CS 310
Scalable Software Architectures
Spring 2023

Project #02 --- Part 01 (v1.3)

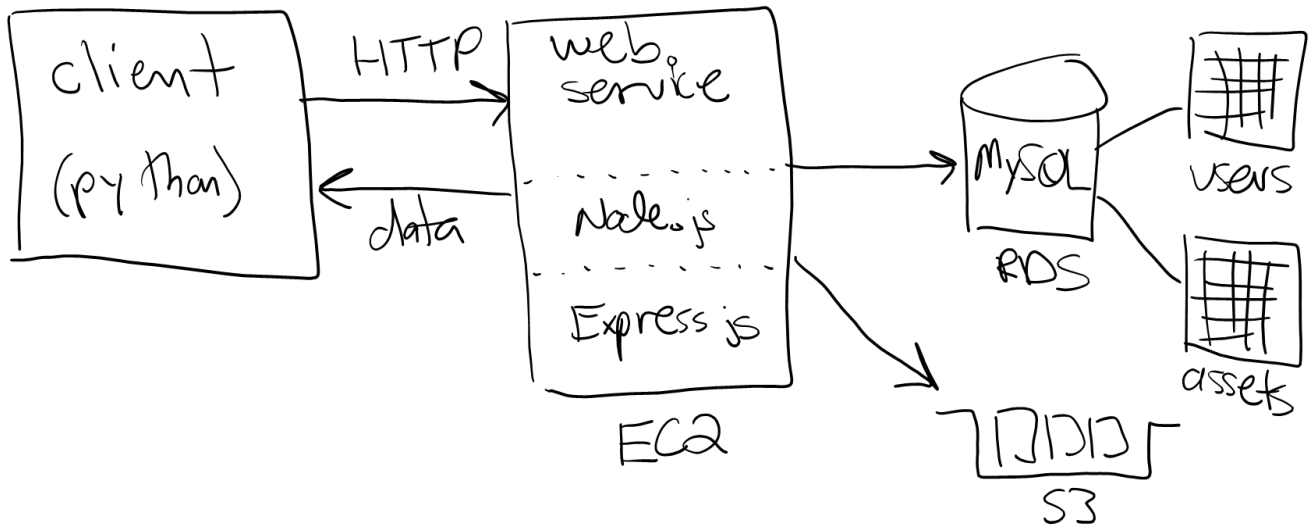
Assignment: Multi-tier PhotoApp with AWS EC2, S3 and RDS
Submission: via Gradescope (unlimited submissions)
Policy: individual work only, late work is accepted
Complete By: Monday May 01 @ 11:59pm CST

Late submissions: you can submit up to 3 days late (Thursday May 04), no penalty using late days. NO submissions accepted after Thursday May 04.

Pre-requisites: Lectures 05, 06 and 07 (April 13, 18 and 20). See Canvas for lecture recordings and links to PPT.

Overview

In Project 01 we built a client-server (two-tier) PhotoApp where the client-side Python code interacted directly with AWS, in particular the RDS and S3 services. Here in Project 02 we're going to inject a web service tier between the Python-based client and the AWS services:



As we've discussed in class, the web service will be written in JavaScript using Node.js and the Express js framework. The client is still Python-based, rewritten to interact with the web service instead of AWS directly. The database and S3 bucket remain unchanged from Project 01.

Before we start…

We're going to approach Project 02 much like Project 01 --- in steps. Here are the major steps:

1. *Build the web service, running either in replit or on your local machine. This way it's easy to run, test and debug. You will test using a web browser as the client, not the Python-based client.*
2. *Build the Python-based client, providing a better way to test. You'll also be able to confirm images are downloaded properly by displaying.*
3. *Add another feature (image upload). Update web service, test. Update python client, test.*
4. *Package and deploy using AWS Elastic Beanstalk / EC2, making it available to the world.*

Steps 1 and 2 are the focus on this handout (part 01). Steps 3 and 4 are the focus of part 02. Please note that parts 01 and 02 will have *different* due dates. Part 01 (this handout) has a due date of Monday May 01 (max late submission of Thursday May 04). Part 02 (future handout) will have a due date of Monday May 08 (max late submission of Thursday May 11).

Getting started (server-side)

For the server-side web service, a total of 11 files are being provided so you have a framework in which to work. You'll find these files on replit under "**Project 02 (server)**", or in this dropbox folder. The files:

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

The web service's main file is "**app.js**" (in class it was "index.js", but has been renamed based on AWS preferences). This file starts listening on the proper port, and registers the web service functions (API) we are defining:

```
/stats
/users
/assets
/bucket?startafter=bucketkey
/download/:assetid
```

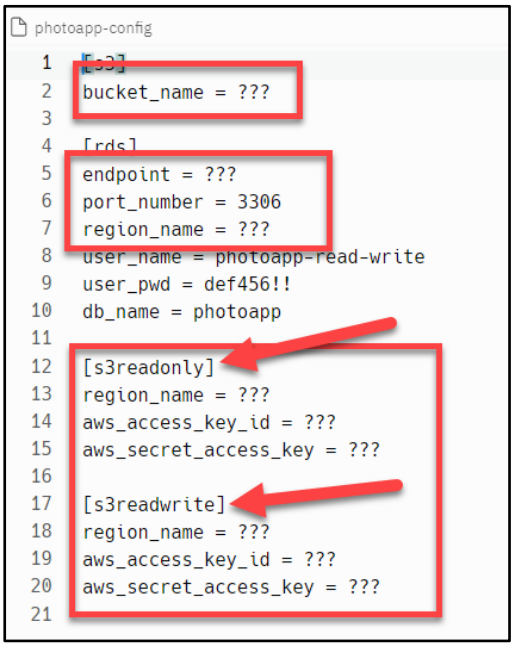
We talked extensively about **/stats** in class, and this handler is completely implemented in "**api_stats.js**". For modularity, each web service function is defined in a separate .js file. You'll want to review the code in "api_stats.js" (and the lecture notes if necessary) before implementing the other functions in the API.

The remaining .js files --- aws.js, config.js, and database.js --- create the necessary S3 and DB objects for talking to S3 and MySQL, respectively. Review but do not modify these files. Finally, we have two config files much like we did in Project 01: **photoapp-config** and **test-config**. Continue reading before doing anything…

Configuring the server

The handout is going to assume you are working in **replit**. You are free to work outside of replit, but in that case you'll need to setup an environment running Node.js and Express js, then download the code from dropbox and get it running. If you run into problems, you're on your own --- for our own sanity the course staff is only supporting replit. That said, it should be straightforward e.g. to get Node.js up and running in VS code.

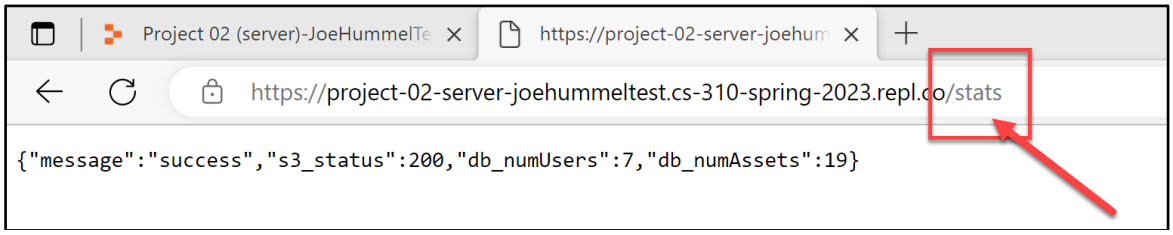
Open the team project "Project 02 (server)". The first step is to update photoapp-config based on your configuration from Project 01. You need to replace each ??? with your AWS values --- bucket name, RDS endpoint, etc. Feel free to copy-paste or upload your photoapp-config file from Project 01 --- however, please note one VERY IMPORTANT difference. The sections names cannot have "-", so the sections names "s3-read-only" and "s3-read-write" must be changed to "s3readonly" and "s3readwrite" --- these are called out by the arrows in the screenshot to the right ---------->



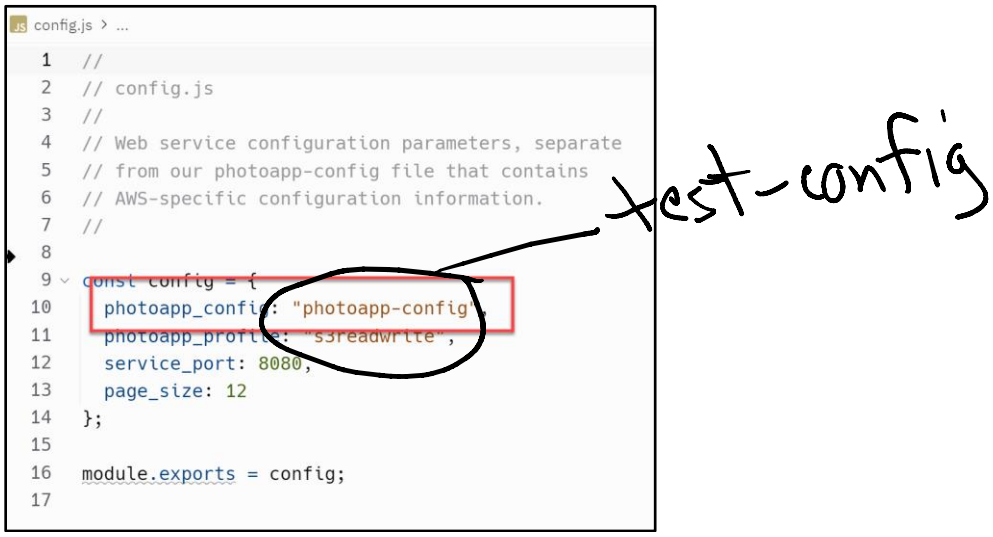
Once you have edited **photoapp-config**, test as follows. First, make sure your RDS service (database) is running. Now, back in replit, stop the service if it's running. Then run. The app will read the config file and replit will open two windows on the right-side --- you should see a client-side browser and a console window:

The upper window acts alike a client and browses to the home directory "/" --- this will show the status of the app, how long it's been running, and the state of the database connection. You can refresh this window at any time. More importantly is the "baseurl" shown --- that's the endpoint for your web service. Copy this URL and paste it into a new browser tab (or click the little "pop-out" button denoted in the screenshot). Append **/stats**

to the URL, and this will call the /stats API function in the web service. You should see something similar to the following (but not identical since your bucket and database will differ from ours):



If you see something like the above, then all is well with your configuration and you can continue with the next section. If adding /stats doesn't work, then either (a) your configuration is wrong, or (b) something is wrong with your internet connection. There's a provided **test-config** file that you can try to determine if it's (a) or (b). Open the provided "config.js" file and change the configuration file that is referenced from "photoapp-config" to "test-config" so the web service targets our AWS services:



Stop the web service. Run the web service. Change to the browser tab that contains your baseurl/stats, and refresh --- does it work? If so, then your internet connection is fine and your photoapp-config is wrong (or one of your services is not running?). If it doesn't work with our test-config file, then your internet connection is likely the problem.

