UNIVERSITY OF TARTU

INSTITUTE OF COMPUTER SCIENCE

Basics of Cloud Computing – Lecture 7

More AWS & Serverless Computing

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Mobile & Cloud Lab

Outline

- Overview of Amazon Web Services
- Serverless computing
  - FaaS Model
  - Apache OpenWhisk
  - Advantages and disadvantages

Cloud Providers and Services we have discussed

- Amazon Web Services
  - **Compute:** EC2
  - **Storage:** S3, EBS
  - **Scaling:** Elastic Load Balancing, Auto Scale, CloudWatch
- Eucalyptus
- OpenStack
- Management providers
  - AWS Management Console
  - OpenStack Horizon
  - RightScale
- PaaS
  - Google AppEngine
  - Windows Azure
  - Elastic MapReduce

AWS services we will discuss

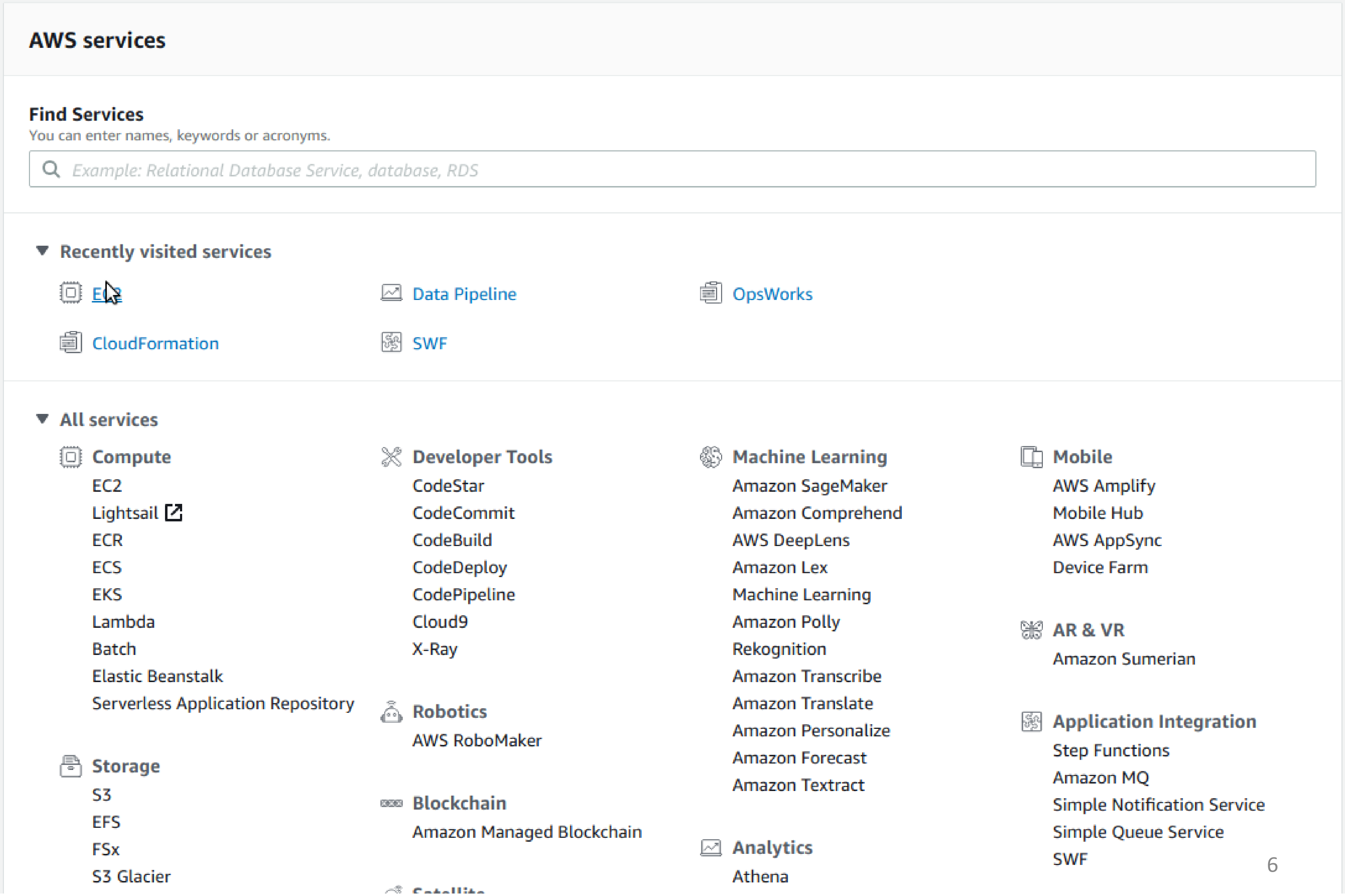
- Management Console
- Identity and Access Management
- CloudFormation
- Data Services
- Data Pipelines
- Data migration services

AWS Management Console

- Hope some of you have started using Amazon accounts
- You can manage your complete Amazon account with management console
  - AMI Management
  - Instance Management
  - Security Group Management
  - Elastic IP Management
  - Elastic Block Store
  - Key Pair management
  - etc.
- Have different pages for different services

AWS Management Console

https://console.aws.amazon.com/



AWS services

Find Services
You can enter names, keywords or acronyms.

