amazon web services

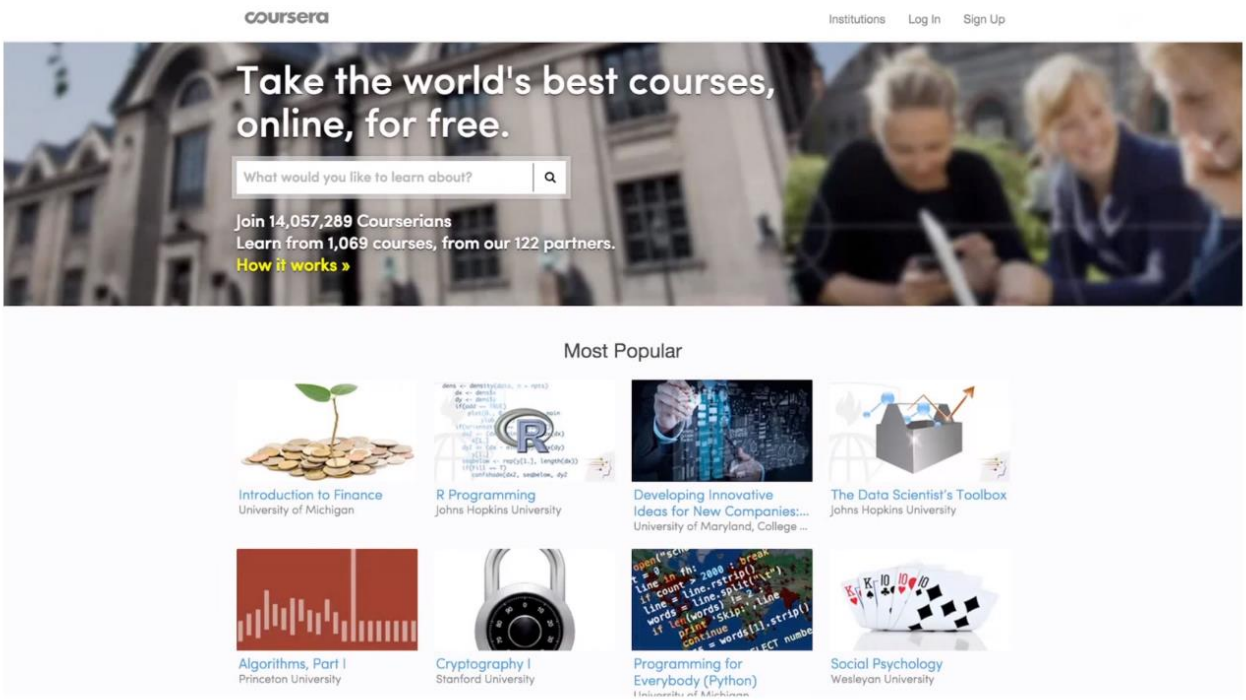
Container Day 2015

AWS Pop-up Loft - San Francisco

Container Day: Batch Processing with Amazon EC2 Container Service

Coursera: Brennan Saeta, Frank Chen

amazon web services



What We Do

Massive Open Online Courses

14 million
learners

1000
courses

2.2 million
course completions

120
partners

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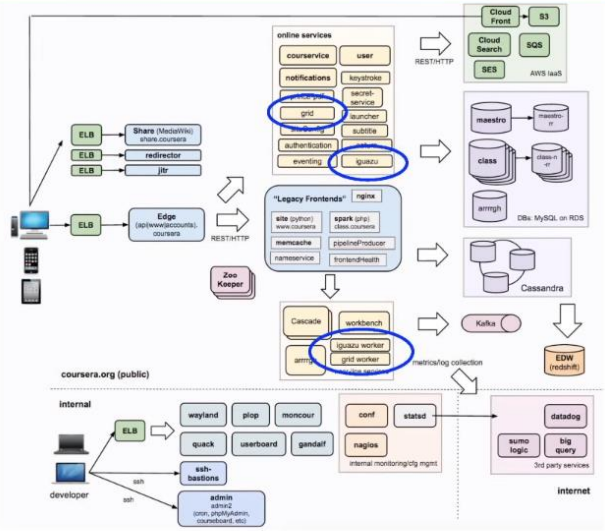
Coursera Technical Architecture



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Batch Processing Enables...

