CS 5413: High Performance Systems and Networking

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CS 5413: High Performance Systems and Networking
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Goals for Today

- Be brief!
- Background on Professor
- Why take this course?
- How does this class operate?
- Class details
Who am I?

• Prof. Hakim Weatherspoon
  – (Hakim means Doctor, wise, or prof. in Arabic)
  – Background in Education
    • Undergraduate University of Washington
      – Played Varsity Football
        » Some teammates collectively make $100’s of millions
        » I teach!!!
    • Graduate University of California, Berkeley
      – Some class mates collectively make $100’s of millions
      – I teach!!!
  – Background in Operating Systems
    • Peer-to-Peer Storage
      – Antiquity project - Secure wide-area distributed system
      – OceanStore project – Store your data for 1000 years
    • Network overlays
      – Bamboo and Tapestry – Find your data around globe
    • Tiny OS
      – Early adopter in 1999, but ultimately chose P2P direction
The promise of the Cloud

– A computer utility; a commodity
– Catalyst for technology economy
– Revolutionizing for health care, financial systems, scientific research, and society
The promise of the Cloud

- ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

NIST Cloud Definition
• The promise of the Cloud
  – ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. NIST Cloud Definition
• The promise of the Cloud
  – ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. NIST Cloud Definition

• Requires fundamentals in distributed systems
  – Networking
  – Computation
  – Storage
High Performance Networks

• How to optimize a global network of data centers?
• How to optimize a global network of data centers?
  – E.g. Need to optimize movement of data between DCs
High Performance Networks

- How to optimize a global network of data centers?
  - E.g. Investigate novel data center designs

  [ToN 2013 and ANCS 2012; best paper]

Core Switch (CS)

Aggregate Switch (AS)

ToR
High Performance Storage

• Large organizations considering using the cloud
  – New York Times
  – Netflix
  – Nintendo
  – Cornell
  – Library of Congress

• The more data you have, the harder it is to move
  – Switching providers entails paying for bandwidth *twice*
  – Inhibits opportunistic migration
High Performance Storage

• How hard is it to move a PetaByte?

Titan tech boom, randy katz, 2008
High Performance Storage

• All my valuable data/computation is in the cloud. Am I locked in to one provider forever?
  – The more data you have, the harder it is to move

• RACS: Redundant Array of Cloud Storage
  – Collaboration with the Internet Archive and IBM
  – [SOCC 2010]; See Also [EuroSys 2007, FAST 2009, FAST 2013]
High Performance Storage

- All my valuable data/computation is in the cloud. Am I locked in to one provider forever?
  - The more data you have, the harder it is to move.

- RACS: Redundant Array of Cloud Storage
  - Collaboration with the Internet Archive and IBM
  - See Also [EuroSys 2007, FAST 2009, FAST 2013]
High Performance Storage

Estimated Cost of Switching Cloud Providers

- Single Provider
- RACS (4,5)
- RACS (6,7)
- RACS (8,9)

Cost in $K

Date

High Performance Storage

- **RACS**: How do I optimize storage globally
  - Collaboration with Internet Archive / IBM
- **Gecko**: How do I optimize storage locally
  - Collaboration with Google and Microsoft

Relative Storage: $n/k$
Relative Upload Bandwidth: $n/k$
Relative Download Bandwidth: 1

Object: 100 KB
High Performance Computation

- Can I compute in the cloud if some of my data is in a vault at home or on another provider
- Xen-Blanket and VirtualWire
  - Collaboration with IBM
  - [HotCloud 2012, EuroSys 2012]
High Performance Computation

- Can create your own **Cloud-within-a-Cloud**

- Migrate computation among different cloud providers
High Performance Computation

• Can create your own
  *Cloud-within-a-Cloud*

Object
100 KB

• Migrate computation among different cloud providers

Xen-Blanket

VMM

Cornell University
My Contributions

• Cloud Networking
  – SoNIC in NSDI 2013
  – Wireless DC in ANCS 2012 (best paper) and NetSlice in ANCS 2012
  – Bifocals in IMC 2010 and DSN 2010
  – Maelstrom in ToN 2011 and NSDI 2008
  – Chaired Tudor Marian’s PhD 2010 (now at Google)

• Cloud Computation & Vendor Lock-in
  – Plug into the Supercloud in IEEE Internet Computing-2013
  – Supercloud/Xen-Blanket in EuroSys-2012 and HotCloud-2011
  – Overdriver in VEE-2011
  – Chaired Dan William’s PhD 2012 (now at IBM)

• Cloud Storage
  – Gecko in FAST 2013 / HotStorage 2012
  – RACS in SOCC-2010
  – SMFS in FAST 2009
  – Chaired Lakshmi Ganesh’s PhD 2011 (now at Facebook)
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• Class details
Why take this course

- Learn about systems abstractions, principles, and artifacts that have lead to the high performance systems and networks we see in the cloud,
- Understand attributes of systems research that is likely to have impact,
- Become comfortable navigating the state of the art in systems and networking,
- Gain experience in thinking critically and analytically about systems research, and
- Acquire the background needed to work on cloud and data center problems currently under study at Cornell and elsewhere.
Who is the course “for”? 

