

CMPE 110: Computer Architecture

Week 1

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[Adapted in part from Jose Renau, Mary Jane Irwin, Joe Devietti, Onur Mutlu, and others]

Today

- Course administrivia
- Introduction to this class
 - What is computer architecture
 - Why study computer architecture

Course administrivia

- Class Meetings
 - M/W/F, 1:20 to 2:25pm in Earth&Marine B206, Sep. 23rd ~ Dec. 2nd
- Instructor
 - Jishen Zhao (jishen.zhao@ucsc.edu)
 - Office Hours: M/W 2:50 – 3:50pm/Office: Engineering 2 Room 217
- TAs
 - Rebecca Rashkin (rrashkin@ucsc.edu): Office hours TBD
 - Xin Li (xli178@ucsc.edu): Office hours TBD
 - Narendra Kumar Govinda Raju (nagovind@ucsc.edu): Office hours TBD
 - Abdulazaz Albalawi (aalbalaw@ucsc.edu): Office hours TBD
 - (Plus 5 graders)
- MSI Tutors
 - Learning assistant: Lawrence Chong (lchong2@ucsc.edu)
 - Tutor: Bowen Yi (boyi@ucsc.edu)

Course administrivia

- Instructor responsibility
 - Lectures
 - Create quizzes, help create homeworks
 - Create exams
 - Office hours
- TA responsibility
 - Grade HWs, exams, and quizzes
 - I'll go over every homework before posting grades
 - I'll also propose most of HW questions
 - Office hours & discussion sessions
 - Answer questions at Piazza

Course administrivia

- Discussion sessions: Q&A, lectures run by TAs
(NOT Mandatory)
 - Section 1: Tue 08:30 - 09:35am in Kresge Clrm 327 TA: TBA
 - Section 2: Wed 04:00 - 05:05pm in Kresge Clrm 327 TA: TBA
 - Section 3: Wed 05:20 - 06:25pm in Kresge Clrm 327 TA: TBA
 - Section 4: TBA TA: TBA
- Open to all enrolled students

DRC accommodations

- Student responsibilities are as follows:
 - 1. Students contact the DRC to determine their eligibility for accommodations. When approved by DRC, they will receive their Accommodation Authorization form.
 - 2. Students then notify their instructor during office hours or after class of their accommodations, and provide their instructor with their Accommodation Authorization form (**physically printed forms**).
 - 3. Please note that it is the student's responsibility to contact the instructor about their accommodations. If they do not contact their instructor, accommodations will not be made.

Course administrivia

- Course Websites: [Google site](#) + [eCommons](#) + [Piazza](#)
 - Google site: (link on UCSC course web page)
Calendar, slides, lecture notes, homework questions and solutions, etc.
<https://sites.google.com/a/ucsc.edu/cmpe110-computer-architecture-fall-2016/>
 - eCommons: Homework submissions, quiz and submissions, grades
<https://ecommons.ucsc.edu/portal/site/a65354fb-b479-4c0a-bdec-60c7068039c3>
 - Piazza: Announcements, Q&A, discussions, polls
<https://piazza.com/class/ite44w7e9an2nf>



The screenshot shows the homepage of the CMPE110 course website. The header features a dark background with colorful bokeh light effects and the text "CMPE110: Computer Architecture Fall 2016". Below the header is a navigation bar with five links: "HOME", "ANNOUNCEMENTS", "CALENDAR", "LECTURE NOTES", and "ASSIGNMENTS". The "HOME" link is underlined and highlighted with a red oval. The "CALENDAR" link is also highlighted with a red oval. The main content area contains sections for "Course Description" and "Prerequisite(s)".

Course Description:
This course provides an introduction to computer architecture, including examples of current approaches and the effect of technology and software. Computer performance evaluation, basic combinatorial and sequential digital components, different instruction set architectures (ISAs). Evolution of CPU microarchitecture from single-cycle to multi-cycle pipelines. Memory system, cache, virtual memory, and relationship between memory and performance. Evolution of PC system architecture. May include advanced topics, such as parallel processing, GPU, and cloud computing.

