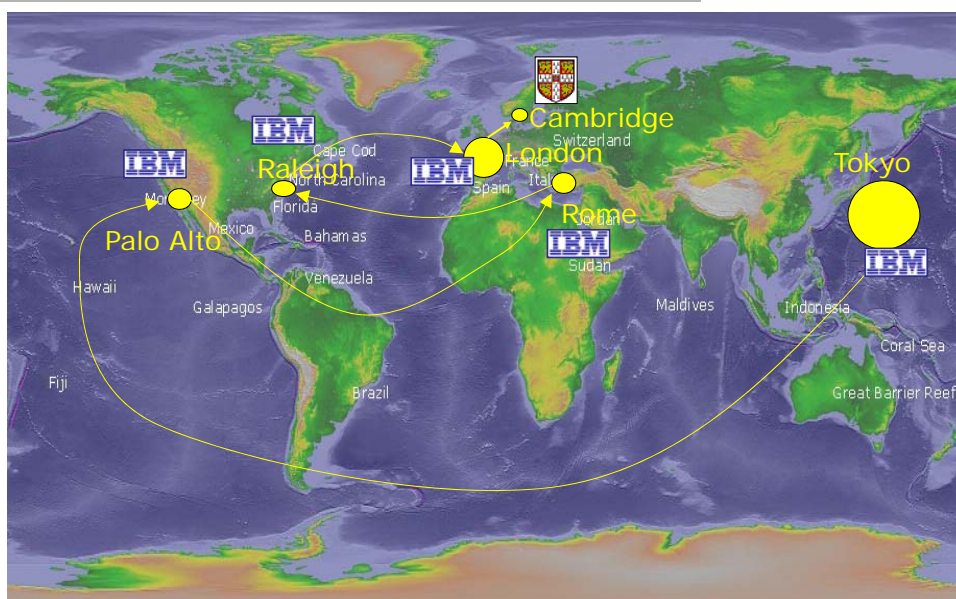# Large-Scale Data Processing and Optimisation (LSDPO)

Session 1: Introduction

Eiko Yoneki

Systems Research Group
University of Cambridge Computer Laboratory

My Trajectory

My Research Interests

- Spanning over Distributed Systems, Networking and Database

- Current Focus: Large-Scale Data Processing and Optimisation of Computer Systems exploiting ML

- MPhil project Suggestions
  http://www.cl.cam.ac.uk/~ey204/teaching/Projects/2019_2020

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My Group: Data-Centric Systems

Optimisation of Complex Data Processing in Computer Systems

- Auto-tuning to deal with complex parameter space using machine-learning
  - Structured Bayesian Optimisation, Reinforcement Learning
  - Build a solid auto-tuning platform in a complex and large parameter space

- e.g. Cluster task scheduling, ML framework, JVM garbage collector, NN model, LLVM Compiler, ASICS design, DB indexing, Stream processing, Traffic signal control…

### Data Analysis at the Edge

- Real world data processing in Africa/South America
- e.g. TB - sensing CO_2 and proximity of people → building complex networks
- e.g. Pest/Disease monitoring by Raspberry Pi camera – use ML to identify at the edge node

Large-scale Graph Processing

- Fast, flexible, and programmable graph processing
- Cost effective but efficient storage
  - Move to SSDs from RAM
- Reduce latency
  - Runtime prefetching
  - Dynamic CPU/GPU scheduling
- Dynamic SSSP

Large Graph

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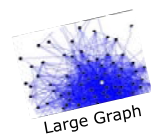
R244 Course Objectives

- Understand key concepts of scalable data processing

- Understand how to build distributed systems in data driven approach

- Understand a large and complex parameter space in computer system's optimisation and applicability of Machine Learning approach

- Research skills
  - Establish basic research domain knowledge in large data processing
  - Obtain your view of research area for thinking forward

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Topic Areas

Session 1: Introduction

Session 2: Data flow programming: Map/Reduce to TensorFlow

Session 3: Large-scale graph data processing

Session 4: Hands-on Tutorial: Map/Reduce and Deep Neural Network

Session 5: Probabilistic Programming + Guest lecture (Brooks Paige)

Session 6: Exploring ML for optimisation in computer systems

Session 7: ML based Optimisation examples in Computer Systems

Session 8: Project Study Presentation (2019.12.12 @11:00)

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Course Structure

- Reading Club (not Lecture Class!)
  - ~5 Paper review presentations and discussion per session (~=20 minutes presentation + discussion)
  - Each of you will present ~2 reviews during the course
    - Revised (if necessary) presentation slides needs to be emailed on the following day

  - *Review_Log*: minimum 1 per session
    - Email me by noon on Monday
    - Prepare questions
  - Active participation to review discussion!