Reporting

Instructor Reports

- Grade exports
- Learner demographics
- Course progress statistics

Internal Reports

- Business metrics
- Payments reconciliation

Batch Processing Enables...

Marketing

- Recommendation emails
- Batch marketing / reactivation emails

Batch Processing Enables...

Pedagogical Innovation

- Auto-graded programming assignments
- Peer-review matching & analysis

Bad Old Days of Batch Processing

Cascade

- **PHP-based** job runner
- Run in screen sessions
- Polled for new jobs
- Fragile and unreliable
- Forced restarts on regular basis

Bad Old Days of Batch Processing II

Saturn

- **Scala-based** scheduled batch process runner
  - Powered by Quartz Scheduler library
- **Cron-only jobs**
  - Cannot run jobs on demand
  - Some jobs have to wake up frequently to poll
- All jobs ran on same instance (and JVM), causing interference

What Do We Want?

Reliability

- Saturn / Cascade were flaky
- Developers became frustrated with jobs not running properly

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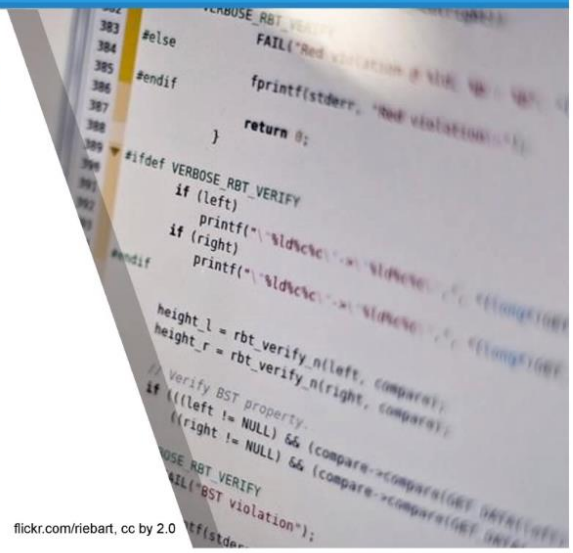
What Do We Want?

Easy Development

- Developing & testing locally was difficult
- Little or no boilerplate should be required



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What Do We Want?

Easy Deployment

- Deployment was difficult and non-deterministic
- *"Other services have one-click tools, why can't your service have that too?"*

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What Do We Want?

High Efficiency

- Cost-conscious
- Most jobs complete < 20 minutes
  - EC2 rounds costs up to full hour
- Startup time of individual instances

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What Do We Want?

Low Ops Load

- Only one dev-ops engineer -- can't manage everything
- Developers own their services
- Developers shouldn't have to actively monitor services

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Alternative Technologies

Home-grown Tech

- Tried, but proved to be unreliable
- Difficult to handle coordination and synchronization

MESOS

- Very powerful, but hard to productionize
- Needs actual DevOps team

kubernetes by Google

- GCE first-class, everything else second-class

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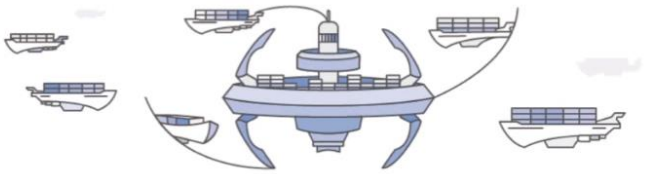
Amazon ECS

- Low-to-no maintenance solution
- Integrated with AWS infrastructure
- Easy to understand and program for



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However...