Prerequisite(s):
Courses 12/L, and courses 13/L or Computer Science 12A/L or Computer Science 11. Course 16 recommended. If you do not have the appropriate background, you should either 1) not take this class or 2) spend significant time reviewing

Lecture notes

- PPTX files will be posted before each class. These are for you to preview the materials for each class, may have minor errors.
- PDF files will be posted after each class. These are the ones you should use for reviewing the class, homework, quizzes, and exams.

Class Schedule at the Google site

The screenshot shows a Google Calendar view for the course CMPE 110. The calendar interface includes a header with 'Today' and navigation arrows, followed by the date 'Friday, September 23'. Below the header, it says 'Showing events after 8/15. [Look for earlier events](#)'. The main area displays a weekly schedule from September 23 to October 7, 2011. The events listed are:

- Friday, September 23:** 1:20pm Introduction
- Monday, September 26:** 1:20pm Performance
- 2:50pm Prof. Zhao's office hour**
- Wednesday, September 28:** 1:20pm Performance & ISA
- 2:50pm Prof. Zhao's office hour**
- Friday, September 30:** 1:20pm ISA
- Monday, October 3:** 1:20pm ISA & Datapath
- 2:50pm Prof. Zhao's office hour**
- Wednesday, October 5:** 1:20pm In-class Quiz
- 2:50pm Prof. Zhao's office hour**
- Friday, October 7:** 1:20pm Datapath

At the bottom, it says 'Events shown in time zone: Pacific Time' and has a 'Google Calendar' link.

Homework submission

- Questions will be posted on the Google site
- Submission: Electronically through eCommons
- NO hard copy
- Four homeworks
- **Usually due at 11:59pm**

The screenshot shows the eCommons interface for the CMPE 110 Computer Architecture course. The left sidebar includes links for Home, Announcements, Calendar, Polls, Assignments, Gradebook, Tests & Quizzes, Roster, Site Editor, and Help. The main content area displays the 'Site Information Display' for '20688 LEC 01: CMPE 1 ...' and the 'Recent Announcements' section, which states 'There are currently no announcements at this location.' Below that is the 'Calendar' section for September 2015, showing dates from 30 to 3. The calendar highlights the 24th as the due date.

Homework and Quiz Late Policy

- **Late penalty for each homework/quiz**
 - One day (i.e., by 11:59pm the second day): 25% off
 - Two days: 50% off
 - Three days: 100% off
- **No exception, no excuse, in any case**
 - E.g., I submitted the wrong file, I fell asleep, I forgot to submit my homework, I don't know how to use eCommons, my computer was broken down...
 - Only DRC students can ask for extension through **documents**

Piazza for announcements, Q&A, discussions, polls Enroll yourself at Piazza, if not already

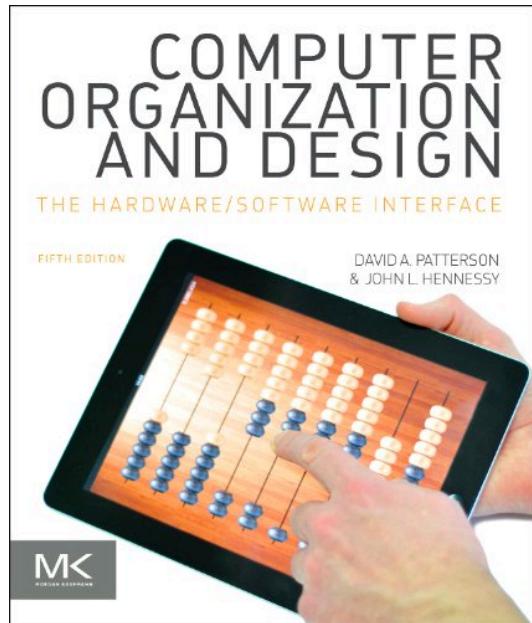
The screenshot shows the Piazza interface. On the left, there's a sidebar with navigation links like 'polls', 'hw1', 'hw2', 'hw3', 'hw4', and a search bar. The main area has a post titled 'Read tips and tricks for a successful Piazza Class' with a 'read now' button. Below it is a section for 'Enroll your students' where email addresses can be pasted. A progress bar shows '202 enrolled' out of 220. At the bottom, there's a reminder to 'Set up your Course Page'.

