Digital Design & Computer Arch.
Lecture 2a: Course Goals & Logistics

Prof. Onur Mutlu

ETH Zürich
Spring 2020
21 February 2020
The Lecture Was Slightly Different When I Was at CMU
What Is This?

Source: https://roadtrippers.com/stories/falling-water
Fallingwater or Kaufmann Residence is a house designed by architect Frank Lloyd Wright in 1935 in rural southwestern Pennsylvania, 43 miles (69 km) southeast of Pittsburgh. The home was built partly over a waterfall on Bear Run in the Mill Run section of Stewart Township, Fayette County, Pennsylvania, in the Laurel Highlands of the Allegheny Mountains.

*Time* cited it after its completion as Wright's "most beautiful job";[5] it is listed among *Smithsonian*’s Life List of 28 places "to visit before you die."[6] It was designated a National Historic Landmark in 1966.[3] In 1991, members of the American Institute of Architects named the house the "best all-time work of American architecture" and in 2007, it was ranked twenty-ninth on the list of America's Favorite Architecture according to the AIA.

Source: https://en.wikipedia.org/wiki/Fallingwater
Find The Differences of This and That
A Key Question

- How was Wright able to design his masterpiece?
- Can have many guesses
  - (Ultra) hard work, perseverance, dedication (over decades)
  - Experience
  - Creativity, Out-of-the-box thinking
  - A good understanding of past designs
  - Good judgment and intuition
  - Strong skill combination (math, architecture, art, engineering, …)
  - Funding ($$$), luck, initiative, entrepreneurialism
  - **Strong understanding of and commitment to fundamentals**
  - **Principled design**
  - …

- (You will be exposed to and hopefully develop/enhance many of these skills in this course)
A Quote from The Architect Himself

- “architecture [...] based upon principle, and not upon precedent”

Source: http://www.fallingwater.org/
A Principled Design

Organic architecture

Organic architecture is a philosophy of architecture which promotes harmony between human habitation and the natural world through design approaches so sympathetic and well integrated with its site, that buildings, furnishings, and surroundings become part of a unified, interrelated composition.

A well-known example of organic architecture is Fallingwater, the residence Frank Lloyd Wright designed for the Kaufmann family in rural Pennsylvania. Wright had many choices to locate a home on this large site, but chose to place the home directly over the waterfall and creek creating a close, yet noisy dialog with the rushing water and the steep site. The horizontal striations of stone masonry with daring cantilevers of colored beige concrete blend with native rock outcroppings and the wooded environment.
A Key Question

- How was Wright able to design his masterpiece?

- Can have many guesses
  - (Ultra) hard work, perseverance, dedication (over decades)
  - Experience
  - Creativity, Out-of-the-box thinking
  - A good understanding of past designs
  - Good judgment and intuition
  - Strong skill combination (math, architecture, art, engineering, …)
  - Funding ($$$), luck, initiative, entrepreneurialism
  - Strong understanding of and commitment to fundamentals
  - Principled design
  - …

- (You will be exposed to and hopefully develop/enhance many of these skills in this course)
Takeaways

- It all starts from the **basic building blocks and design principles**

- And, **knowledge of how to use & apply them**

- **Underlying technology might change** (e.g., steel vs. wood)
  - but **methods** of taking advantage of technology **bear resemblance**
  - **methods used for design** depend on the **principles** employed
The Same Applies to Processor Chips

- There are **basic building blocks** and **design principles**

**AMD Barcelona**
- 8 cores
- 4 cores

**Intel Core i7**
- 8+1 cores

**IBM Cell BE**
- 8 cores

**IBM POWER7**
- 8 cores

**Sun Niagara II**
- 8 cores

**Nvidia Fermi**
- 448 “cores”

**Intel SCC**
- 48 cores, networked

**Tilera TILE Gx**
- 100 cores, networked
The Same Applies to Computing Systems

- There are basic building blocks and design principles
The Same Applies to Computing Systems

- There are **basic building blocks** and **design principles**

Different Platforms, Different Goals

Source: https://iq.intel.com/5-awesome-uses-for-drone-technology/
Different Platforms, Different Goals
Different Platforms, Different Goals
Different Platforms, Different Goals

Source: https://fossbytes.com/wp-content/uploads/2015/06/Supercomputer-TIANHE2-china.jpg
Different Platforms, Different Goals

Figure 3. TPU Printed Circuit Board. It can be inserted in the slot for an SATA disk in a server, but the card uses PCIe Gen3 x16.

Figure 4. Systolic data flow of the Matrix Multiply Unit. Software has the illusion that each 256B input is read at once, and they instantly update one location of each of 256 accumulator RAMs.

Different Platforms, Different Goals

- ML accelerator: 260 mm$^2$, 6 billion transistors, 600 GFLOPS GPU, 12 ARM 2.2 GHz CPUs.
- Two redundant chips for better safety.

https://youtu.be/Ucp0TTmvqOE?t=4236
Different Platforms, Different Goals

- The largest ML accelerator chip
- 400,000 cores

Cerebras WSE
1.2 Trillion transistors
46,225 mm²

Largest GPU
21.1 Billion transistors
815 mm²

https://www.anandtech.com/show/14758/hot-chips-31-live-blogs-cerebras-wafer-scale-deep-learning
https://www.cerebras.net/cerebras-wafer-scale-engine-why-we-need-big-chips-for-deep-learning/
Basic Building Blocks

- Electrons
- Transistors
- Logic Gates
- Combinational Logic Circuits
- Sequential Logic Circuits
  - Storage Elements and Memory
- ...
- Cores
- Caches
- Interconnect
- Memories
- ...
Reading Assignments for This Week

- Chapter 1 in Harris & Harris
- Supplementary Lecture Slides on Binary Numbers
- Chapters 1-2 in Patt and Patel
Major High-Level Goals of This Course

- In Digital Circuits & Computer Architecture
- Understand the basics
- Understand the principles (of design)
- Understand the precedents

Based on such understanding:
- learn how a modern computer works underneath
- evaluate tradeoffs of different designs and ideas
- implement a principled design (a simple microprocessor)
- learn to systematically debug increasingly complex systems
- Hopefully enable you to develop novel, out-of-the-box designs

The focus is on basics, principles, precedents, and how to use them to create/implement good designs
Why These Goals?

