Workloads in the cloud

- Types of workloads
- Packaging options
- Execution options

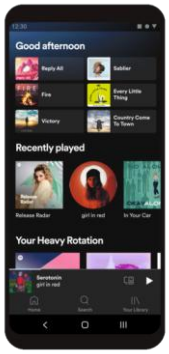
New architectural concepts…

- I want to motivate two design concepts…

1. Lambda functions
2. Serverless computing

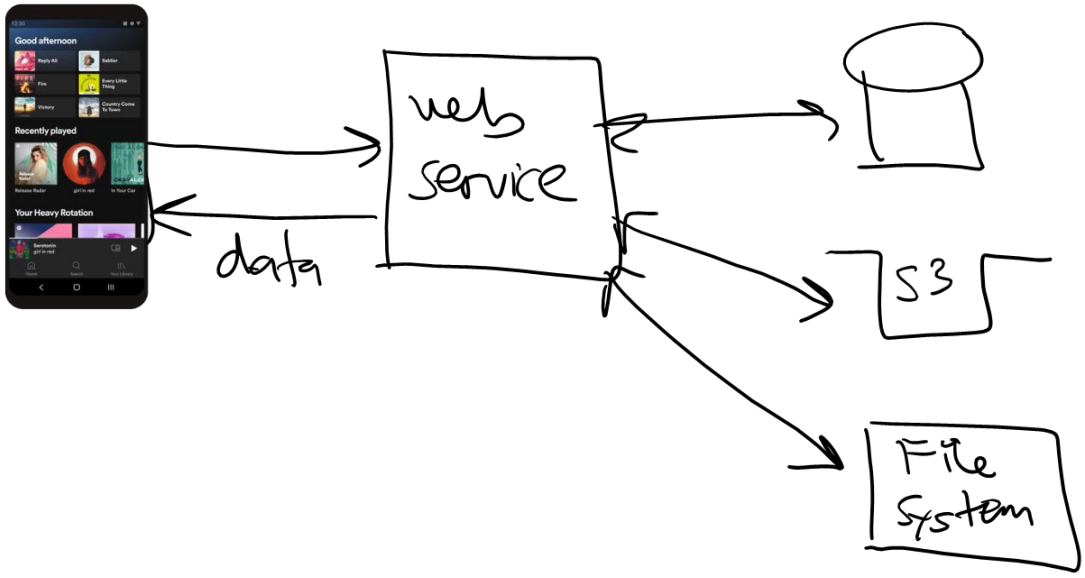
Multi-tier, data-driven apps

- **Our examples (so far) have all been data-driven**



I/O bound

- **We call this kind of workload "I/O bound"**
  - *Server is spending most of its time waiting for requests / data, i.e. input/output*
  - *This is typically handled via async programming*



Lambda

- **Lambda functions**
- **Intro to serverless computing**

Execution continuum

EC2, EKS, ECS, Fargate	Elastic Beanstalk	API Gateway + Lambda	Lambda
• *Run any software you want for as long as you want* • *Complete control over HW and SW* • *Hardest to config*	• *Upload .zip file* • *Limited software choices* • *Some control over HW and SW*	• *Function based* • *Near-zero config* • *Web service + functions (15-min limit)*	• *Function based* • *Near-zero config* • *Short execution (< 15 mins)*

AWS lambda

- **By far the simplest, least expensive way to compute**

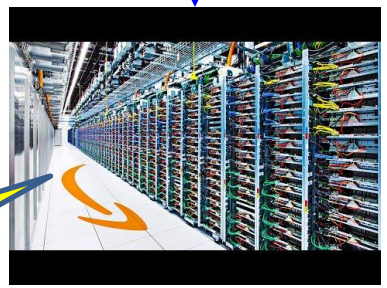
EC2, EKS, ECS, Fargate

Elastic Beanstalk

API Gateway + Lambda

Lambda

function



Scalable! Each call executes independently on different HW => horizontal scaling

AWS lambda / Azure functions / Google functions

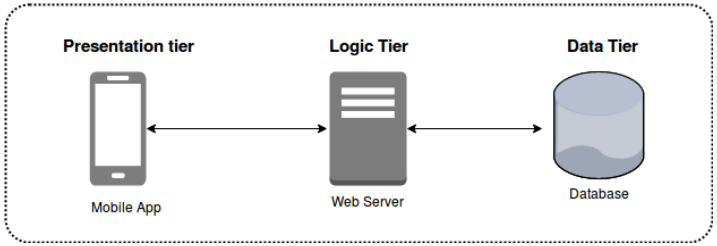
- **Standalone functions executed on demand**
  - *Can be written in JavaScript, Python, Java, C++, etc.*
  - *Execution time is limited (AWS => 15 minutes)*

