

# EECS151/251A

# Introduction to Digital Design and ICs

## Lecture 25: Summary

### A New Golden Age for Computer Architecture: History, Challenges, and Opportunities

We began our Turing Lecture June 4, 2018<sup>11</sup> with a review of computer architecture since the 1960s. In addition to that review, here, we highlight current challenges and identify future opportunities, projecting another golden age for the field of computer architecture in the next decade, much like the 1980s when we did the research that led to our award, delivering gains in cost, energy, and security, as well as performance.

"Those who cannot remember the past are condemned to repeat it." George Santayana,  
1905  
<https://cacm.acm.org/magazines/2019/2/234352-a-new-golden-age-for-computer-architecture/fulltext>

## Sophia Shao



turing lecture

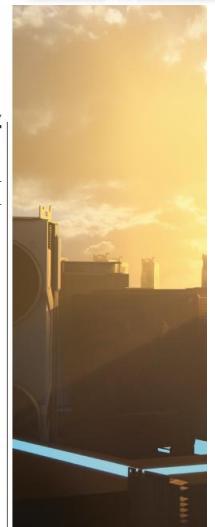
DOI:10.1145/3282307  
**Innovations like domain-specific hardware, enhanced security, open instruction sets, and agile chip development will lead the way.**

BY JOHN L. HENNESSY AND DAVID A. PATTERSON

### A New Golden Age for Computer Architecture

WE BEGAN OUR Turing Lecture June 4, 2018<sup>11</sup> with a review of computer architecture since the 1960s. In addition to that review, here, we highlight current challenges and identify future opportunities, projecting another golden age for the field of computer architecture in the next decade, much like the 1980s when we did the research that led to our award, delivering gains in cost, energy, and security, as well as performance.

*"Those who cannot remember the past are condemned to repeat it."*  
—George Santayana, 1905



engineers, including ACM A.M. Turing Award laureate Fred Brooks, Jr., thought they could create a single ISA that would efficiently unify all four of these ISA bases.  
 They needed a technical solution for how computers as inexpensive as

- » **key insights**
- Software advances can inspire architecture innovation.
- Enabling hardware/software interface creates opportunities for architecture innovation.
- The marketplace ultimately settles architecture debates.



