Graduate Operating Systems COP5614

Spring 2022

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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

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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”

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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?

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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

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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

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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!**

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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!**

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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

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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)

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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!**

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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

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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

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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.)

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Research Papers: LaTeX

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

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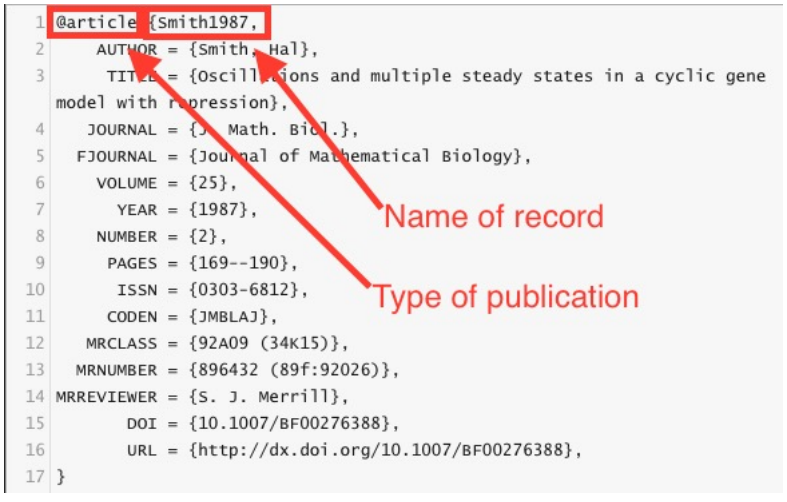
Research Papers: bibtex



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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?

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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?

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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)

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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!

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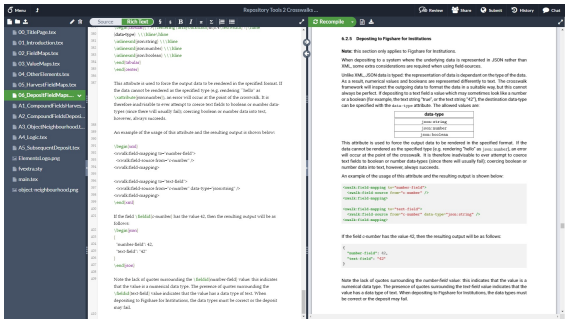
Writing a Paper

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



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“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, …)

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"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**?

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"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**)?

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“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**?

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“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?

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"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**?

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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

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Next Lecture & Next Week

- Thursday:
  - Introduction
  - Revisit ”entrance exam”
- Next week:
  - **OS History and Architecture**
    - **[1]** P. Brinch Hansen, "The Nucleus of a Multiprogramming System", Communications of the ACM, 238-242, April 1970.
    - **[2]** Dennis M. Ritchie and Ken Thompson, "The UNIX Time-Sharing System", Communications of the ACM, volume 17, number 7, July 1974.
    - **[3]** Dawson R. Engler, M. Frans Kaashoek, and James O'Toole Jr., "Exokernel: An Operating System Architecture for Application-Level Resource Management", Proc. of the 15th Symposium on Operating Systems Principles, December 1996.

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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.

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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.

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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.

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