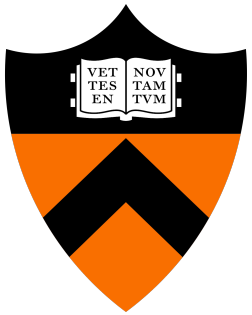
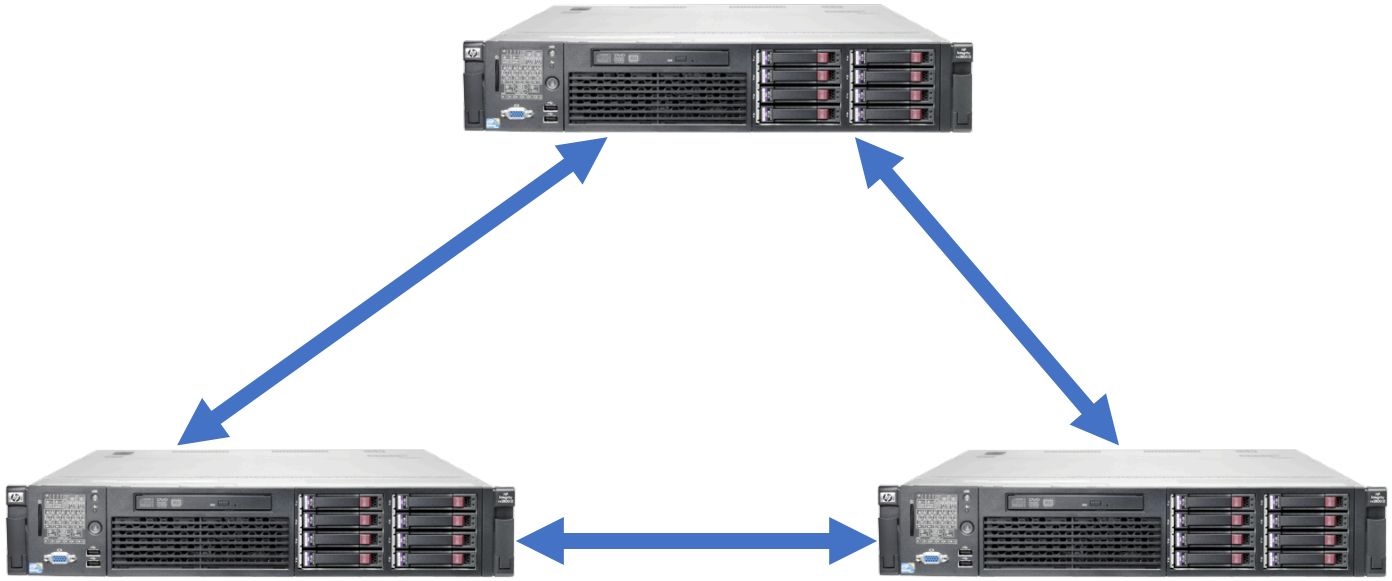
Distributed Systems Intro



COS 418: Distributed Systems
Lecture 1

Wyatt Lloyd

Distributed Systems, What?



