CmpSci 535
Computer Architecture
Course Syllabus
Spring, 2025: MW 9:05 - 10:20 ET (2H30M/wk), In Person, CS142, 3 Credits

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Textbook: Computer Architecture A Quantitative Approach, 6th Ed.
John Hennessy and David Patterson, Morgan Kaufmann 2019

Course Goals: Modern computers present a user-facing interface, called the instruction set architecture (or ISA) that we use for programming them. But behind the ISA can lurk many different implementations, called the microarchitecture. To really appreciate why computers act as they do, it is necessary to understand the design decisions that stand behind each of these layers of implementation. This class focuses on a project in which you will design your own ISA, experiencing the tradeoffs that must be dealt with, and then implementing it in a software simulation, with four variations of microarchitecture that illustrate the impact of caches and pipelines. Along the way, we will explore many of the options and their implications, along with features more advanced than you will have time to incorporate in your simulator, through reading and discussing the most widely used text in the field. The class is meant to also serve as preparation for understanding cutting-edge research in architecture.

Course Notes: Slides, recordings of lectures, exercises, handouts, etc, will be on Canvas.

Grading: In-class exercises: 35% Reading Homework: 18%
Project Phase 1: 15% Project Phase 2: 14% Final Project Report: 14%
Team effort: 4% There are no exams

Grade Scale:
A: 94%, A-: 89%, B+: 85%, B: 80%, B-: 77%, C+: 74%, C: 70%, C-: 67%, D+ 63%, D: 60%

In-Class Work

Form: To help in starting the project and in solidifying concepts presented in class, exercises will be done in each class. These are due at the end of the class in which they are done. When they represent participation in team or group discussions, they must be done in class, unless prearranged due to an unavoidable absence. The exercises in the first two classes will be for practice, and will not count toward the grade.

Grading: The in-class work will total 35% of the grade. The number of exercises will depend on how the class is proceeding. If we fall behind, some may be skipped. There may be some days with multiple exercises, but each day will account for an equal fraction of the 35%. Project demo days will not have in-class exercises.

Submission Methods: Group discussion exercises will usually be submitted via a Canvas questionnaire or quiz. There will also be worksheets, often in the form of a Canvas quiz. When a worksheet is done collaboratively in a group, it is fine to copy and paste pieces. Everyone in the group **must** submit a copy.

Attendance: Not officially taken, but effectively required for this aspect of the class.

Reading Homework

Form: For each reading assignment (see class schedule document on Canvas) from February 10 through May 7 submit at least two questions pertaining to the reading. They can be aspects you would like clarified, or that you would like to know more about. In class there will be time to have a few of these answered. The book is the canonical text in the field, and goes into more depth than the lecture can cover, so it is worth reading.

Due Dates: They are each due on the date we are scheduled to cover the material in class.

Late Policy: Please do these on time in preparation for class. Partial credit if handed in late unless arranged in advance.

Collaboration: The purpose of this homework is to encourage you to do the reading. That's impossible to do collaboratively. It should be fairly easy to jot down a couple of original questions as you go through it. But if I find that people are submitting copies of the same questions, I will divide the credit among the copies.

Grading: Each homework is 1% of the grade. There are 18 of them. You can get extra credit by asking more than two questions (up to four).

Semester Project (see the detailed description document on Canvas):

Overview: The project involves designing an architecture and a simulator for it that enables accurate measurement of execution time. This is probably where you will learn the most in the class, as you work through design decisions and implementation details. I encourage you to be creative in your design. In addition to the simulator you will write an assembler, and at least two benchmark programs. The project work is divided into two phases. See the separate handout for the details of the project.

Team effort: The project is best done as a two-person team. Three person teams can be more difficult to manage and thus present a greater risk of failure. They will be considered only when a team has identified a set of ambitious goals that need the extra labor, and a clearly defined project management strategy designed to ensure success. 4% of the grade is allocated for evaluation of the effectiveness of the team in working together. It is *very* challenging to do this project alone. For individual projects, this fraction becomes additional emphasis on use of good software engineering methodology and tools, and staying on schedule. At each demo, each team member is expected to report on their assigned tasks in terms of progress to date and goals to be achieved before the next demo.

Phase one consists of (1) the ISA design proposal and presentation, (2) a demo of the memory subsystem, and (3) a demo of the functional simulation with a minimal subset of instruction types and basic user interface. Each of these components is 5% of the grade.

Phase two consists of (1) a demo of the simulator with all of the instructions operational, a complete user interface, and a working assembler, and (2) a final demo showing the two benchmarks running in all four modes of operation. Each of these demos is 7% of the grade. A draft final report is submitted with the last demo, to get feedback.

Report: You will submit a final report on the project that is worth 14% of the grade. It is due at the time scheduled for the final exam.

Teamwork tips: Your grade for the semester is partially dependent on your performance as a team. Some ways that you can help to ensure that your team does well:

Be realistic with your partner in discussing your abilities and time commitments when you divide up project work. Look at the long-term project workload – you can partition the work over the semester as well as on each module.

Be explicit in your expectations of each other. Write them down and give everyone a copy.

Make sure that you have each other's schedules, phone numbers, e-mail addresses, etc. Establish a clear policy of when it is OK to contact one another. Let each other know when you are going to be unavailable with enough advance warning for good contingency planning.

