Course Overview

• Instructor:
  – Christian Poellabauer (cpoellab@nd.edu)

• Course Meetings
  – TR 9:35 – 10:50
  – McCourtney Hall B01 (& Zoom)

• Office Hours
  – Primarily Zoom Office Hours (in-person only by request)
    • Times TBD (Doodle Poll); probably 2-3 slots
  – Zoom# will be on website, Sakai, etc.
  – Office hours will be “public”, but you can request 1-1 meetings
Course Overview

• **Primary components:**
  – Read and discuss papers (homeworks, exams)
  – Work on a mini research project (reports, papers, presentations, software, review)
  – “Grad Student 101”
    • Note that department also offers “Research Methods” now!

Goals of Course

• (Operating) systems research
• Reading, reviewing, critiquing research literature
• Conduct (a little bit) of systems research (including paper writing process)
• Satisfy core requirement & pass the qualifying exam
• Learn about “life as a grad student & researcher”
OS Research Literature

- How has the role of the OS evolved?
- What are key principles for OS?
- How did past influence present?
- What are current trends and what will the future bring?

Reading/Critiquing Papers

- Read many papers
- Discuss papers, methodology, problems they address, solutions they propose, etc.
- Determine what makes a good research paper
- Typically discuss 1-2 papers per lecture
Papers and Discussions

- Classical/important/recent papers
- Papers that demonstrate excellence in research
- Papers that demonstrate how the field is changing
- Be willing to question the paper
- Be willing to take a position
- Be willing to be wrong
- Understand that there is not always a “right” or “wrong” answer

Course Organization

- **In-person lectures** for students on campus
- **Live streaming** of lectures via Zoom for students sick, in quarantine, off campus, etc.
- **Asynchronous lectures** via recorded Zoom for students in off campus in different time zones
  - **Zoom office hour** attendance mandatory (1x per week minimum)
Course Organization

• For every lecture, read 1-2 papers as shown in the online schedule
• Submit (via Sakai) a brief (1 paragraph) summary of reading assignments PLUS answer potential questions; due by 9.35am EST of the day of the lecture!

Summary Example

**Paper 1:** First Author, Second Author, and Third Author, “This is the title of the paper”, Cool Journal, volume 2, number 3, July 2019.

**Summary:** This paper proposes a novel scheduling algorithm that adjusts the CPU cycles allocated to a process based on the predicted CPU and I/O loads of all processes in the runqueue. Specifically, the authors use a game-theoretic approach that considers recent utilization history, past process traces, resource availability, and other factors to make these predictions. The paper also proposes a novel mechanism to “donate” resources between processes if the processes have certain dependencies. The evaluation section compares the proposed approach to another recent predictive scheduler that utilizes a neural network based approach, showing that the game theory based approach on average predicts future resource utilization 18% more accurately. The authors identify several shortcomings of their approach and propose to investigate multi-processor systems in their future work. A strength of the proposed work is that the proposed approach is computationally much more efficient than prior solutions. However, I believe that the authors made several simplifications that make the results somewhat questionable. Specifically, they assume that all processes ...

**Question 1:** In this paper, process dependencies are automatically detected by detecting calls to locking mechanisms at run-time.

**Question 2:** The resource donation process uses a mechanism based on shared memory.
What is Research?

• “Creative and systematic work undertaken to increase the stock of knowledge” [Wikipedia]

• Engineering vs Research
  – “I want to build a mouse trap”
    • This is not research!
  – Research requires a question!

Engineering vs Research

• “I want to build a mouse trap”
  – “Is my new mouse trap better at trapping mice than a conventional mouse trap?” (Why?)
  – “Are there common traits among the mice that are being captured (and the ones not being captured)?”
  – Are there characteristics (materials) that make better traps?
  – “Does habituation occur and how?”
  – If my mousetrap were invisible, would it be better?
  – How can we build an invisible mousetrap?

  – Research requires a question!
  – Research often requires engineering!
Engineering vs Research

• Engineering helps you answer the question
  – Create a prototype mousetrap
  – Build a framework in which to evaluate the efficacy of mousetraps
  – Designing experiments combines engineering and research
  – Conducting experiments is often engineering
  – Analyzing and interpreting the results is research

Rigor & Reproducibility

• **Rigor**: strict application of the scientific method to ensure unbiased and well-controlled experimental design, methodology, analysis, interpretation and reporting of results
• **Reproducibility**: ability of a study or experiment to be reproduced (by somebody else)
Diligent Research

- Write down everything
- Understand the data
- Question yourself constantly
- Remind yourself of the question you are asking
- Keep (publish) the data
- Avoid bias
  - Introduction of systematic error
- Be careful (ethical) using & interpreting data
- Discuss your work with others (share data, paper drafts, etc.)
- **Know the literature!**

Research

- There are not necessarily any right answers
- No one can tell you with certainty that you are right
- You are never really done
- Understanding (and working with) large systems is difficult
Examples of Research Approaches

- Form a hypothesis
- Measure a real system (trace data)
- Instrument existing systems (and measure again)
- Run simulations
- Analytical investigation of collected data
- Micro vs macro investigations
- Draw conclusions
- Compare results against others’ results
- Use results to form new hypotheses

