2020

CS 485 Computer Architecture

Danyang Zhang
CUNY York College

CS 485 Computer Architecture

4 hours 4 credits (face to face)
Monday, Wednesday 4:00-5:50 pm in AC-2E03A
Blackboard *2020 Spring Term (1) Computer Architecture CS 485 EF[41266] (York College)*

Danyang Zhang, Ph.D.
Associate Professor
Department of Mathematics and Computer Science
School of Arts and Sciences
York College, The City University of New York
Office: AC-2D04
Office Hours: Monday, Wednesday 3:00-4:00pm
Phone: (718)262-2560
Email: dzhang@york.cuny.edu

Prerequisites

CS 397 Assembly Language Programming

Course Description

Computer Architecture 4 hrs. 4 crs. Logical devices and digital circuits, data representation, register transfer, central processor organization, microprogram control and organization. Preq: CS 397. 4 hours lecture.

Course Narrative

This course will present the basic concepts and technologies in computer organization and architecture. For example, logical devices and digital circuits, data representation, register transfer, central processor organization, microprogram control and organization, parallel computing. Although there could be multiple perspectives in studying computer architecture, our focus would be to better understand computer organization in order to design more efficient and reliable application software. The OER (Open Educational Resources) session of this course will have no textbook required (ZTC: Zero Textbook Cost), conduct lectures based on online resources and other open educational resources, and have students involved in active learning including giving presentations and creating and sharing open pedagogical materials, e.g., students need to finish four writing projects in this class (refer to course schedule on page 6) where each project is to write an article about a given topic in computer architecture on Wikipedia. Students writing articles about what they are learning can help them understand the course contents creatively.

Required learning materials

Since this is an OER session of computer architecture class, no textbook is required and students mainly refer to lecture slides, online text tutorials (ppts and pdfs), online video tutorials (YouTube), and other online resources (Wikipedia). For example,

1) https://www.geeksforgeeks.org/computer-organization-and-architecture-tutorials/ (online text tutorial, if a window pops up when clicking the above link, simply click ok button or close the window)

2) https://www.javatpoint.com/computer-organization-and-architecture-tutorial (online text tutorial, if a window pops up when clicking the above link, simply click ok button or close the window)
3) https://tutorialspoint.dev/computer-science/computer-organization-and-architecture (online text tutorial)
4) http://www.bottomupcs.com/ (online text tutorial)
5) https://www.bottomupcs.com/csbu.pdf (online digital book pdf)
6) https://www.youtube.com/channel/UCIwQ8uOeRFgOEvBLYc3kc3g (online video tutorial)
7) https://en.wikipedia.org/wiki/Computer_architecture (Wikipedia page, more links)

Course Requirements

- Submission labs
- Presentation labs
- Writing assignments
- Midterm exam
- Final exam
- Attendance
- Class participation

Learning Objectives

By the end of the semester, students will be able to:

1) identify the computer level hierarchy;
2) demonstrate data representations and design digital logic;
3) identify instruction set architectures;
4) illustrate memory hierarchy;
5) differentiate how I/O and storage systems work;
6) recognize the basics of parallel and multiprocessor architectures;
7) write articles about computer architectures fluently.

Ancillary Learning Objectives

By the end of the semester, students will also be able to:

1) improve active learning skills through presentation and writing Wikipedia articles;
2) collaborate with group members smoothly;
3) demonstrate clearly understandable presentation skills by presenting at least two labs per group in front of the class.

Final Exam Sample

1. Computer system model questions, for example:

What is The von Neumann Model? Describe how it works in general, and then give a specific example to explain it in detail (e.g. how is the assembly language code Add R1, First executed?)

2. Number representation questions, for example:

Convert the following decimal number to binary number with a maximum of six places to the right of the binary point: 26.78123

3. Error detection and correction questions, for example:

Suppose you want to send out 1110110, and the CRC polynomial is 1011. What data do you actually send out by using CRC syndrome?

4. Boolean function and digital circuit questions, for example:

Simplify the following Boolean function and draw the corresponding digital circuit:

$F(x, y, z) = (x + \overline{y})(x + y)(x\overline{z})$

5. Instruction set questions, for example:

In Marie (a simple computer system architecture), what does the following two instructions mean respectively?
(1). What is the RTL for the SUBT instruction?
(2). What does instruction 1000010000000000 mean?

6. Effective access time (EAT) questions, for example:

Consider a system with a main memory access time of 150ns supported by a cache having a 6ns access time and a miss rate of 2%.
(1). If the accesses do not overlap, how much is the EAT?
(2). If the accesses overlap, how much is the EAT?

7. Memory management questions, for example:

Suppose a system has a virtual address space of 8K and a physical address space of 4K, and the system uses byte addressing with 1KB per page and the following page table,

3	1
-	0
-	0
1	1
0	1
2	1
-	0
-	0

What happens when CPU generates address 3070_{10}?