Example: Relational Database Service, database, RDS

▼ **Recently visited services**

EC2 | Data Pipeline | OpsWorks
CloudFormation | SWF

▼ **All services**

Compute
EC2
Lightsail
ECR
ECS
EKS
Lambda
Batch
Elastic Beanstalk
Serverless Application Repository

Storage
S3
EFS
FSx
S3 Glacier

Developer Tools
CodeStar
CodeCommit
CodeBuild
CodeDeploy
CodePipeline
Cloud9
X-Ray

Robotics
AWS RoboMaker

Blockchain
Amazon Managed Blockchain

Machine Learning
Amazon SageMaker
Amazon Comprehend
AWS DeepLens
Amazon Lex
Machine Learning
Amazon Polly
Rekognition
Amazon Transcribe
Amazon Translate
Amazon Personalize
Amazon Forecast
Amazon Textract

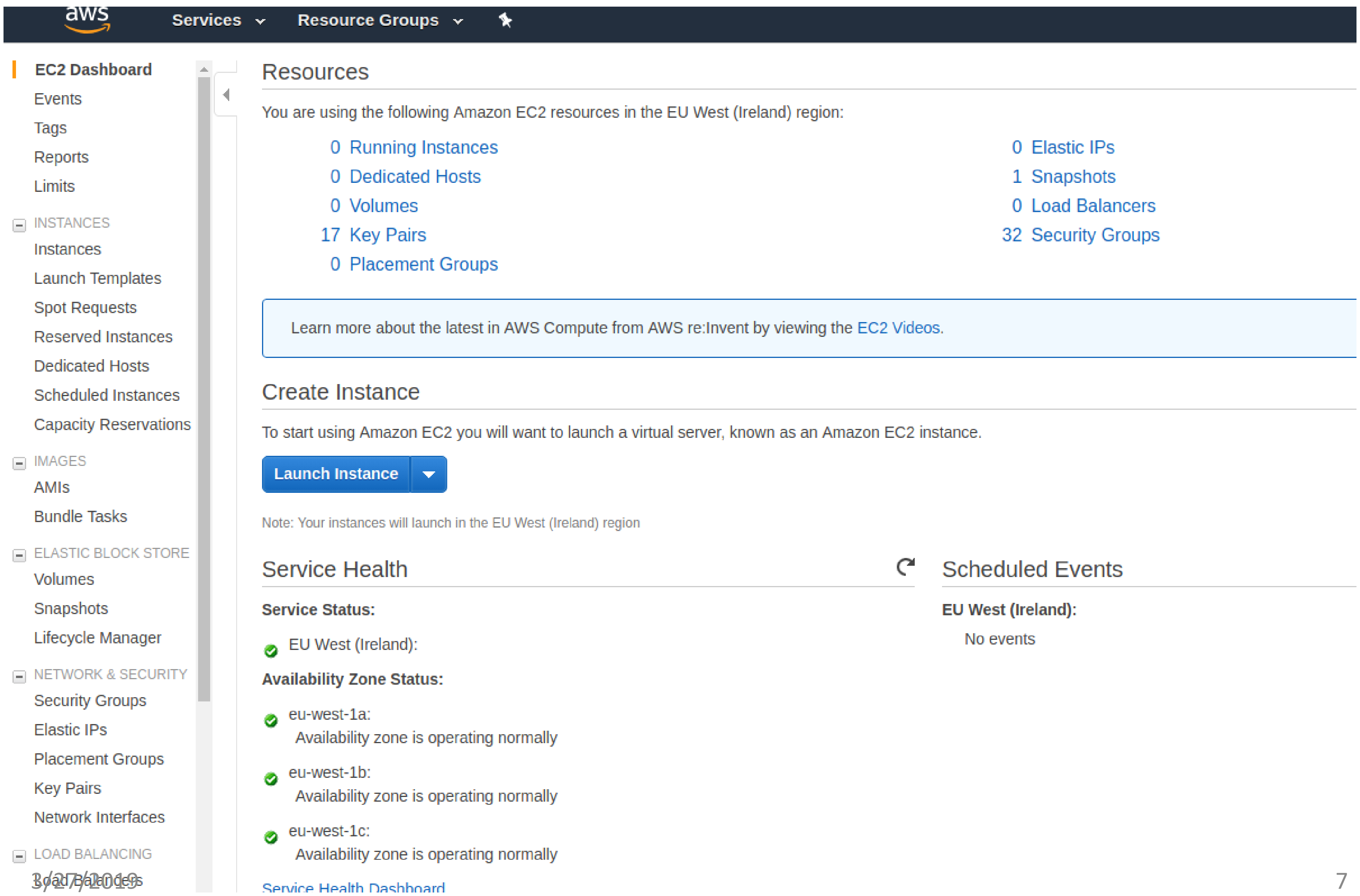
Analytics
Athena

Mobile
AWS Amplify
Mobile Hub
AWS AppSync
Device Farm

AR & VR
Amazon Sumerian

Application Integration
Step Functions
Amazon MQ
Simple Notification Service
Simple Queue Service
SWF

AWS EC2 DashBoard



Resources

You are using the following Amazon EC2 resources in the EU West (Ireland) region:

0 Running Instances	0 Elastic IPs
0 Dedicated Hosts	1 Snapshots
0 Volumes	0 Load Balancers
17 Key Pairs	32 Security Groups
0 Placement Groups	

Learn more about the latest in AWS Compute from AWS re:Invent by viewing the EC2 Videos.

Create Instance

To start using Amazon EC2 you will want to launch a virtual server, known as an Amazon EC2 instance.

