Graduate Operating Systems
COP5614

Spring 2022

Course Overview

• Instructor:
  – Christian Poellabauer (cpoellab@fiu.edu)
• Course Meetings
  – TR 9:30 – 10:45
  – Academic Health Center 3 - 205
  – Zoom/recording (Canvas)
• Office Hours
  – Tuesday 11-12 & Wednesday 10-11 or by appointment
  – Zoom office hours (link on website)
  – Course web site, announcements
Course Overview & Goals

- (Operating) systems research
- Reading, reviewing, critiquing research literature
- Conduct (a bit of) operating 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
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

```
@article{smith1987,
    AUTHOR = {Smith, J.},
    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 = {JMBLA},
    MRCLASS = {92A09 (34C15)},
    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)

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**?


Summary

• Course website; “resources” link

• 1-2 papers per lecture

• Typical course structure:
  – Introduction into subject (not each lecture)
  – Discussion of paper(s)
  – Discussion of “grad student life” topics (time permitting)

• First papers: next week Tuesday

• Start thinking about annotated bibliography & project proposal
Next Lecture & Next Week

• Thursday:
  – Introduction
  – Revisit “entrance exam”

• Next week:
  – OS History and Architecture

COVID Reminder

• Daily and before arriving to campus, complete the P3 app. If you are not given the green check mark to enter campus, then return home, and contact the instructor by email.
COVID Reminder

• If you do not feel well, have tested positive for COVID-19, or have been in contact with a person with COVID-19 while not yet being fully vaccinated, please do not come to class, immediately complete the P3 app to notify the COVID Response Team or call them at 305-348-1919, and contact the instructor by email as soon as you can. In order to receive an excused absence for P3 failure/COVID-19, you must contact the COVID Response Team at 305-348-1919.

COVID Reminder

• If you are directed to isolate or quarantine because of COVID-19, your absences will be considered excused. The instructor will discuss make-up opportunities with you.