Advanced Operating Systems

RICE UNIVERSITY

All problems in computer science can be solved by another level of indirection – David Wheeler.

Instructor

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Course Information

Website:	`https://nathandautenhahn.com/comp517`
Communications:	Microsoft Teams (invite will be direct)
Discussion Section Time:	T/R 10:50a - 12:05p CST
Discussion Section Location	DCH 1075 OR Microsoft Teams
Credits:	3
Education Requirement:	COMP417 may serve as an elective or capstone and COMP517 may serve as an elective
Syllabus Flexibility:	This syllabus is provided as a starting point for the semester. Specific topics and duration of coverage may change as the semester continues.
Survey:	`https://forms.gle/4BYLn2Z9bLNA7YLF8`

Overview and Purpose

Operating Systems are ubiquitous, allowing hardware to be used by multiple applications as if each owned the whole thing. The key is virtualization, along with a vast supply of libraries that simplify programming complex and diverse hardware. Although our present ecosystem of Android, iOS, and Windows seems relatively stable, it did not arrive overnight nor is it quite settled about what exactly an operating system should be and do. Additionally, in its role as both presenter and protector of digital information, operating system security is paramount, but security comes at the cost of performance and ease of use. With rising

attacks due to missing abstractions, mechanisms, and policies, will operating systems evolve?

In this course, we will explore key operating systems results by reading original discoveries and pair that with modern "hot" operating systems research to get a sense of where the field is going. Specifically, we will explore the structure of operating systems and how that structure impacts performance and security. The aim of this course is to understand the state-of-the-art while preserving what came before so that we can push the frontier of operating systems research. Research will take place through a semester long project occurring simultaneously with readings and discussions. Additionally, this course will instruct on how to develop research proposals, papers, and presentations.

Much is still to be said on the topic, what will you contribute to the discussion?

Prerequisites

This course assumes an introductory operating systems course has been completed (*e.g.* COMP 421/521). It also assumes a basic understanding of computer architecture.

Themes and Objectives

This course will examine foundations as well as hot topics in operating systems in order to develop a deeper understanding and appreciation of key design choices and their impact on security and performance. By completing this course you will be able to:

- Describe fundamental operating systems concepts such as layering, information hiding, and abstractions, mechanisms, and policies for information protection
- Describe fundamental differences between key operating system organizations: monolithic, virtual machine monitors, exokernel, microkernel, and nested kernel
- Describe principles for the operating system as an information protection system: including the key concepts of security engineering and protection systems
- Understand and describe solutions to key performance bottlenecks in modern operating systems design and implementation
- Understand and describe trade-offs between modern security approaches and performance

In addition, this course provides a context for learning how to think about and execute research. The primary objectives are:

- Systematically read and describe a paper's summary, strengths, weaknesses, key contributions, and a justification on those observations
- Write abstracts and introductions that quickly and precisely define the relevant contribution
- Create presentations that emphasize novelty of work in clear, simple language

Materials

The primary content for this course will be original scientific results and provided to students in the form of PDF downloads. We will rely heavily on discussion and online postings to track and evaluate reading and participation. Online postings platform: TBD. Other helpful materials include:

- How to read a research paper: `https://cseweb.ucsd.edu/~wgg/CSE210/howtoread.html`
- If you are interested or need to catch up on operating system basics, checkout OSTEP: http://pages.cs.wisc.edu/ remzi/OSTEP/

Course Sessions

You are responsible for knowing about all announcements made in lecture. We will discuss expectations about the project, suggestions for how to succeed, and grading guidelines in class, and general class policy issues, so make sure you don't miss any lectures. Each session will include a presentation on the required reading for the day which will be followed by discussion. In class we will discuss the papers in two different phases. First, we will break into small groups (3-4 students) to discuss the papers for 10-15 minutes before we break into larger groups. This small group discussion will be guided by a set of questions given to you at the beginning of each class. A few sessions throughout the semester will have a different organization.

Course Work

There are three primary aspects to this course: 1) getting to know the field, 2) learning how to critique and write research, and 3) carry out an original exploration of operating system research. In general, this course is covering scholarship in the context of operating systems. As such the core requirements will be to participate in weekly readings and discussions, lead discussions, and propose and execute a research project.

