6.S897 Large-Scale Systems

Instructor: Matei Zaharia
Fall 2015, TR 2:30-4, 34-301

bit.ly/6-s897
Outline

What this course is about

Logistics

Datacenter environment
What this Course is About

Large-scale computer systems
– **Web applications:** Facebook, Gmail, etc
– **Big data:** one computation on many machines
– **Clouds:** software or infrastructure as a service

“Systems that run on hundreds of nodes”
Why Study Large-Scale Systems?

Increasingly run “most” computer applications

One of the more likely areas for impact

Rich systems & algorithmic problems
Trends Behind Large-Scale Systems

1. Growth of workloads (users, data) relative to machine speeds

2. Faster Internet

3. Economics
   - Benefits of software and infra as a service
   - Economies of scale for providers
1. Growth of Workloads

Growing # of Internet users

Growth of data w.r.t. computation speeds
– Mostly from machines: sensors, images, IoT, etc
2. Faster Internet

Speed of a high-end residential connection

Internet Connectivity (Bits Per Second)
3. Economics

Benefits of software as a service:
– For vendors: single deployment target, visibility
– For users: easier to manage

Benefits of infrastructure as a service:
– Elastic scaling, pay-as-you-go

Economies of scale (lower costs in bulk)
This Course

Papers & readings on influential systems
– File systems, databases, coordination, processing frameworks, resource managers, networks, performance, programming tools

Guest talks from 4 speakers

Focus on what’s widely deployed
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Datacenter environment
Readings

2-3 per class

Each has summary questions
- Email answers to 6.s897staff@gmail.com

Each student will present 1 paper in class
- 15 minute talk; see website
Projects

Ideally in groups of 2-3

Term-long mini research project of your choice
  – Can be related to your research
  – Matei will list some ideas

Report + poster session at end of term
Project Timeline

Oct 2       Form groups, run idea by Matei
Oct 9       Initial proposal (1-2 pages)
Nov 10      Mid-term review
Dec 10      Poster session
Dec 15      Final write up (10-12 pages)
Grading

70% project

15% paper presentation

15% summary questions + participation
Course Staff

Instructor: Matei Zaharia
  – Office hours TBD, likely Tuesday at 4

TA: Rohan Mahajan
  – Will help with summary questions & logistics
Other Notes

The course is 12 units!

I have some EC2 credits for the projects
Outline

What this course is about

Logistics

Datacenter environment
Typical Datacenter
Typical Datacenter

- 10K-100K servers
- 40 servers per rack
- 10 Gbps bandwidth in rack;
- 20%-100% bisection bandwidth
- 10-100 MW of power
Typical Server

CPUs: 16-32 cores

DRAM: 64-256 GB

HDDs: 2-40 TB

SSDs?

NIC: 10 Gbps

50 GB/s each

0.1 GB/s each

1 GB/s each

1 GB/s
Recent Hardware Changes

Node bandwidth: 1 Gbps → 10 Gbps

Embrace of SSDs (flash)
– Almost a given for transactional workloads
– “Soon” may be competitive for capacity / $

Better I/O virtualization
Types of Applications

1. Single big computation (e.g. big data)

2. Hosted apps for many tenants (e.g. Gmail, web hosting, cloud)

3. Single big multi-user app (e.g. Facebook)
Software Stack

Web Server
Java, PHP, JS, ...

Cache
memcached, TAO, ...

Operational Store
SQL, Spanner, Dynamo, Cassandra, BigTable, ...

Other Services
search, chat, ML; Unicorn, Druid, ...

Logging Bus
Kafka, Kinesis, ...

Higher Interfaces
Hive, Pig, HiPal, ...

Processing Engines
MapReduce, Dryad, Pregel, Spark, ...

Metadata
Hive, Parquet, ...

Distributed File System
GFS, Hadoop FS, Amazon S3, ...

Resource Manager
Mesos, Borg, Kubernetes, EC2, ...

Coordination
Chubby, ZK, ...

Data Processing
Software Stack

Available as Open Source

Web Server
Java, PHP, JS, ...

Cache
memcached, TAO, ...

Operational Store
MySQL, HBase, Redis, Cassandra, Mongo, ...

Other Services
search, chat, ML;
ElasticSearch, Druid, ...

Logging Bus
Kafka, Flume, ...

Higher Interfaces
Hive, Pig, HiPal, ...

Processing Engines
Hadoop MR, Giraph,
Storm, Spark, ...

Metadata
Hive, Parquet, ...

Distributed File System
GFS, Hadoop FS, Ceph, Amazon S3, ...

Resource Manager
Mesos, Borg, Kubernetes, OpenStack, ...

Coordination
ZooKeeper, …
Coverage in This Course

Broad overview + a few “hot” areas
– Streaming, performance, complex analytics

Focus on what people actually do

Meant to drive new ideas / research
Key Themes

1. Cost of people vs software/hardware
   - Everyone works to lower development time, operations time, and time-to-answer

2. Simple, reusable abstractions

3. Statistical effects of scale

4. Moving target of efficiency
   - New hardware, app needs, multitenancy, …
Next Week

**Tuesday:** 3 intro readings (cloud computing and two readings from Facebook)

Volunteers for these?

**Thursday:** talk by Ali Ghodsi (Databricks) on big data processing as a service