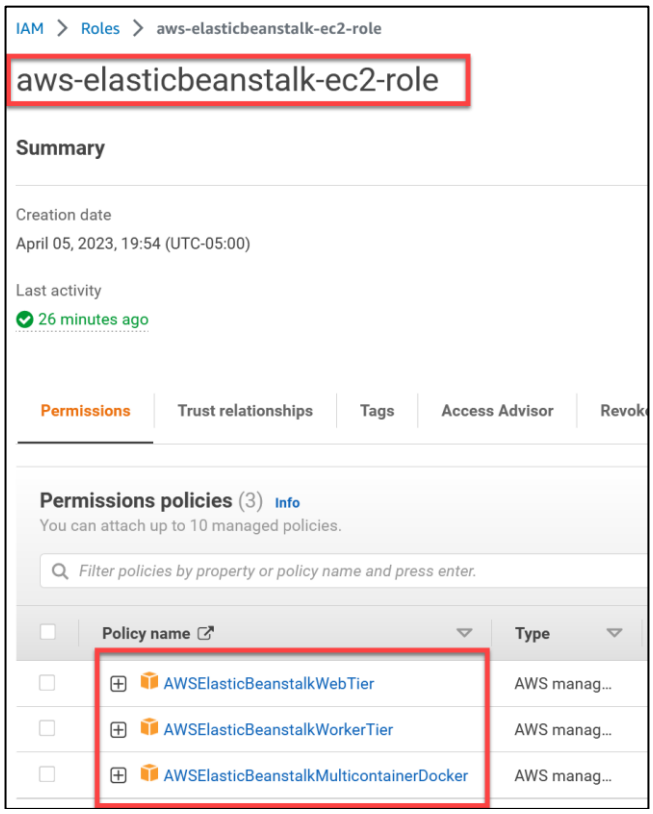



6. On the next screen name the role “**aws-elasticbeanstalk-service-role**” and click “Create Role”:





7. After a few minutes the role should be created --- if anything goes wrong, you can delete and start over.
8. We need to repeat this process and create another role named “aws-elasticbeanstalk-ec2-role”. Repeat steps 2 – 6, except when you “Add permissions”, select these 3 policies instead:



## (4) AWS Elastic Beanstalk

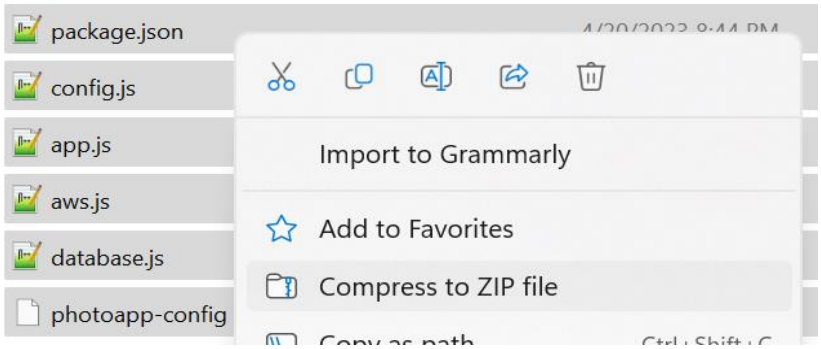
Now that the roles are created, here are the steps to get your web service up and running on EC2 using EB. When you're done, you'll have a public endpoint that allows your API to be called by anyone with an internet connection. Test by pointing your Python-based client at this endpoint.

1. Download your web service, in particular the following 12 files (if you are working on replit, you can download the files individually, or you can download as .zip and then extract the files). Either way, you need the following 12 files in a local folder on your laptop named "web-service":

   app.js
   api_asset.js
   api_bucket.js
   api_download.js
   api_image.js
   api_stats.js
   api_user.js
   api_users.js
   aws.js
   config.js
   database.js
   photoapp-config

2. Download the file "package.json" from dropbox and save this in your "web-service" folder. This is a configuration file for Elastic Beanstalk for configuring Node.js and Express js.

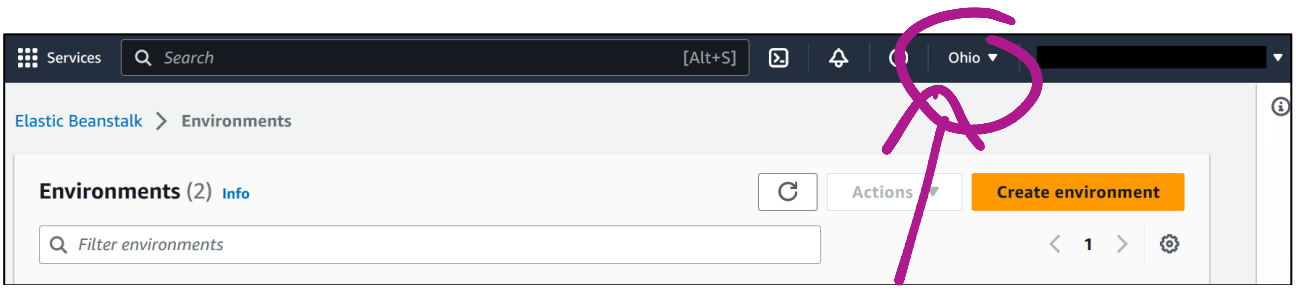
3. Select all the files in your "web-service" folder --- 13 files in total --- and create a compressed / archive file. The resulting file should have a .ZIP extension, and you should compress the files directly into the .ZIP:



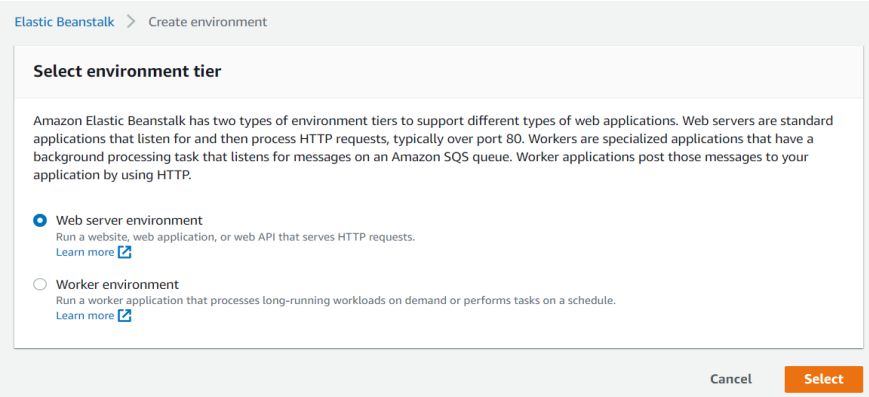

   For example, do *not* compress the web-service folder --- the .ZIP needs to contain just the files, no folders. Normally you select all the files, right-click, and select compress. [ *On windows, it might also be select all the files, right-click, select "Send to", and then select "Compressed (zipped) folder"* ]

4. Login to AWS and open the Management Console. Search for "Elastic Beanstalk".

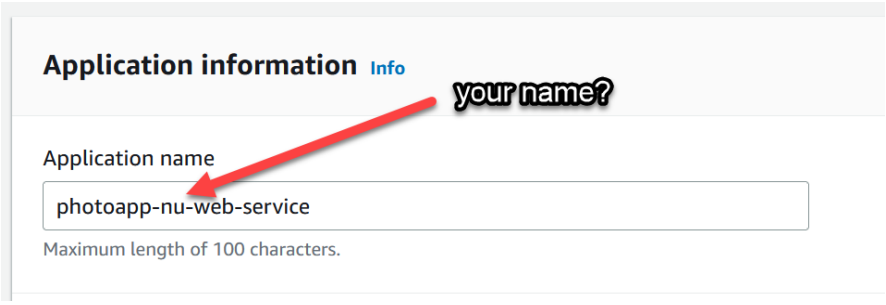
5. Use the drop-down to select your region --- it should be the same region that contains your database and bucket. When in doubt, select "Ohio" (us-east-2). You should see something like this:



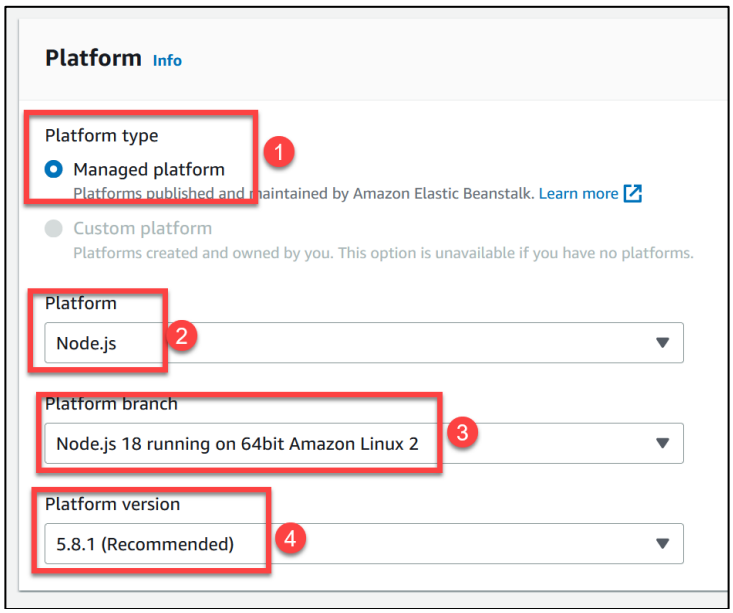
6. Click “Create environment”. Select a “Web server environment” and press Select if you see a button (or maybe just scroll down, there may be differences):