Why Piazza

- More flexible like anonymous questions
- Android app
- Good feedback from students, TAs, and instructors of previous classes
- DO NOT send me, TAs, or tutors emails, if you can post your question at Piazza
- Piazza is the best place to get quick answers

Textbooks (not required)

- No required textbook
- Everything will be in the lecture notes, homeworks, materials distributed through course websites
- I will provide a copy of questions if needed

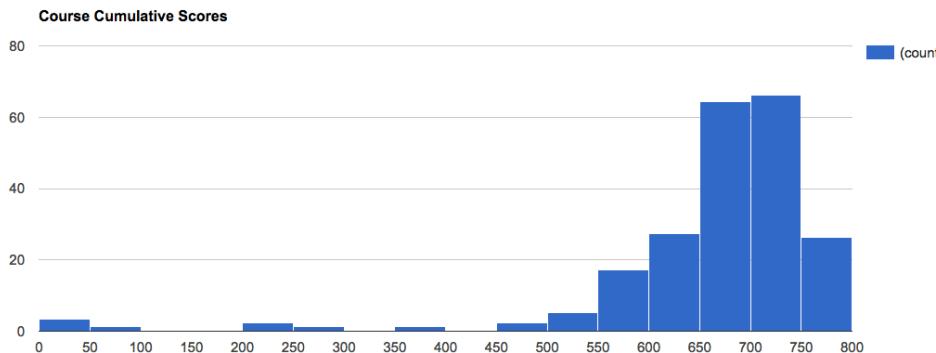


Grading

- Homework: 32% (around 8% per homework)
- Exams: 60%
 - Midterm1: 15%
 - Midterm2: 15%
 - Final: 30%
- * Exams are closed book, closed notes
- Quizzes: 8%
 - Four quizzes
 - Around 2% per quiz

Smiling: 0% 😊

Curve of previous class



- Scale 100% to 800
 - A: > 750 (~10%); A-: > 650 (~30%)
 - B: > 550; B-: > 450
 - C: > 350; C-: > 250
 - D: > 150; D-: > 50
 - Etc.

No cheating

- No tolerance for cheating
 - Homework, quizzes, and exams are done INDIVIDUALLY
- UCSC Academic Misconduct Policy
 - https://www.ue.ucsc.edu/academic_misconduct
 - Disciplinary hearings are no fun
- We will have a new set of homework and exam questions different from last year

Questions?

Introduction to Computer Architecture

Course focus: Computer Architecture

Computer
Assembly



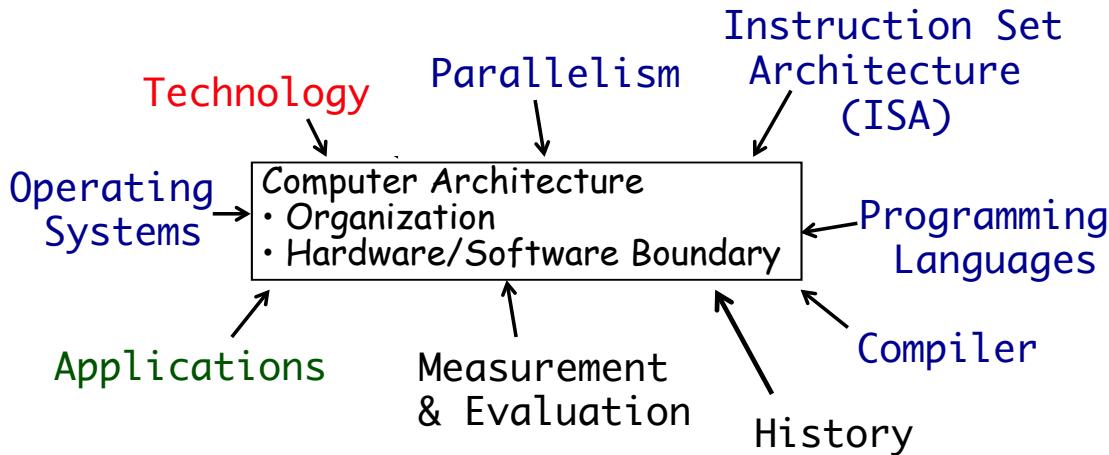
Course focus:

Basic ideas about Computer Organization and
Hardware/software interface



Computer architecture: Relationship with other disciplines

Standing at the boundary of hardware and software



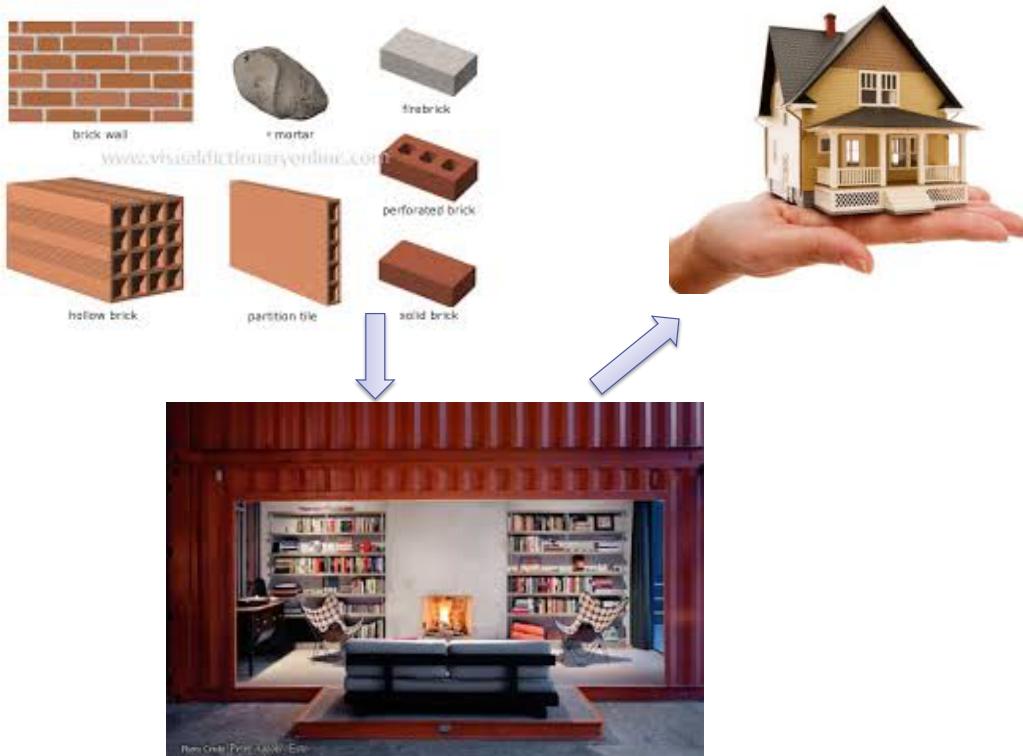
Why study computer architecture?

- **Understand where computers are going**
 - Future capabilities drive the (computing) world
 - Real world-impact: no computer architecture → no computers!
- **Understand high-level design concepts**
 - The best architects understand all the levels
 - Devices, circuits, architecture, compiler, OS, applications
- **Understand computer performance**
 - learn valid experimental methodologies
- **Write better software**
 - The best software designers also understand hardware
 - Need to understand hardware to write fast software
- **Design hardware**
 - At Intel, AMD, IBM, ARM, Qualcomm, Oracle, NVIDIA, Samsung