Review_Log

Paper Review Log: Session x (xx/xxxx/xx)

Name and (crsid):

Paper Title and Authors

1. Paper Summary (<100 words)
Describe a brief summary (extract essentials)

2. Punch-line of the Paper (<200 words):
What is the significant contribution?
What is the difference from the existing work?

3. Any major criticism to the authors (<150 words)
Any criticism and suggestions to the authors?

Course Work: Reports 1&2

- **Review report** on full length of paper (<1800 words)
  - Describe the contribution of paper in depth with criticism
  - Crystallise the significant novelty in contrast to the other related work
  - Suggestion for future work
- **Survey report** on sub-topic in data centric networking (<2000 words)
  - Pick up to 5 papers as core papers in your survey scope
  - Read them and expand your reading through related work
  - Comprehend your view and finish as your survey paper

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Study of Open Source Project

- Open Source project normally comes with new proposal of system/networking architecture
- Understand the prototype of proposed architecture, algorithms, and systems through running an actual prototype
- Any additional work
  - Writing applications
  - Extending prototype to another platform
  - Benchmarking using online large dataset
- Present/explain how prototype runs
- Some projects are rather large and may require extensive environment and time; make sure you are able to complete this assignment

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Course Work: Reports 3

- **Report on project study** and exploration of a prototype (<2500 words)
  - Project selection by November 8, 2019
    - Title and brief description (>150 words) by email
  - Project presentation on November 29, 2019
  - Final report on the project study by January 15, 2020 (by December 20, 2019 is preferable)

Candidates of Open Source Project

http://www.cl.cam.ac.uk/~ey204/teaching/ACS/R244_2019_2020/opensource_projects.html

- List is not exhausted and discuss with me if you find more interesting one for you
- Expectation of workload on open source project study is about intensive 3 full days work except writing up report
- One approach: pick one in the session topic, which you are interested in along your survey report

Important Dates

- November 8 (Friday) 16:00
  - Project selection

- November 15 (Friday) 16:00
  - Review report

- November 29 (Friday) 16:00
  - Survey report

- January 15, 2020 (Wednesday) – December 20 (Friday) is preferable
  - Open source project study report

Assessment

- The final grade for the course will be provided as a letter grade or percentage and the assessment will consist of two parts:

- 25%: for a reading club (presentation, participation, tutorial session exercise and *review_log*)

  - 10%: Presentation
  - 15%: Participation

- 75%: for the three reports
  - 15%: Intensive review report
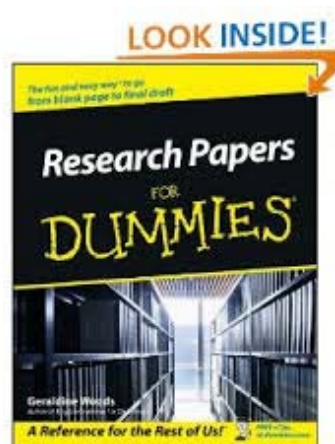 - 25%: Survey report
  - 35%: Project study

Welcome to R244

- Now tell about yourself
  - Your name and where you studied before ACS (or Part III)
  - What is your research interests (topics)
  - Why are you interested in R244

How to Read a Paper?

How to Read a Paper?

- Scope of LSDPO is wide

- …includes distributed systems, OS, networking, programming language, database…

- Type of papers
  - Building a real system
  - Proposing algorithm/logic on architecture design
  - Optimising computer systems
  - New idea

Critical Thinking

- Reading a research paper is not like reading a text book
- But the most important one is that the paper is not necessary the *truth*

  - there is no right and wrong, just good and bad
  - There are inherently subjective qualities…but you can't get away with just your opinion: must argue

- Critical thinking is the skill of marrying subjective and objective judgment of a piece of work

First Let's Argue for...

- What is the problem?
- What is important?

