CS 736: Advanced Operating Systems

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Lecture 1: Introduction

Questions for Today:
- What does it mean to do Operating Systems and Systems Research?
- What will you learn and do in this course?

To do:
- Read 3 papers for next lecture: THE, Nucleus, UNIX
- Answer question and send to me in email
- Form reading group and email by next Friday

CS 736 Goals

Understand important concepts and issues in OS and systems

Learn how to critically evaluate papers and ideas

Gain experience developing systems research project
- You are learning how to do systems research

What should you already know?

Undergraduate Operating Systems (CS 537)
- What is an inode? What is stored in it?
- Threads vs processes?
  Semaphores vs. condition variables?
- Paging vs segmentation?

Undergraduate Computer Architecture (CS 552)
- Caching? TLBs? Disks?
- Understand layer beneath to build on top

Self-starter (take initiative, take ownership)
- If you don't know something, find answer yourself!

What is an OS?

Definition:
Software that converts hardware into something more useful for applications (or users)

Role 1: Standard interface; What does that mean?
- Reuse functionality
- Make different devices look the same
- Provide higher-level abstractions
- Questions: What interface should be provided?
  What features should be exposed?

Role 2: Resource Coordinator; What does that mean?
- Virtualize so multiple applications can share
- Provide protection
- Provide fair and efficient access
- Question: Can policy and mechanism be separated?

What is Systems Research?

What is a system?
- Group of components combined as to form a whole and to operate in unison
- Collection of interacting components over which one does not have complete control
- Examples: operating system, parallel/distributed systems, databases

What is systems research?
- Building something new, evaluating its contribution
- Evaluation is critical! What questions are you asking and answering?

Theory or Practice?
- Practical, with room for theory as needed

Science Or Engineering?

Science or engineering?
- "A good scientist is a person with original ideas. A good engineer is a person who makes a design that works with as few original ideas as possible."
  – Freeman Dyson (physicist)

Science?
- Observe phenomena, formulate hypothesis to explain, use hypothesis to predict

Engineering?
- Design and manufacture complex products

System researchers are some of both

Better Analogy?

Analogy: Building Architect
- "Where form meets function"
- "Elegant", "Beautiful" systems
- Le Corbusier: "Architects everywhere have recognized the need of a tool which may be put in your hands, with the simple aim of making the bad difficult and the good easy"



Where does design matter in systems?

Example OS Function: Creating a new process

UNIX: fork() and exec()
- Simple calls, few args, powerful

NT: CreateProcess()
- Requires 10 args!
- David Korn: "…but still cannot perform the simple operation of overlaying the current process with a new program as execve() requires"

What will you Learn?

Two main components: Readings and Projects

Read: How to evaluate other's research
- Learn from the best of the past
- What has been tried, what has worked, what hasn't
- Research must be done at the right time given technology

Projects: How to do research yourself
- Sophocles: "One must learn the thing by doing, for though you think you know it, you have no certainty until you try"
- Harder to synthesize than criticize
- Start with a mini-project

CS 736 Topics

General OS Structure

File and Storage systems

Scheduling and Resource management

Memory Management

Distributed Systems

Current Research

Paper Readings

Purpose: Learn how to evaluate papers on your own
- Reading is fundamental for every researcher
- Key to idea formation
- "Everything has been thought of before; the problem is to think of it again" -- Goethe

1-2 papers per lecture
- Papers are 10-20 pages, dense
- Selected from "best of best"
  - SOSP, OSDI, TOCS, …

How to read a paper?
- Read many times to understand well
- Once to get basic ideas and terminology
- Second time to understand
- Review before class

Paper Write-Up

Purpose: To ensure you've read the paper before lecture

1 question per lecture, found on web page

Answer: Up to 3 paragraphs (full sentences, no bullet points)

send email to me (dusseau@cs) with Subject "736: <DUE DATE>" before lecture

Work on this alone

Graded simply with 0, 1, 2, or 3 points

Reading Groups

Purpose: To share knowledge with others
- Be comfortable sharing your thoughts and questions
- Come to class prepared to discuss

3-4 people, meet weekly or so to discuss readings
- Ideally before lecture

Must be formed by next Friday (send me email)

What should you think about as you read?

What problem are the authors trying to solve?
- Why was the problem important?
- Why was the problem not solved by earlier work?

What is the authors solution?
- How does their approach solve the problem?
- How is the solution unique and innovative?
- What are the details?

How do the authors evaluate their solution?
- What specific questions do they answer?
- What simplifying assumptions do they make?
- What is their methodology?
- What are their strengths and weaknesses?
- What is left unknown?

What do you think?
- Is the problem still important?
- Did the authors solve the stated problem?
- Did the authors adequately demonstrate that they solved the problem?

What future work does this research point to?

Project

1 warm-up project
- Goal: Obtain basic experience with systems and measurement
- Somewhere in between straight-forward and open-ended
- Work on your own
- Time-line: Finish in first few weeks

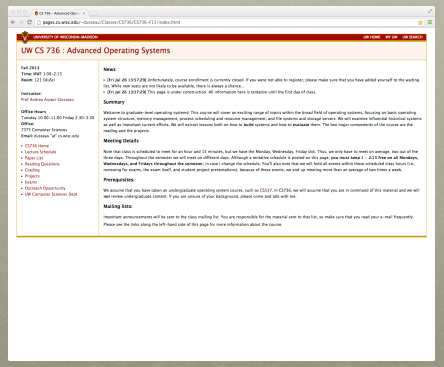
1 mini-research project
- Goal: Something new and interesting
  - Be a self-starter
  - Will have suggested projects (can also suggest your own)
- Work with project partner (pick carefully!)
- Talk to classmates and paper write-up
  - Presentation counts
  - "Communication of your ideas may be more important than content" – Hamming
- Time-line: Due at end of semester

Exams

Two in-class exams
- Exam 1 (Friday, Oct 11) Covers overview material, operating system structure, and file and storage systems.
- Exam 2 (Friday, Dec 6): Covers entire course material with an emphasis on memory management, process synchronization and scheduling, distributed systems, and recent topics.

Will have in-class reviews as well

Web Page



Conclusions

Goal of systems research:

- Find good ideas/solutions for current or future problems

To come up with ideas, must read a lot

- Synthesize ideas from past with new ones of your own

To determine if ideas are good, must evaluate them

- Have QUESTIONS you are trying to answer
- Measure whether or not your system is better and SHOW WHY!!!

Research is a struggle!

Next Lecture

Few weeks of complete OS overview (background)

- Friday: THE, Nucleus, and UNIX

Friday's Question:

- In your own words, describe how the definition of a process differs across THE, Nucleus, and UNIX. You may want to discuss if different features or functionality (related to processes) are included across the three systems, or how processes are managed differently across systems.