Web service API

The goal of your web service (here in Part 01) is to support the following five API functions. Here are the paths (also called routes):

/stats
/users

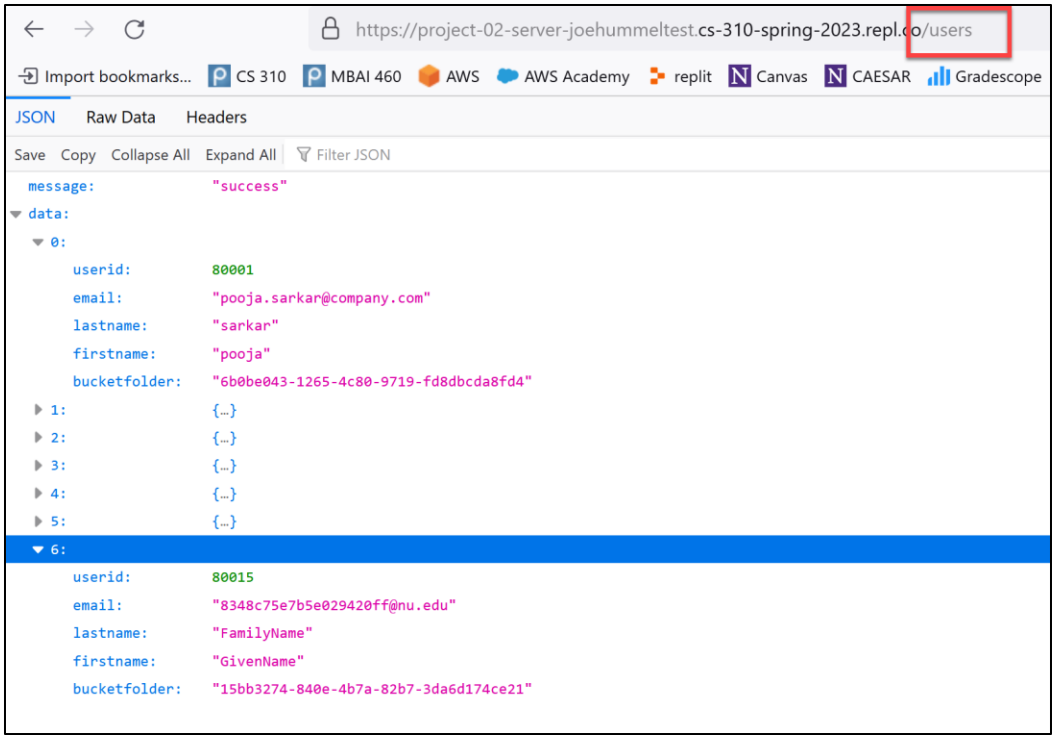
/assets
/bucket?startafter=bucketkey
/download/:assetid

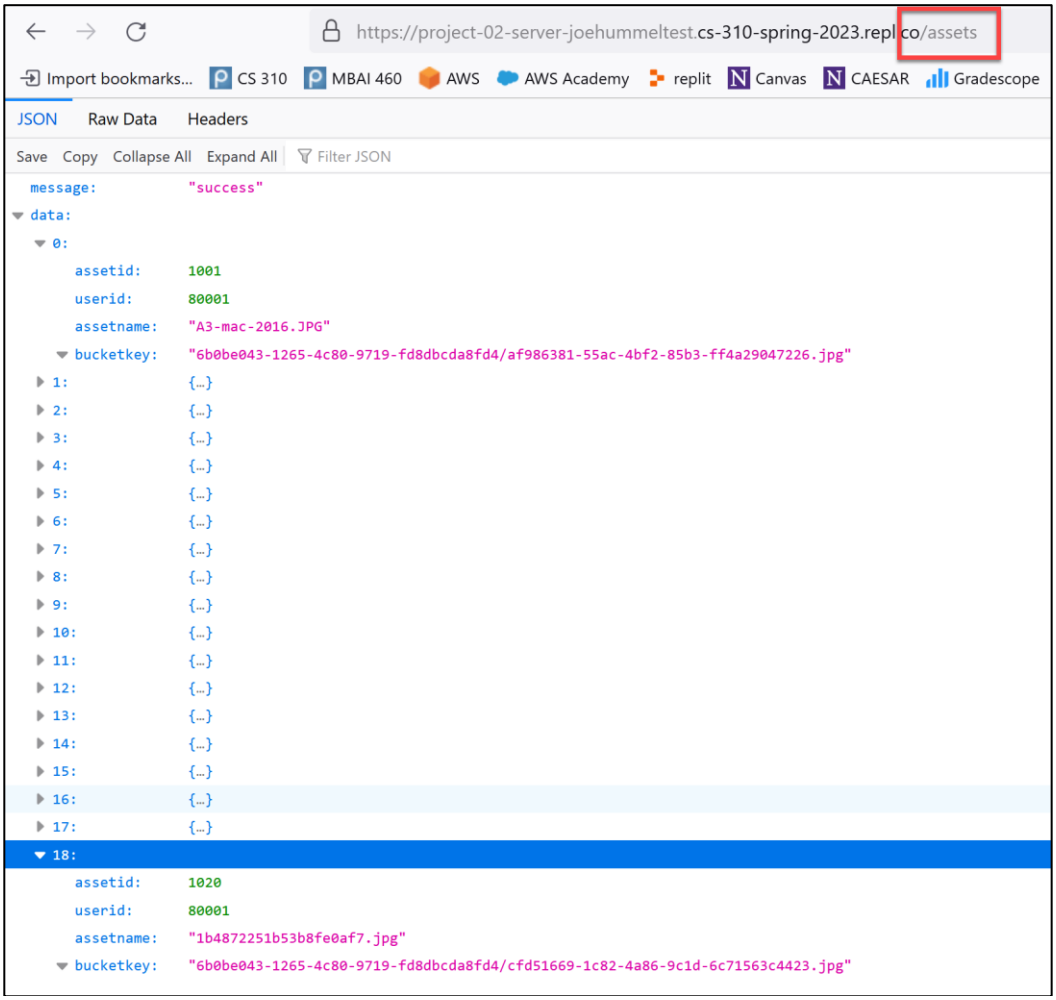
The first is already implemented for you. Each API function is defined by a corresponding .js file. For example, /users is implemented in the file "api_users.js". Here's the contents of that file, which defines the handler to throw an error until implemented:

```
//
// app.get('/users', async (req, res) => {...});
//
// Return all the users from the database:
//
const dbConnection = require('./database.js')

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

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

  try {

    throw new Error("TODO: /users");

    //
    // TODO: remember we did an example similar to this in class with
    // movielens database (lecture 05 on Thursday 04-13)
    //
    // MySQL in JS:
    //   https://expressjs.com/en/guide/database-integration.html#mysql
    //   https://github.com/mysqljs/mysql
    //

  }//try
  catch (err) {
    res.status(400).json({
      "message": err.message,
      "data": []
    });
  }//catch

}//get
```

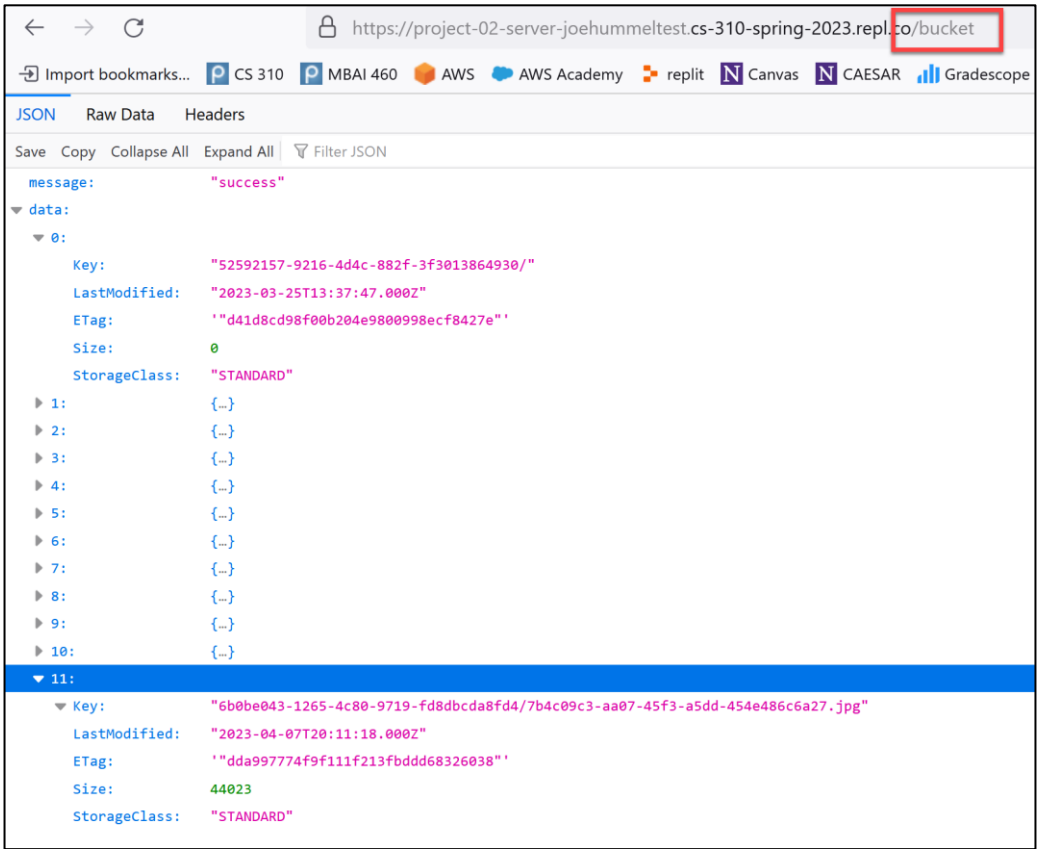
Notice the "TODO" comment contains links to one or more online resources to help you implement the function; each .js file has similar links to supporting resources. The recommended order of implementation is as follows: /users, /assets, /bucket, and /download.

The first two functions --- **/users** and **/assets** --- are single calls to MySQL, selecting all columns for all users or all columns for all assets. Retrieve the users in ascending order by userid; retrieve the assets in ascending order by assetid. Test your code using the client browser tab, appending /users or /assets to your web service's baseurl. Your output should look similar to the screenshots on the next page. Note that the screenshots were made using **Firefox**, which defaults to a more readable display of the response:

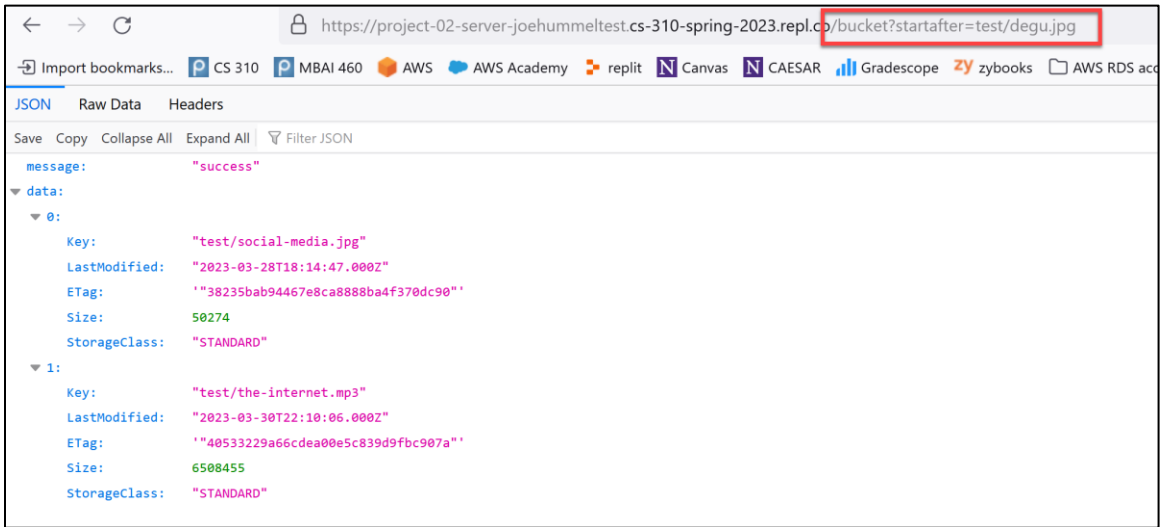

https://project-02-server-joehummeltest.cs-310-spring-2023.repl.co/users
Import bookmarks... CS 310 MBAI 460 AWS AWS Academy replit Canvas CAESAR Gradescope
JSON Raw Data Headers
Save Copy Collapse All Expand All Filter JSON
message: "success"
data:
0:
userid: 80001
email: "pooja.sarkar@company.com"
lastname: "sarkar"
firstname: "pooja"
bucketfolder: "6b0be043-1265-4c80-9719-fd8dbcda8fd4"
1: {…}
2: {…}
3: {…}
4: {…}
5: {…}
6:
userid: 80015
email: "8348c75e7b5e029420ff@nu.edu"
lastname: "FamilyName"
firstname: "GivenName"
bucketfolder: "15bb3274-840e-4b7a-82b7-3da6d174ce21"


https://project-02-server-joehummeltest.cs-310-spring-2023.repl.co/assets
Import bookmarks... CS 310 MBAI 460 AWS AWS Academy replit Canvas CAESAR Gradescope
JSON Raw Data Headers
Save Copy Collapse All Expand All Filter JSON
message: "success"
data:
0:
assetid: 1001
userid: 80001
assetname: "A3-mac-2016.JPG"
bucketkey: "6b0be043-1265-4c80-9719-fd8dbcda8fd4/af986381-55ac-4bf2-85b3-ff4a29047226.jpg"
1: {…}
2: {…}
3: {…}
4: {…}
5: {…}
6: {…}
7: {…}
8: {…}
9: {…}
10: {…}
11: {…}
12: {…}
13: {…}
14: {…}
15: {…}
16: {…}
17: {…}
18:
assetid: 1020
userid: 80001
assetname: "1b4872251b53b8fe0af7.jpg"
bucketkey: "6b0be043-1265-4c80-9719-fd8dbcda8fd4/cfd51669-1c82-4a86-9c1d-6c71563c4423.jpg"