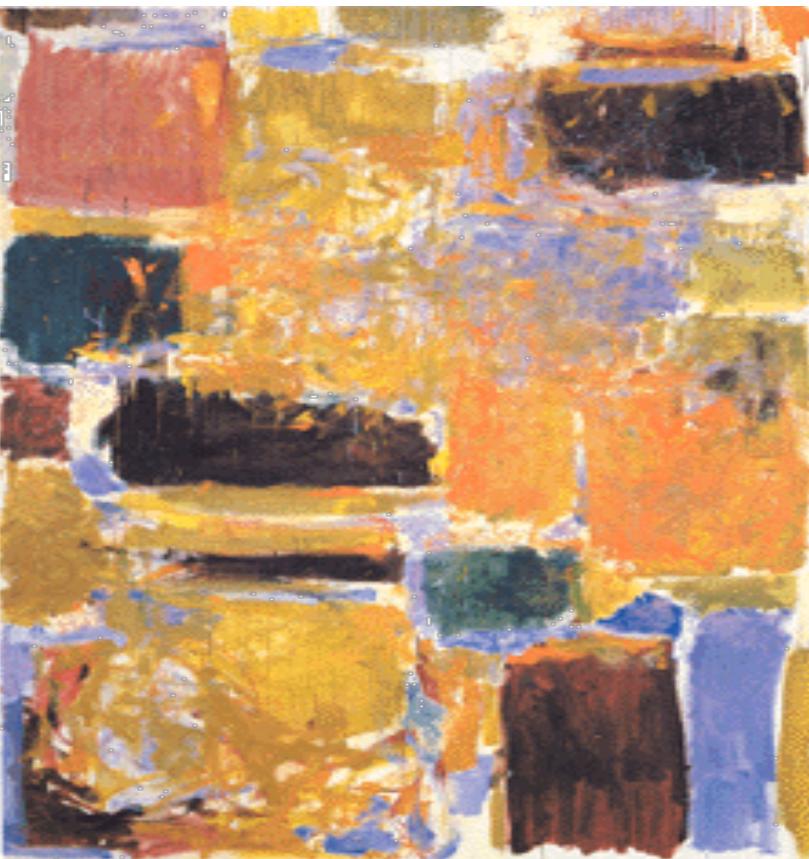
# Review

- Memory arrays:
  - SRAM:
    - Unique combination of density, speed, power
    - SRAM cell: stability and writeability
  - Caches
    - Direct mapped and set-associative
  - DRAM
    - 1-T volatile
    - Content-Addressable Memory (CAM)
      - SRAM cell + XOR
  - Flash
    - Floating gate

# Course Evaluation

- Course Survey