1) Multiple computers
2) Connected by a network
3) Doing something together

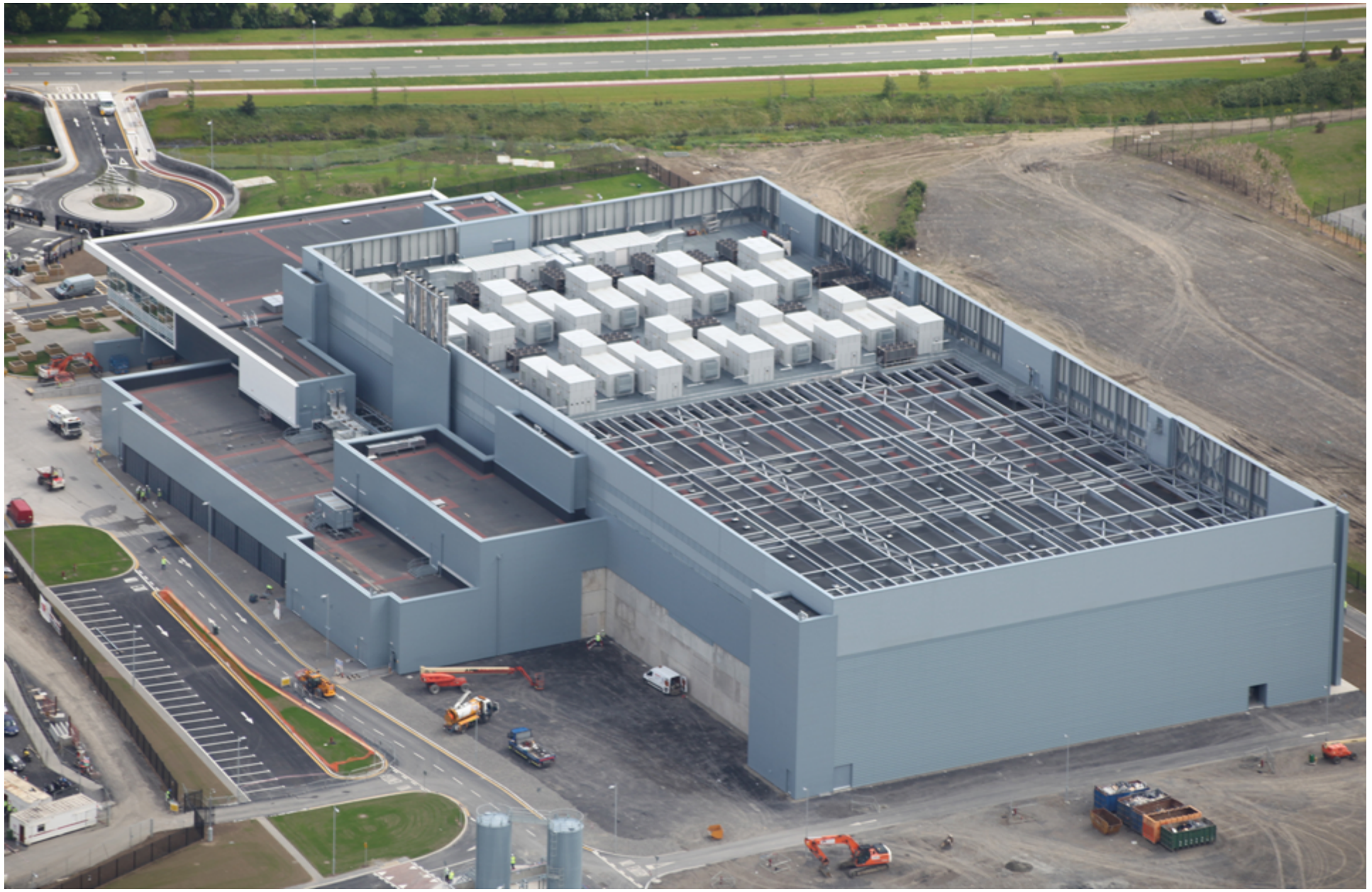
Distributed Systems, Why?

- Or, why not 1 computer to rule them all?
- Failure
- Limited computation/storage/…
- Physical location

Distributed Systems, Where?

- Web Search (e.g., Google, Bing)
- Shopping (e.g., Amazon, Walmart)
- File Sync (e.g., Dropbox, iCloud)
- Social Networks (e.g., Facebook, Twitter)
- Music (e.g., Spotify, Apple Music)
- Ride Sharing (e.g., Uber, Lyft)
- Video (e.g., Youtube, Netflix)
- Online gaming (e.g., Fortnite, DOTA2)
- …