- No scheduled tasks
- No fine-grained monitoring of tasks
- No retries / delays when cluster out of resources
- Does not integrate well with our

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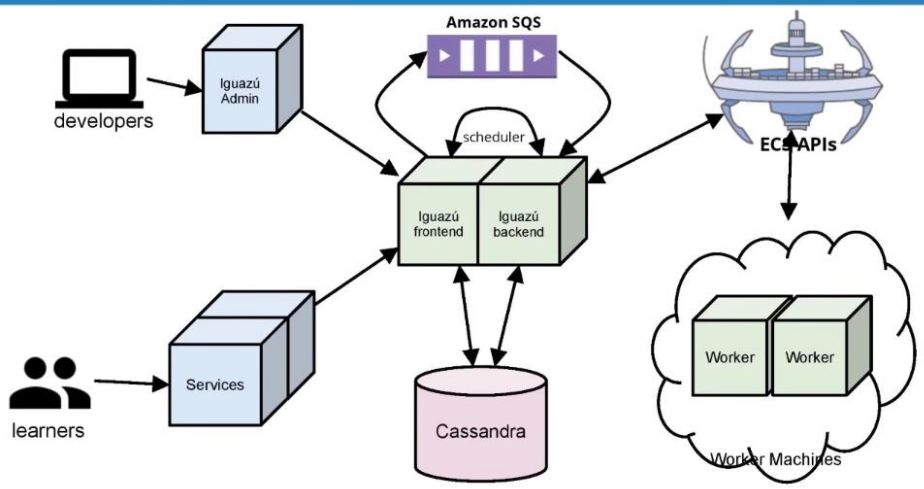
Iguazú -- Batch Management for ECS

- Named for Iguazú Falls
  - World's largest waterfall
- Batch Task Scheduler
  - Immediately
  - Deferred (run once at X time)
  - Scheduled recurring (cron-like)
- Programmatically accessible

Iguazú Semantic Guarantees

- **At most once** execution for all jobs
- Jobs will be provided with **at least** the **CPU** and **RAM** they requested
- Scheduler may elect to skip execution of some scheduled jobs under adverse conditions

Iguazú Architecture



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Iguazú Design

- Frontend + Scheduler
  - Generates requests (either via API calls or internally from the scheduler)
  - Puts new requests in SQS queues
  - Handles requests for status from other services
- Backend
  - Attempts to run tasks via ECS API
    - Failure (e.g. lack of resources) means task goes back into queue to try again later
  - Keeps track of task status and updates Cassandra

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Iguazú Admin User Interface

IGUAZÚ

Home

Jobs

Invocations

Scheduled Jobs

Iguazú Scheduled Jobs

Filter Scheduled Jobs

ID	Cron Expression	Next Invocation	Family	Job Name	Actions
319au6PDnnDwiKyP	0 15,45 * 1/1 * ? *	Today at 4:15 PM PDT	peerreviewgradereadyemail	peerreviewgradereadyemail	
ZtZny5H4OzocOEuN	0 59 23 1/1 * ? *	Today at 4:59 PM PDT	translationpipelineupdatesubtitlelanguages	translationpipelineupdatesubtitlelanguages	
pKMkmTpS8oVibYW1	0 0 20 1/1 * ? *	Tomorrow at 1:00 PM PDT	translationpipelinedownload	translationpipelinedownload	
9m9nRGN1JgjebbVw	0 0 7 1/1 * ? *	Tomorrow at 12:00 AM PDT	translationpipelineupload	translationpipelineupload	
yVCDUTGps3huOIZF	0 0 7 1/1 * ? *	Tomorrow at 12:00 AM PDT	mega	mega	
VYrHEGNFfHLQiAGL	0 30 17 1/1 * ? *	Tomorrow at 10:30 AM PDT	phoenixsessionemail	phoenixsessionemail	
gd7xlyxxcgelyjSp	0 0 18 ? * MON-FRI *	Tomorrow at 11:00 AM PDT	ondemandvideoreport	ondemandvideoreport	
neCafzkgCv1cCNTq	0 0 19 1/1 * ? *	Tomorrow at 12:00 PM PDT	searchindexupdater	searchindexupdater	
EdMQbhGOTCT77GcQ	0 0 12 1/1 * ? *	Tomorrow at 5:00 AM PDT	fullcoursetranslationupload	fullcoursetranslationupload	