Note: Your instances will launch in the EU West (Ireland) region

Service Health

Service Status:

EU West (Ireland):

Availability Zone Status:

eu-west-1a:
Availability zone is operating normally

eu-west-1b:
Availability zone is operating normally

eu-west-1c:
Availability zone is operating normally

Service Health Dashboard

Scheduled Events

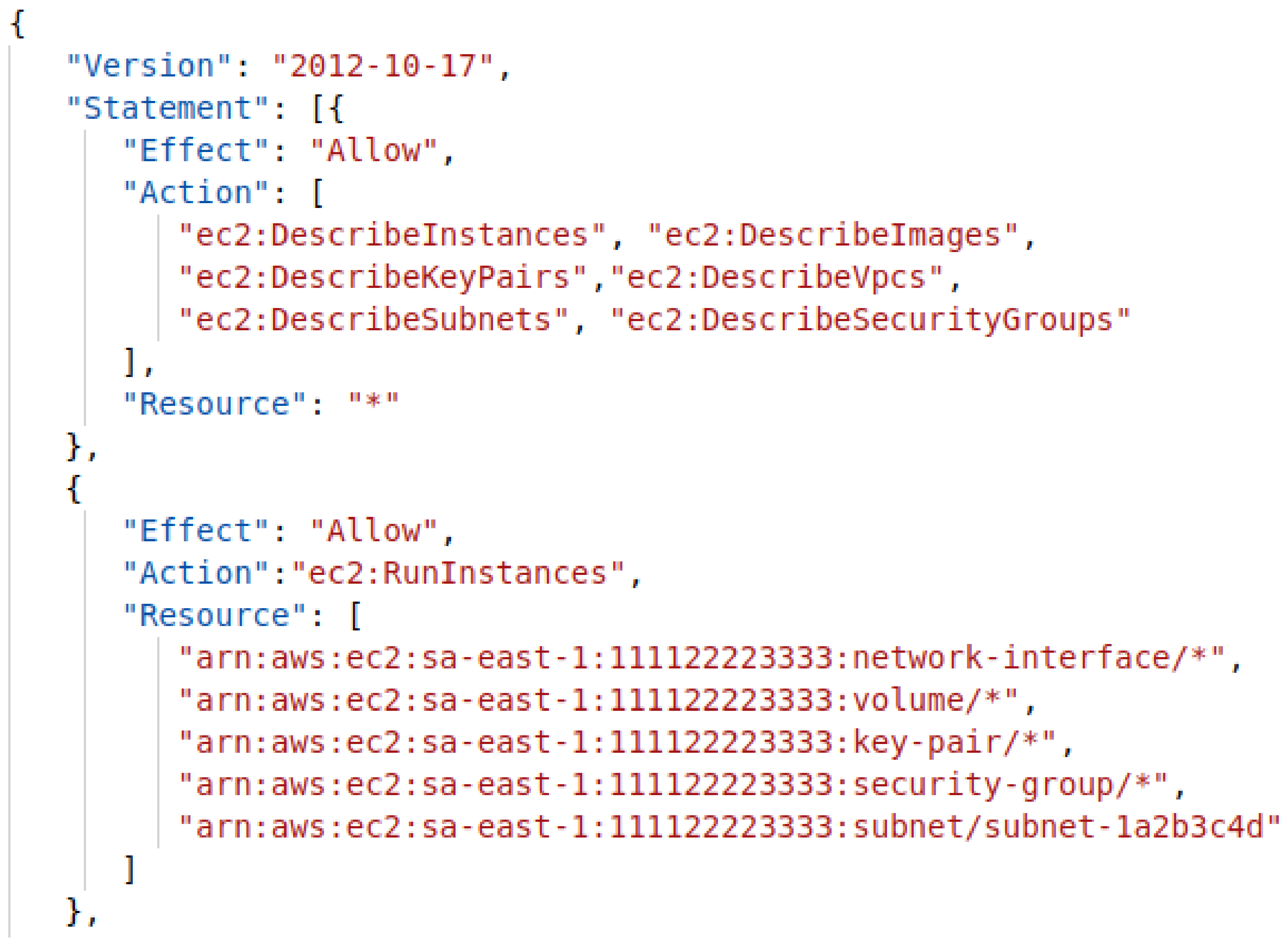
EU West (Ireland):

No events

AWS Identity and Access Management (IAM)