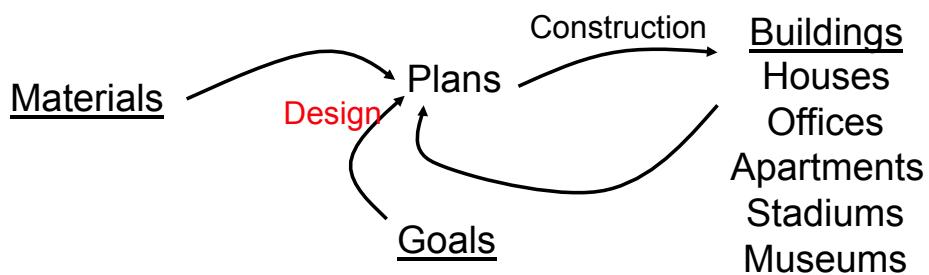
What is Computer Architecture?

What is Computer Architecture?

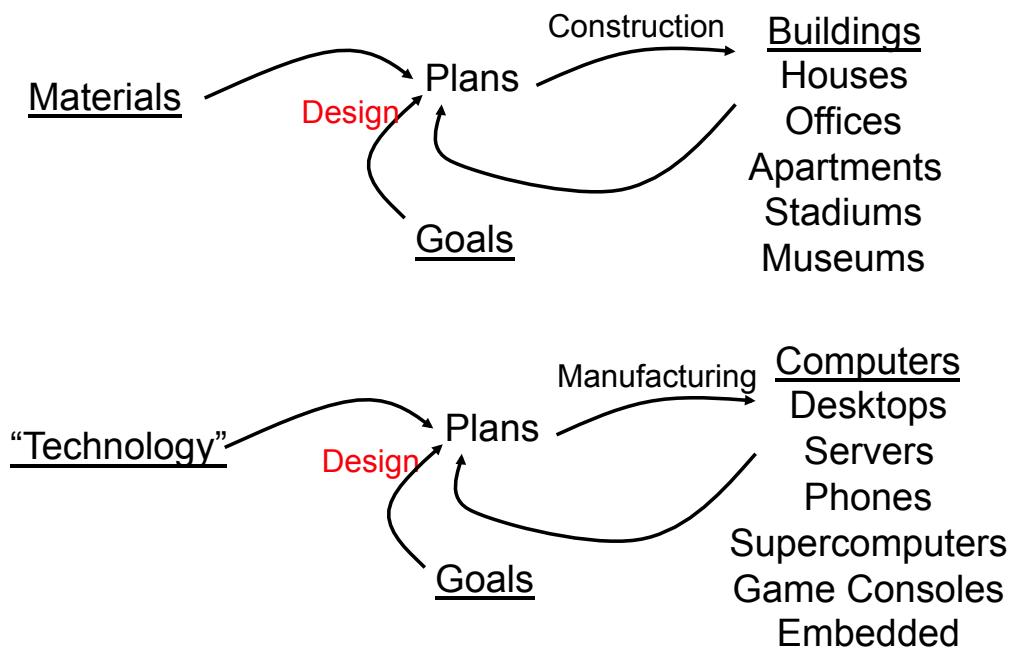
- "*Computer Architecture* is the science and **art** of selecting and interconnecting hardware components to create computers that meet functional, performance and cost goals." - WWW Computer Architecture Page
<http://pages.cs.wisc.edu/~arch/www/>
- An analogy to architecture of buildings...



~~What is Computer Architecture?~~ *building*



What is Computer Architecture?



Details

- A house has a few **rooms**
 - Living room
 - Bedroom
 - Restroom
 - ...

They are interconnected
- A computer has a few **components**
 - Processor core (CPU core)
 - Caches
 - Main memory
 - Disk
 - ...

They are interconnected too

What are the important differences?