- <https://course-evaluations.berkeley.edu/berkeley/>
- We VALUE your feedback!
- Tell us your experience!
- Tell us what worked and what could be improved!
- Extra credits:
  - 1pt if you submit a confirmation screenshot (private post on Piazza)!
  - 1 more pt for everyone who complete the survey if we hit 70% response rate!



- Course Recap
- What's Next

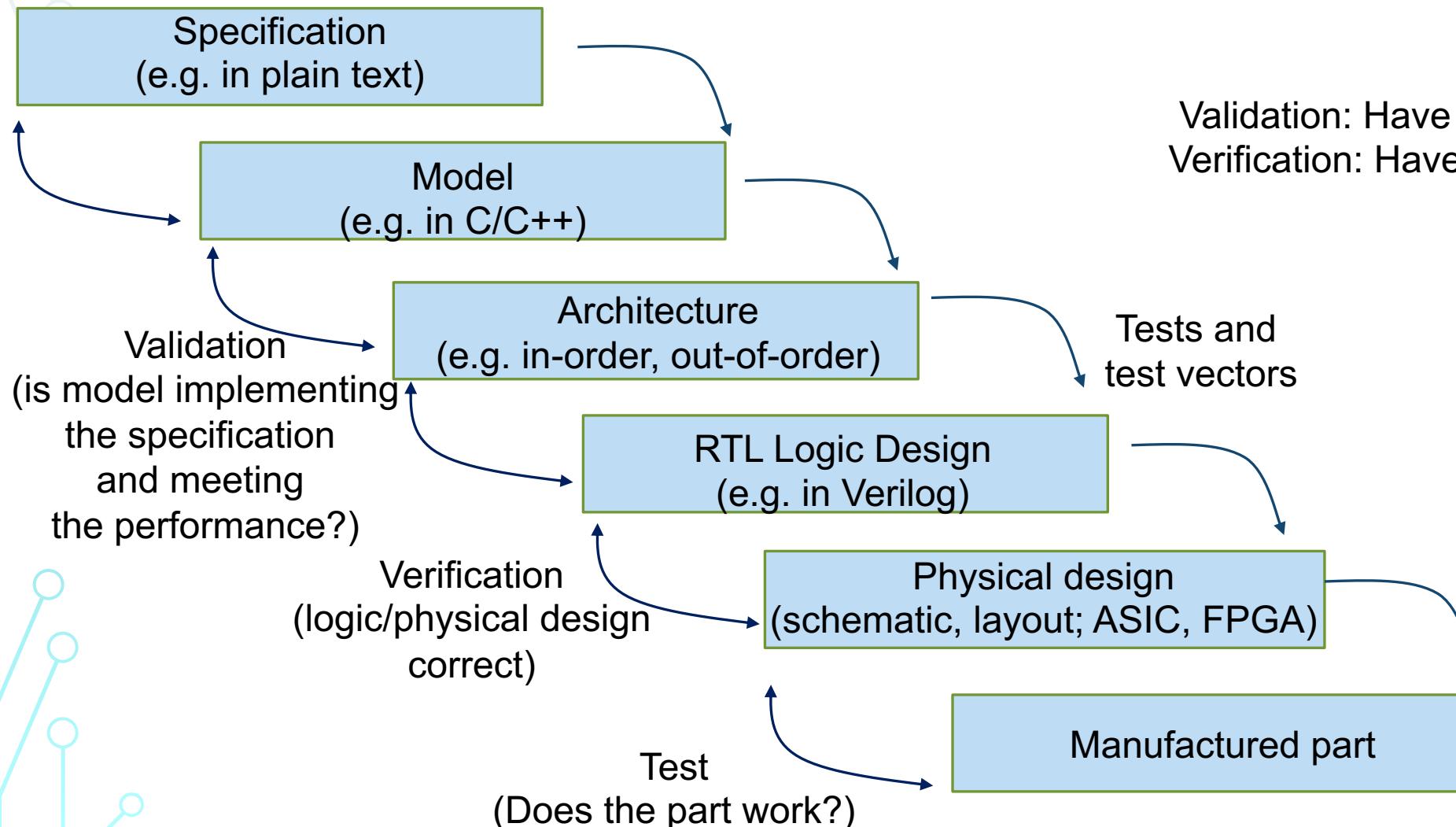
# What This Class is All About?