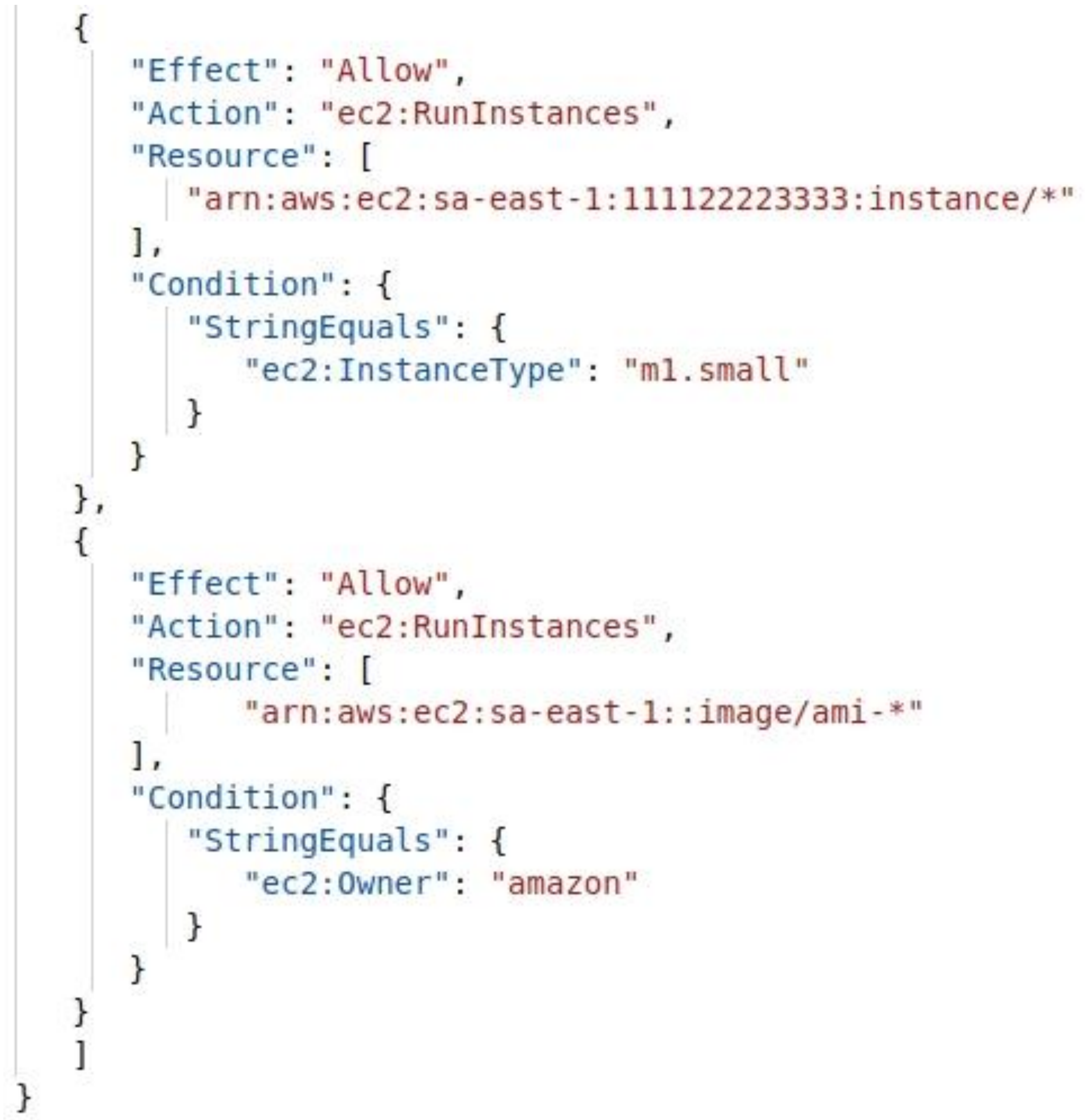
- How can an enterprise or group of users use one credit card?
- Manage IAM users
  - Create new users and manage them
  - Create groups
- Manage credentials
  - Create and assign temporary security credentials
- Manage permissions
  - Creating policies for specific services and users
  - Can use very fine-grained granuality

IAM policy example



```
{
    "Version": "2012-10-17",
    "Statement": [{
        "Effect": "Allow",
        "Action": [
            "ec2:DescribeInstances", "ec2:DescribeImages",
            "ec2:DescribeKeyPairs","ec2:DescribeVpcs",
            "ec2:DescribeSubnets", "ec2:DescribeSecurityGroups"
        ],
        "Resource": "*"
    },
    {
        "Effect": "Allow",
        "Action":"ec2:RunInstances",
        "Resource": [
            "arn:aws:ec2:sa-east-1:111122223333:network-interface/*",
            "arn:aws:ec2:sa-east-1:111122223333:volume/*",
            "arn:aws:ec2:sa-east-1:111122223333:key-pair/*",
            "arn:aws:ec2:sa-east-1:111122223333:security-group/*",
            "arn:aws:ec2:sa-east-1:111122223333:subnet/subnet-1a2b3c4d"
        ]
    },
```

IAM policy example



```
   {
      "Effect": "Allow",
      "Action": "ec2:RunInstances",
      "Resource": [
         "arn:aws:ec2:sa-east-1:111122223333:instance/*"
      ],
      "Condition": {
         "StringEquals": {
            "ec2:InstanceType": "m1.small"
         }
      }
   },
   {
      "Effect": "Allow",
      "Action": "ec2:RunInstances",
      "Resource": [
            "arn:aws:ec2:sa-east-1::image/ami-*"
      ],
      "Condition": {
         "StringEquals": {
            "ec2:Owner": "amazon"
         }
      }
   }
   ]
}
```

AWS CloudFormation

- Provides an easy way to create and manage a collection of related AWS resources, provisioning and updating them in an orderly and predictable fashion
- It is based on templates model
  - Templates describe the AWS resources, the associated dependencies, and runtime parameters to run an app.
  - The templates describe stacks, which are set of software and hardware resources.
  - Something similar to CloudML and RightScale server templates
- Hides several details
  - How the AWS services need to be provisioned
  - Subtleties of how to make those dependencies work.

```yaml
Resources:
  Ec2Instance:
    Type: 'AWS::EC2::Instance'
    Properties:
      SecurityGroups:
        - !Ref InstanceSecurityGroup
        - MyExistingSecurityGroup
      KeyName: mykey
      InstanceType: t2.micro
      ImageId: ami-7a11e213
  InstanceSecurityGroup:
    Type: 'AWS::EC2::SecurityGroup'
    Properties:
      GroupDescription: Enable SSH access via port 22
      SecurityGroupIngress:
        - IpProtocol: tcp
          FromPort: '22'
          ToPort: '22'
          CidrIp: 0.0.0.0/0
```