The **/bucket** API function returns information about each asset in the bucket: Key, LastModified date, etc. However, instead of returning all data in one call, data is returned a page at a time where a page is defined as at most 12 assets. This implies that the path /bucket returns information about the first 12 assets in the bucket (the assets are always returned in alphabetical order by key):

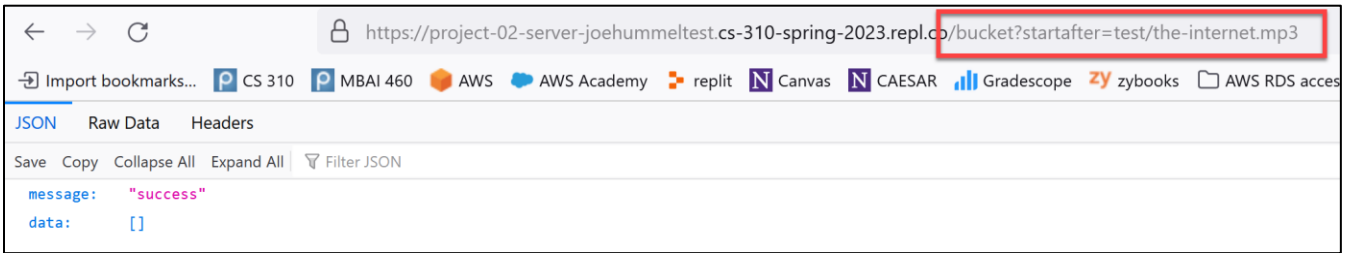


The client can retrieve the next page of data by using a query parameter **?startafter=bucketkey**, where bucketkey is the last key in the previous page. Recall that lecture 05 (Thursday 4/13) discussed how to retrieve query parameters in JavaScript. Here's an example URL:



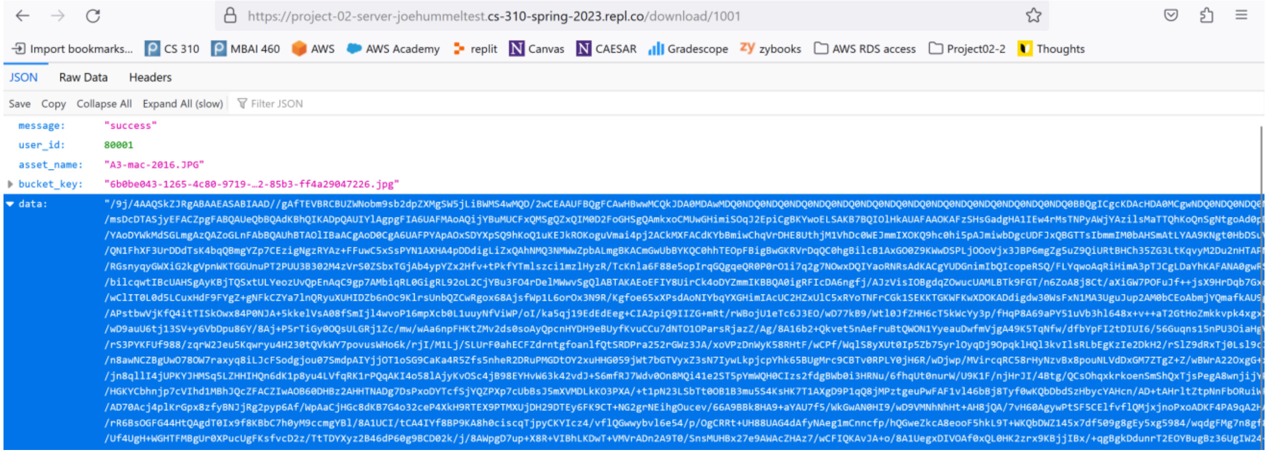
The /bucket API function is implemented using S3's **ListObjectsV2** command; see the TODO section in "api_bucket.js" for resources on how to use this command. You control the page size via the *MaxKeys* parameter within the input object (S3 commands take an input object that controls how the command behaves); the "startafter" functionality is specified by providing a *StartAfter* parameter as well. Note that S3 may respond with fewer than 12 assets; check the *KeyCount* in the response to see how many assets were actually returned. The data itself is returned in the response *Contents*.

NOTE: if KeyCount is 0 then Contents does not exist, so you'll need to handle that as a special case to properly return an empty list to the client if the last page is empty (i.e. the client happens to pass the last key in the bucket as the value to "startafter"):



The last API function is **/download/:assetid**, which uses the assetid to lookup the asset's bucket key in the database, and then calls S3 to download this asset and then send it to the client as a base64-encoded string. Recall that this path syntax implies assetid is a parameter to the API function, and passed as part of the path. For example, to download asset id 1001, the client appends **/download/1001** to the baseurl as shown below:

The image data is contained in the **data** element of the response --- in the screenshot above you only see the first 50 characters or so because the element is not expanded (Firefox allows the elements to be expanded or contracted). Expanding data in this case would reveal a string with over 100,000 characters (and this is a small image):

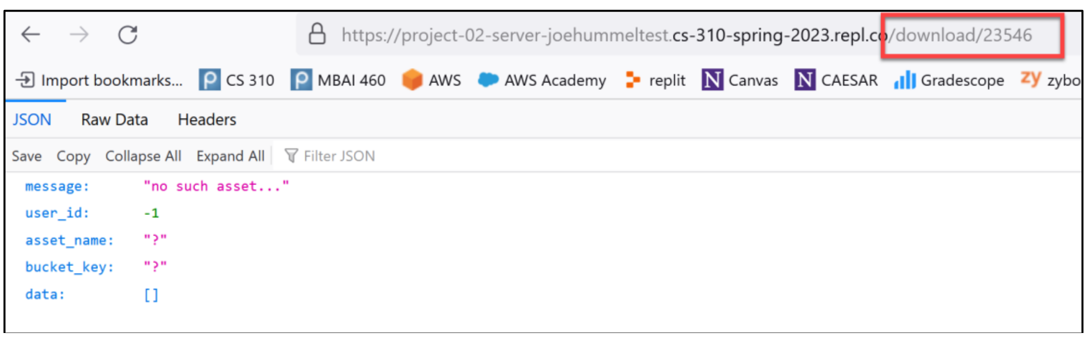


When the parameter is part of the path it's known as a URL parameter; how to retrieve a URL parameter is discussed in Lecture 05 (Thursday 4/13). To download an asset from S3, use the **GetObject** command, see the TODO comment in "api_download.js" for documentation and example code. After you await for the result from s3.send( ), the next step is to transform the Body of the result into a base64-encoded string so it can be sent to the client. This is also an asynchronous process, so you have await for it to finish:

```
var datastr = await result.Body.transformToString("base64");
```

Welcome to asynchronous programming! [*BTW, you might be wondering… Why can't we send the raw bytes? This is one of the impacts of building our service as a web service. The HTTP protocol for request/response limits the range of characters that can be sent, so raw binary data cannot be transmitted over HTTP. Base64 limits the character set to 64 chars, which is safe. The tradeoff is the resulting string is longer.*]

What happens if the asset id is invalid? Your response should look as follows (with a status code of 200, do not return 400):



There's no way to really test to make sure the image is being properly downloaded from S3 and encoded. That's one reason we need our Python-based client, in this case to download and display the image so we can see if it's correct.

At this point your web service should be implemented and working. Now it's time to focus on the client-side.

Getting started (client-side)

For the Python-based client, only 3 files are being provided. You can find these files on replit under "**Project 02 (client)**", or in this dropbox folder. Here are the files:

main.py photoapp-client-config test-client-config

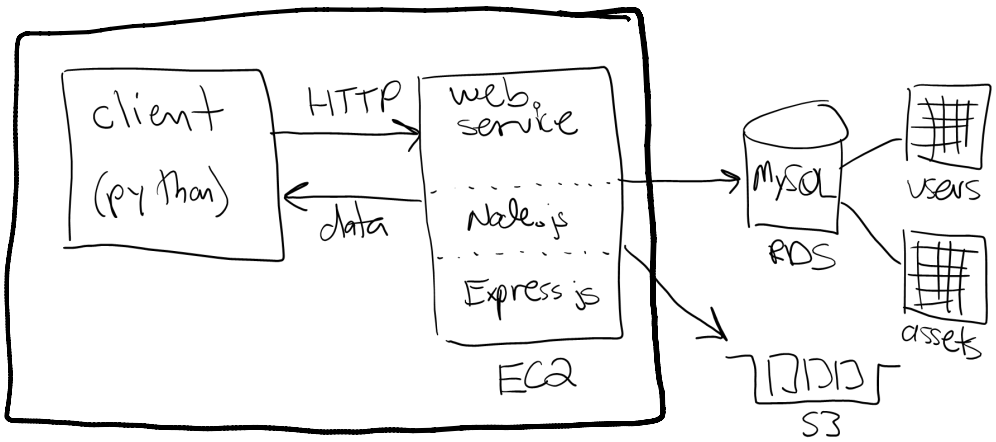
There's just the "main.py" file for your program, and two configuration files. Edit "photoapp-client-config" to contain the baseurl for your web service. The other configuration file "test-client-config" contains the baseurl for our CS 310 web service, which you can use as another test case for your client.

There are a total of 6 commands to implement, very similar to project 01. Those commands are the following:

```
** Welcome to PhotoApp v2 **

What config file to use for this session?
Press ENTER to use default (photoapp-config),
otherwise enter name of config file>


>> Enter a command:
   0 => end
   1 => stats
   2 => users
   3 => assets
   4 => download
   5 => download and display
   6 => bucket contents
```

1. Get stats
2. Get list of users
3. Get list of assets
4. Download
5. Download and display
6. Get list of bucket contents, displaying one page at a time

Commands 1 and 2 are implemented for you, and follow the approach we discussed in Lecture 05 (Thursday 4/13). Your job is to implement the remaining 4 commands via **web service calls** --- your Python-based client cannot communicate with AWS S3 or RDS directly. In other words, your python client cannot execute SQL, and cannot access the S3 bucket directly using boto3.



