CS554:
Data-Intensive Computing

Syllabus

Ioan Raicu
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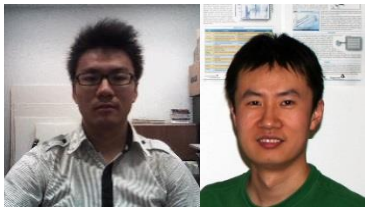
Illinois Institute of Technology

CS554: Data-Intensive Computing

- **Semester:** Fall 2013
- **Lecture Time:** Monday/Wednesday, 11:25AM - 12:40PM
- **Location:** Stuart Building 238
- **Professor:** Dr. Ioan Raicu (iraicu@cs.iit.edu, 1-312-567-5704)
  - **Office Hours Time:** Wednesday, 12:45PM - 1:45PM
  - **Office Hours Location:** Stuart Building 237D

- **Teaching Assistant:** Ke Wang
  - **Office Hours Time:** Monday/Tuesday 12:45PM – 1:45PM
  - **Office Hours Location:** Stuart Building 002



- **Teaching Assistant:** Tonglin Li
  - **Office Hours Time:** Thursday 10AM-11AM, Friday 12:45PM – 1:45PM
  - **Office Hours Location:** Stuart Building 002
- **URL:** http://www.cs.iit.edu/~iraicu/teaching/CS554-F13/

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, March 2009
- **Funding/Awards:**
  - NSF CAREER, 2011 – 2015 ($450K)
  - DOE LANL, 2013 ($75K)
  - DOE FNAL, 2011-2013 ($70K)
  - NSF/CRA CIFellows, 2009 – 2010 ($140K)
  - NASA GSRP, 2006 – 2009 ($84K)
- **More info:** http://www.cs.iit.edu/~iraicu/index.html
- **Over 70+ Collaborators:**
  - Ian Foster (UC/ANL), Rick Stevens (UC/ANL), Rob Ross (ANL), Marc Snir (UIUC), Arthur Barney Maccabe (ORNL), Alex Szalay (JHU), Pete Beckman (ANL), Kamil Iskra (ANL), Mike Wilde (UC/ANL), Douglas Thain (ND), Yong Zhao (UEST), Matei Ripeanu (UBC), Alok Choudhary (NU), Tevfik Kosar (SUNY), Yogesh Simhan (USC), Ewa Deelman (USC), and many more…

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
  - 2 MS Students
  - 4 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):
  - **15-node (150-core) private cloud using virtualization and Linux**
  - **Amazon AWS - $100 credit per student**
- Other systems that could be used, on as needed basis:
  - IIT/CS SCS Linux Cluster (512-cores x64)
  - IIT/CS CUDA Linux Cluster (80-cores x64 with NVIDIA GPUs)
  - IBM BlueGene/P at Argonne National Laboratory (160K-cores PPC)
  - SiCortex at Argonne National Laboratory (5832-cores MIPS)

Research Papers Reading and Discussion

- 1~2 papers per lecture
- Each paper must be summarized in writing
- Serve as background to the lecture
- Serve as basis for discussion

Projects

- Major quarter long project
  - Topic of choice of the student (from a given list)
  - Can work in groups of 2 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
- Programming models: MapReduce (Hadoop), 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
- Simulation environments: GridSim, SimGrid, OptorSim, GangSim, Bricks, SimMatrix, PeerSim
- Virtualization: Oracle Virtual Box, XEN, VMWare

Grading

- Homework: 20%
- Project Proposal: 10%
- Mid-Semester Progress Report: 10%
- Final Oral Presentation: 30%
- Final Project Report: 30%

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
  - Sending email to cs554-f13@datasys.cs.iit.edu
  - More info at:
    - http://datasys.cs.iit.edu/mailman/listinfo/cs554-f13

Questions

- Write me:
  - iraicu@cs.iit.edu
- Skype me:
  - ioan.raicu
- Call me:
  - 1-312-567-5704
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