- Age of discipline
 - 60 years (vs. five thousand years)
- Rate of change
 - All three factors (technology, applications, goals) are changing
 - Quickly!
- Automated mass production
 - Design advances magnified over millions of chips
- Bootstrapping effect
 - Better computers help design next generation

Design Goals & Constraints

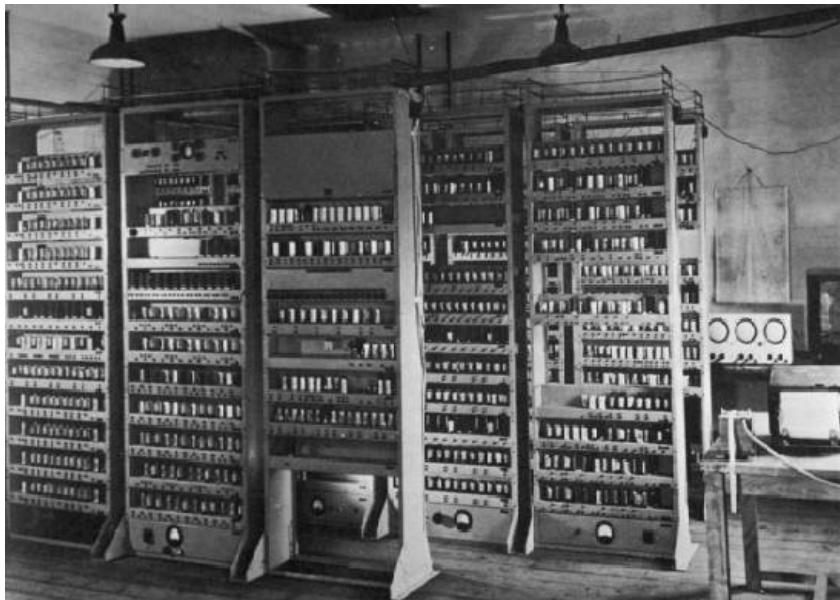
- **Functional**
 - Needs to be correct
 - And unlike software, difficult to update once deployed
 - What functions should it support (Turing-completeness aside)
- **Reliable**
 - Does it **continue** to perform correctly?
 - Space satellites vs. desktop vs. server
- **High performance**
 - “Fast” is only meaningful in the context of a set of important tasks
 - Not just “Gigahertz” – truck vs. sports car analogy

Design Goals & Constraints

- **Low cost**
 - Per unit manufacturing cost (wafer cost)
 - Cost of making first chip after design (mask cost)
 - Design cost (huge design teams)
- **Low power/energy**
 - Energy in (battery life, cost of electricity)
 - Energy out (cooling and related costs)
 - Cyclic problem, very much a problem today
- **Challenge: balancing the relative importance of these goals**
 - And the balance is constantly changing
 - No goal is absolutely important at expense of all others
 - Our focus: *performance*, only touch on cost, power, reliability