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Iguazú Admin User Interface

IGUAZÚ

Home

Jobs

Invocations

Scheduled Jobs

E5fpbocaQOWlOm1qFAJHzg

Family	peerreviewmetrics
Invocation Time	July 7th 2015, 5:04:59 pm PDT
Requested Invocation Time	N/A
Status	SUCCESSFUL
ARN	
Command	

Filter Invocations

Invocation Time	Requested Invocation Time	Status	Actions
July 7th 2015, 5:04:59 pm PDT	N/A	SUCCESSFUL	
July 7th 2015, 5:09:59 pm PDT	N/A	SUCCESSFUL	
July 7th 2015, 5:14:59 pm PDT	N/A	SUCCESSFUL	
July 7th 2015, 5:14:59 pm PDT	N/A	SUCCESSFUL	
July 7th 2015, 5:14:59 pm PDT	N/A	SUCCESSFUL	
July 7th 2015, 5:14:59 pm PDT	N/A	SUCCESSFUL	
July 7th 2015, 5:19:59 pm PDT	N/A	SUCCESSFUL	
July 7th 2015, 5:29:59 pm PDT	N/A	SUCCESSFUL	
July 7th 2015, 5:29:59 pm PDT	N/A	SUCCESSFUL	

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Developing Iguazú Tasks

```
class Job extends AbstractJob with StrictLogging {
  override val reservedCpu = 1024
  override val reservedMemory = 1024

  def run(parameters: JsValue) = {
    logger.info("I am running my Job!")
    expensiveComputationHere()
  }
}
```

Running Tasks Locally

```
$ sbt
> project iguazuJobs
[info] Set current project to iguazu-jobs
> run sample sample.json
[info] Running org.coursera.iguazu.internal.IguazuJobsMain sample
sample.json
[info] 2015-07-08 13:31:52,368 INFO [o.c.i.j.s.Job] >>> I am running my job!
[success] Total time: 5 s, completed Jul 8, 2015 1:31:58 PM
>
```

Running Tasks from Other Services

```
// invoking a job with one command
// from another service via Naptime REST framework

val invocationId = IguazuJobInvocationClient
  .create(IguazuJobInvocationRequest(
    family = "mailer",
    jobName = "recommendationsEmail",
    parameters = emailParams))
```

Deploying Tasks

Easy Deployment

1. Merge into master. Done!

Jenkins Build Steps:

1. Builds zip package from master
2. Prepares Docker image
3. Pushes docker image into docker registry
4. Registers updated tasks with ECS APIs

Logs

- Logs are in /var/lib/docker/containers/*
- Upload into log analysis service (Sumologic for us)
- Wrapper prints out task name and task ID at the start for easy searching

Metrics

- Using third-party metrics collector (Datadog)
- Metrics for both tasks and container instances
- So long as can talk to Internet,
  things will work out pretty well

Programming Assignments

Programming Assignments

Programming Assignment: 编程作业

Instructions My submission Discussions

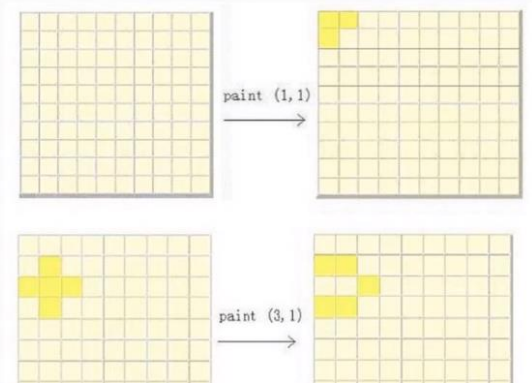
编程题 # 1： 画家问题

来源: POJ (Coursera声明：在POJ上完成的习题将不会计入Coursera的最后成绩。)