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Python-based client

Command 1: Get stats

Command 1 calls the web service API function **/stats** and displays the response. This command is already implemented in the provided "main.py" file.

```
1
bucket status: success
# of users: 7
# of assets: 19
```

Command 2: List users

Command 2 calls the web service API function **/users** and displays information about each user returned in the response. This command is already implemented in the provided "main.py" file.

```
2
80001
  pooja.sarkar@company.com
  sarkar , pooja
  6b0be043-1265-4c80-9719-fd8dbcda8fd4
80002
  e_ricci@email.com
  ricci , emanuele
  ab099de4-ea33-4237-8c78-5584dc591231
80003
  li_chen@domain.com
  chen , li
  52592157-9216-4d4c-882f-3f3013864930
80012
  ecf16af39d6120b463f9@nu.edu
  FamilyName , GivenName
  4fdd4244-7ae9-4fc8-a0eb-e6eebf28901e
```

Take a minute to review the implementation, in particular notice we're converting the response data into Python objects using the jsons module:

```
class User:
  userid: int  # these must match columns in DB
  email: str
  lastname: str
  firstname: str
  bucketfolder: str

.
.
.

users = []
for row in body["data"]:
  user = jsons.load(row, User)
  users.append(user)
```

This is commonly done in client-side programming involving databases, and is known as ORM --- "Object-Relational Mapping". This allows the client-side code to be written in a more natural object-oriented style:

```
for user in users:
  print(user.userid)
  print(" ", user.email)
  print(" ", user.lastname, ",", user.firstname)
  print(" ", user.bucketfolder)
```

Command 3: List assets

```
3
1001
  80001
  A3-mac-2016.JPG
  6b0be043-1265-4c80-9719-fd8dbcda8fd4/af986381-55ac-4bf2-85b3-ff4a29047226.jpg
1002
  80001
  A3-verve-Megan-on-bow.jpg
  6b0be043-1265-4c80-9719-fd8dbcda8fd4/62ec70d5-ba0c-4822-9017-3864b1d1fb47.jpg
1003
  80001
```

Command 3 calls the web service API function **/assets** and displays information about each asset returned in the response. Your implementation must use try-except to handle errors that might occur, and handle status codes != 200 in a similar manner to the provided commands. You are encouraged to use a similar ORM approach as used in command 2.

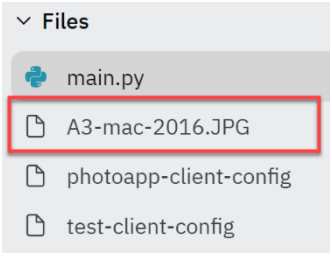
Command 4: Download

Command 4 inputs an asset id from the user, and then passes this id to the API function **/download**. Based on the response, the output is either "No such asset…"

```
4
Enter asset id>
101
No such asset...
```

or the returned base64-encoded string is decoded and written to the file system as a binary file. The name of the file should be the **asset name** returned in the response, in this case "A3-mac-2016.JPG":

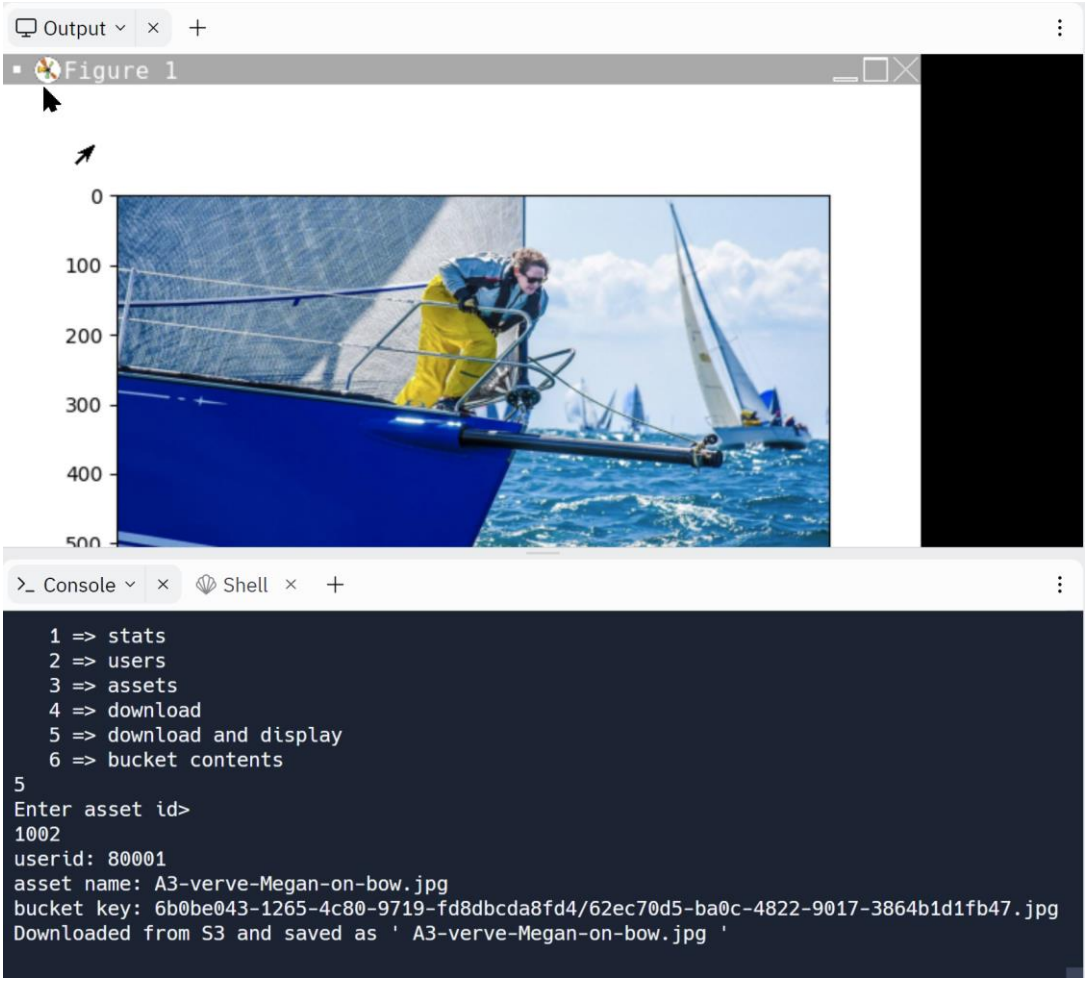
```
4
Enter asset id>
1001
userid: 80001
asset name: A3-mac-2016.JPG
bucket key: 6b0be043-1265-4c80-9719-fd8dbcda8fd4/af986381-55ac-4bf2-85b3-ff4a29047226.jpg
Downloaded from S3 and saved as ' A3-mac-2016.JPG '
```



Your implementation must use try-except to handle errors that might occur, and handle status codes != 200 in a similar manner to the provided commands. To decode the data use the base64.b64decode( ) function. And when you write the decoded bytes to the file, it must be a binary file, not a text file:

```
outfile = open(assetname, "wb")  # wb => write binary
```

Command 5: Download and display



Same as command 4, except display the image like we did in Project 01 using **matplotlib**.

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Command 6: List bucket contents one page at a time

Command 6 calls the web service API function **/bucket** and displays information about each bucket asset returned in the response. Recall that the /bucket function returns information in pages of size 12, so the client needs to call the web service each time the user asks for a page:

```
6
52592157-9216-4d4c-882f-3f3013864930/
  2023-03-25T13:37:47.000Z
  0
52592157-9216-4d4c-882f-3f3013864930/195e06c8-6005-4006-97f2-1c7c19b3414b.jpg
  2023-03-25T13:58:12.000Z
  43534
52592157-9216-4d4c-882f-3f3013864930/564055dc-f109-4df8-bdf1-27a629d4a0c6.jpg
  2023-03-25T13:57:13.000Z
  5438
52592157-9216-4d4c-882f-3f3013864930/a68cab2e-7d23-4af3-bbb1-f067befc6712.jpg
  2023-03-25T13:56:36.000Z
  60222
```

.
.
.

```
6b0be043-1265-4c80-9719-fd8dbcda8fd4/701521d6-c273-43dc-ad7f-bcc1e4d76bcd.jpg
  2023-04-11T22:26:52.000Z
  44023
6b0be043-1265-4c80-9719-fd8dbcda8fd4/7b4c09c3-aa07-45f3-a5dd-454e486c6a27.jpg
  2023-04-07T20:11:18.000Z
  44023
another page? [y/n]
```

If the user inputs **y**, then the client calls the web service to request the next page, displays these to the user, and prompts again. Do not assume the web service will return exactly 12 assets --- it could be any number from 0..12. If the user inputs anything else, break out of your paging loop and the command ends.

```
another page? [y/n]
n

>> Enter a command:
   0 => end
   1 => stats
   2 => users
   3 => assets
   4 => download
   5 => download and display
   6 => bucket contents
```

Special case: if the web service returns 0 assets, do not prompt the user for another page --- automatically break out of your paging loop. Your implementation must use try-except to handle errors that might occur, and handle **status** codes != 200 in a similar manner to the provided commands.

Electronic Submission --- Part 01

Programs will be collected and auto-graded using Gradescope. A few days before the due date, two Gradescope assignments will open named

Project 02 (server part01) **Project 02 (client part01)**

Make sure your database is running in RDS, and then for "Project 02 (server part01)" submit all the files except "test-config":

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

You have unlimited submissions, and the goal is a score of 100/100.

For the client, it doesn't matter if your database is running because we plan to test your client against our web service. For "Project 02 (client part01)", submit just one file:

main.py

You have unlimited submissions, and the goal is a score of 100/100.

By default, Gradescope records the score of your **LAST SUBMISSION** (not your highest submission score). If you want us to grade a different submission, activate a different submission via your "Submission History". This must be done before the due date.

This is a 300-level CS class, so we expect you'll comment your code, write functions, use error handling, etc. At the very least, be sure to put your name at the top of the "app.js" and "main.py" files in the header comments. We reserve the right to manually review your submissions for the required elements (e.g. the client-side Python code should be using try-except and check response status codes). You may lose points if these required elements are not present.

Part 02?

Expect Part 02 to be posted during the week of April 24-28. Part 02 will involve additions to the web service and client, as well as details on how to deploy your web service to AWS EC2 using *Elastic Beanstalk*. The due date for Part 02 is one week after the due date for Part 01, which means Part 02 will be due Monday May 08 @ 11:59pm.

CS 310
Scalable Software Architectures
Spring 2023

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

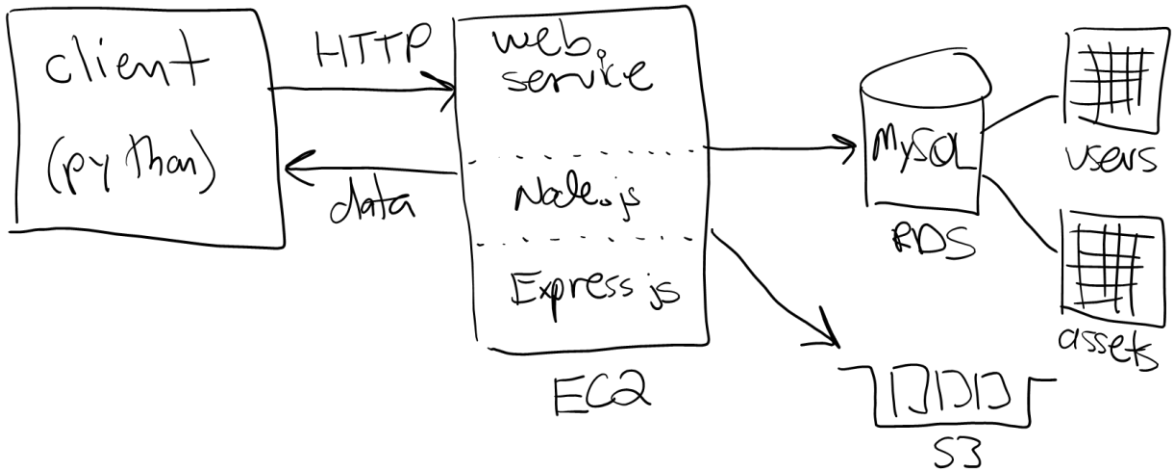
Assignment: Multi-tier PhotoApp with AWS EC2, S3 and RDS
Submission: via Gradescope (unlimited submissions)
Policy: individual work only, late work is accepted
Complete By: Friday May 12 @ 11:59pm CST