AWS CloudFormation

- Amazon provides several pre-built templates to start common apps, such as:
  - WordPress (blog)
  - LAMP stack (Linux, Apache, MySQL, and PHP)
  - Gollum (wiki used by GitHub)
- There is no additional charge for AWS CloudFormation.
- You pay for the utilized AWS resources (e.g. EC2 instances, Elastic Load Balancers, etc.)
- http://aws.amazon.com/cloudformation/

AWS Data Services

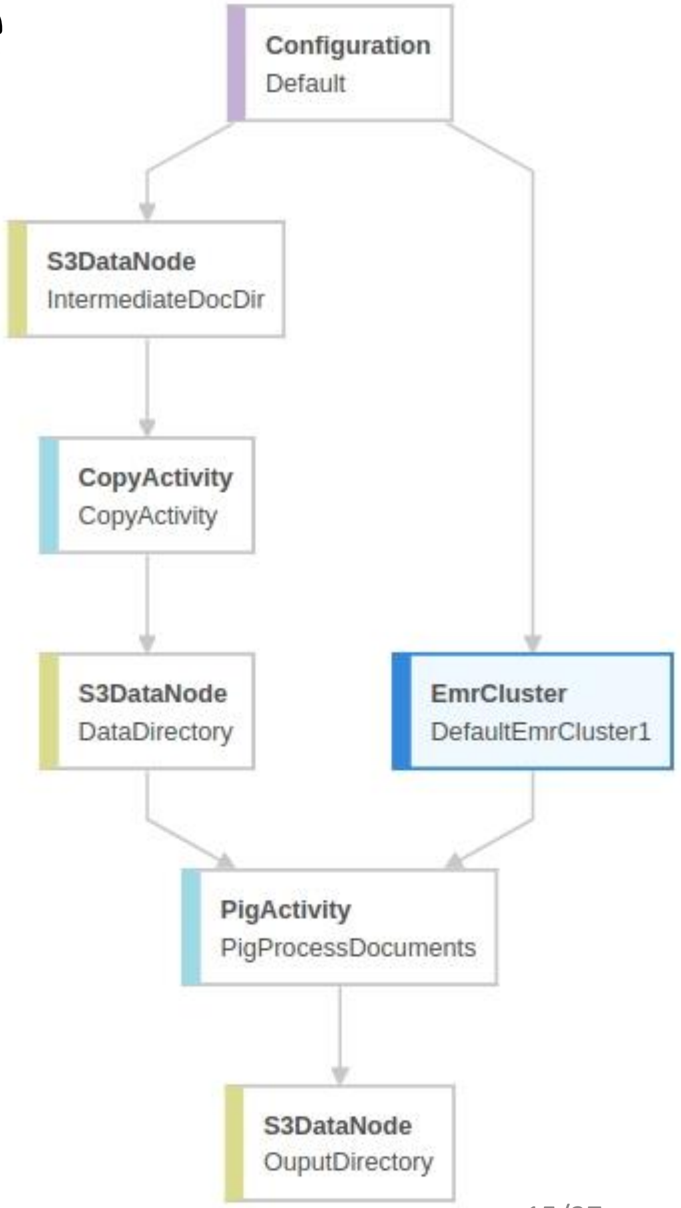
- Amazon Relational Database Service
  - Scalable and re-sizable SQL DB service
  - Supports most of the familiar database engines
    - MySQL, PostgreSQL, Oracle, Microsoft SQL Server
- Amazon Aurora
  - High Performance SQL service (MySQL and PostgreSQL compatible)
  - Distributed, fault-tolerant, self-healing storage
- NoSQL databases
  - DocumentDB - Managed Document DB (MongoDB compatible)
  - DynamoDB – Managed NoSQL database
  - Neptune – Managed Graph Database

AWS Data Pipeline

- Service for orchestrating data movement and processing tasks inside AWS

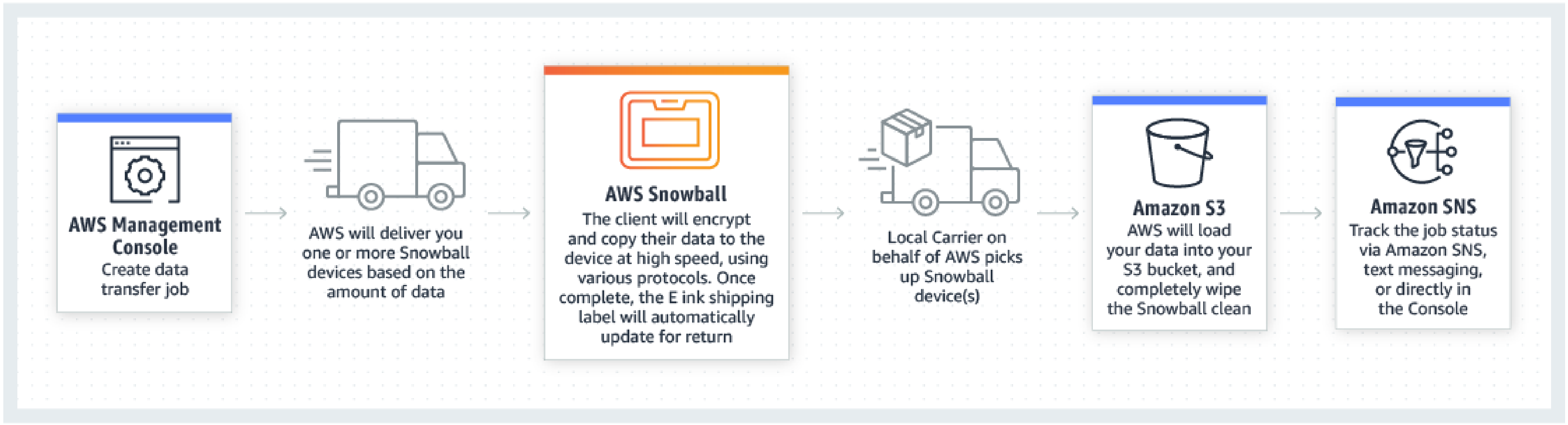
- **DataNode** - Location of the data source or destination. (SqlDataNode, S3DataNode, ...)
- **Activity** - Operation to perform on data (CopyActivity, EmrActivity, ...)
- **Schedule** - When data pipelines activities are initiated (On-demand, CRON, ...)
- **Precondition** - Conditions for when pipeline tasks can be executed
- **Resource** - EC2 resources or other AWS services Activities depend on