Grading Breakdown

Submission and Presentation Labs	25%
Writing Assignments	20%
Midterm exam	15%
Final Exam	30%
Attendance and Class Participation	10%

Course and Instructor Policies

1. Attendance is **MANDATORY**. Students are required to attend each class. For absence due to emergency reasons, related documentation needs to be submitted to the instructor.
2. Labs, projects and writing assignments are primarily completed in groups. Each group usually contains three students. Groups are formed by students themselves.
3. Report to the instructor if any group member does not contribute to the completion of the labs or assignments. No contribution, no credits.
4. Late submissions will **NOT** be accepted without a college verified excuse.
5. Other academic policies. Refer to "Academic Integrity Policy" below.

York College and CUNY Policies

- **Policy on Academic Integrity**
  Academic dishonesty is prohibited. Penalties include failing grade, suspension, and expulsion:
  http://web.cuny.edu/academics/info-central/policies/academic-integrity.pdf
  No use of cell phone or any communications device during class and exam hours; No cheating, no act of plagiarism in any forms or media. Students are required to follow the CUNY policy on academic integrity, which is available on the CUNY site above. A brief description of the policy is also included in the Schedule of Classes booklet.

- **Policy on INC grades**
  A student who, because of extenuating circumstances, has not taken the final examination and/or completed the work for the course and has a passing average may be assigned an INC grade.

  The student, in consultation with the instructor, has up to 10 weeks in the subsequent semester to complete the work and have the grade resolved even if not registered in the subsequent semester.

  Grade changes resolving INC grades must be received by the Office of the Registrar by the last day of the 10th week of classes of the subsequent semester. (See Academic Calendar for exact due date) Grades received after the deadline will not be processed unless the student has obtained approval form the Committee on Academic Standards.

  The grade of INC is not considered in computing the academic index. However, if a grade change is not received by the Office of the Registrar within the above specified limits, the grade of INC is changed to FIN. This grade is considered an F grade when computing the academic index. When compiling the Dean's List INC grades are calculated as F.

  For more, refer to https://www.york.cuny.edu/academics/policies/grading-policies

- **Policy on accommodations for disabled students**
  Special arrangement can be made for students with verification letter from the Office in 1G02.

Student Support Resources

IT Service Desk at AC 3G01
by Phone: (718) 262-5300, or x5300 on campus
online Y-Connect: https://www.york.cuny.edu/it/service-delivery-unit/y-connect

(CTLET) Center for Teaching, Learning and Educational Technologies
Blackboard and Online Technologies
Walk-in Hours:
Mornings and all Fridays in room AC-4G01
Mondays and Wednesday
9 AM to 12 PM
Tuesdays to Thursdays
9 AM to 11 AM

Afternoons in room AC-4EA1
Mondays and Wednesday
12 PM to 5 PM
Tuesdays to Thursdays
11 AM to 5 PM

Phone: (718) 262- 5219
Email: bbhelp@york.cuny.edu

Library Reference Desk at AC 3G01
by Phone: (718)262-2034

Course Schedule

Day 1 (01/27/20): Discussion about Class Participation, Syllabus, what OER means, and class policies; divide students into groups where each group contains about three students.
Reading assignment: Computer components

Day 2 (01/29/20): Lecture on computer components such as CPU, motherboard, memory, hard drive, and monitor.
Lab 1 (presentation lab): All groups work on how to build a computer by a given budget and one group will be randomly chosen to present their work.
Reading assignment: Historical development of computers

Day 3 (02/03/20): Lecture on historical development of computers including the four generations of computers with the development of computer processors; von Neumann model; Moore's Law; Rock's Law; The Computer Level Hierarchy.
Lab 2 (submission lab): All groups work on a question about von Neumann model and each group needs to submit the lab by the end of the class.
Reading assignment: Number conversion: how to convert numbers with different bases

Day 4 (02/05/20): Lecture on number conversion; two methods converting decimal numbers into binary numbers: subtraction method and division method
Lab 3 (presentation lab): All groups work on a question about number conversion and one group will be randomly chosen to present their work.
Reading assignment: How to convert fractional numbers in decimal into numbers in binary

Day 5 (02/10/20): Lecture on number conversion; two methods converting decimal fractional numbers into binary numbers: subtraction method and multiplication method; signed integer representation: signed magnitude
Lab 4 (submission lab): All groups work on a question about number conversion and each group needs to submit the lab by the end of the class.
Writing Project 1: Each group writes a Wikipedia article about how to convert decimal numbers into binary numbers including the whole number part and the fractional part (due in two weeks).
Reading assignment: Signed integer representation: one's and two's complement

Note: 02/12/20 and 02/17/20: college is closed – no classes scheduled.