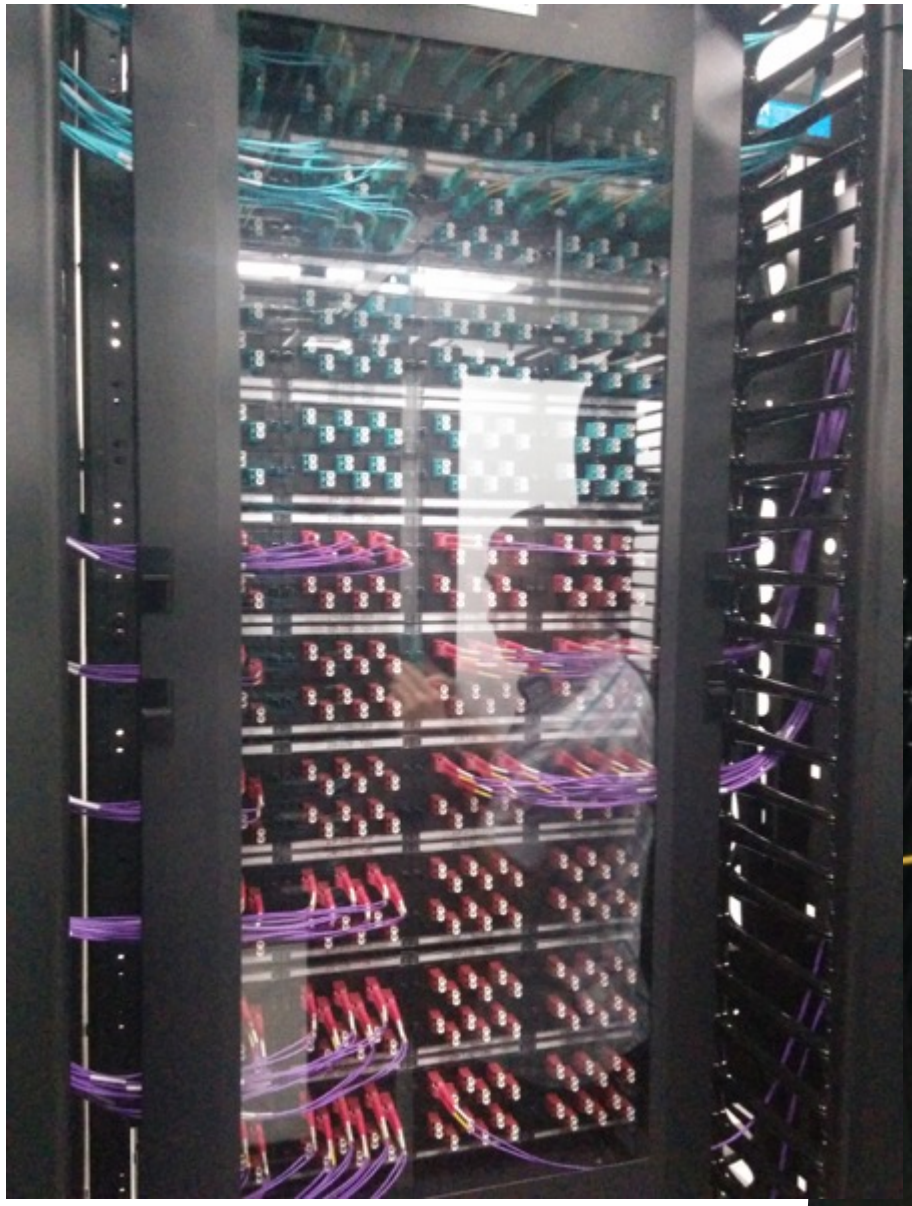
“The Cloud” is not amorphous

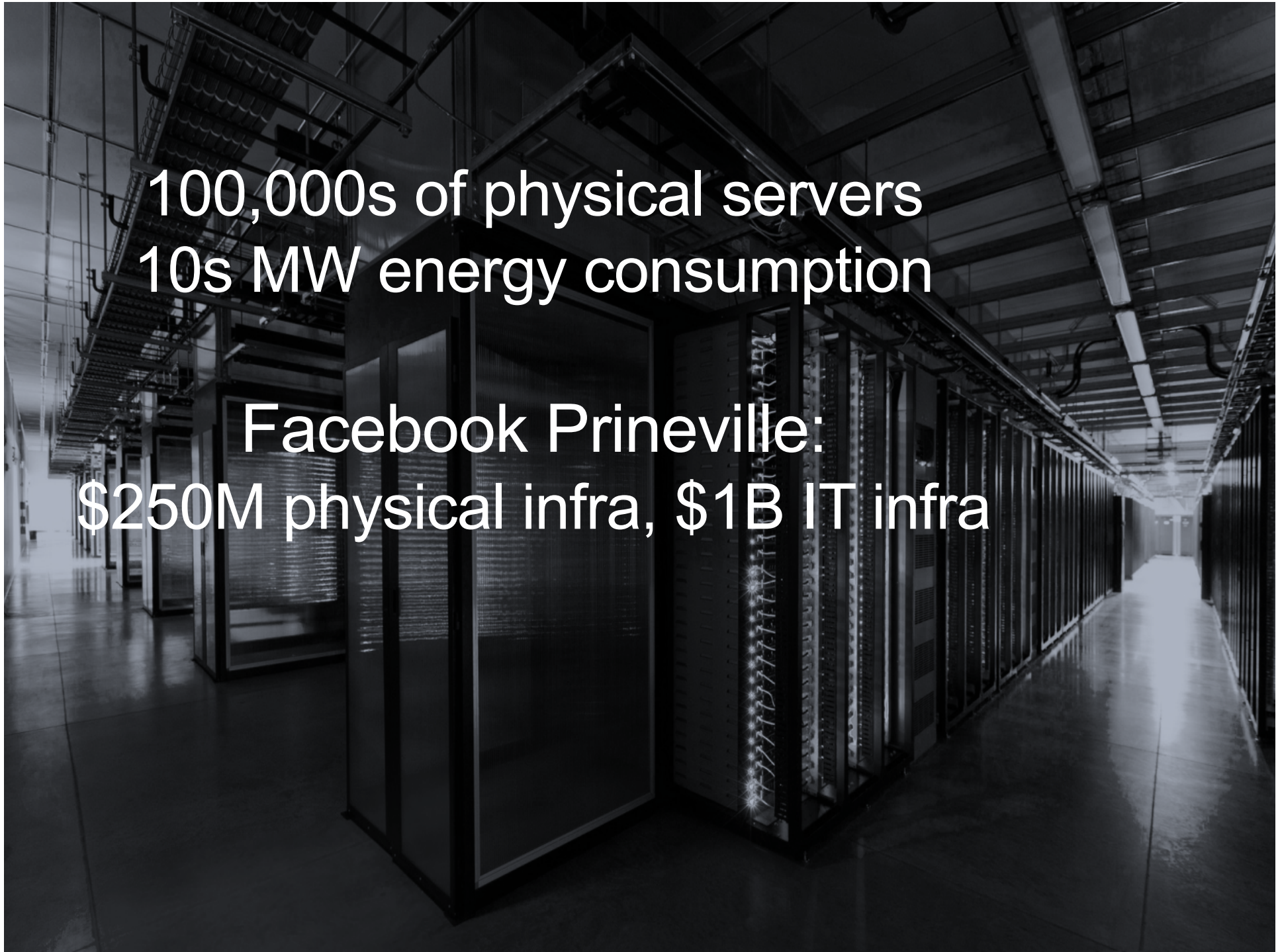


Microsoft

Google

Facebook




100,000s of physical servers
10s MW energy consumption
Facebook Prineville:
$250M physical infra, $1B IT infra

Distributed Systems Goal

- Service with higher-level abstractions/interface
  - e.g., file system, database, key-value store, programming model, …
- Hide complexity
  - Scalable (scale-out)
  - Reliable (fault-tolerant)
  - Well-defined semantics (consistent)
- Do “heavy lifting” so app developer doesn’t need to

Scalable Systems in this Class

- Scale computation across many machines
  - MapReduce, Streaming Video Engine
- Scale storage across many machines
  - Dynamo, COPS, Spanner

Fault Tolerant Systems in this Class

- Retry on another machine
  - MapReduce, Streaming Video Engine

- Maintain replicas on multiple machines
  - Primary-backup replication
  - Paxos
  - RAFT
  - Bayou
  - Dynamo, COPS, Spanner

Range of Abstractions and Guarantees

- Eventual Consistency
  - Dynamo
- Causal Consistency
  - Bayou, COPS
- Linearizability
  - Paxos, RAFT, Primary-backup replication
- Strict Serializability
  - 2PL, Spanner

Learning Objectives

- Reasoning about concurrency
- Reasoning about failure
- Reasoning about performance

- Building systems that correctly handle concurrency and failure

- Knowing specific system designs and design components

Conclusion

- Distributed Systems
  - Multiple machines doing something together
  - Pretty much everywhere and everything computing now

- “Systems”
  - Hide complexity and do the heavy lifting (i.e., **interesting**!)
  - Scalability, fault tolerance, guarantees