CS554:
Data-Intensive Computing

Syllabus

Ioan Raicu
Computer Science Department
Illinois Institute of Technology

CS554: Data-Intensive Computing
January 12th, 2015

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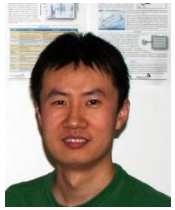
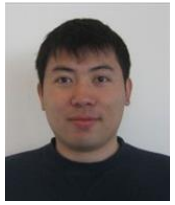




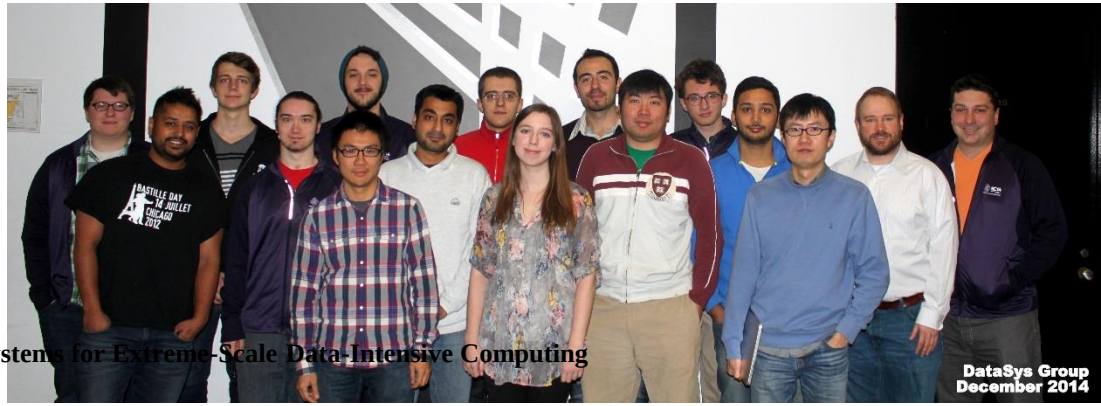
- **Semester:** Spring 2015
- **Lecture:** Monday/Wednesday, 11:25AM - 12:40PM
- **Location:** Stuart Building 113
- **Professor:** Dr. Ioan Raicu (iraicu@cs.iit.edu)
  - **Office Hours Time:** Wednesday, 12:45PM - 1:45PM, SB237D
- **Teaching Assistant:** Ke Wang
  - **Office Hours Time:** Monday 10:15AM – 11:15AM, SB002
- **Teaching Assistant:** Tonglin Li
  - **Office Hours Time:** Tuesday 12:45PM – 1:45PM, SB002
- **Teaching Assistant:** Dongfang Zhao
  - **Office Hours Time:** Thursday 12:45PM – 1:45PM, SB002
- **URL:** http://www.cs.iit.edu/~iraicu/teaching/CS554-S15/

Who am I?

- **Current position:**
  - Assistant Professor at Illinois Institute of Technology (CS)
    - Director of the Data-Intensive Distributed Systems Laboratory (DataSys)
  - Guest Research Faculty, Argonne National Laboratory (MCS)
- **Education:** PhD, University of Chicago, 2009
- **Postdoc:** Northwestern University
- **Funding/Awards:**
  - NSF, DOE, NASA (~$1.3M)
- **Over 70+ Collaborators:**
  - DOE Labs: ANL, ORNL, LANL, PNNL, LBL, FNAL
  - Academia: UIUC, UChicago, Northwestern, John Hopkins, UCBerkeley, Notre Dame
  - Industry: Amazon, Microsoft, Google, Cleversafe
- **My students work at:**
  - Microsoft, IIT, NetApp, Hortonworks, Dell, Amazon, Nokia, Here, ANL, etc
- More info: http://www.cs.iit.edu/~iraicu/index.html

DataSys: Data-Intensive Distributed Systems Laboratory

- **Research Focus**
  - Emphasize designing, implementing, and evaluating systems, protocols, and middleware with the goal of supporting **data-intensive applications on extreme scale distributed systems**, from many-core systems, clusters, grids, clouds, and supercomputers
- **People**
  - Dr. Ioan Raicu (Director)
  - 6 PhD Students (spanning 2nd to 6th year)
  - 7 MS Students
  - 5 UG Students
- **Contact**
  - http://datasys.cs.iit.edu/
  - iraicu@cs.iit.edu



Who are you?

- Background?
  - Math/CS/ECE?
  - UG/MS/PhD?
- What do you want to get out of this course?

Course Overview

- Data Intensive Computing is critical to advancing modern science
  - Applies to cluster computing, grid computing, supercomputing, and cloud computing
- Increasing gap between compute capacity and storage bandwidth
- Need for advanced techniques to manipulate, visualize and interpret large datasets
- Building large-scale distributed systems is hard
  - network (e.g., transport, routing)
  - algorithmic (e.g., data distribution, resource management)
  - social (e.g., incentives)

Course Overview (cont)

- Understand methods and approaches to:
  - Design, implement, and evaluate distributed systems
- Topics include:
  - Resource management (e.g. discovery, allocation, compute models, data models, data locality, virtualization, monitoring, provenance), programming models, application models, and system characterization
- Course involves:
  - Lectures, outside invited speakers, discussions of research papers, homework, and a major project