- **Callable in a variety of ways:**
  - *Like a traditional function( ) using AWS library*
  - *Based on **events** that occur (e.g. uploading an item into S3)*
  - *Via **function URL** through AWS-managed web server*
  - *Via **API Gateway** offering a more customizable AWS-managed web server (e.g. test vs. production, more authentication options, …)*

Serverless

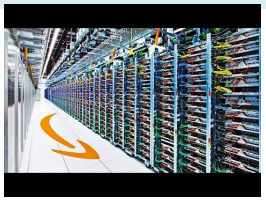
- Serverless computing
- API Gateway + lambda

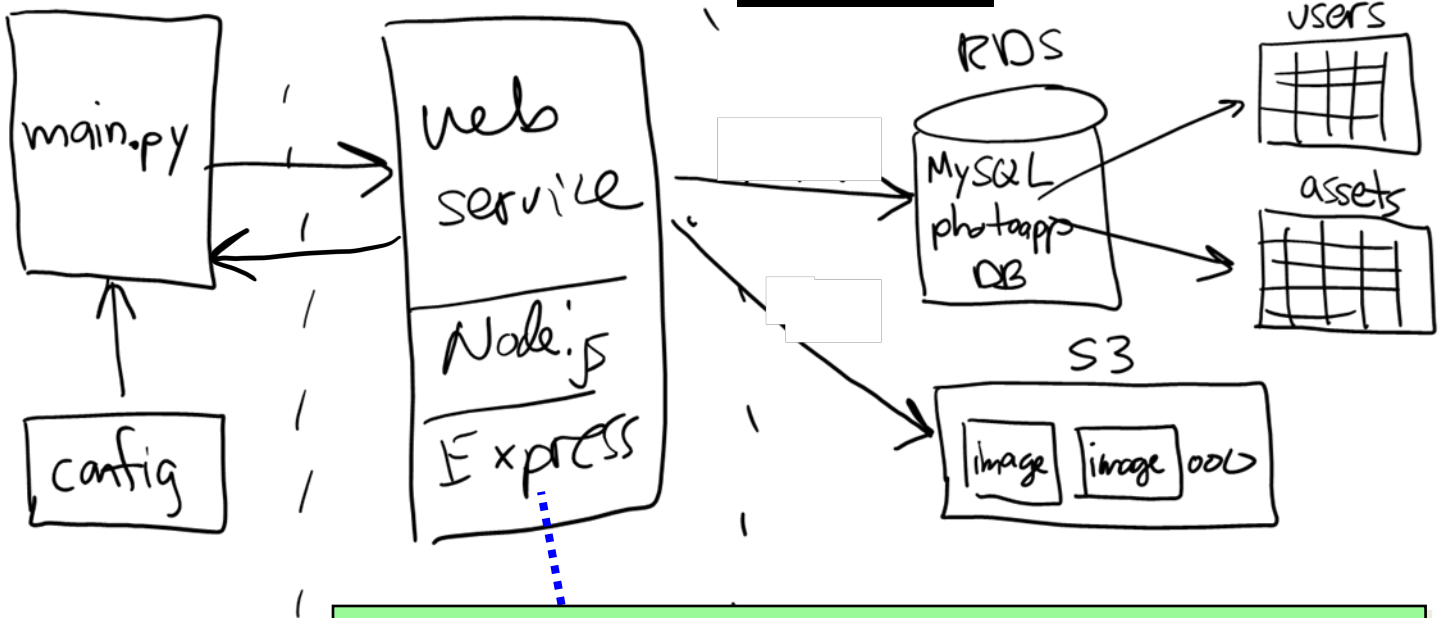
Monolithic multi-tier



- **Traditional software design for the cloud**
- **Monolithic approach --- one large code base on server**
  - *Safe, conservative engineering*
  - *No one gets fired for building systems this way :-)*

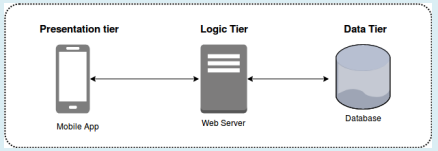
Project 02 --- monolithic web service






```
//
// PhotoApp web service
//
app.get('/stats', (req, res) => {…});
app.put('/user', (req, res) => {…});
app.get('/users', (req, res) => {…});
app.get('/assets', (req, res) => {…});
app.get('/bucket', (req, res) => {…});
app.get('/image/:assetid', (req, res) => {…});
app.post('/image/:userid', (req, res) => {…});
```

Alternative designs?