• MEng students
  – Students who have mastered 4410/4411
  – PhD students as well
  – Serious undergraduates

• MEng Project
  – Projects in this course can be used to satisfy MEng project requirements
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How this class operates

• Instructor: Hakim Weatherspoon
  – hweather@cs.cornell.edu
  – Office Location: 427 Gates Hall

• TA: Ki Suh Lee and Han Wang
  – kslee@cs.cornell.edu and hwang@cs.cornell.edu

• Lectures:
  – Three slots reserved a week,
    ***but lecture will be twice a week on average***
Course Help

• Course staff, office hours, etc:
  – http://www.cs.cornell.edu/courses/cs5413/2014fa

• MEng projects
CS 5413: Overview

• Prerequisite:
  – Mastery of CS 4410 and 4411 material
    • Fundamentals of OS design
    • How parts of the OS are structured
    • What algorithms are commonly used
    • What are the mechanisms and policies used
    • Programming in C/C++

• Class Structure
  – Lecture/Readings
  – Labs/Homeworks
  – Project
  – In class Quizzes
CS 5413: Topics

• Overview
  – Cloud computing, and Internet vs Data Center Networks

• High Performance Networking Basics
  – Textbook networking vs Data Center Networks
  – Network protocol stack: TCP/IP protocol stack

• High Performance Data Center Systems & Networks
  – Basic Switching Technologies: 50Gb/s routers & NetFPGA
  – Data Center Topologies, Software Router Designs,
  – Alternative switching technologies, Data Center Transport
  – Software defined networking, virtual networks
  – Middleboxes, advanced topics
  – Data Center traffic and analysis
Required reading is always one paper and/or book reading
  - Book reading provides basic background knowledge
  - Papers pulled from, best journals and conferences
    • TOCS, SOSP, OSDI, ...
Read papers before each class and bring notes
  - Takes ~2 hrs, write notes and questions
Write a review and turn in at least two hours before beginning of class
  - Turn on online via Course Management System (CMS)
  - No late reviews will be accepted
Each student is **required** to prepare notes on each paper before class and to bring them to class for use in discussion.

Your notes should list assumptions, innovative contributions and criticisms. Every paper in the reading list has at least one major weakness.

Turn paper reviews in online before class via CMS

- Be succinct—One paragraph per paper
  - Short summary of paper (two or three sentences)
  - Two to three strengths/contributions
  - and at least one weaknesses
CS 5413: Lecture Format

- 40 minute presentation
- All students are required to read ahead of time and participate!
- Counts in final grading.
• 4 labs/homeworks
  – work in groups
  – 1-3 weeks per lab/homework
  – Topics
    • Building a network proxy (single, then multi-threaded)
    • Implement an N-port switch
    • Implement a software-defined network (sdn) switch/controller

• Facilities
  – Using cloud (Amazon EC2/S3 or local Fractus cloud)
CS 5413: Project

- One major project per group
  - Groups include *three* people
- Group formation – early September
- Initial selection of project topic – due mid-September
- Survey of area (related works)–due begin of October

- Midterm draft paper – due begin of November
- Peer reviews—due a week later

- Final demo/presentation–due begin of December
- Final project report – due a week later
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• GENI: Global Environment for Networking Innovations
• SoNIC: Software Network Interface Cards
• NetFPGA

• Fractus: our very own (mini) cloud
• Amazon’s Cloud Infrastructure EC2/S3
• Emulab
• PlanetLab
• Cornell’s Center for Advanced Computing (CAC)
• ...

CS 5413: Project Infrastructure
Academic Integrity

• Submitted work should be your own

• Acceptable collaboration:
  – Clarify problem, C syntax doubts, debugging strategy
  – You may use any idea from any other person or group in the class or out, provided you *clearly state what you have borrowed and from whom.*
  – If you do not provide a citation (i.e. you turn other people's work in as your own) that is *cheating.*

• Dishonesty has no place in any community
  – May NOT be in possession of someone else’s homework/project
  – May NOT copy code from another group
  – May NOT copy, collaborate or share homework/assignments
  – University Academic Integrity rules are the general guidelines

• Penalty can be as severe as an ‘F’ in CS 6410
Stress, Health and Wellness

• Need to pace yourself to manage stress
  – Need regular sleep, eating, and exercising

• Do **not** come to class sick (with the flu)!
  – Email me *ahead* of time that you are not feeling well
  – People not usually sick more than once in a semester
Before Next time

• Read one paper below and write review

• Check website for updated schedule