Day 6 (02/19/20): Lecture on signed integer representation: one's complement and two's complement; signed integer addition
Lab 5 (submission lab): All groups work on a question about signed integer addition and each group needs to submit the lab by the end of the class.
Reading assignment: Booth's algorithm

Day 7 (02/24/20): Writing Project 1 is due.
Lecture on overflow; Booth's algorithm
Lab 6 (presentation lab): All groups work on a question about Booth's algorithm and one group will be randomly chosen to present their work.
Reading assignment: Floating-point number representation

Day 8 (02/26/20): Lecture on Floating-point number representation
Lab 7 (submission lab): All groups work on a question about floating-point number representation and each group needs to submit the lab by the end of the class.
Reading assignment: IEEE Floating-point number representation

Day 9 (03/02/20): Lecture on IEEE Floating-point representation
Lab 8 (presentation lab): All groups work on a question about IEEE floating-point number representation and one group will be randomly chosen to present their work.
Reading assignment: Error detection and correction: cyclic redundancy checking

Day 10 (03/04/20): Lecture on character codes and cyclic redundancy checking (CRC)
Lab 9 (presentation lab): All groups work on a question about cyclic redundancy checking (CRC) and one group will be randomly chosen to present their work.
Writing Project 2: Each group writes a Wikipedia article about how to correct and detect one bit errors in computer communications and storage. (due in two weeks).
Reading assignment: Error detection and correction: Hamming codes

Day 11 (03/09/20): Lecture on Hamming codes
Lab 10 (submission lab): All groups work on a question about Hamming codes and each group needs to submit the lab by the end of the class.
Reading assignment: Boolean algebra

Day 12 (03/11/20): Lecture on Boolean algebra
Lab 11 (submission lab): All groups work on a question about Boolean algebra and each group needs to submit the lab by the end of the class.
Reading assignment: Logic gates and Combinational circuits

Day 13 (03/16/20): Lecture on logic gates and combinational circuits
Lab 12 (presentation lab): All groups work on a question about combinational circuits and one group will be randomly chosen to present their work.
Reading assignment: Basic sequential circuits

Day 14 (03/18/20): Writing Project 2 is due.
Lecture on basic sequential circuits
Lab 13 (submission lab): All groups work on a question about sequential circuits and each group needs to submit the lab by the end of the class.
Reading assignment: Advanced sequential circuits and circuit design

Day 15 (03/23/20): Lecture on advanced sequential circuits and circuit design
Lab 14 (presentation lab): All groups work on a question about advanced sequential circuits and one group will be randomly chosen to present their work.
Reading assignment: Review all contents studied so far
Midterm exam will be in one week

Day 16 (03/25/20): Review class
Midterm exam will be in one week

Day 17 (03/30/20): Midterm exam
Reading assignment: CPU basics and memory organization

Day 18 (04/01/20): Lecture on CPU basics and memory organization
Lab 15 (presentation lab): All groups work on a question about bus and one group will be randomly chosen to present their work.
Reading assignment: registers and instructions

Day 19 (04/06/20): Lecture on registers and instructions
Lab 16 (submission lab): All groups work on a question about registers and each group needs to submit the lab by the end of the class.
Writing Project 3: Each group writes a Wikipedia article about what happens inside a computer processor when an instruction is being processed. (due on 04/22).
Reading assignment: instruction processing and real world architecture

04/08-04/16 Spring Recess.

Day 20 (04/20/20): Lecture on instruction processing and real world architecture
Lab 17 (submission lab): All groups work on a question about instruction processing and each group needs to submit the lab by the end of the class.
Reading assignment: instruction formats

Day 21 (04/22/20): Writing Project 3 is due.
Lecture on instruction formats
Lab 18 (presentation lab): All groups work on a question about instruction formats and one group will be randomly chosen to present their work.
Reading assignment: addressing and instruction pipelining

Day 22 (04/27/20): Lecture on addressing and instruction pipelining
Lab 19 (submission lab): All groups work on a question about instruction pipelining and each group needs to submit the lab by the end of the class.
Writing Project 4: Each group writes a Wikipedia article about how cache memory makes data retrieval more efficient and how virtual memory increases memory storage capacity. (due on 05/13).
Reading assignment: cache memory

Day 23 (04/29/20): Lecture on cache memory
Lab 20 (presentation lab): All groups work on a question about cache memory and one group will be randomly chosen to present their work.
Reading assignment: fully associative cache and set associative cache

Day 24 (05/04/20): Lecture on fully associative cache and set associative cache
Lab 21 (submission lab): All groups work on a question about set associative cache and each group needs to submit the lab by the end of the class.
Reading assignment: virtual memory: page management

Day 25 (05/06/20): Lecture on virtual memory: page management
Lab 22 (presentation lab): All groups work on a question about page management and one group will be randomly chosen to present their work.
Reading assignment: virtual memory: segment management

Day 26 (05/11/20): Lecture on virtual memory: segment management
Lab 23 (submission lab): All groups work on a question about segment management and each group needs to submit the lab by the end of the class.
Reading assignment: review all contents studied in this semester.

Day 27 (05/13/20): Writing Project 4 is due.
Review all the contents studied in this semester.

Day 28 (05/18/20): Final exam.