Weekly Readings and Online Posting

A major part of this course will be reading, analyzing, and discussing papers. We will cover one or two papers per lecture typically. Required readings for each class are posted on the class web site. For each required paper, your assignment is to read the paper carefully before the lecture and to post on the course newsgroup an insight or question about this paper. A good model is the comments and question that take place after someone presents a paper at a research conference. The postings can take many forms, for example, you could post any of the following:

- What you appreciated about the paper
- Where you felt the paper fell short
- Future work that the paper inspired you to think of
- Questions about the meaning of a section of the paper
- Comparisons between the paper and another paper or approach for the same problem
- Relationship between the problem being attacked in this paper and another problem
- How the paper relates to another paper or approach
- Speculation about how the author's idea would apply in a new situation
- Something you wished the author had addressed
- Assumptions in the paper that you disagree with and how you think different assumptions would affect the outcome
- Answering another student's question or following up on another student's comments

Your posting need not be long; the ideal is a few thought-provoking sentences. You should submit your posting to the group no later than 11:59pm on the day before we discuss the paper. You need not post anything for the papers being discussed during the first week (August 27 and 29), so your first posting will be about "The UNIX time-sharing system".

Participating in the class discussions on each paper is an important part of the class. Lively participation by the entire class will help us all understand the material better and have more fun in the process.

You are required to submit thoughtful comments before each class. For classes where we discuss two papers, you must submit comments about at least one of the two papers to get credit. You are allowed two classes where you do not submit comments to the newsgroup before omissions start to affect your grade.

Paper Presentation and Discussion Leader

Once during the semester, you and 1 or 2 teammates (1-3 per group) will be responsible for presenting the paper and leading the discussion. You can divide up the presentation responsibilities however you see fit and you will be graded as a group. Make sure at least one of the discussion leaders can attend class. You must present the paper(s) in a quals style where you assume everyone has read the paper, so you focus on the most important aspect of the work. You will also be responsible for clearing up any confusing aspects of the paper and for leading a discussion. For discussion topics, use the suggested newsgroup questions as a starting point for thinking about the type of things that would be useful for discussion.

Further details will be sent out shortly.

Please also note that you must still submit a newsgroup post as usual before your own presentation.

Course Project: Writings, Presentation, and System Building

You will design and carry out a semester-long research project (done in teams of 2-4). The hope is that these projects will lead to published papers, but need not be that by the end of the semester. You will need to coordinate your work using GitHub and make it possible for others to execute it.

- Group Selection and Topic Statement: select your partner and turn in a topic sentence.
- Proposal: Written proposal for the project that states the problem you will address, the motivation for why this is an interesting problem, the goal of your project, the relationship between your project and other work, the plan and methodology for your project, and the resources needed to carry out your project. Include a set of incremental milestones that you will achieve in carrying out the project and a schedule for meeting these milestones.
- Midterm Meetings: meet with me personally to check up on progress for schedule and milestones. The goal is to produce a real system, if implementing, or initial data for measurement projects.
- Midterm Report: Preliminary results and report, which is close to final report.
- Project Presentation: Each group will present their work at the end of the semester.
- Final Project Report: Final project report written in conference style.

I have project ideas, but encourage you to come up with a research idea by yourself. I encourage you to start this process early and to solicit feedback from me.

For any part of the project you turn in, you must Usenix two-column formatting. For an example, feel free to start from the latex template latex-template.tgz or you can use the latex template that I personally use for my papers (this one includes a makefile) latex-example.tgz. Note: You are required to use LaTeX in this class.

Participation

Learning in this course will be highly dependent upon the quality and contents of the discussion. Therefore, not only is attendance necessary, but also coming to the course prepared and contributing to the discussion.

Time Expectations

The readings should take approximately between 1-3 hours per lecture. Leading a discussion will require a more in depth examination of the text and alternative papers that will take approximately 10-15 hours to complete and prepare the presentation. Course projects should take around 50-90 hours total time throughout the semester.

Exams

There will no exams in this course.

Grading

Grades will be approximately weighted: Discussion and Participation 25%, Presentation and Discussion Lead 25%; and Project (50%). A complete distribution will be uploaded to Canvas with all associated assignments.

Course Policies

Professional Etiquette

We expect all of your interactions to be positive and never derogatory to anyone. We anticipate personal differences, but as you interact with others on the discussion boards, and in-class, we expect common courtesy and never condone offensive behaviors.

Attendance and Online Interaction

You and your peers will benefit from your presence at discussions. Attendance will be tracked to ensure you attend ten of the sessions, and your online interactions will be tracked to ensure that you complete the required assignments by the end of the course.

Accommodations

If you have a documented disability that may affect academic performance, you should: 1) make sure this documentation is on file with Disability Resource Center (Allen Center, Room 111 / adarice@rice.edu / x5841) to determine the accommodations you need; and 2) meet with me to discuss your accommodation needs.

Academic Integrity

The integrity of **your** work is a precious commodity. Any violations will addressed according to the Rice Honor Code.