- **Introduction to digital integrated circuit and system engineering**
  - Key concepts needed to be a good digital system designer
  - Discover your own creativity!
- **Learn abstractions that allow reasoning about design behavior**
  - Manage design complexity through abstraction and understanding of tools
  - Allow analysis and optimization of the circuit's performance, power, cost, etc.
- **Learn how to make sure your circuit and system works**
  - *There are way more ways to mess up a chip than to get it right.*

**Digital design is not twitch.com!  
Learn by doing!**

# Design Abstractions

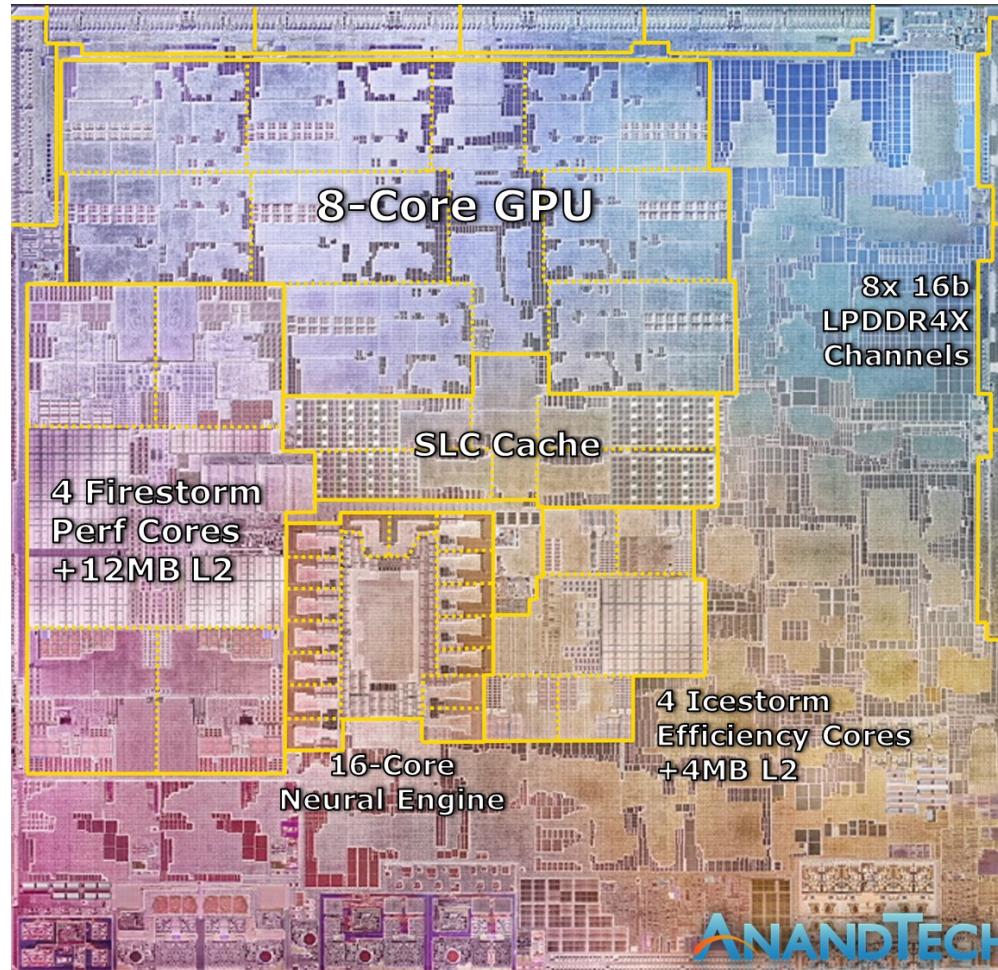
- Design through layers of abstractions



Validation: Have we built the right thing?  
Verification: Have we built the thing right?

# Field has advanced!

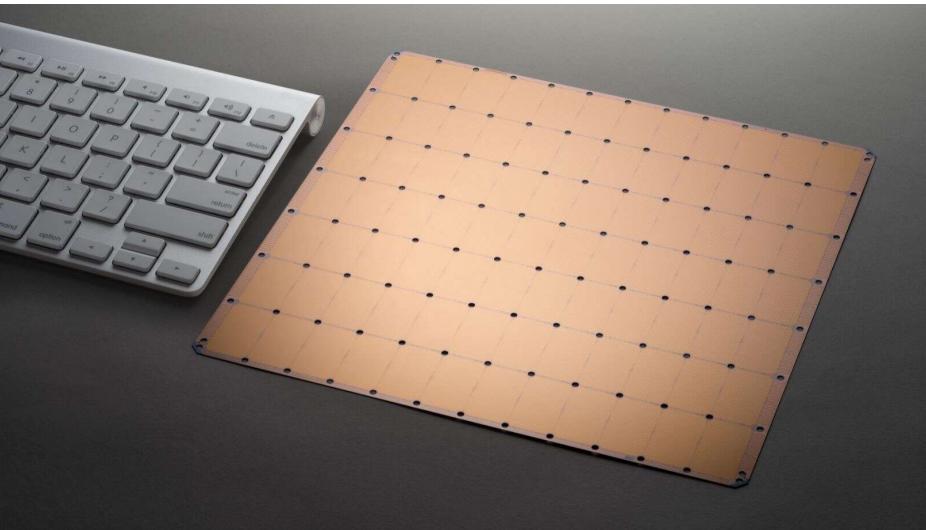
- Apple Announces The Apple Silicon M1: Ditching x86



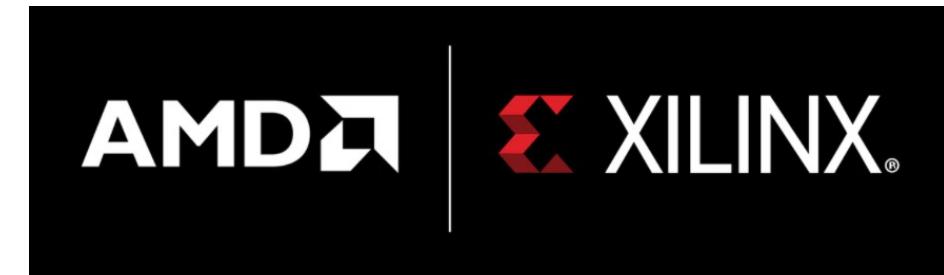
<https://www.anandtech.com/show/16226/apple-silicon-m1-a14-deep-dive>

# Field has advanced!

- Cerebras: Wafer-scale Computing!