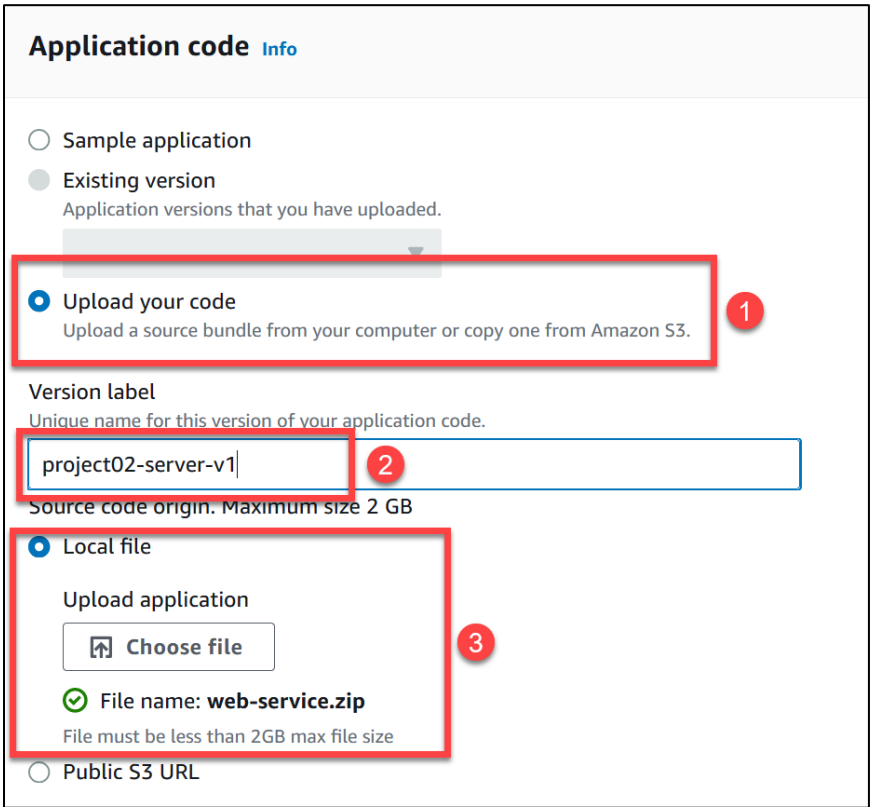

7. Enter an application name. Like your bucket, this should be unique so use your name and some combination of “photoapp” and “web-service”:




8. Now configure the application as a managed platform running Node.js:

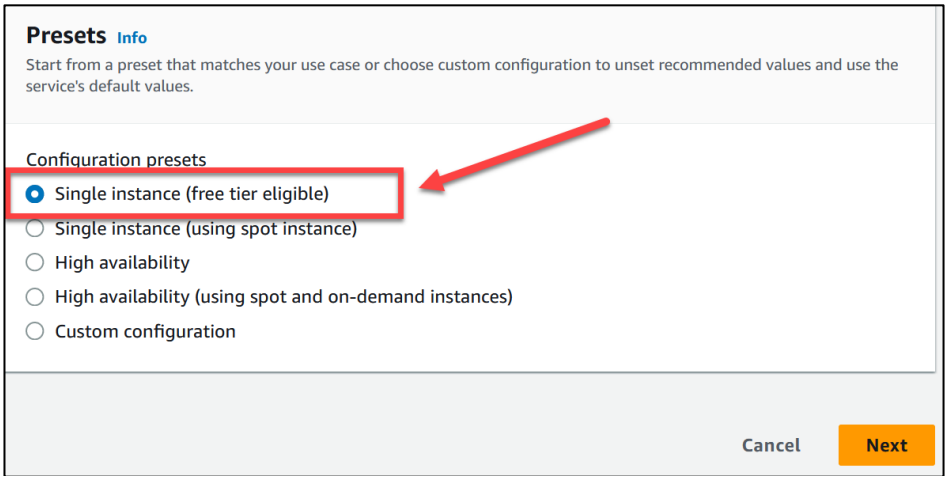


9. Next, upload the .ZIP file containing your web service files:

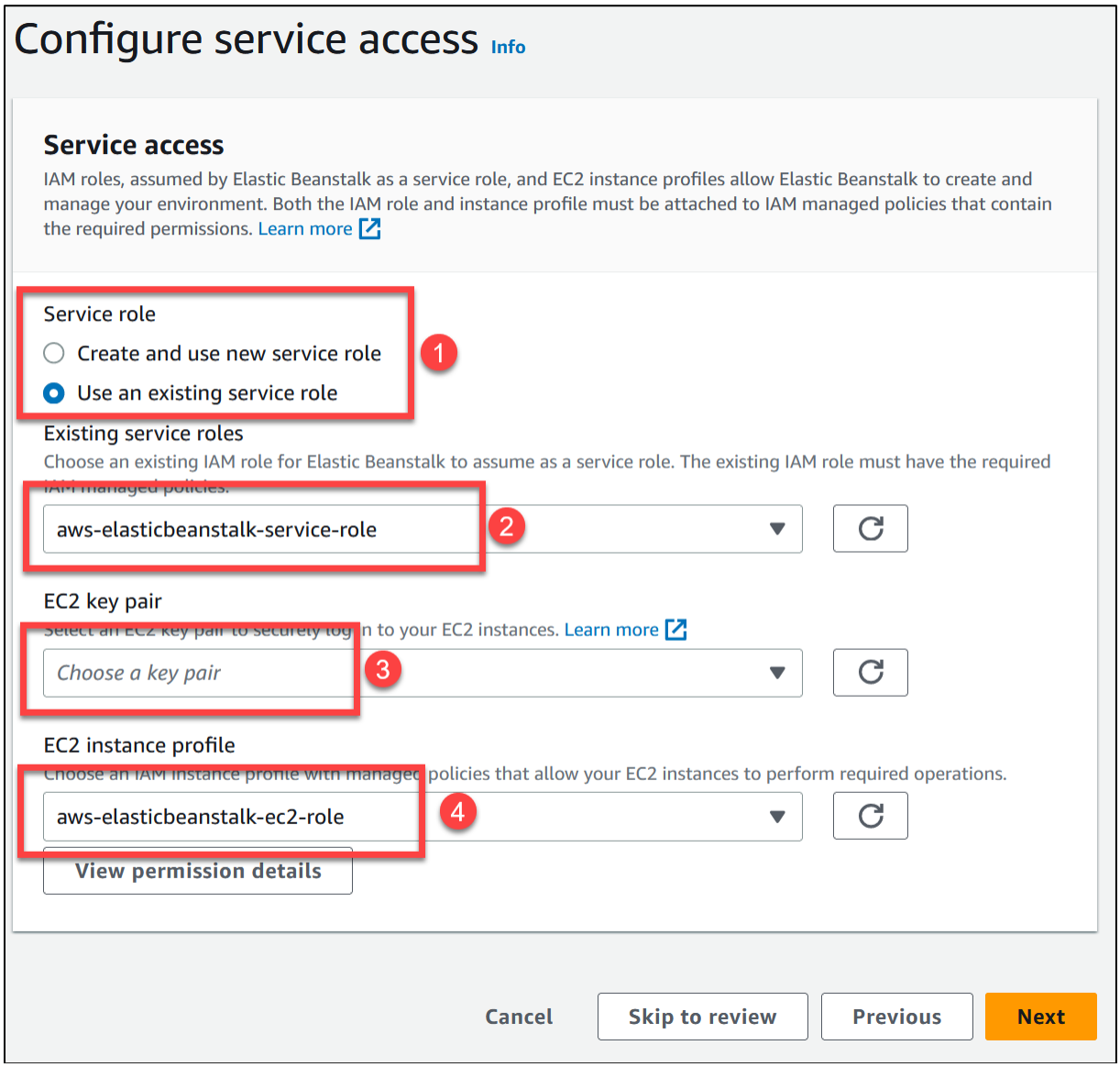



Fun fact: the .zip file is stored in S3.

10. Under "Configuration presets", be sure to select "single instance" which is free tier eligible. My screen shows a Next, in which case click and continue:



11. Next is “Configure service access”. In steps 2 and 4 you’ll select the roles you created earlier --- skip step 3 (leave EC2 key pair blank). Click Next when you’re ready:

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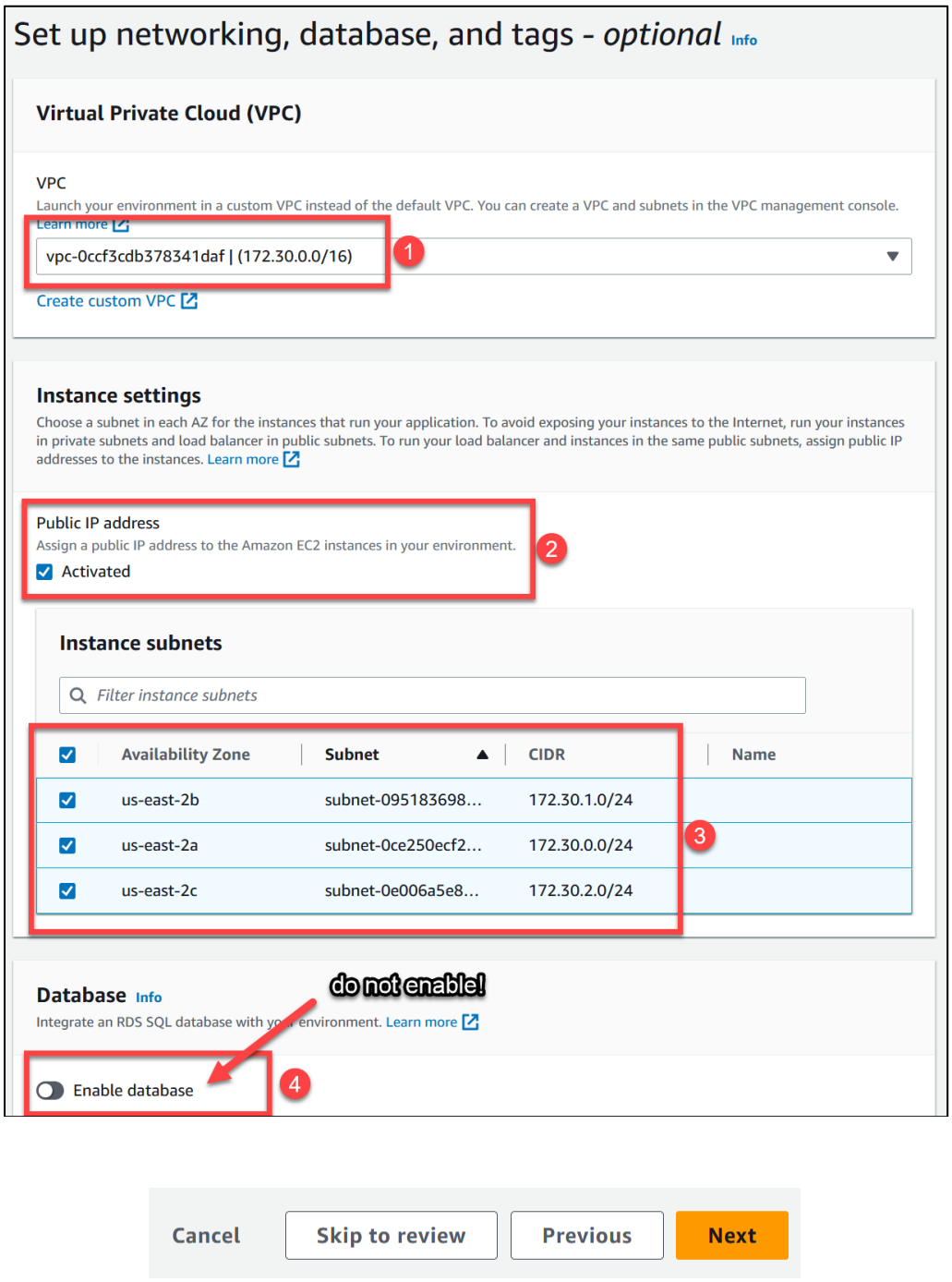
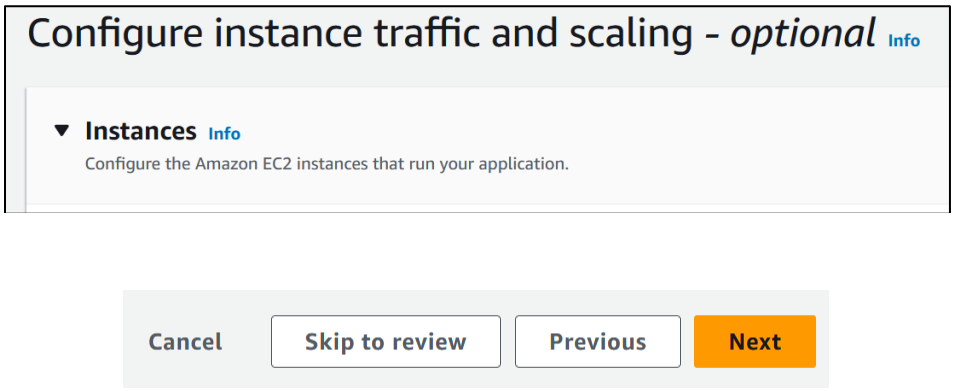
12. Setup networking, database, and tags… Under VPC, you should have one option to select --- this is the VPC that contains your MySQL database. Select this option because we want EC2 to run on the same VPC as the database. Note that your VPC will be named differently. If you have multiple choices, you should probably stop, look at your database under RDS, scroll to the right, and see which VPC is being used by your database --- you want to select that VPC here.

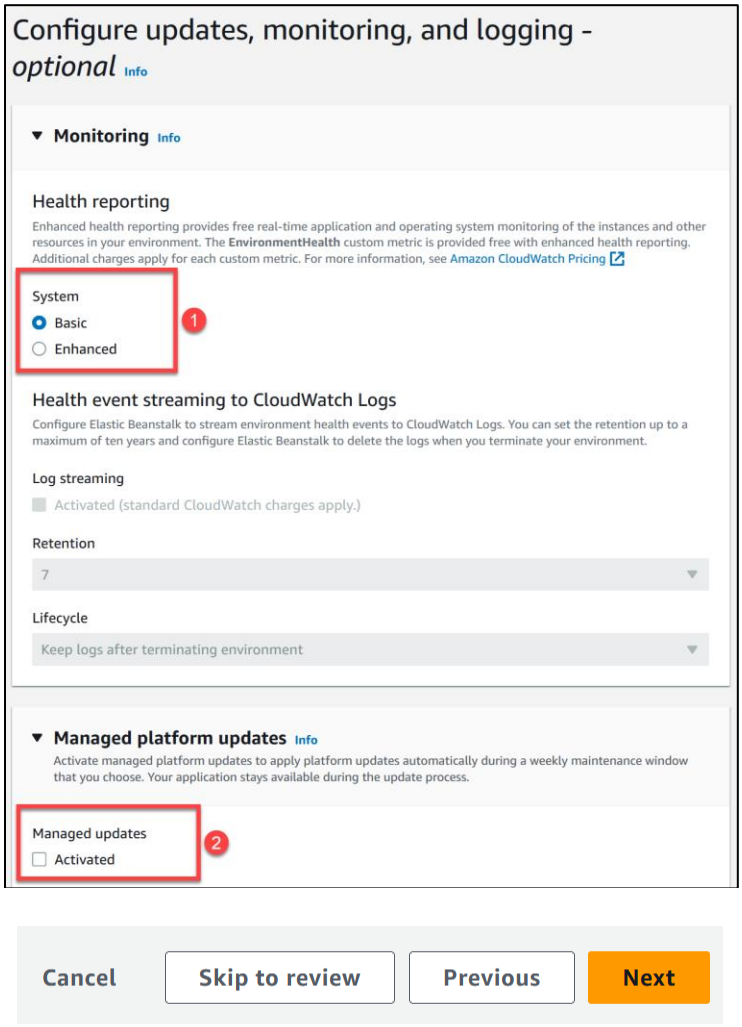
    For the other options, you want to activate “Public IP address” (step 2) so your web service is accessible by the outside world. The “instance subnets” should be auto-populated based on the selected VPC --- select them all (step 3). Finally, do *not* enable a database, we already have one!