- Because you are here for a Computer Science degree

- Regardless of your future direction, learning the principles of digital design & computer architecture will be useful to
  - design better hardware
  - design better software
  - design better systems
  - make better tradeoffs in design
  - understand why computers behave the way they do
  - solve problems better
  - think “in parallel”
  - think critically
  - …
Course Info and Logistics
Course Info: Instructor

- Onur Mutlu
  - Professor @ ETH Zurich CS, since September 2015 (started May 2016)
  - Strecker Professor @ Carnegie Mellon University ECE/CS, 2009-2016, 2016-…
  - PhD from UT-Austin, worked at Google, VMware, Microsoft Research, Intel, AMD
  - [https://people.inf.ethz.ch/omutlu/](https://people.inf.ethz.ch/omutlu/)
  - omutlu@gmail.com (Best way to reach me)
  - Office hours: By appointment (email me)

- Research and Teaching in:
  - Computer architecture, computer systems, bioinformatics, hardware security
  - Memory and storage systems
  - Hardware security
  - Fault tolerance
  - Hardware/software cooperation
  - Genome analysis and application-algorithm-hardware co-design
  - …
Course Info: Lecturer & PhD Assistants

- **Head Assistant**
  - Dr. Juan Gómez Luna

- **Vice-Head Assistant**
  - Hasan Hassan

- **Lecturer**
  - Dr. Frank Gurkaynak

- **(Other) Key Assistants and Guest Lecturers**
  - Dr. Mohammed Alser
  - Dr. Lois Orosa
  - Dr. Jawad Haj-Yahya
  - Dr. Jisung Park
Course Info: PhD Assistants

- (Other) Key Assistants and Guest Lecturers (cont.)
  - Minesh Patel
  - Giray Yaglikci
  - Can Firtina
  - Geraldo De Oliveira Junior
  - Rahul Bera
  - Konstantinos Kanellopoulos
Course Info: Student Assistants

- Roknoddin Azizibarzoki
- Tim Fischer
- Lukas Gygi
- Leo Horné
- Lara Lazier
- Artur Melo
- Chris Mnuk
- Nathan Neike
- Arpan Prasad
- Nina Richter
- João Dinis Sanches Ferreira
- Taha Shahroodi
- Roberto Starc
Course Info: Lab Assistants (I)

- **Tuesday 15-17**
  - TBD

- **Wednesday 15-17**
  - TBD
Course Info: Lab Assistants (II)

- **Friday 8-10**
  - TBD

- **Friday 10-12**
  - TBD
If You Need Help

- Post your question on Q&A Forum (soon announced)
  - Preferred for technical questions

- Write an e-mail to:
  - digitaltechnik@lists.inf.ethz.ch
  - The instructor and all assistants will receive this e-mail

- Come to office hours (CAB H 31.2)
  - Monday 1:30pm-2:30pm
  - Tuesday: 5pm-6pm
  - Wednesday: 10am-11am
  - We might need to change the room due to space limitations. In that case, we will announce it in advance
Where to Get Up-to-date Course Info?

- Website:
  - [https://safari.ethz.ch/digitaltechnik/](https://safari.ethz.ch/digitaltechnik/)
  - Lecture slides and videos
  - Readings
  - Lab information
  - Course schedule, handouts, FAQs
  - Software
  - Plus other useful information for the course
  - Check frequently for announcements and due dates
  - This is your single point of access to all resources

- Your ETH Email
- Lecturers and Teaching Assistants
Lecture and Lab Times and Policies

- Lectures:
  - Thursday and Fridays, 13:15-15:00
  - HG F7 (F5 overflow)
  - Attendance is for your benefit and is therefore important
  - Some days, we will have guest lectures and exercise sessions

- Lab sessions:
  - See online
  - You should definitely attend the lab sessions
  - In-class evaluation (70%) and mandatory lab reports (30%)
  - Labs will start on February 28th
  - Lab information and handouts are here:
Lab Organization

- **Groups**
  - Choose your preferred group in Moodle
    - Due 24.02.2020 at 11:59pm
  - Choose your partner
    - Due 24.02.2020 at 11:59pm

- **Lab grades from previous years**
  - Choose among (due 26.02.2020 at 11:59pm):
    - 1) I will use my lab grades from previous years, and I won't do the labs this year
    - 2) I will use my lab grades from previous years, but I will do the labs this year
    - 3) I won't use my lab grades from previous years. I will do the labs this year
Final Exam

- **180-minute written exam**

- Find examination rules in Course Catalogue

- Also in the first page of previous exams

- Some exam questions are similar to questions in **Optional HWs**
  - Optional HWs are optional, but highly recommended
Reading Assignments for This Week

- Chapter 1 in Harris & Harris
- Chapters 1-2 in Patt and Patel
- Supplementary Lecture Slides on Binary Numbers
Reading Assignments for Next Week

- Combinational Logic chapters from both books
  - Patt and Patel, Chapter 3
  - Harris and Harris, Chapter 2

- Check course website for all future readings
  - Required
  - Recommended
  - Mentioned
Digital Design & Computer Arch.
Lecture 2a: Course Goals & Logistics

Prof. Onur Mutlu

ETH Zürich
Spring 2020
21 February 2020