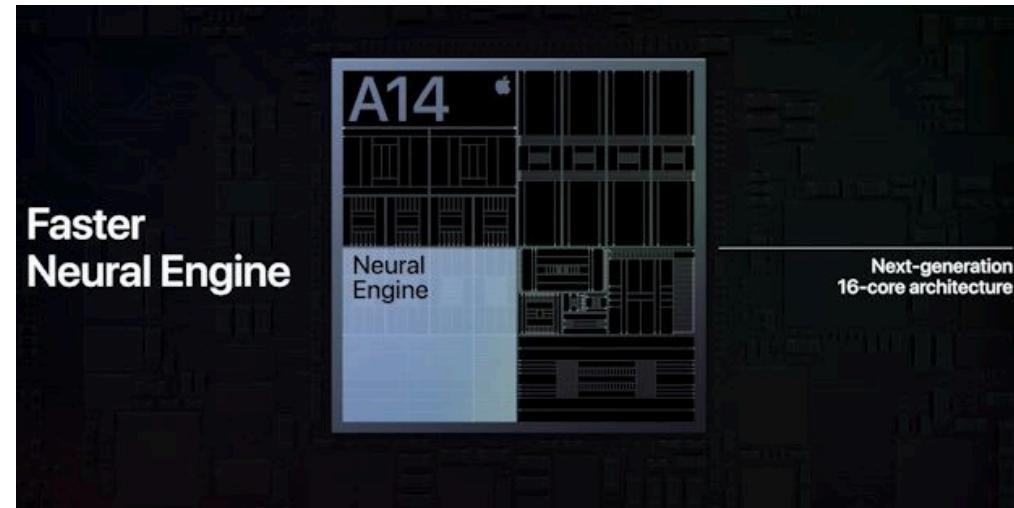
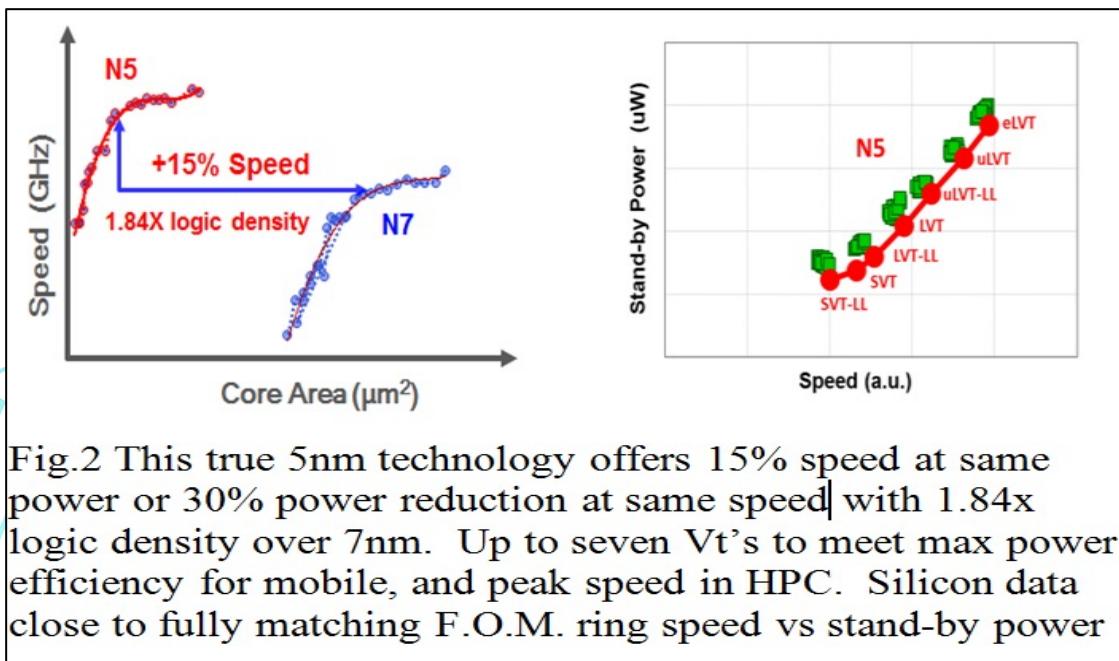


- More consolidation in the area!