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
}
```

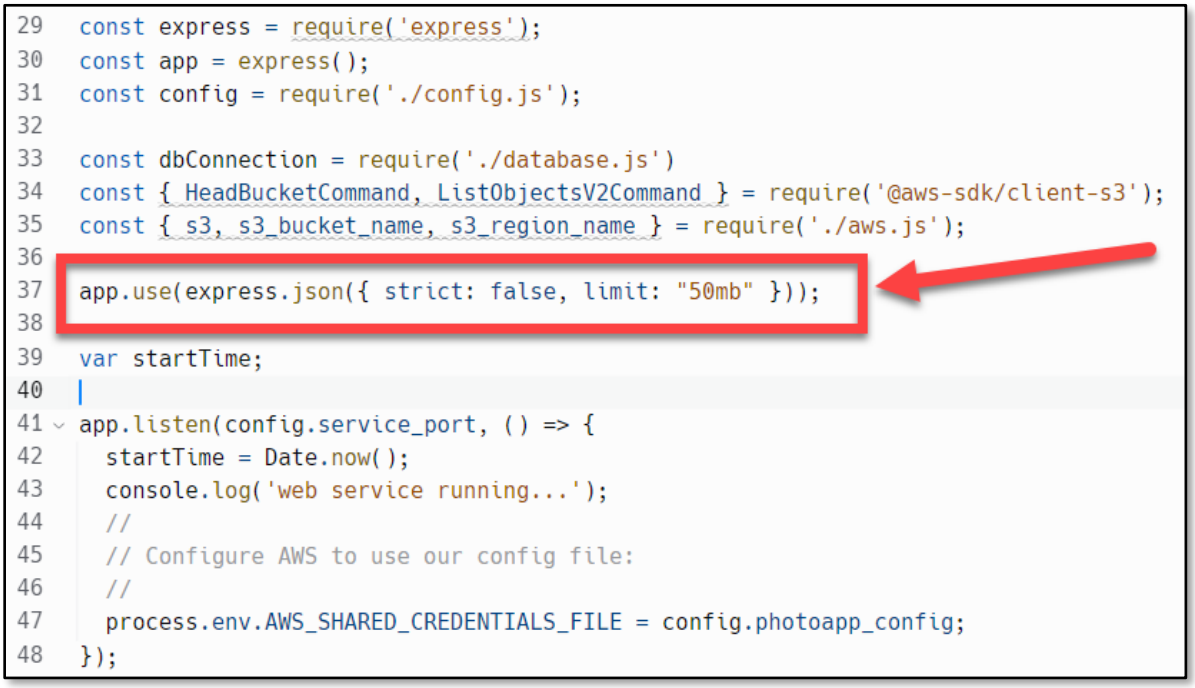
To get started, download the JS file "api_user.js" from dropbox. This file exports the function **put_user**:

```
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".

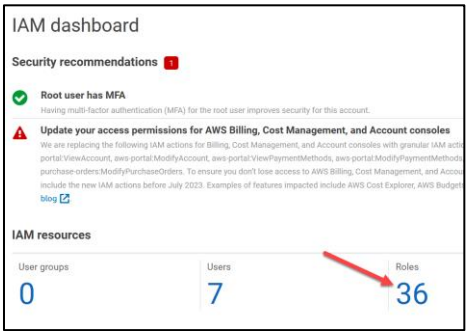
SAME SUGGESTION: build the web service function one small step at a time. Use console.log( ) to confirm your steps.

(3) AWS IAM Roles

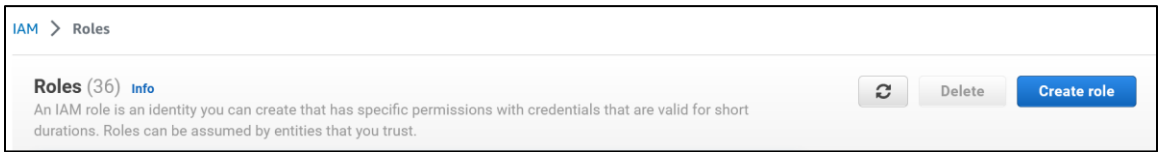
Congratulations, you have built a non-trivial web service using JavaScript, Node.js, and Express js! Well done. The programming is over, the last two steps are to configure AWS to run your web service using **EC2**, Amazon's *Elastic Compute* service. Since we are using a well-known framework, AWS makes 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:

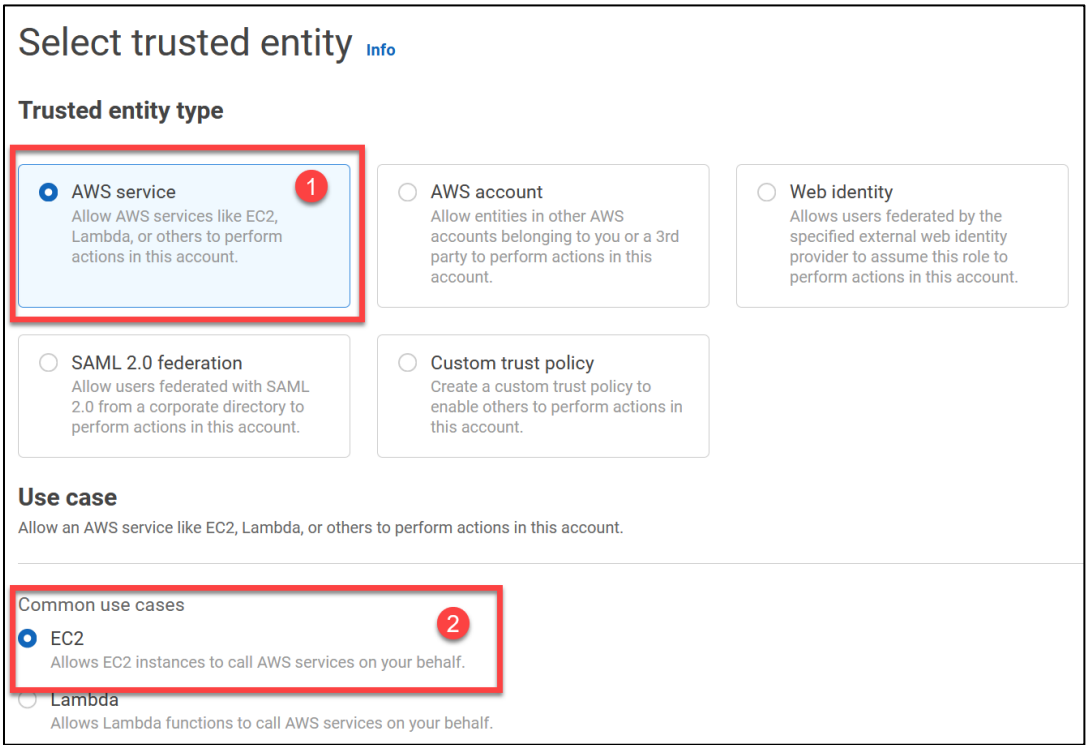
1. Login to AWS and open the Management Console. Search for "IAM".
2. You'll see 1 or more roles --- click on the number (36 in our case):



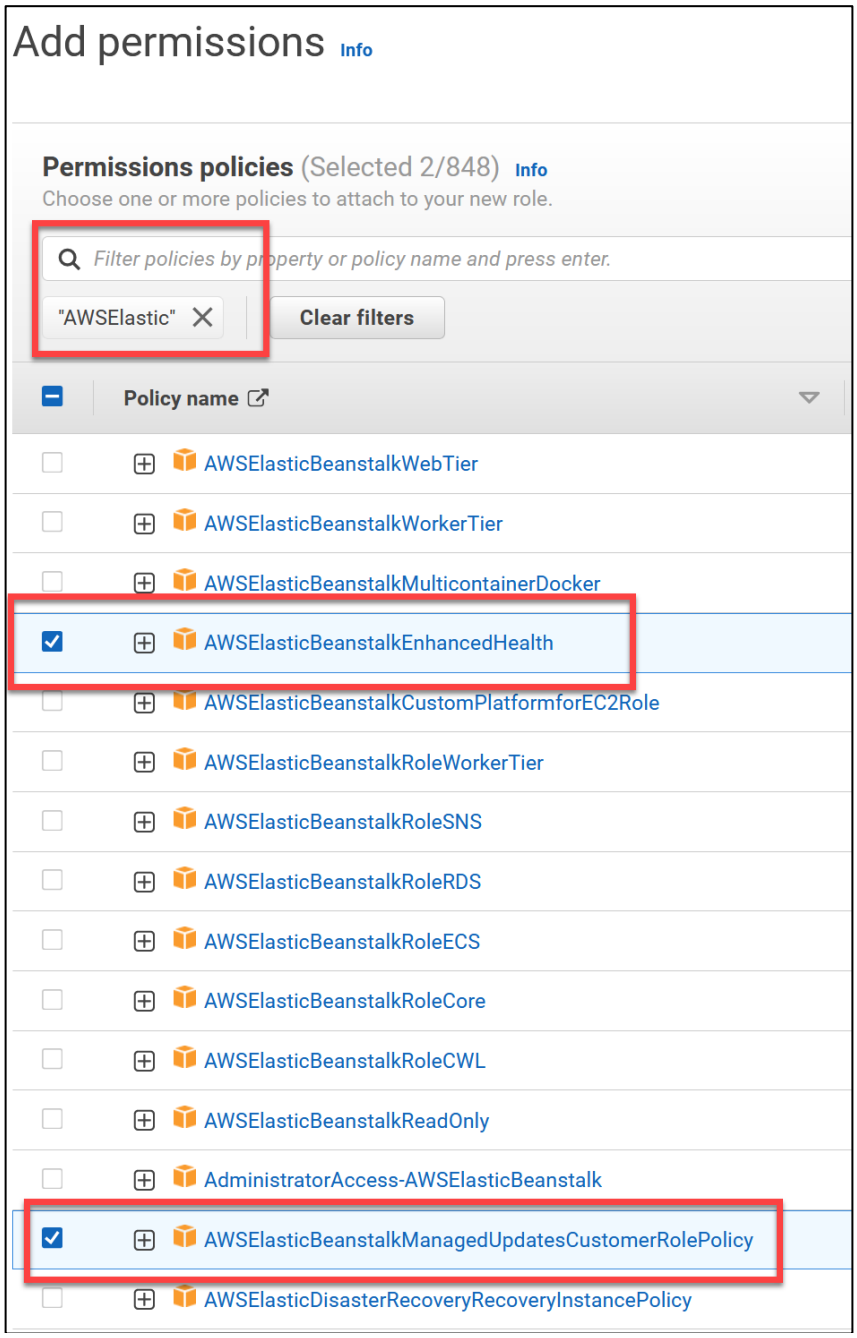
3. Click “Create role” to create a new role:



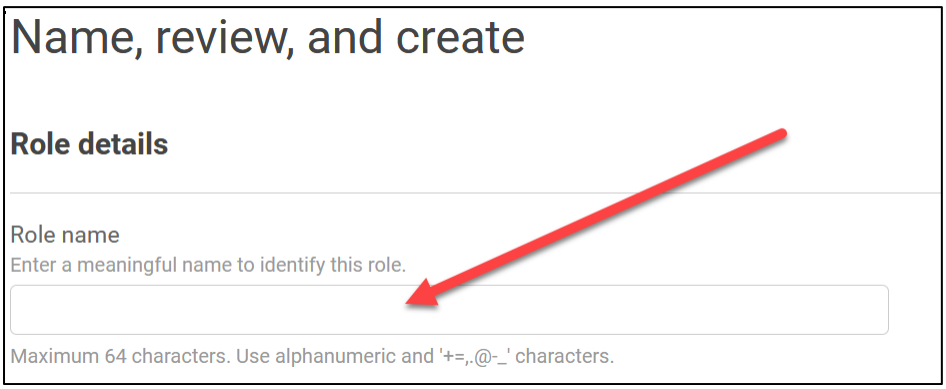
4. On the next screen, select “AWS service” and “EC2” as common use case:



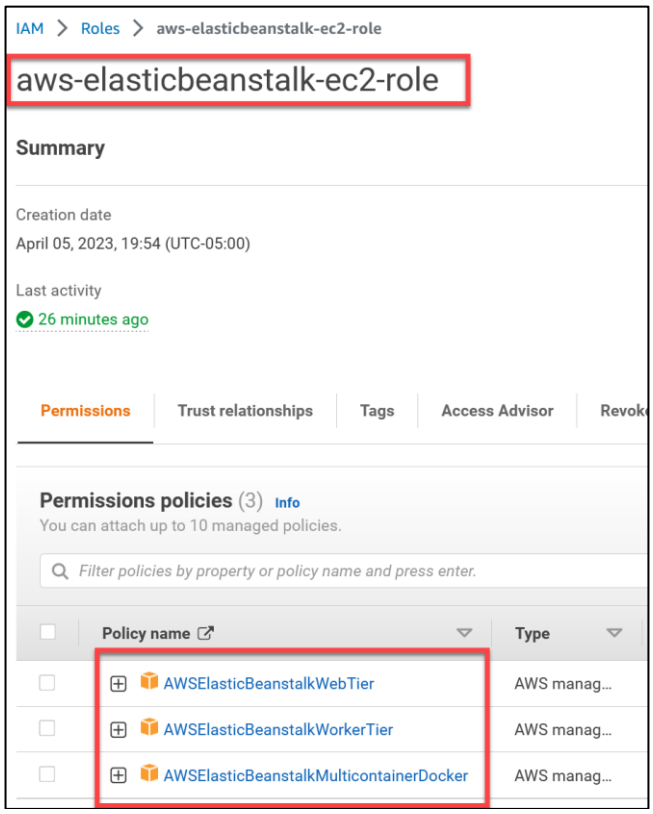
5. The next screen is for adding additional permissions --- narrow down the search by entering "AWSElastic" in the search field and pressing ENTER. Then select the two roles shown and click "Next":



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

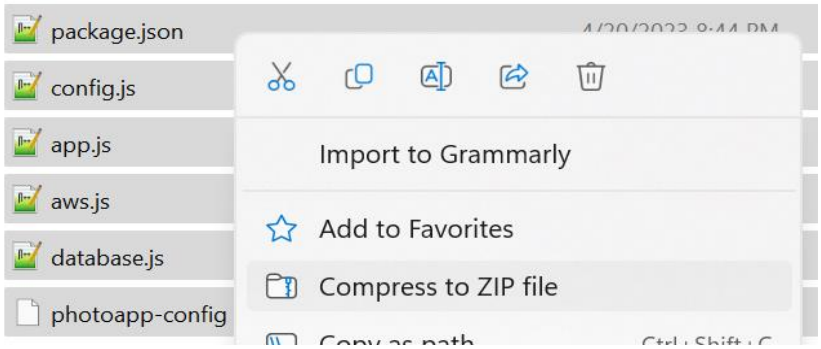
Now that the roles are created, here are the steps to get your web service up and running on EC2 using EB. When you're done, you'll have a public endpoint that allows your API to be called by anyone with an internet connection. Test by pointing your Python-based client at this endpoint.

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.

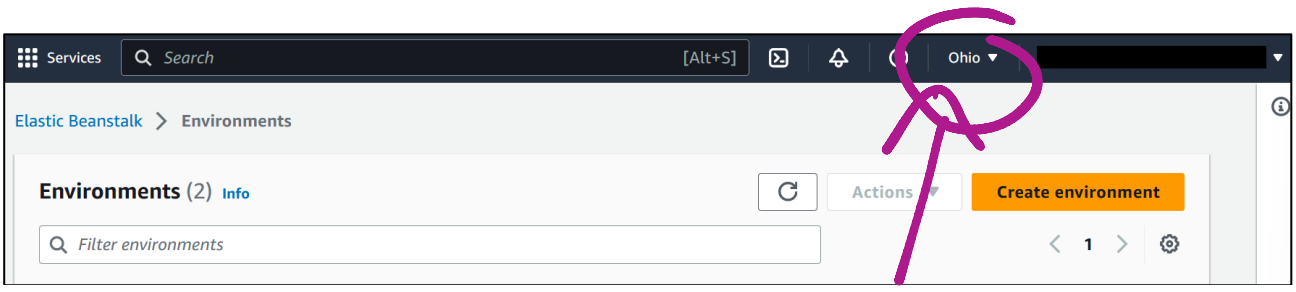
3. Select all the files in your "web-service" folder --- 13 files in total --- and create a compressed / archive file. The resulting file should have a .ZIP extension, and you should compress the files directly into the .ZIP:



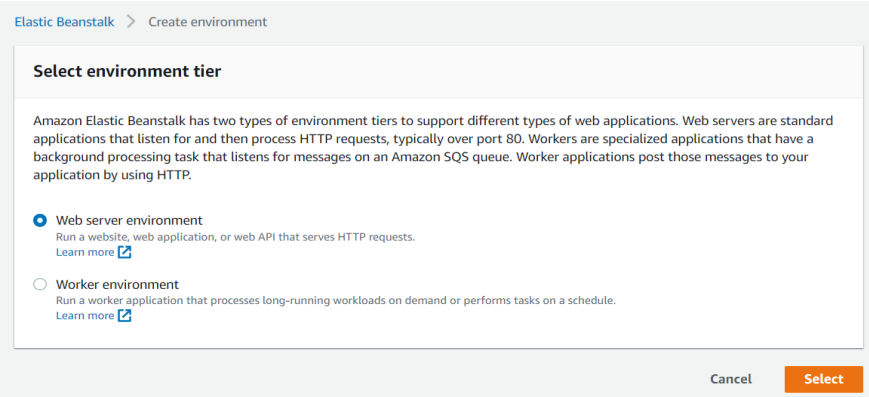
   For example, do *not* compress the web-service folder --- the .ZIP needs to contain just the files, no folders. Normally you select all the files, right-click, and select compress. [*On windows, it might also be select all the files, right-click, select "Send to", and then select "Compressed (zipped)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

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

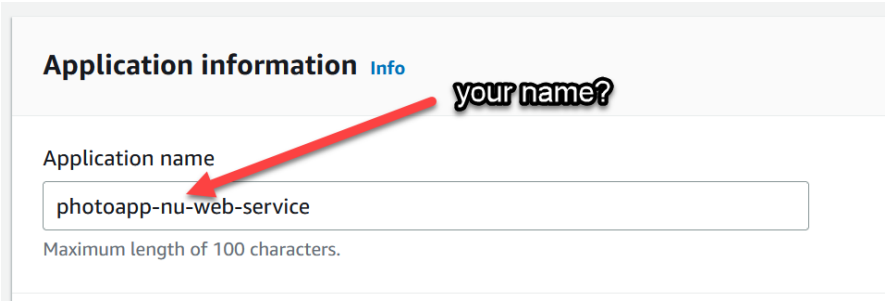
5. Use the drop-down to select your region --- it should be the same region that contains your database and bucket. When in doubt, select "Ohio" (us-east-2). You should see something like this:



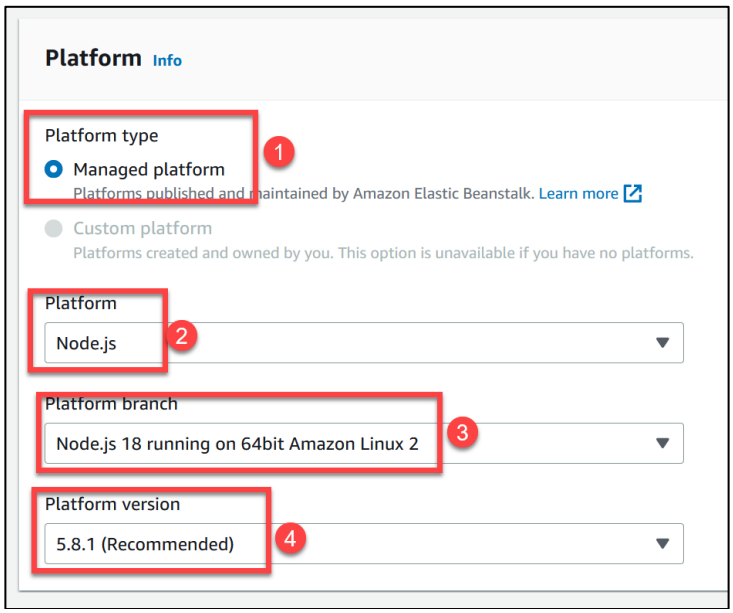
6. Click “Create environment”. Select a “Web server environment” and press Select if you see a button (or maybe just scroll down, there may be differences):



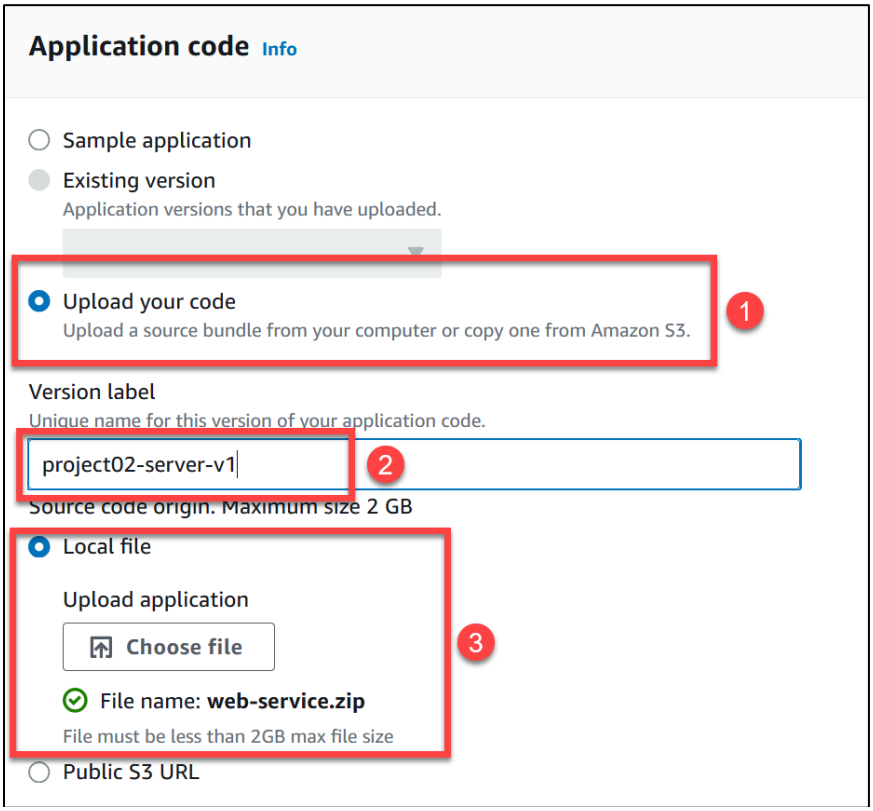
7. Enter an application name. Like your bucket, this should be unique so use your name and some combination of “photoapp” and “web-service”:



