

CS 5341/6341: Advanced Computer Architecture

CRNs: 18075/18076

Fall 2021, 12:00-1:20pm TR, LART 106

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Course Information: What this class is about and what we will do

COURSE DESCRIPTION

Until recently, the performance and power efficiency of computer systems improved steadily with scaling following Moore's Law and transistor efficiency following Dennard scaling. Now, however, device scaling has run into limits on performance and power improvements due to physical constraints. To continue to produce computer systems that are fast and energy efficient in the post-Moore and post-Dennard era, computer architects and systems designers are moving in exciting new directions. One direction has been the shift to parallel computer architectures and systems, including multicore and manycore processors, parallel execution models, and new cache coherency and memory consistency models. Another direction has been the incorporation of heterogeneous and specialized accelerators, including GPUs, TPUs, FPGAs, CGRAs, and ASICs. A third direction is the emergence of radically new types of hardware and software systems, including quantum computing, DNA-based computer systems, neuromorphic computing, and intermittent computing.

The course will begin with a review of the fundamentals of computer design and instruction set principles, followed by study of the basic principles underlying the design of today's computers, including advanced pipelining, instruction-level parallelism, memory-hierarchy design, storage systems, interconnection networks, and multiprocessors. We will also explore the three new directions described above by reading and discussing research papers, listening to and giving technical presentations, running experiments on real and simulated hardware, and planning and carrying out a term research project. The course will help prepare students for research involving aspects of advanced computer architecture and systems, or to work for a national laboratory or company developing or using advanced architectures for applications in high performance computing, large-scale data analysis, or machine learning.

COURSE PREREQUISITES

Programming experience in C/C++; CS 2302 Data Structures and CS 3432 Computer Architecture I, or CPS 5401; or permission of the instructor.

LEARNING OUTCOMES

At the end of this course, students will be able to:

- DESCRIBE and EXPLAIN current and future trends in computer architecture
- READ, UNDERSTAND, CRITIQUE, and PRESENT research papers in computer architecture
- DESIGN, IMPLEMENT, RUN, and EVALUATE RESULTS FROM microbenchmarks
- CONFIGURE, RUN, and EVALUATE RESULTS FROM architectural simulators
- COMPOSE clear and concise technical writing (e.g., paper reviews, research reports)
- DESIGN and CARRY OUT, and PRESENT RESULTS FROM experimental computer architecture research

TEXTBOOKS

Recommended but not required: Hennessy and Patterson, *Computer Architecture: A Quantitative Approach*, Sixth Edition, Morgan Kaufmann, 2019.

Other readings and materials will be posted in the weekly schedule.

COURSE ASSIGNMENTS AND GRADING

Assignments for this course will be assessed according to rubrics.

Grade Distribution:

1000-900 = A 899-800 = B 799-700 = C 699-600 = D 599 and Below = F

- 250 points: Lab Assignments
- 150 Points: Midterm Exam 1
- 150 Points: Midterm Exam 2
- 200 Points: Term Project
- 250 Points: Paper Reviews and Presentations

Lab Assignments: Lab assignments will be experimental work on real hardware systems or using architectural simulators. Experiments on real systems will involve running microbenchmarks and collecting and analyzing timing and hardware counter data. Experiments on architecture simulators (e.g., GEM5, Accel-Sim) will enable students to explore the effects of changing various hardware parameters and configurations and to explore new architectural features.

Midterm Exams: Midterm exams will assess achievement of the learning outcomes. Exams will have both in-class and take-home portions. The take-home portion will be different for 5341 and 6341 sections.

Term Project: The term project will be either an individual or a small group research project on a topic of your choice. The instructor will prepare a list of suggested topics, but you will be free to choose a different topic that interests you subject to instructor approval. 6341 students are required to investigate a research question for their project. 5341 students may opt to repeat or confirm previous research results or do an applied project.

Paper Reviews and Presentations: A research paper will be assigned each week. All students are responsible for reading and writing a review of each paper. The instructor will present the first paper. Subsequent paper presentations will be done by students in the class.

COMPUTER SYSTEM ACCESS

For class activities, homework, and lab assignments that involve programming, we will sometimes use our own computers and sometimes use Linux machines or clusters with multicore and GPU hardware and with software (e.g., architectural simulators) already installed. You should be familiar with Linux, using a command-line interface, and using Git for version control. If you need to brush up on or learn Linux skills, Software Carpentry has a nice set of tutorials at <https://github.com/swcarpentry/swcarpentry> .