1. **Microservices**
   - *Break monolithic system apart --- easier to develop, update, release, but more moving parts to manage*
   - *Example: **Netflix** was one of the first to do this*

2. **Event-driven**
   - *Design based on events that occur / application states*
   - *Example: food delivery => menu, order, purchase, prepare, deliver*

3. **Serverless computing…**

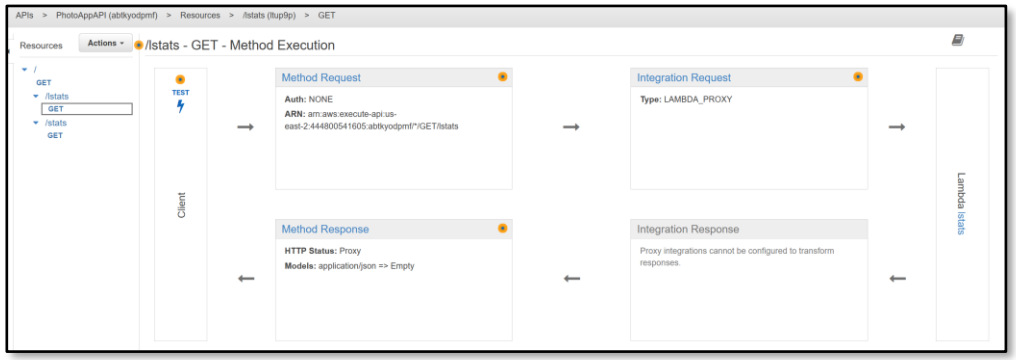
API Gateway

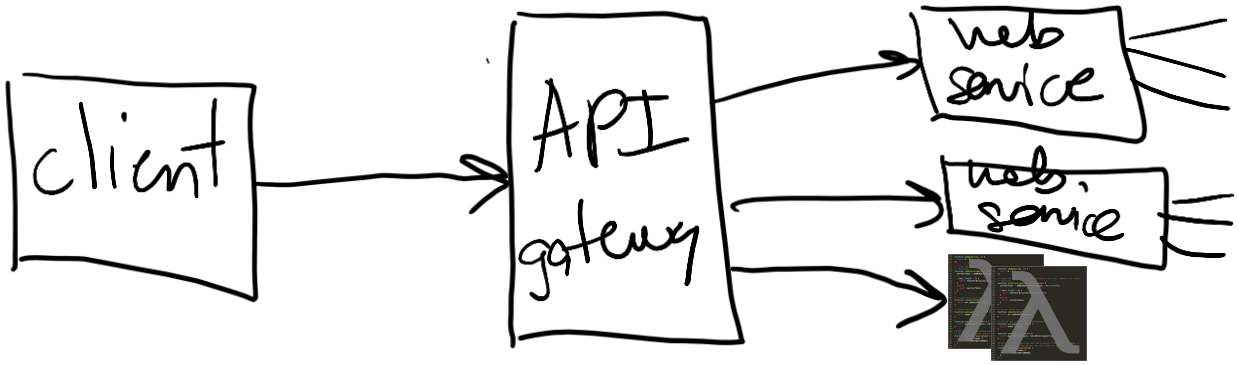
- **Programming example**
  - **API Gateway + lambda**

- **Other ways to call lambda functions**

API Gateway

- **API Gateway allows you to define a RESTful API that forwards to other services / lambdas**
  - *Define HTTP verb and URL path (e.g. GET /movies)*
  - *Specify target…*





Programming demo

- **Let's build a simple calculator using API Gateway and lambda…**

(1) lambda functions

```
#
# uuid()
#
import json
import uuid

def lambda_handler(event, context):
  result = str(uuid.uuid4())

  print("uuid:", result)

  return {
    'statusCode': 200,
    'body': json.dumps(result)
  }
```

gives u a uuid

```
#
# pow(x, e)
#
import json

def lambda_handler(event, context):
  params = event["pathParameters"]
  x = float(params["x"])
  e = float(params["e"])

  result = x ** e

  print("pow:", x, e, result)

  return {
    'statusCode': 200,
    'body': json.dumps(result)
  }
```

power function

```
#
# factors(n)
#
import json

def lambda_handler(event, context):
  params = event["queryStringParameters"]
  n = int(params["n"])

  i = 2
  factors = []
  while i * i <= n:
    if n % i:
      i += 1
    else:
      n //= i
      factors.append(i)

  if n > 1:
    factors.append(n)

  print("factors:", n, factors)

  return {
    'statusCode': 200,
    'body': json.dumps(factors)
  }
```

tells you prime factors