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

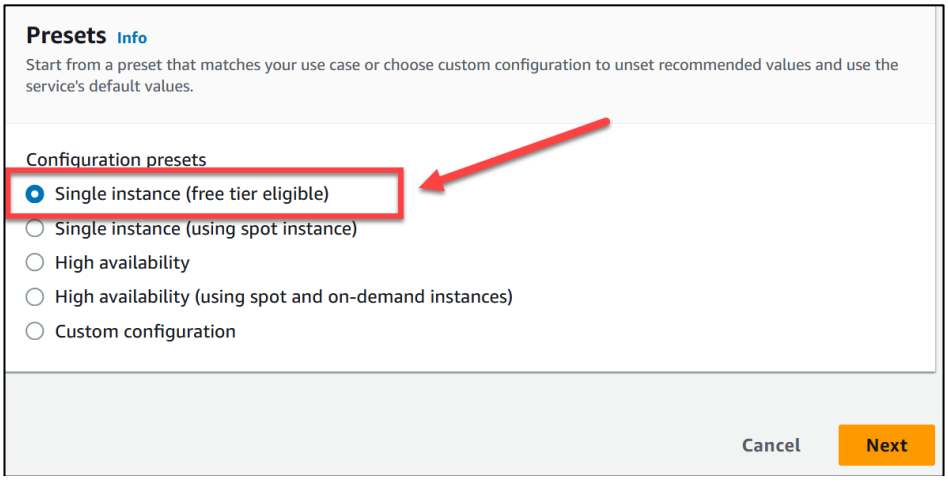


9. Next, upload the .ZIP file containing your web service files:

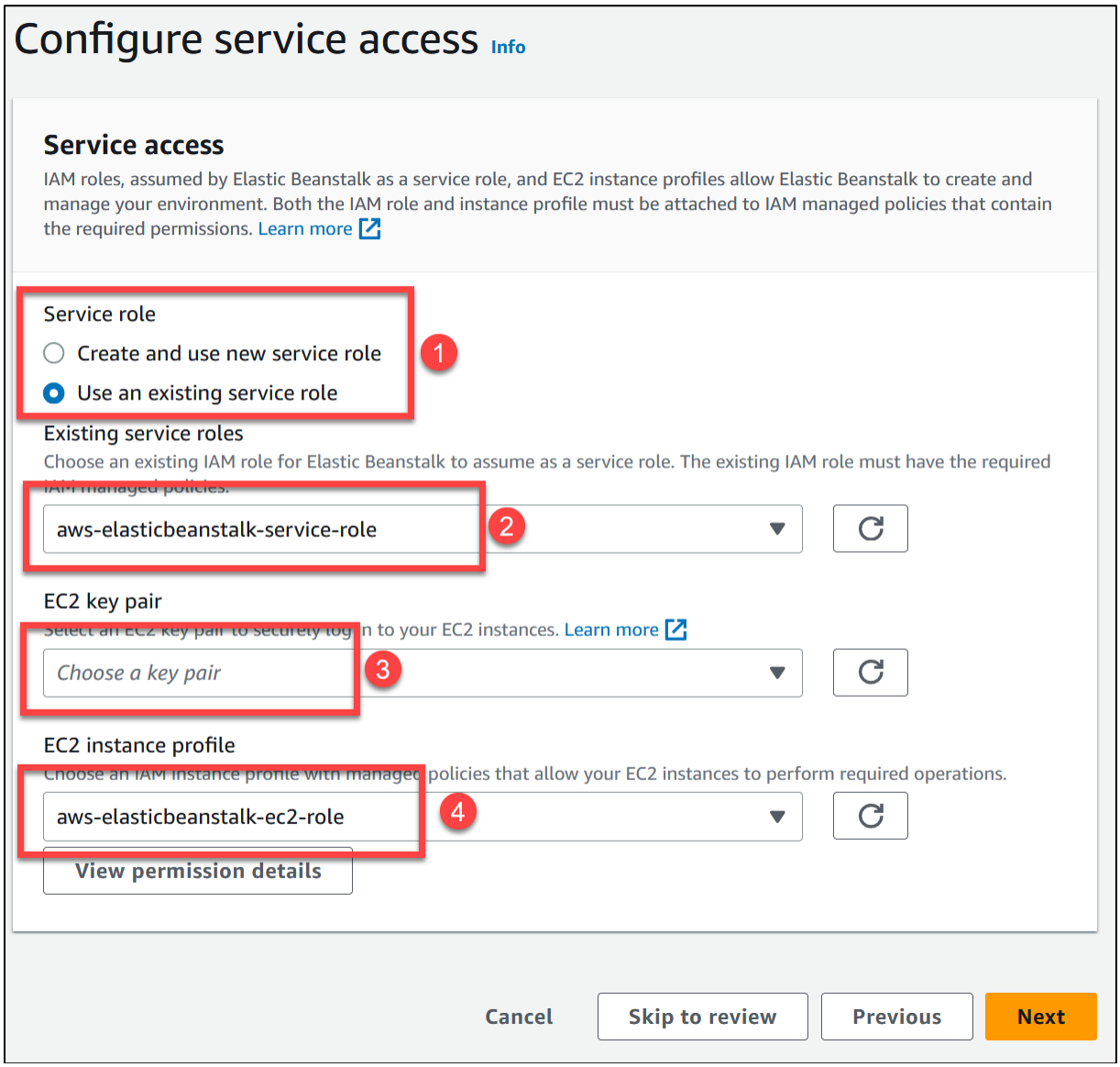


Fun fact: the .zip file is stored in S3.

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:



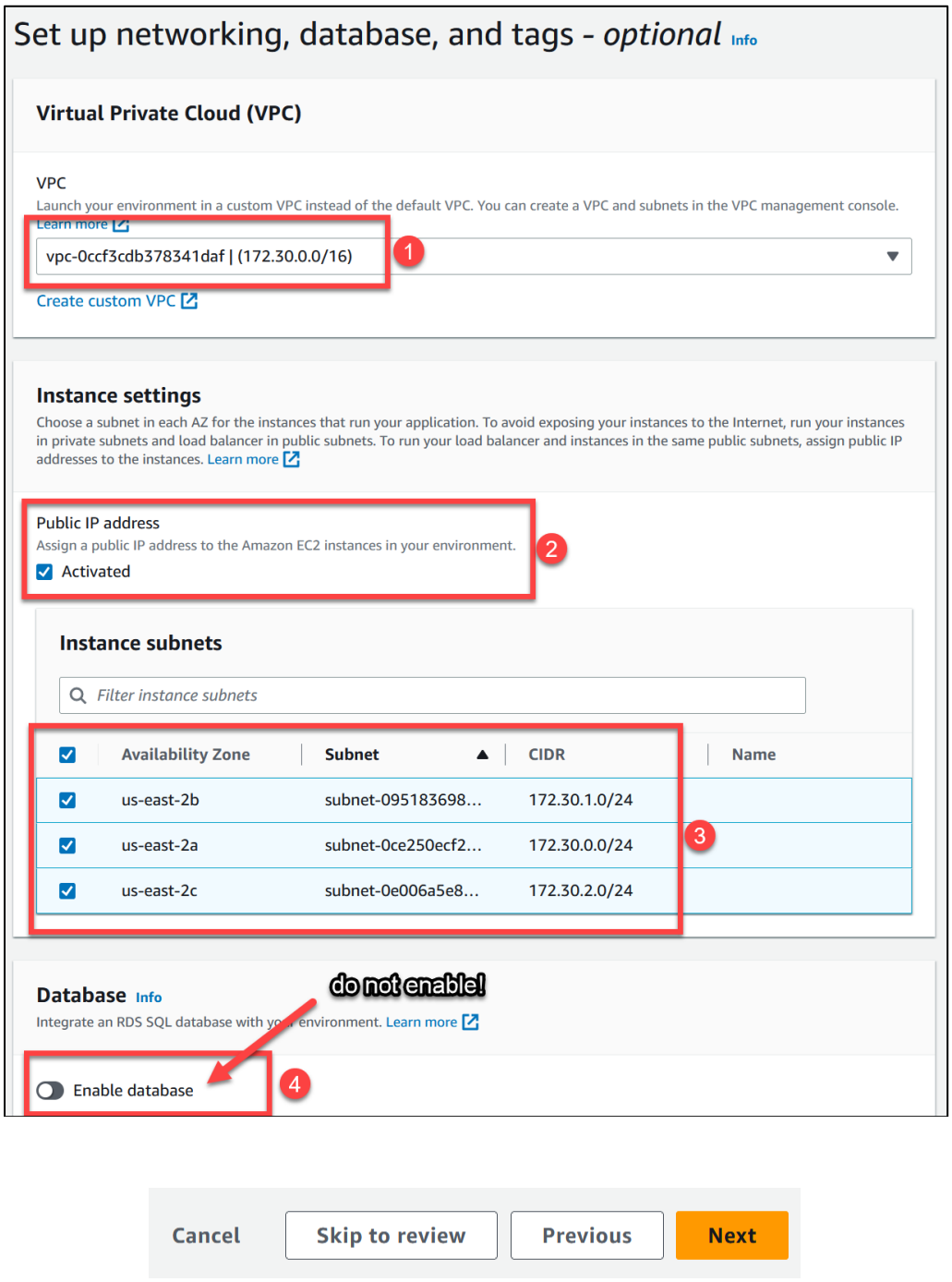
11. Next is “Configure service access”. In steps 2 and 4 you’ll select the roles you created earlier --- skip step 3 (leave EC2 key pair blank). Click Next when you’re ready:



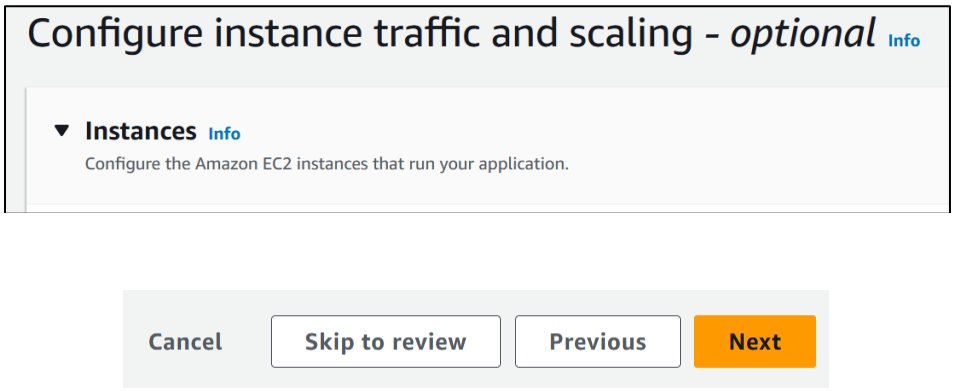
<< continued on next page >>

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.

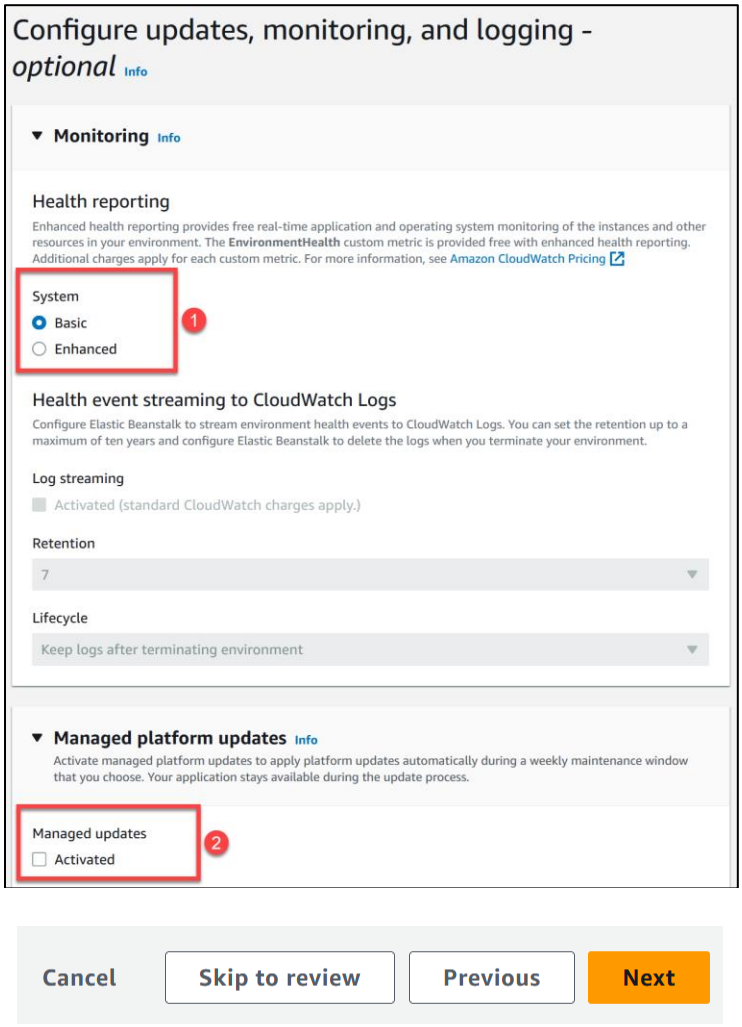
    For the other options, you want to activate “Public IP address” (step 2) so your web service is accessible by the outside world. The “instance subnets” should be auto-populated based on the selected VPC --- select them all (step 3). Finally, do *not* enable a database, we already have one!