Course Communication: How we will stay in contact with each other

In addition to seeing each other during class, please take advantage of the following:

- **Office Hours:** You may meet with me during my office hours either in person or on Teams. My office hours will be held during the following times:
Tuesdays: 1:30-2:30 p.m. Mountain Time
Wednesdays: 12-1 p.m. Mountain Time
Or by appointment
- **Email:** UTEP e-mail is the best way to contact me. I will make every attempt to respond to your e-mail within 24 hours of receipt. When e-mailing me, be sure to email from your UTEP student account and please put the course number in the subject line. In the body of your e-mail, clearly state your question. At the end of your e-mail, be sure to put your first and last name.
- **Online Discussion:** If you have a question that you believe other students may also have, please post it in the Chat in Teams. Please respond to other students' questions if you have a helpful response.
- **Announcements:** Check Teams frequently for any updates, deadlines, or other important messages. You can turn on notifications so that you will get an email about any updates.

ETIQUETTE

As we know, sometimes communication can be challenging. It's possible to miscommunicate what we mean or to misunderstand what our classmates mean, especially when communicating online given the lack of body language and immediate feedback. Therefore, please keep these etiquette and netiquette (network etiquette) guidelines in mind.

- Always consider the audience. This is a graduate-level course; therefore, all communication should reflect polite consideration of other's ideas.
- Respect and courtesy must be provided to classmates and to the instructor at all times. No harassment or inappropriate postings will be tolerated.
- When reacting to someone else's message, address the ideas, not the person. Post only what anyone would comfortably state in a face-to-face situation.
- Blackboard and Teams are not public internet venues; all postings to them should be considered private and confidential. Whatever is posted in these online spaces

is intended for classmates and professor only. Please do not copy documents and paste them to a publicly accessible website, blog, or other space.

Course Policies: What do you need to do to be successful in the course

ATTENDANCE AND PARTICIPATION

Your participation in the course is important not only for your learning and success but also to create a community of learners. Participation is determined by completion of the following activities:

- Reading/Viewing all course materials to ensure understanding of assignment requirements
- Participating in engaging discussion with your peers
- Participating in class sessions, or in the event that you are unable to attend a class and have an excused absence, viewing and commenting on class materials
- Other activities as indicated in the weekly assignments

EXCUSED ABSENCES AND COURSE DROP POLICY

According to UTEP Curriculum and Classroom Policies, "When, in the judgment of the instructor, a student has been absent to such a degree as to impair his or her status relative to credit for the course, the instructor may drop the student from the class with a grade of "W" before the course drop deadline and with a grade of "F" after the course drop deadline." See academic regulations in the UTEP Graduate Catalog for a list of excused absences. Therefore, if I find that, due to non-performance in the course, you are at risk of failing, I will drop you from the course. I will provide 24 hours advance notice via email.

DEADLINES, LATE WORK, AND ABSENCE POLICY

Lab Assignments

- Lab assignments will be due on Sundays at 11:59 PM. No late work will be accepted if the reason is not considered excusable.

Paper Discussion Assignments

- Paper reviews will be due at 11:59pm the day before the paper is scheduled to be discussed in class. Students should also come to call prepared to ask questions about the paper.

MAKE-UP WORK

Make-up work will be given *only* in the case of a *documented* emergency. Note that make-up work may be in a different format than the original work, may require more intensive preparation, and may be graded with penalty points. If you miss an assignment and the reason is not considered excusable, you will receive a zero. It is therefore important to reach out to me—in advance if at all possible—and explain with proper documentation why you missed a given course requirement. Once a deadline has been established for make-up work, no further extensions or exceptions will be granted.

INCOMPLETE GRADE POLICY

Incomplete grades may be requested only in exceptional circumstances after you have completed at least half of the course requirements. Talk to me immediately if you believe an incomplete is warranted. If granted, we will establish a contract of work to be completed with deadlines.