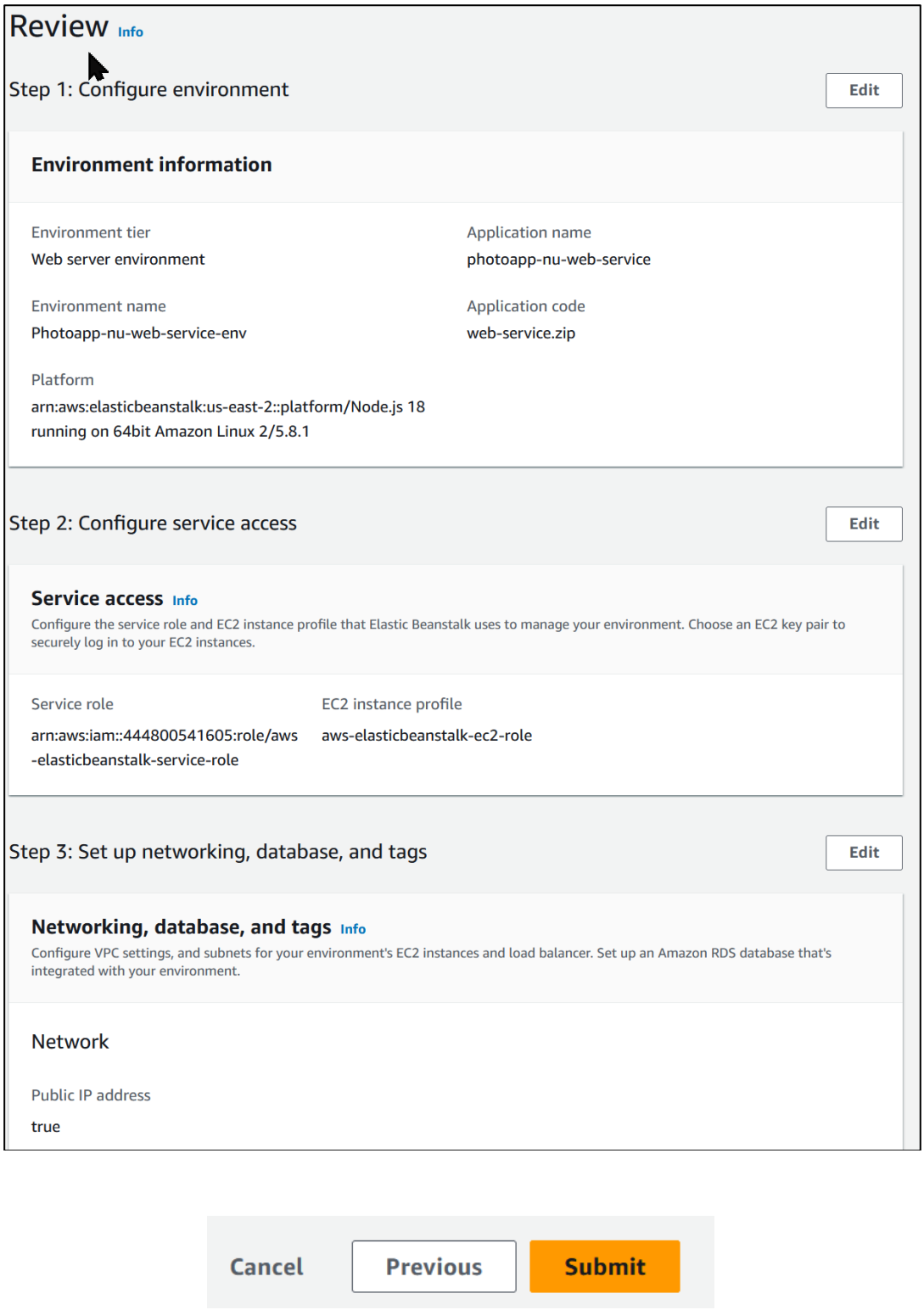
13. Configure instance traffic and scaling… Leave alone and click Next…