Communicate! Tell each other what you are thinking. Don't keep thoughts inside. Praise each other for jobs well done. If you feel the need to criticize, use statements that start with "I think…." or "I feel…" Avoid criticism with the accusatory "You did…," or "You always…"

Think of yourselves as a team. Develop some team spirit. Name your team or your architecture. Develop a unique style for your team homework and demos (e.g., team colors, a logo). Get to know each other as individuals. Do lunch. Discuss hobbies, career goals. If you each take the time to care about one another, then you'll do what it takes to excel as a team.

Extension Requests: If you have an accommodation from Disability Services that allows for extensions on assignments, you only need to tell me that you are requesting one as per your accommodation. I automatically get a letter from them at the start of the semester. If you have a chronic health issue that sometimes interferes with your ability to attend class or finish homework on time, then you should enquire with them to see if you can get an accommodation (**https://www.umass.edu/disability/**). If you become sick, you can also ask for an extension, but please accompany the request with some documentation, such as a note from your doctor or UHS (if you're sick, you should at least do a telehealth screening to be sure it isn't something serious), a picture of a positive Covid or flu test or thermometer showing a fever, etc. As mentioned above, if you have a known time conflict, such as an away game, please ask in advance.

Learning Outcomes: You are a unique human being with your own history and capacities. Not a vessel to be filled or an animal to be trained. Therefore, what you learn in this class will be a unique set of concepts, capacities, and understanding. The class is structured to provide you with a set of experiences in which you gain a deeper understanding of how modern processors are designed and simulated, and how the lowest layer of the software development stack is built. The grading criteria are an opportunity for you to demonstrate that you have engaged fully with these experiences, and that you are able to take what you have learned and apply it in a creative manner. This is not an outcome-oriented learning environment, with a goal of ensuring that every student will answer the same question on the same test the same way. It's your responsibility to bring your whole self to the experiences, and to creatively show what you've gained from them.

Course Inclusiveness Statement: No matter who you are or how you define yourself you are welcome in this class. Each person here is a human being deserving of dignity and respect. My goal is to help you learn the subject matter in a way that you will find useful, and to help you have an enjoyable and empowering experience in doing so. It is important to keep in mind that we are all coming to this class with different backgrounds. For some, this may be a first hardware course, while others have significant prior experience. We are all here to learn together! There are no dumb questions! From time to time, I may enlist some students to help others in class. If I ask you to help, remember that we all have different modes of learning, and there is no stigma to be associated with needing assistance. Please reach out to me if you have any concerns.

Pronouns Policy Statement: Everyone has the right to be addressed by the name and pronouns that they use for themselves. You can indicate your preferred/chosen first name and pronouns on SPIRE, which appear on class rosters. I will do my best to ensure that I address you with your chosen name and pronouns. Please let me know what name and pronouns I should use for you if they are not on the roster. Please remember: A student's chosen name and pronouns are to be respected at all times in the classroom.

University Accommodation Statement: The University of Massachusetts Amherst is committed to making reasonable, effective and appropriate accommodations to meet the needs of students with disabilities and help create a barrier-free campus. If you have a disability and require accommodations, please register with Disability

Services to have an accommodation letter sent to your faculty. Information on services and materials for registering are also available on the University of Massachusetts Amherst Disability Services page

University Academic Honesty Statement: Since the integrity of the academic enterprise of any institution of higher education requires honesty in scholarship and research, academic honesty is required of all students at the University of Massachusetts Amherst. Academic dishonesty is prohibited in all programs of the University. Academic dishonesty includes but is not limited to: cheating, fabrication, plagiarism, and facilitating dishonesty. Appropriate sanctions may be imposed on any student who has committed an act of academic dishonesty. Instructors should take reasonable steps to address academic misconduct. Any person who has reason to believe that a student has committed academic dishonesty should bring such information to the attention of the appropriate course instructor as soon as possible. Instances of academic dishonesty not related to a specific course should be brought to the attention of the appropriate department Head or Chair. Since students are expected to be familiar with this policy and the commonly accepted standards of academic integrity, ignorance of such standards is not normally sufficient evidence of lack of intent (http://www.umass.edu/dean_students/codeofconduct/acadhonesty/).

University Title IX Policy Statement: In accordance with Title IX of the Education Amendments of 1972 that prohibits gender-based discrimination in educational settings that receive federal funds, the University of Massachusetts Amherst is committed to providing a safe learning environment for all students, free from all forms of discrimination, including sexual assault, sexual harassment, domestic violence, dating violence, stalking, and retaliation. This includes interactions in person or online through digital platforms and social media. Title IX also protects against discrimination on the basis of pregnancy, childbirth, false pregnancy, miscarriage, abortion, or related conditions, including recovery. There are resources here on campus to support you. A summary of the available Title IX resources (confidential and non-confidential) can be found at the following link: https://www.umass.edu/titleix/resources. You do not need to make a formal report to access them. If you need immediate support, you are not alone. Free and confidential support is available 24 hours a day / 7 days a week / 365 days a year at the SASA Hotline 413-545-0800.

Members of the CICS community can also contact Erika Lynn Dawson Head, director of diversity and inclusive community development (erikahead@cics.umass.edu | 860-770-4770).