- Open Source alternative: **Apache NiFi**



AWS Snowball

- Device for secure and physical Data Migration
- Storage capacity: 50 – 80TB
- Migrate Big Data: analytics data, genomics data, video libraries, image repositories, backups, etc.


AWS Management Console
Create data transfer job
AWS will deliver you one or more Snowball devices based on the amount of data
AWS Snowball
The client will encrypt and copy their data to the device at high speed, using various protocols. Once complete, the E ink shipping label will automatically update for return
Local Carrier on behalf of AWS picks up Snowball device(s)
Amazon S3
AWS will load your data into your S3 bucket, and completely wipe the Snowball clean
Amazon SNS
Track the job status via Amazon SNS, text messaging, or directly in the Console

AWS Snowball Edge

- Device for Data Migration together with Onboard pre-processing capability.
- Onboard compute service options:
  - AWS Lambda, EC2 AMIs
  - 26 or 52 vCPUs
  - **Optional GPU** for machine learning and real time video analysis
- Storage capacity: 100TB
- Clustering: Up to 20 nodes

AWS Snowmobile

- Petabyte- to Exabyte-scale data transfer service for moving extremely large amounts of data to AWS
- 100 PB of Data => as much as 1,250 AWS Snowball devices
- Pricing:
  - $0.005/GB per month
  - $5243/PB per month

45-foot long rugged container & truck
Connect to your datacenter with fiber cable
Fill 'er Up!
Transports Data To AWS

Other AWS Services

- **Analytics** (EMR, Athena serverless queries, Kinesis vido analytics)
- **Machine Learning** (DeepLens, SageMaker, Lex)
- **Application Integration** (Message Queue, Step Funtions)
- **Internet of Things**
- **Media Services** (Transcoding pipelines, stream management)
- **Networking** (VPC, Domains)
- **Augmented & Virtual Reality**
- **RoboMaker** (Cloud services for Robot Operating System)
- **Security** (User management, Firewalls, Data privacy tools)
- **BlockChain**

A BIT MORE ON SERVERLESS COMPUTING

What is Serverless?

Abstraction of servers

Event-driven/ instant scale

Sub-second billing

Serverless computing - continued

- Newer workloads are a better fit for event driven programming
  - Execute application logic in response to database triggers
  - Execute app logic in response to sensor data
  - Execute app logic in response to scheduled tasks etc.
- Applications are charged by compute time (millisecond) rather than by reserved resources
- Greater linkage between cloud resources used and business operations executed
- Serverless in a nutshell
  - Event-action platforms to execute code in response to events

Current platforms for serverless

APACHE OpenWhisk

AWS Lambda

OpenLambda

fission

Kubernetes

Iron.io

Azure Functions

Google Functions

f(x)

Red-Hat

FaaS in Public Clouds

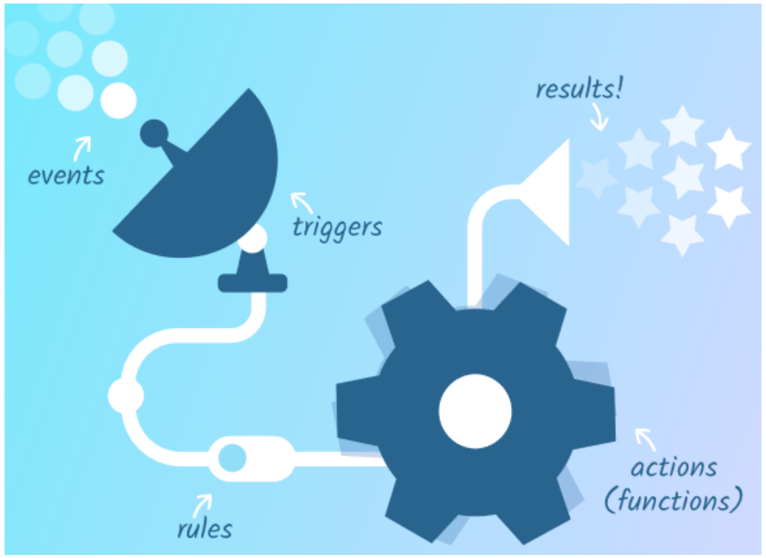
- **AWS Lambda**
  - Run code in AWS without managing infrastructure or software
  - Java, Go, PowerShell, Node.js, C#, Python, and Ruby code
  - Pricing is based on number of **requests** and **GB-Sec** "**Memory-Duration**"
  - Free: 1M **requests** a month. After: $0.20 per 1M
  - Free: 400,000 **GB-Sec.** After: $0.000017 per 1 **GB-Sec**
- **IBM BlueMix Cloud Function**
  - Based on OpenWhisk - Open Source Serverless cloud platform
  - Event, trigger & rule based execution
  - Supports any language*
  - Free: 400,000 **GB-Sec.** After: $0.000017 per 1 **GB-Sec**