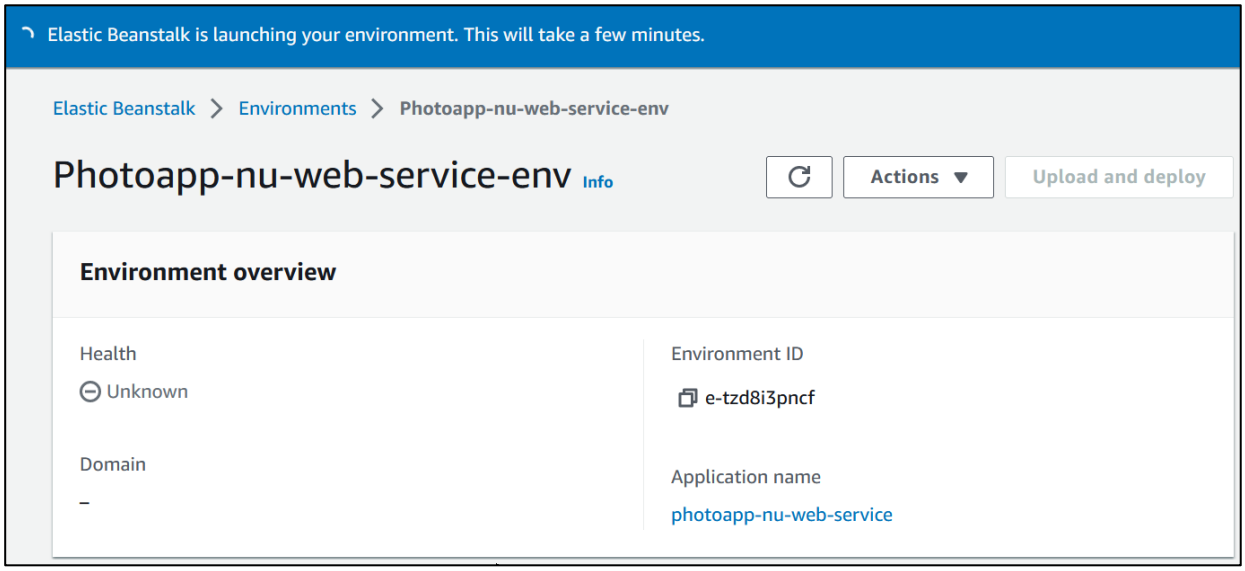

14. Configure updates, monitoring, and logging… Switch to “basic” health reporting and “de-activate” platform updates:



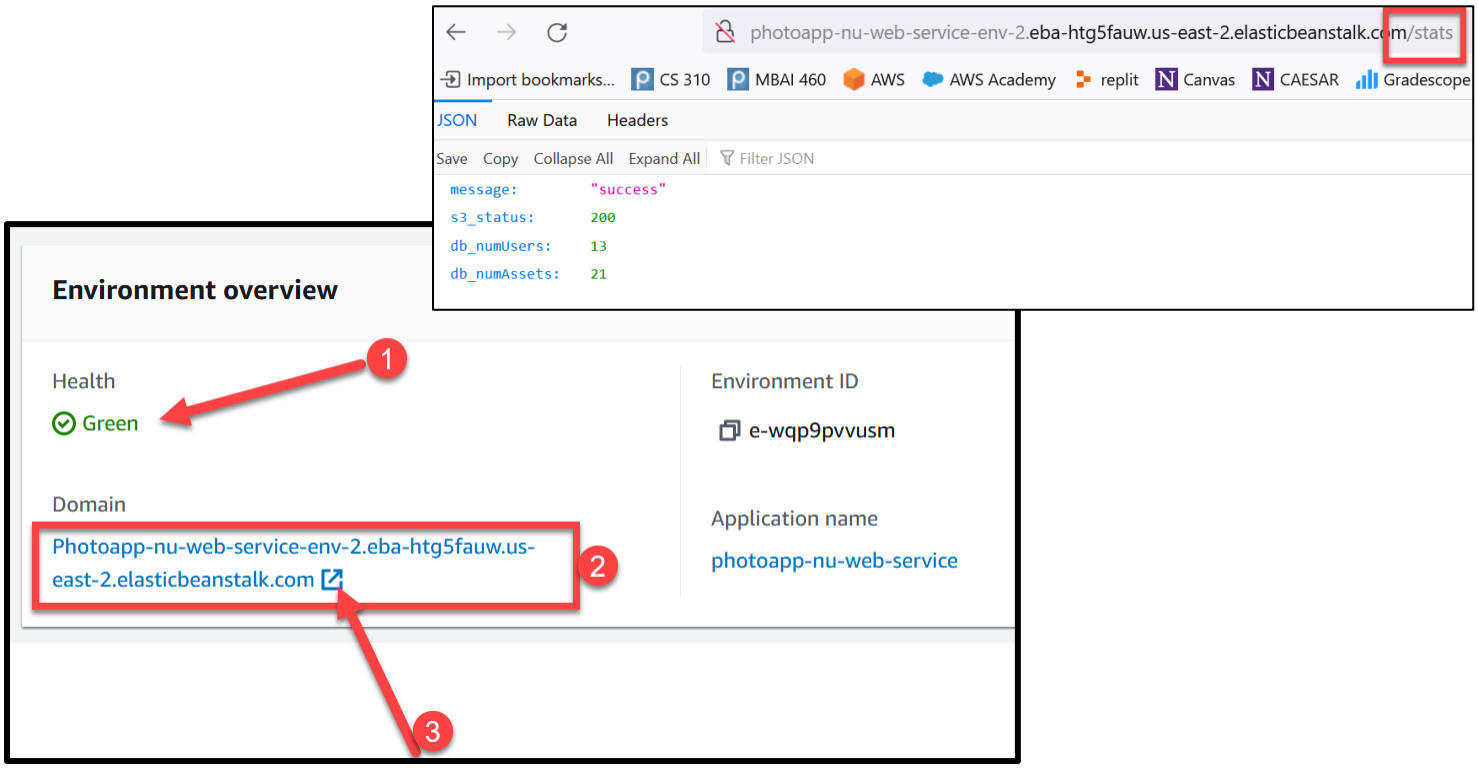
15. You should see the final review page. If everything looks good, scroll down and click Submit!