注意： 总时间限制: **1000ms** 内存限制: **65536kB**

描述

有一个正方形的墙，由N*N个正方形的砖组成，其中一些砖是白色的，另外一些砖是黄色的。Bob是个画家，想把全部的砖都涂成黄色。但他的画笔不好使。当他用画笔涂画第(i, j)个位置的砖时，位置(i-1, j)、(i+1, j)、(i, j-1)、(i, j+1)上的砖都会改变颜色。请你帮助Bob计算出最少需要涂画多少块砖，才能使所有砖的颜色都变成黄色。



How to submit

When you're ready to submit, you can upload files for each part of the assignment on the "My submission" tab.

Programming Assignment: 编程作业

You have not submitted. You must earn 80/100 points to pass.

Instructions **My submission** Discussions

✖ Cancel

Upload Files and Submit

To upload a file, click the part below. Then, submit the files. You can submit as many times as you like. You do not need to upload all parts in order to submit.

编程题 # 1： 画家问题 50 points	source.cpp
编程题 # 2： 拨钟问题 50 points	source.cpp

Submit

Your Submissions

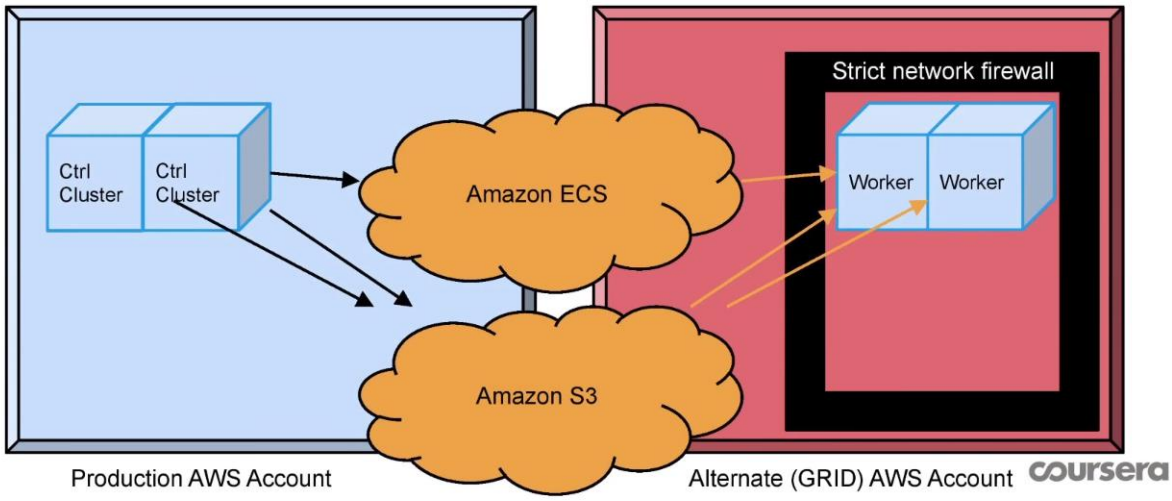
Graded submissions will appear here

Grading Prog. Assignments

- Special case of batch processing
- Near real-time feedback
  - <30 seconds for fast graders

- Compiling and running ***untrusted code***
- Infrastructure security huge concern
  - Minimize exfiltration of info (e.g. test cases)
  - Avoid turning into bitcoin miners or DDoS attack

GRading Inside Docker: Architecture



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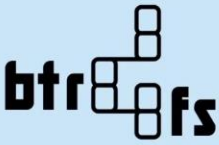
GRID: Defense in depth