Apache OpenWhisk

- Initiated by IBM but now an Apache project
- Open source cloud platform
- Serverless deployment and operations model
- Optimal utilization and granular pricing
- Scales on a per-request basis
- Supports JS, Swift, Python, Java, Docker

Triggers, actions, rules (and packages)

- Services or data sources define the events they emit as **triggers**
- Developers associate the **actions** to handle the events via **rules**
- **Packages** are a shared collection of Triggers and Actions



Triggers and Rules

- Trigger examples
  - changes to database records
  - IoT sensor readings that exceed a certain temperature
  - new code commits to a GitHub repository
  - simple HTTP requests from web or mobile apps
- Rule is an association of a trigger to an action
  - Many to many mapping

Actions

- They can be
  - small snippets of JavaScript or Swift code
  - custom binary code embedded in a Docker container
- Instantly deployed and executed whenever a trigger fires
- It is also possible to directly invoke an action by using the OpenWhisk API, CLI, or iOS SDK
- A set of actions can be chained

CLI – Command line interface

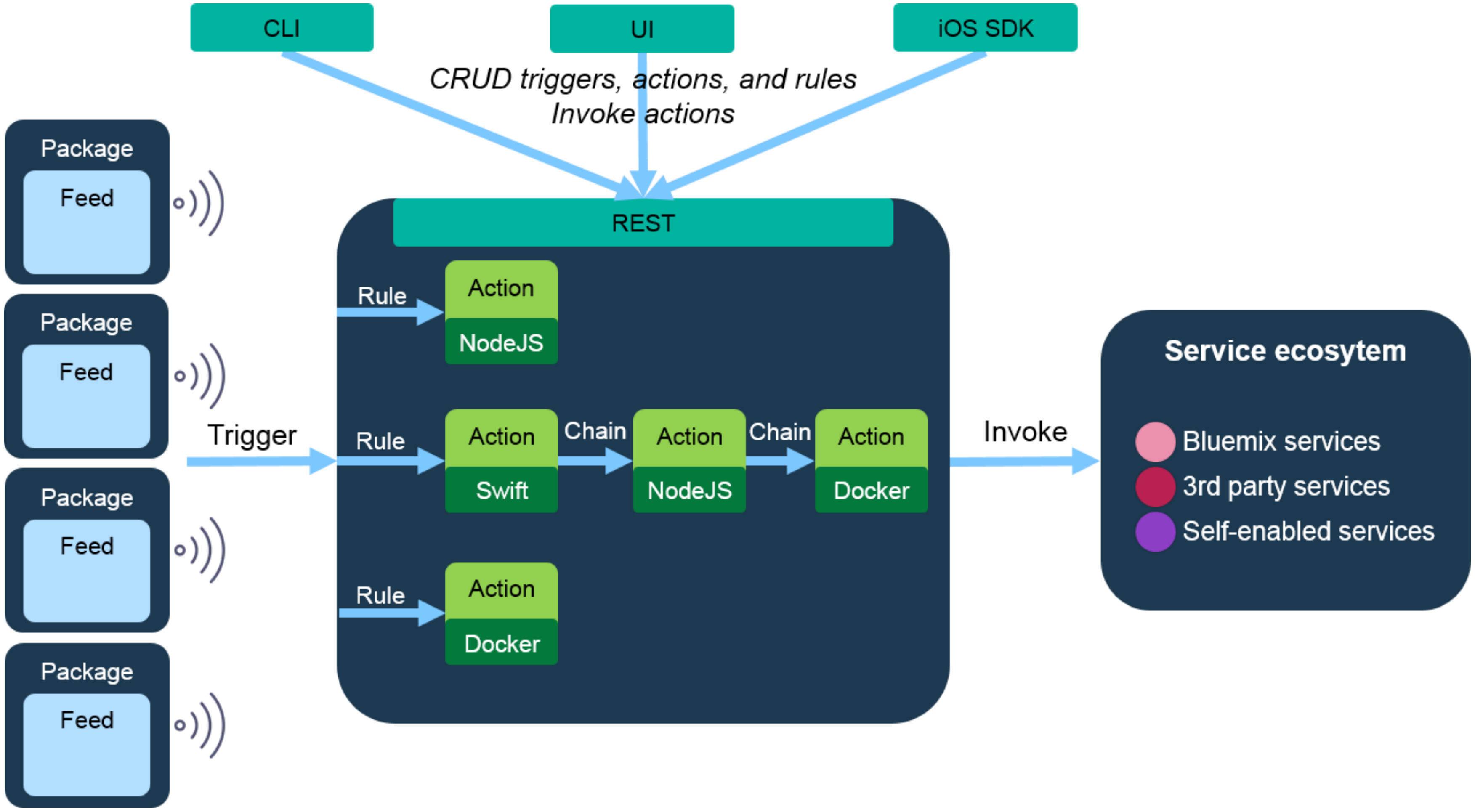
Actions - continued

```
# Hello world as an OpenWhisk action.

def myFunction(args):
    name = args['name']
    greeting = "Hello " + name + '!'
    return {"greeting": greeting}
```