Research Papers

- Big idea papers, unifying themes, small ideas with evaluation, measurements, comparisons, retrospective or experience papers, ...
- Keep track of important/relevant/good papers in your field (bibliography, bib file, etc.)
Research Papers: LaTeX

- High-quality typesetting system
- De facto standard for the communication and publication of scientific documents
- www.overleaf.com

Research Papers: bibtex

```latex
@article{Smith1987,
  AUTHOR = {Smith, Hal},
  TITLE = {Oscillations and multiple steady states in a cyclic gene model with repression},
  JOURNAL = {J. Math. Biol.},
  FJOURNAL = {Journal of Mathematical Biology},
  VOLUME = {25},
  YEAR = {1987},
  NUMBER = {2},
  PAGES = {169--190},
  ISSN = {0303-6812},
  CODEN = {JMBLAJ},
  MRCLASS = {92A09 (34K15)},
  MRNUMBER = {896432 (89f:92026)},
  MRREVIEWER = {S. J. Merrill},
  DOI = {10.1007/BF00276388},
  URL = {http://dx.doi.org/10.1007/BF00276388},
}
```
Research Papers: Critiquing

- Is the problem well described/motivated?
- Does the idea make sense?
- Does the paper make a difference?
- What is being measured/proven/demonstrated?
- Are the measurements (experimental setup) meaningful?
- Are the results meaningful?

Research Papers: Critiquing

- Summarize paper in a few sentences
- Put papers in categories (e.g., classic, important, useless, ...)
- Is the paper well-written?
- What did you learn from the paper?
- How would you have conducted the research?
- Does the paper suggest any future work?
Writing a Paper

• Abstract: introduce area, state problem, explain approach, summarize conclusions
• Introduction: describe problem, importance, approach and contributions, road map
• Background: anything reader needs to know
• Approach/Solution: what you did
• Results: experimental setup, explain expected results, surprising results
• Related Work: relate your work to prior efforts
• Conclusions (and future work)

Writing a Paper

• SPELL CHECK!!!!!!!!!!!!!!!
• Learn grammar, style, etc., adapt to your field/advisor/community/…
• Read and critique your own work!!! Are you satisfied? If you know there is a problem, a reviewer will find it too
• Write while you do the work; keep track of all you do; safely store data!
Writing a Paper

- LaTeX
  - Recommendation: Overleaf/Sharelatex
- Microsoft Word
  - Recommendation: Google Docs

“Entrance Exam”

- On the following slides, you’ll find the “entrance exam”
- Try to answer questions on your own by next time (you do not have to submit anything and this is NOT graded!)
- Based on how you perform:
  - May want to wait a year and take ugrad OS first if you have no background whatsoever in operating systems or a related field
  - Be willing to learn (some) basic OS concepts in parallel (will require proactiveness, independence, time, ...)

“Entrance Exam”

• What is a multi-threaded process?
• What is the purpose of mutual exclusion?
• What does it mean to say an operation is atomic?
• Use a brief example to describe what a deadlock is or how it can be caused.
• What is the difference between deadlock and starvation?

“Entrance Exam”

• What is the purpose of an interrupt?
• What is priority inversion?
• What does a page table do?
• What does thrashing mean?
• What is a symbolic link?
• What is a parity bit?
• What is an i-node (or file control block)?
“Entrance Exam”

• What does it mean to fork a process?
• What is the danger of caching a write?
• What is a page fault?
• What is the difference between kernel space and user space?
• What is disk fragmentation?
• What is a critical section?

“Entrance Exam”

• What is a runqueue (or ready queue)?
• What is a binary semaphore?
• What is the difference between a direct pointer and an indirect pointer in a file system such as EXT?
• Can you name and very briefly describe a scheduling algorithm that would be fair to all tasks awaiting execution?
“Entrance Exam”

- Can you name and very briefly describe a **scheduling algorithm** that might be a good choice in a **real-time system**?
- What is a **system call**?
- What does it mean for a system call to **block**?

Next Lecture & Next Week

- Thursday:
  - Introduction
  - Revisit “entrance exam”
- Next week:
  - **OS History and Architecture**
Reminder

**Students:**

You must report your permanent seat location using [here.nd.edu/seat](http://here.nd.edu/seat).

All seats have been numbered for your convenience.

Log in to enter your course/section, room, and seat number.

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Reminder

**Instructor Checklist**

- Wear your mask at all times inside the building, including while teaching.
- Remind students to wear their masks and maintain safe distance from each other at all times.
- Remind students to sit in their permanent seats and report their seat numbers using [here.nd.edu/seat](http://here.nd.edu/seat). Provide course/section information to students.
- Use the supplies provided to do a quick wipe-down of the teaching lectern and equipment.
- Turn on the dual-mode Zoom meeting for remote students. If no remote students are present after a reasonable time, shut down the Zoom meeting unless you plan to record the class.
- Remember when remote students are present and engage them.
- Provide time for safe departure; remind students to maintain distance when leaving the classroom.