Network

Completely separate AWS account

Network ACLs & Routing Tables

Host



Docker / Other

Custom cleaning of container images

+ additional mitigation techniques and defenses

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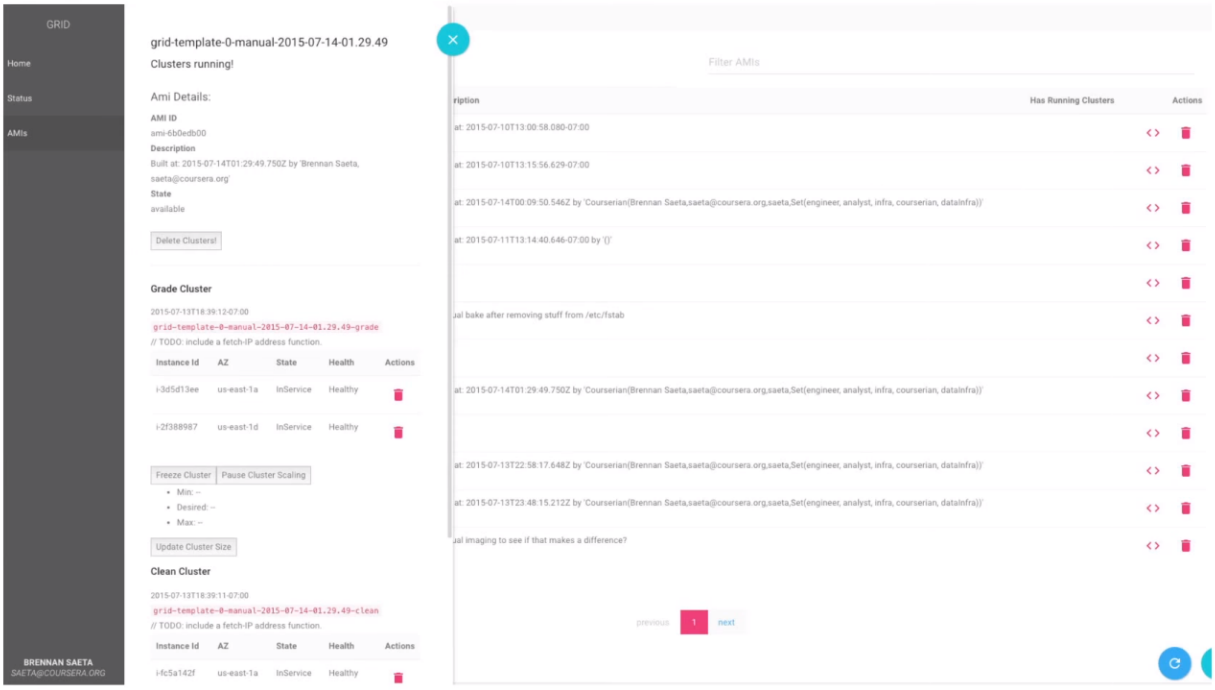
Modifying the ECS Agent

- Coursera has 2 simple forks of ECS agent
  - Allow privileged docker-in-docker access for the “cleaning” agent
  - Disable networking and disk writes for untrusted code in the “grading” agent

- Check it out at: github.com/coursera/amazon-ecs-agent



This is a screenshot of our admin interface

Usage

- Iguazú
  - **38 tasks written** since launch in April
  - **24 scheduled tasks**
  - **>1000 invocations** per day
- Grid
  - Pre-production at this time (launching in weeks)
  - Dozens of graders already written by multiple instructional teams!

Future Improvements

- True Autoscaling
  - Scaling up is easy, scaling down not so much
- Task prioritization (multiple queues)
- Simulate memory and CPU limits in dev modes

Lessons Learned / Docker war stories

- Docker instability fun
  - Container format changing between 1.0 and 1.5.
- btrfs wedging on older kernels
  - Default 14.04 kernel not new enough!
- Disk usage
  - Docker-in-docker can't clean up after itself (yet).