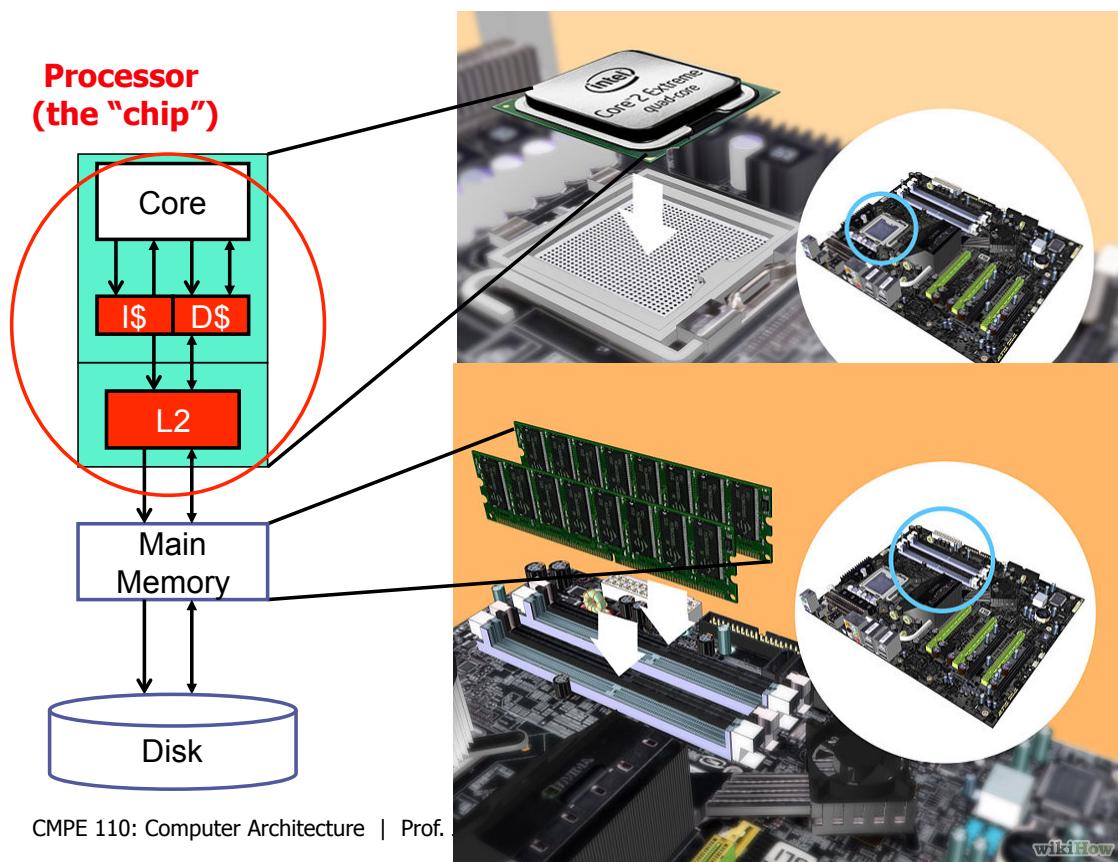
History and Trend

Computing devices then...



Computing devices now





Challenges on data, but not only data



- Data processing
- Data movement
- Data storage:
how our fragile, rapidly obsolete systems of storing data could lead to a digital dark age.

<https://youtu.be/PSIMzirvsFc>

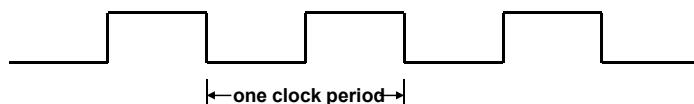
Summary

- Information about this class – how to survive?
- Introduction to the class? – what to learn?

Refresher: Machine clock rates

- Clock rate (clock cycles per second in Megahertz or Gigahertz) is inverse of clock cycle time (aka clock period)

$$CC = 1 / CR$$



1 microsec (10^{-6}) clock cycle => 1 MHz (10^6) clock rate

10 nsec clock cycle => 100 MHz clock rate

5 nsec clock cycle => 200 MHz clock rate

2 nsec clock cycle => 500 MHz clock rate

1 nsec (10^{-9}) clock cycle => 1 GHz (10^9) clock rate

500 psec clock cycle => 2 GHz clock rate

250 psec clock cycle => 4 GHz clock rate

Refresher: Basic memory sizes

- Kilobyte (KB) – 2¹⁰ or 1,024 bytes
- Megabyte (MB) – 2²⁰ or 1,048,576 bytes
 - sometimes “rounded” to 106 or 1,000,000 bytes
- Gigabyte (GB) – 2³⁰ or 1,073,741,824 bytes
 - sometimes rounded to 109 or 1,000,000,000 bytes
- Terabyte (TB) – 2⁴⁰ or 1,099,511,627,776 bytes
 - sometimes rounded to 1012 or 1,000,000,000,000 bytes
- Petabyte (PB) – 2⁵⁰ or 1024 terabytes
 - sometimes rounded to 1015 or 1,000,000,000,000,000 bytes
- Exabyte (EB) – 2⁶⁰ or 1024 petabytes
 - Sometimes rounded to 1018 or 1,000,000,000,000,000,000 bytes

What's next

- Measuring performance



Other reminders

- Keep an eye on course calendar updates and assignments on the course Google site
- Make sure you can access all the course websites: Google site, eCommons, and Piazza