- Why isn't it solved in previous work?
  - Why graph specific parallel processing? MapReduce is not good enough?

- What is the approach?
  - Graph specific MapReduce

- Why is this novel/innovative?
  - Iterative operation for graph parallel

And Now against...

- Problem is overstated (or oversold)

- Problem does not exist

- Approach is broken
  - It does not work for all the algorithms...

- Solution is insufficient
  - Only works when data is in memory...

- Evaluation is unfair/biased
  - Use HPC for experiment

So Which is RIGHT Answer?

- There isn't one!
  - Most of arguments are mostly correct…

- Your judge on what is valuable on topic

- In this course, we'll be reviewing a selection of ~20 papers (4-5 per week)
  - All of these papers were peer-reviewed and published
  - However you can pick your opinion on papers!

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Reviewing Tips & Tricks

- Identify a core/major idea of the topic

- Read related work and/or background section and read key other papers on the topic

- Capture the author's claim of contribution in *introduction* section and judge if it is delivered

- Understand the methodology that demonstrates paper's approach

- Capture what authors evaluate and judge if that is a good way to evaluate the proposed idea

- For theory/algorithm paper, capture what it produces as a result (rather than how)

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Key in Review Comments

- What do YOU think?
  - Where you finally get to explain your opinion!
  - You should aim to give *a judgement* on the work
  - Your judgement should be backed by your argument

- Questions for the authors

How to Review a Paper Aid...

- S. Keshav: How to Read a Paper, ACM SIGCOMM Computer Communication Review 83 Volume 37, Number 3, July 2007.

- T. Roscoe: Writing Reviews for Systems Conferences, 2007.

- Simon Peyton-Jones: How to write a great paper and give a great talk about it, Microsoft Research Cambridge.

- David A. Patterson: How to Have a Bad Career in Research/Academia, 2001.

  See course web page for the paper links.

Structure of Presentation

- Cover 3 things in your presentation
1. Background/context
    - What motivated the authors?
    - What else was going on in the research community?
    - How have things changed since?
2. What is problem to be tackled?
    - What is the problem they tried to solve?
    - What are the key ideas?
    - What did the authors actually do?
    - What were the results?
3. Your opinion of the paper
    - What you agree and what you disagree?
    - What is the strength and weakness of their approach?
    - What are the key takeaway?
    - What was the impact (possible impact)?

Preparing...

- Not too much basics: remember, others would have read the paper
    - Brief overview
    - Do not make exact repeat of the paper

- Aim: generate discussion – spit your straight opinion about the paper to stir the discussion
    - Explore the arguments they make and the conclusions they draw. What is your opinion on it?
    - When you argue, state clearly the point of argument

Presenting...

- Practice beforehand to ensure length of your presentation

- Getting nervous is normal!
  - We are in the same boat and we help each other to understand the paper
  - Presentation is a tool to provide a discussion forum

- Try not to get defensive or angry at questions
  - It is not your paper !

S. Hand'10

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Listening Presentation...

- You need to get involved

- Ask questions from your review – bring your *review_log* copy

- Always be respectful of the speaker

S. Hand'10

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How to Write Reviews (Report 1)

- Paper Summary
  - Provide a brief summary of the paper
  - At this stage you should try to be objective
- Problem
  - What is the problem? Why is it important? Why is previous work insufficient?
- Solution or Approach
  - What is their approach?
  - How does it solve the problem?
  - How is the solution unique and/or innovative?
  - What are the details?
- Evaluation is unfair/biased
  - How do they evaluate their solution?
  - What questions do they answer?
  - What are the strength/weakness of the system and evaluation itself?

S. Hand'10

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How to write Survey paper (Report 2)

- Demonstrate a summary of recent research results in a novel way that integrates and adds understanding to work in the research area

- Must expose relevant details associated, but it is important to keep a consistent level of details and to avoid simply listing the different works

- For example:
  - Define the scope of your survey
  - Classify and organize the trend
  - Critical evaluation of approaches (pros/cons)
  - Add your analysis or explanation (e.g. table, figure)
  - Add reference and pointer to further in-depth information

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Summary

- R244 course web page:

  http://www.cl.cam.ac.uk/~ey204/teaching/ACS/R244_2019_2020

  Email: eiko.yoneki@cl.cam.ac.uk

- Slides of presentation, forms, other information will be on the web

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