16. AWS will now configure EC2, load your code, and startup the web service. This will take a few minutes…

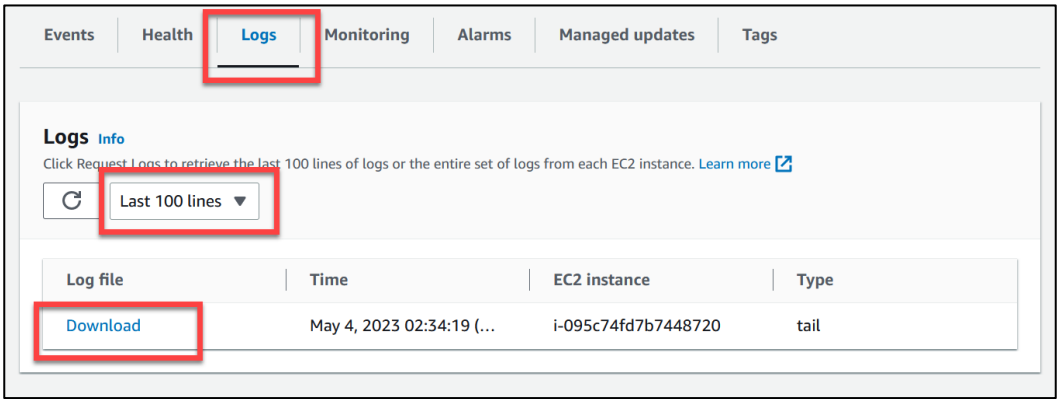



17. If all is well, you should get a “Green” health check (step 1), and your domain endpoint should be displayed (step 2). Click the little “pop-out” button (step 3) to open a browser window so you can test your GET functions like /stats and /users:

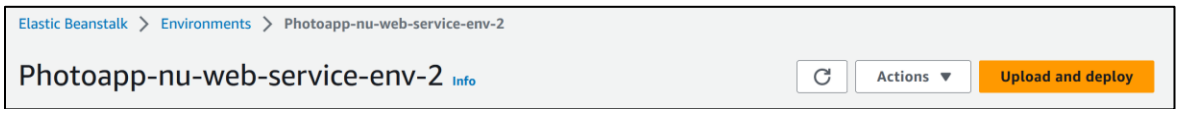


18. At this point, you'll want to test all the API functions using your Python-based client. Create another client config file, and paste your AWS EC2 endpoint into that config file. Run your client and test…

19. If your EC2 setup failed, the best course of action is to start over and see if you missed any steps… Another option is to look at the logs, which contain the output from EC2 but also the output from your console.log( ) statements:




20. Want to upload a new version of your code? View "Elastic Beanstalk" in the management console, select your environment, and you'll see a button on the far-right for "Update and deploy":




Follow the steps to upload a new version of your code…

21. How to stop the instance to save money? Turns out there's no way to stop the instance that's running --- if we stop it, AWS thinks it has crashed and will start a new instance within a few minutes (which is what we would normally want to happen). To "stop" and save money, I would click on the application (in the Application column) and terminate it. This will delete everything, but it's easy enough to recreate. [ NOTE: there is a way to pause an instance, see this post. ]

22. Congratulations, well done!

## Electronic Submission --- Part 02

Step 1 is to create a client-side config file named "ec2-client-config.txt" and paste your EC2 endpoint into this file for submission. The endpoint is the URL for your web service, and the config file should look like this:

```
[client]
webservice=http://photoapp-YOUR-NAME-web-service-env-UNIQUE-ID.elasticbeanstalk.com
```

Step 2 is to submit your files to Gradescope; note that we are only collecting the server-side code, and not the client. A few days before the due date, look for "Project 02 (server part 02)". Submit the same files you deployed to AWS + "ec2-client-config.txt". This should be a total of 13 files:

app.js
api_asset.js
api_bucket.js
api_download.js
api_image.js
api_stats.js
api_user.js
api_users.js
aws.js
config.js
database.js
ec2-client-config.txt
photoapp-config

If you want, add your "ec2-client-config.txt" file to the .ZIP file you uploaded to AWS, and submit the .ZIP to Gradescope. You have unlimited submissions, and the goal is a score of 100/100.