Prerequisites

- Coursework
  - Required: CS450
  - Recommended: CS542, CS546, CS451, CS550, CS551, CS552, CS553, and CS570
- Topics
  - Programming (C, C++, or Java)
  - Networking
  - Operating systems
  - Architecture
  - Distributed systems

Course Topics

- Paradigms
- Parallel Programming Systems
- Job Management Systems
- Storage Systems

Course Topics

- Paradigms
  - Supercomputing (e.g. IBM BlueGene/P/Q, Cray XT6)
  - Grid Computing (e.g. XSEDE, OSG)
  - Cloud Computing (e.g. Amazon AWS, Google App Engine, Windows Azure)
  - Many-core Computing (e.g. NVIDIA GPUs, Xeon Phi)

Course Topics

- Parallel Programming Systems
  - MapReduce (e.g. Hadoop)
  - Workflows (e.g. Swift)
  - MPI (e.g. MPICH)
  - OpenMP
  - Multi-Threading (e.g. PThreads)

Course Topics

- Job Management Systems
  - Batch scheduling (e.g. Condor, Slurm, SGE, PBS)
  - Light-weight Task Scheduling (e.g. Falkon, Sparrow, MATRIX)

Course Topics

- Storage Systems
  - File Systems (e.g. EXT3)
  - Shared File Systems (e.g. NFS)
  - Distributed File Systems (e.g. HDFS, FusionFS)
  - Parallel File Systems (e.g. GPFS, PVFS, Lustre)
  - Distributed NoSQL Key/Value Stores (e.g. Casandra, MongoDB, ZHT)
  - Relational Databases (e.g. MySQL)

Computer Usage

- Computer systems that can be used for development of projects (more information about access to these will be passed in the first several lectures):
  - **20-node Linux cluster**
  - **Amazon AWS - $100 credit per student**
- Other systems that could be used, on as needed basis:
  - IIT/CS SCS Linux Cluster (512-cores x64)

Research Papers Reading and Discussion

- 1~2 papers per lecture
- Serve as background to the lecture
- Serve as basis for discussion
- Quizzes will be from the reading assignments
- Students will be assigned to lead the discussion

Projects

- Major quarter long project
  - Topic of choice of the student (from a given list)
  - Can work in groups of up to 3 students
  - May require the following things:
    - Reading research papers
    - Using open source software
    - Implementation of a real/simulated system
    - Analysis of theoretical work
    - Performance evaluation of theoretical/real systems
    - Written report(s)
    - Oral presentation(s)

Project Ideas

- Distributed file systems
- Data aware scheduling algorithms
- Distributed operating systems
- Distributed job management systems
- Parallel programming languages
- Distributed workflow systems
- Distributed monitoring systems
- Scientific computing with GPUs
- Scientific computing with MapReduce
- Distributed caching strategies
- Distributed cache eviction policies
- Distributed hash tables

Useful Software for your Projects

- Operating systems: Linux
- Scripting: BASH
- Source control: SVN
- Programming languages: Java, C/C++
- Job submission systems: GRAM, PBS, Condor, Cobalt, SGE, Falkon, Sparrow
- Programming models: MapReduce (Hadoop/Spark), MPI (MPICH), Multi-Threading (PThreads), Workflows (Swift)
- File systems: FUSE
- Parallel file systems: GPFS, PVFS, Lustre

Useful Software for your Projects (cont)

- Distributed file systems: GPS, HDFS, FusionFS, Ceph, GlusterFS
- Data services: GridFTP
- Grid middleware: Globus
- Cloud middleware: Nimbus, Eucalyptus, OpenNebula, Open Stack
- Key/Value Stores: Chord, Tapestry, ZHT, Casandra, MongoDB, MemCached, DynamoDB
- Simulation environments: GridSim, SimGrid, OptorSim, GangSim, Bricks, SimMatrix, PeerSim, CODES/ROSS
- Virtualization: Oracle Virtual Box, XEN, VMWare

Grading

- Quizzes: 20%
- Project Proposal: 10%
- Mid-Semester Progress Report: 10%
- Final Oral Presentation: 25%
- Final Project Report: 25%
- Participation: 10%

Grade Scale

- **A: 85% ~ 100%**
- **B: 70% ~ 89%**
- **C: 60% ~ 69%**
- **E: 0% ~ 59%**

Late Policy

- Assignments will be due at 11:59PM on the day of the due date, through BlackBoard
- There will be a 15 minute grace period
- There will also be a 7-day late pass, where students can submit late assignments without penalty
  - the late pass can be used in 1-day increments spread out over multiple assignments
- Any late submissions beyond the grace period and beyond the 7-day late pass, will be penalized 10% every day it is late

Course Outcomes

- Understand the importance of data-intensive computing
- Understand the difference between cluster, grid, clouds, and supercomputing.
- Understand how to build large scale distributed systems
- Understand applications that require data-intensive computing
- Understand trends in many-core computing and challenges that will come with them
- Build distributed systems
- Be familiar with multiple programming models
- Read and understand systems research papers
- Make a formal presentation on a technical topic
- Write up a formal report on the project

Miscellaneous

- Required texts
  - None
  - Readings will be from online material
- We will be using BlackBoard minimally, mostly to post grades
- Mailing list
  - http://piazza.com/iit/spring2015/cs554/home

Questions

- Write me:
  - iraicu@cs.iit.edu
- Skype me:
  - ioan.raicu
- Call me:
  - 1-312-567-5704
- Reach all TAs:
  - cs554-s15@datasys.cs.iit.edu