ACCOMMODATIONS POLICY

The University is committed to providing reasonable accommodations and auxiliary services to students, staff, faculty, job applicants, applicants for admissions, and other beneficiaries of University programs, services and activities with documented disabilities in order to provide them with equal opportunities to participate in programs, services, and activities in compliance with sections 503 and 504 of the Rehabilitation Act of 1973, as amended, and the Americans with Disabilities Act (ADA) of 1990 and the Americans with Disabilities Act Amendments Act (ADAAA) of 2008. Reasonable accommodations will be made unless it is determined that doing so would cause undue hardship on the University. Students requesting an accommodation based on a disability must register with the [UTEP Center for Accommodations and Support Services](#) (CASS). Contact the Center for Accommodations and Support Services at 915-747-5148, or email them at cass@utep.edu, or apply for accommodations online via the [CASS portal](#).

SCHOLASTIC INTEGRITY

Academic dishonesty is prohibited and is considered a violation of the UTEP Handbook of Operating Procedures. It includes, but is not limited to, cheating, plagiarism, and collusion. Cheating may involve copying from or providing information to another student, possessing unauthorized materials during a test, or falsifying research data on laboratory reports. Plagiarism occurs when someone intentionally or knowingly represents the words or ideas of another as one's own. Collusion involves collaborating with another person to commit any academically dishonest act. Any act of academic dishonesty attempted by a UTEP student is unacceptable and will not be tolerated. All suspected violations of academic integrity at The University of Texas at El Paso must be reported to the [Office of Student Conduct and Conflict Resolution \(OSCCR\)](#) for possible disciplinary action. To learn more, please visit [HOOP: Student Conduct and Discipline](#).

CLASS RECORDINGS

Some or possibly all class meetings may be recorded, depending on available technology. The use of recordings will enable you to have access to class lectures, group discussions, and review sessions in the event you miss a class meeting due to illness or other extenuating circumstances. Our use of such technology is governed by the Federal Educational Rights and Privacy Act (FERPA) and UTEP's acceptable-use policy. A recording of class sessions will be kept and stored by UTEP, in accordance with FERPA and UTEP policies. Your instructor will not share the recordings of your class activities outside of course participants, which include your fellow students, teaching assistants, or graduate assistants, and any guest faculty or community-based learning partners with whom we may engage during a class session. **You may not share recordings outside of this course.** Doing so may result in disciplinary action.

COPYRIGHT STATEMENT FOR COURSE MATERIALS

All materials used in this course are protected by copyright law. The course materials are only for the use of students currently enrolled in this course and only for the purpose of this course. They may not be further disseminated.

COVID-19 PRECAUTION STATEMENT

- Please stay home if you have been diagnosed with COVID-19 or are experiencing COVID-19 symptoms. If you are feeling unwell, please let me know as soon as possible, so that we can work on appropriate accommodations. If you have tested positive for COVID-19, you are encouraged to report your results to covidaction@utep.edu, so that the Dean of Students Office can provide you with support and help with communication with your professors. The Student Health Center is equipped to provide COVID-19 testing.
- The Center for Disease Control and Prevention recommends that people in areas of substantial or high COVID-19 transmission wear face masks when indoors in groups of people. The best way that Miners can take care of Miners is to get the vaccine. If you still need the vaccine, it is widely available in the El Paso area, and will be available at no charge on campus during the first week of classes. For more information about the current rates, testing, and vaccinations, please visit epstrong.org.

Course Resources: Where you can go for assistance

UTEP provides a variety of student services and support:

Technology Resources

- [Help Desk](#): Students experiencing technological challenges (email, Blackboard, software, etc.) can submit a ticket to the UTEP Helpdesk for assistance. Contact the Helpdesk via phone, email, chat, website, or in person if on campus.

Academic Resources

- [UTEP Library](#): Access a wide range of resources including online, full-text access to thousands of journals and eBooks plus reference service and librarian assistance for enrolled students.
- [University Writing Center \(UWC\)](#): Submit papers here for assistance with writing style and formatting, ask a tutor for help and explore other writing resources.
- [RefWorks](#): A bibliographic citation tool; check out the RefWorks tutorial and Fact Sheet and Quick-Start Guide.

Individual Resources

- [Military Student Success Center](#): Assists personnel in any branch of service to reach their educational goals.
- [Center for Accommodations and Support Services](#): Assists students with ADA-related accommodations for coursework, housing, and internships.
- [Counseling and Psychological Services](#): Provides a variety of counseling services including individual, couples, and group sessions as well as career and disability assessments.