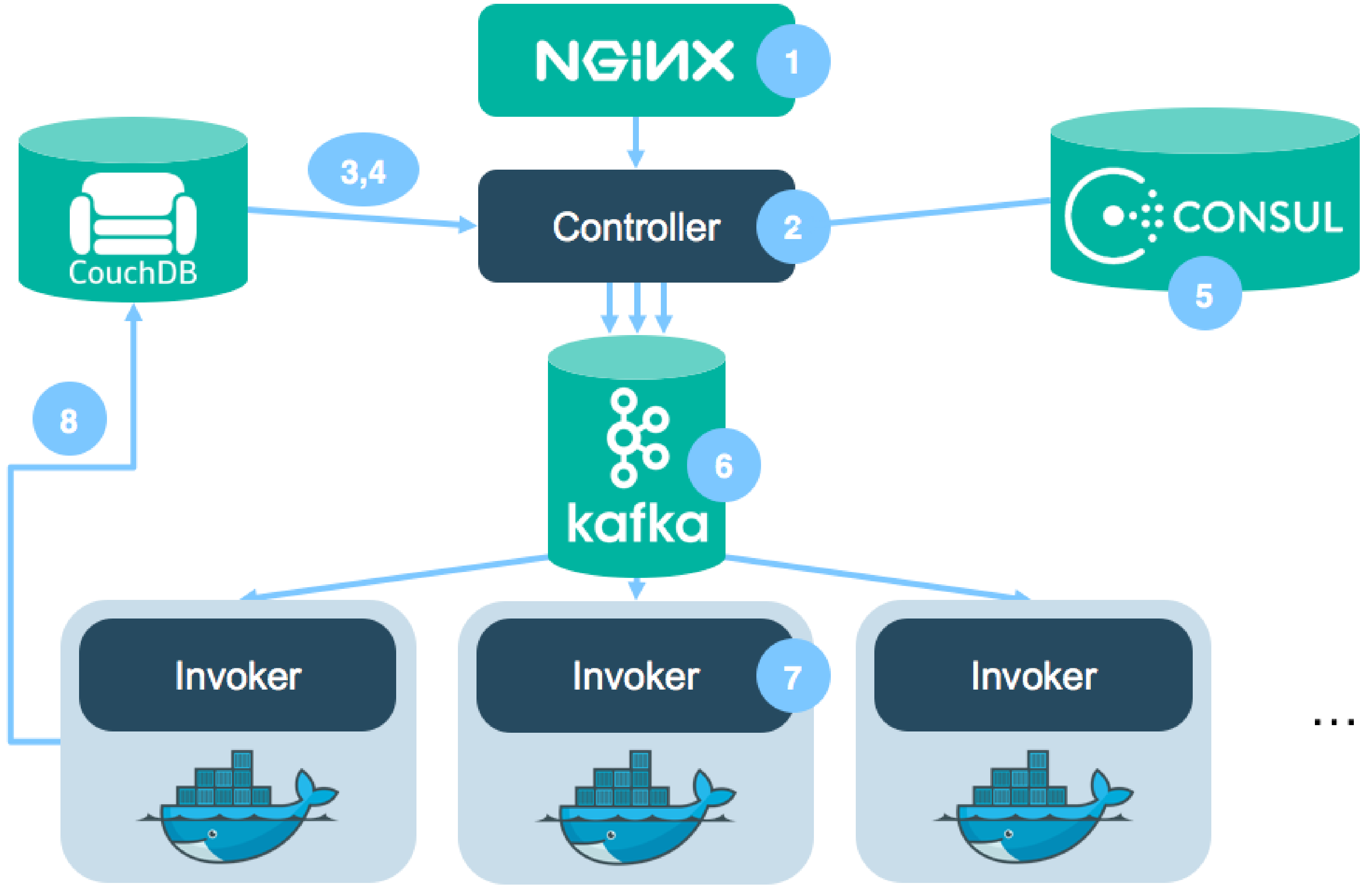
- **Create an action:**
  `wsk action create myfunction Hello-Python.py`
- **Invoke an action:**
  `wsk action invoke myfunction --result --param name World`
- **Update an action:**
  `wsk action update myfunction Hello-Python.py`

System overview



https://github.com/apache/incubator-openwhisk/blob/master/docs/about.md

The internal flow of processing



For more information read
https://github.com/apache/incubator-openwhisk/blob/master/docs/about.md

Advantages of Serverless/FaaS

- Very simple and "cheap" to scale
- Rapid prototyping
- Easy to modify serverless functions
- Pay only for the execution time, not for idle computation time
- Can create applications by composing functions written in different languages

Disadvantages of Serverless

- Harder to avoid vendor lock-in
  - Depend heavily on built in triggers and rules
- Lack of monitoring and debugging tools
- Composition and architecture complexity
- Slow cold-start
- What about stateful computations?
- Harder to predict costs

Next labs

- This week Lab
  - Continue working with Google AppEngine
- Next week Lab
  - Cloud Functions in IBM Bluemix (Managed OpenWhisk service)

Next Lecture

- Overview of Mobile & Cloud Lab research
- Cloud computing challenges

- **NB!** Opportunity to ask additional questions about the exam

References

- Check Amazon videos and webinars at http://aws.amazon.com/resources/webinars/
- Mike Roberts, "Serverless Architectures", https://martinfowler.com/articles/serverless.html
- Abel Avram, "FaaS, PaaS, and the Benefits of the Serverless Architecture", https://www.infoq.com/news/2016/06/faas-serverless-architecture
- Apache OpenWhisk - https://github.com/apache/incubator-openwhisk/blob/master/docs/about.md
- E. Jonas, J. Schleier-Smith, et. Al. "Cloud programming simplified: A berkeley view on serverless computing." Technical report, University of California, Berkeley, Feb 2019. https://arxiv.org/abs/1902.03383