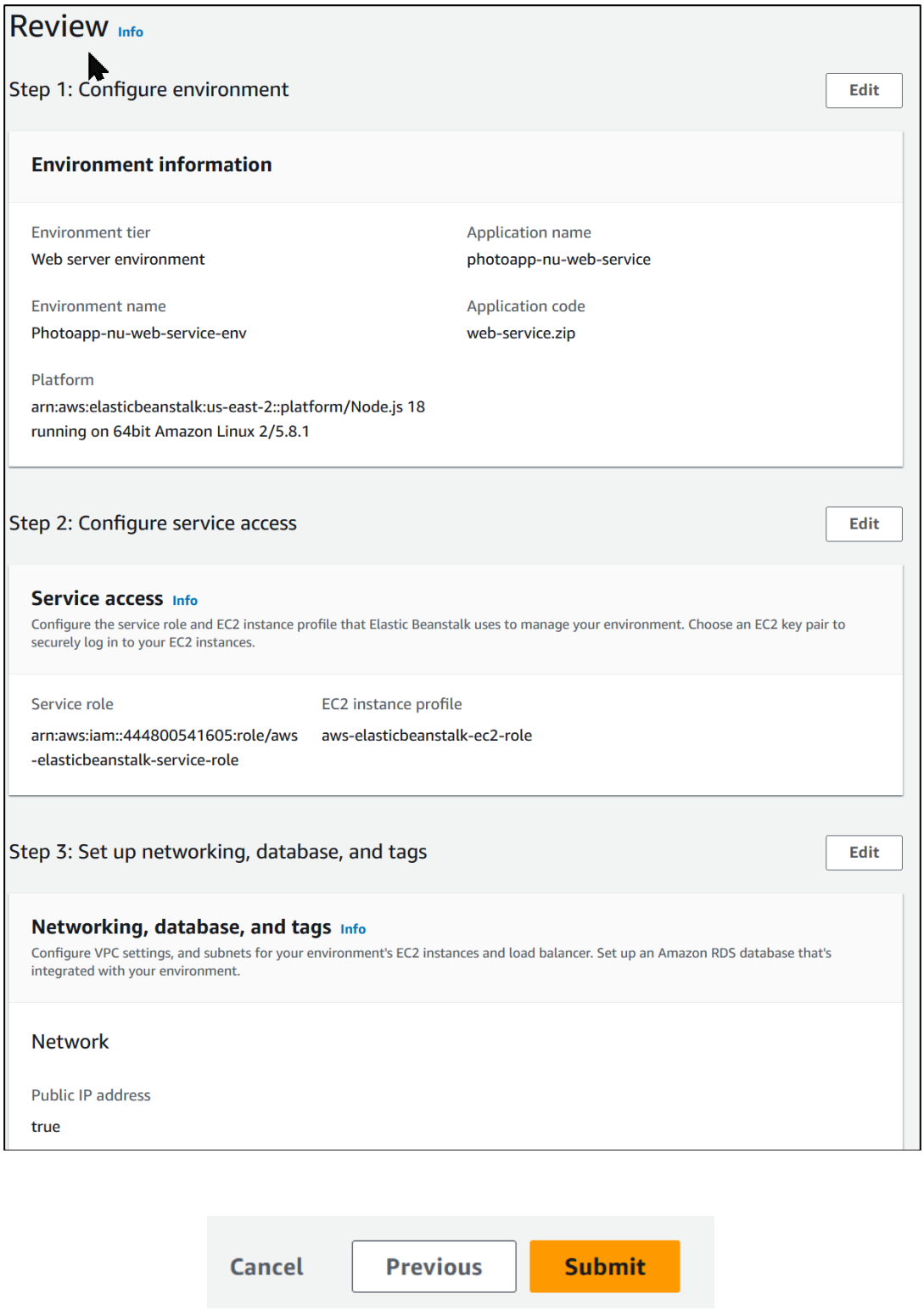
13. Configure instance traffic and scaling… Leave alone and click Next…



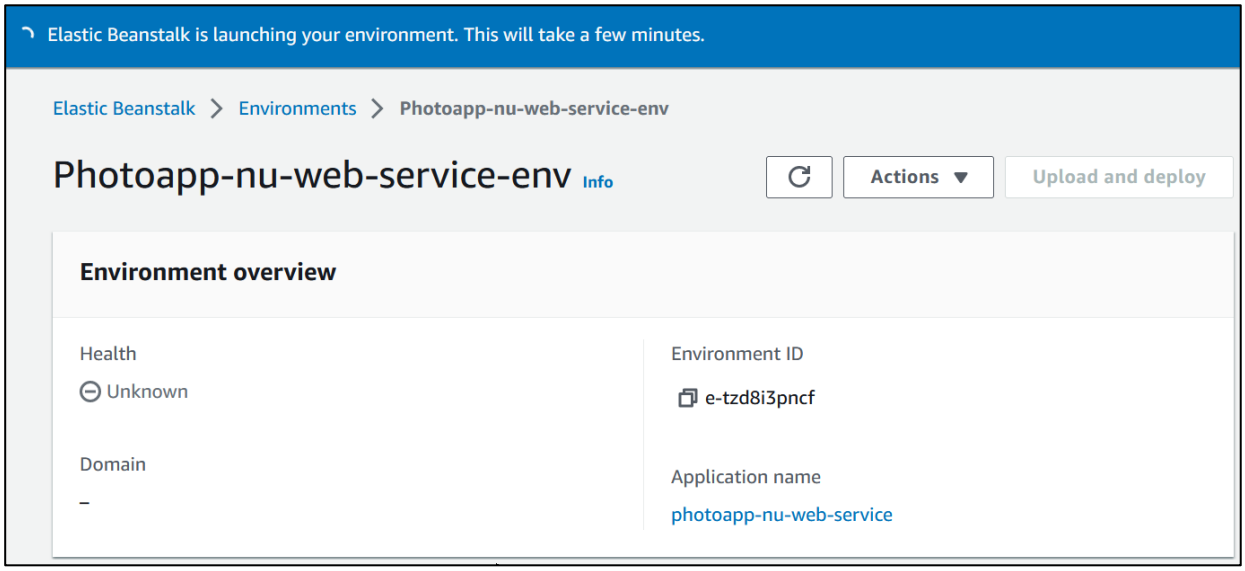
14. Configure updates, monitoring, and logging… Switch to “basic” health reporting and “de-activate” platform updates:



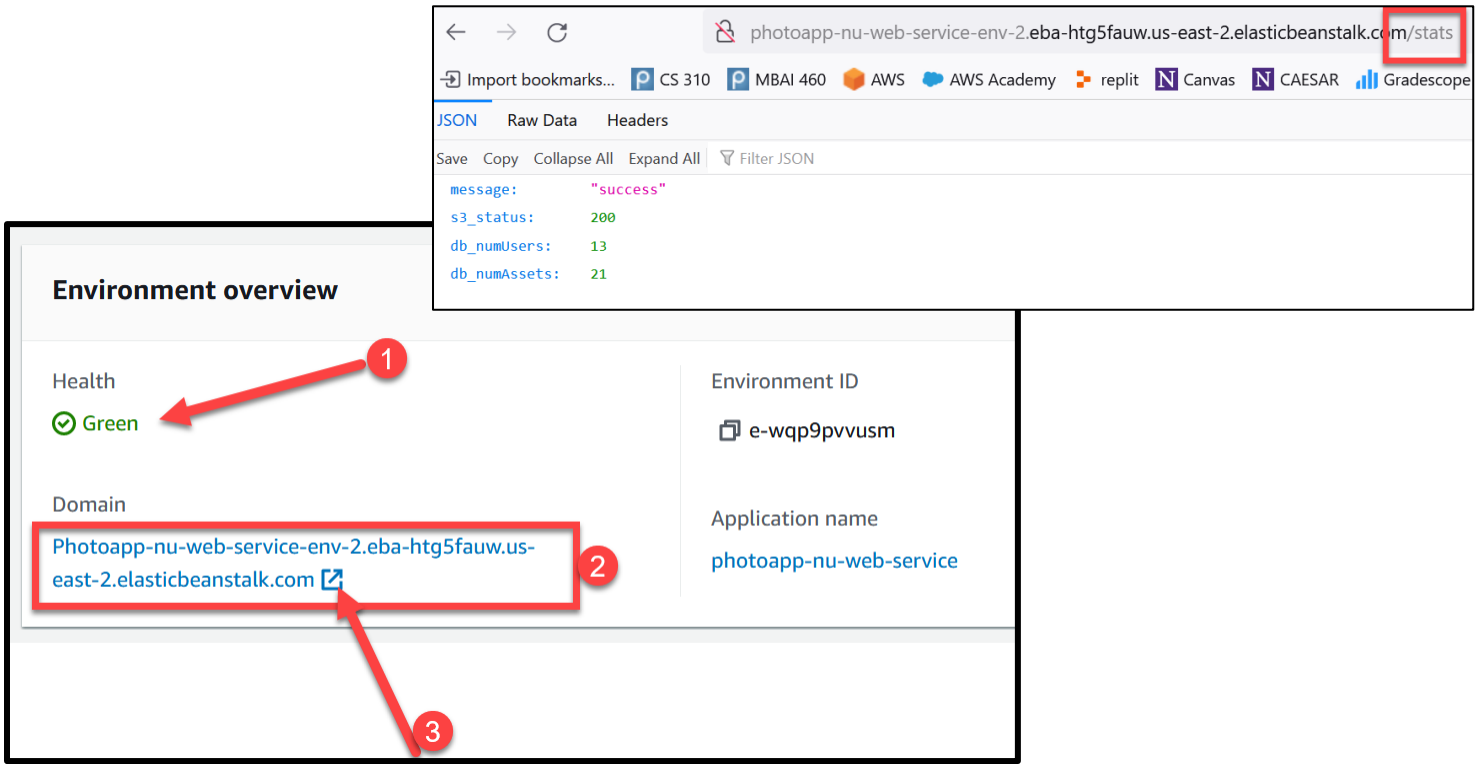
15. You should see the final review page. If everything looks good, scroll down and click Submit!



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

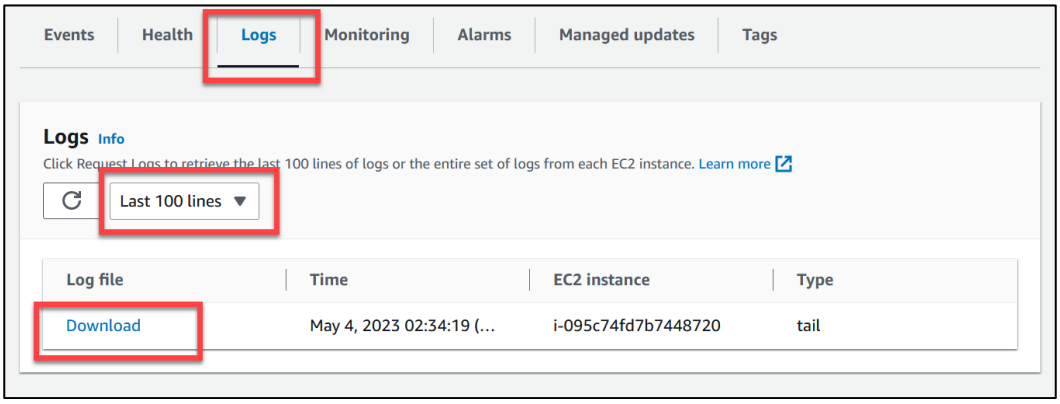


17. If all is well, you should get a “Green” health check (step 1), and your domain endpoint should be displayed (step 2). Click the little “pop-out” button (step 3) to open a browser window so you can test your GET functions like /stats and /users:

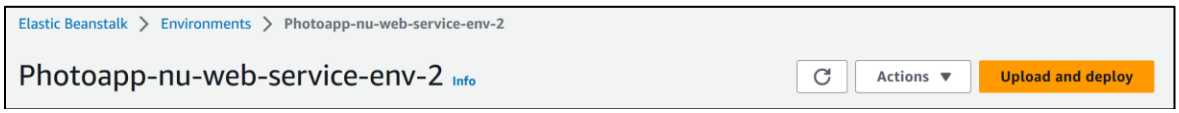


18. At this point, you'll want to test all the API functions using your Python-based client. Create another client config file, and paste your AWS EC2 endpoint into that config file. Run your client and test…

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.