# Field has advanced!

- 5nm SoC announced this year
- TSMC's 5nm process at IEDM'19



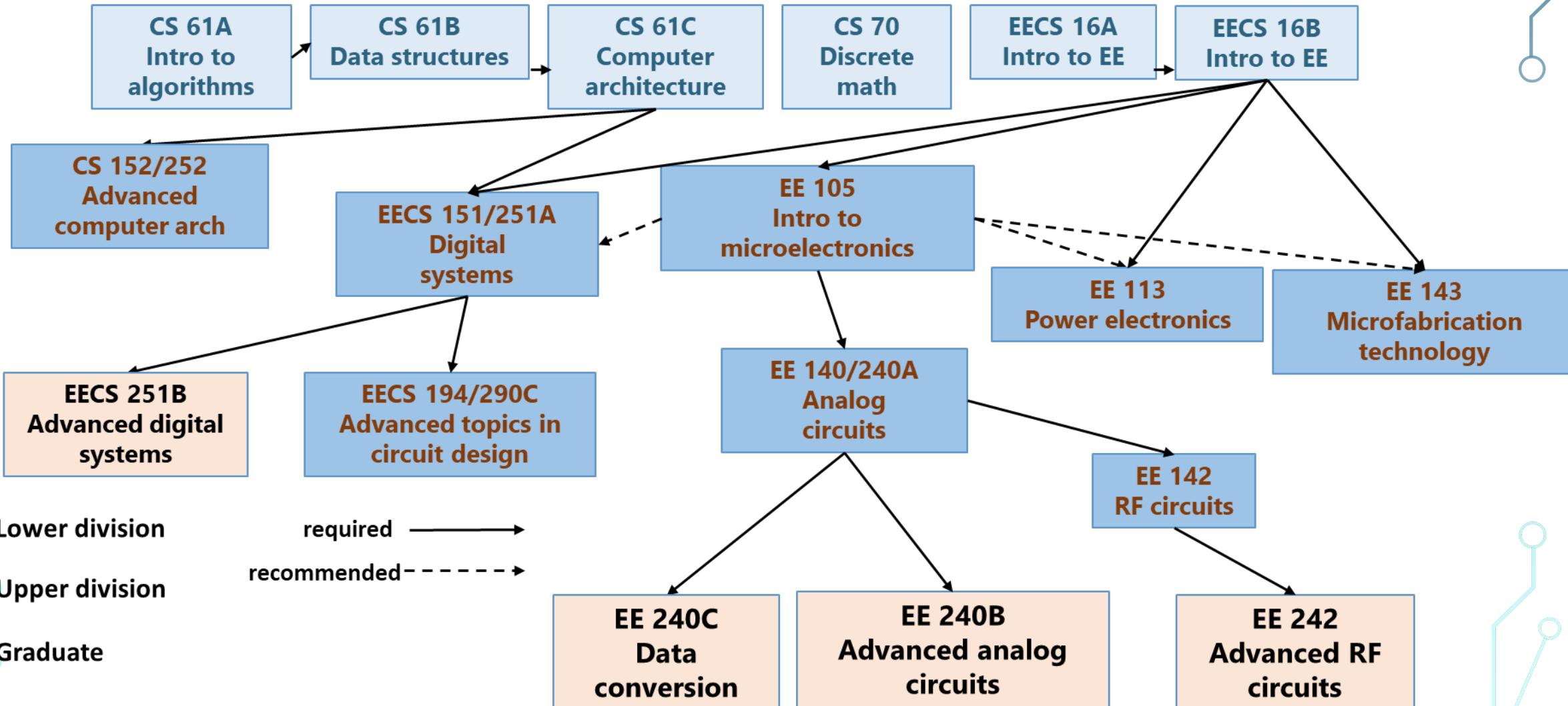
# Administrivia

- Guest lecture next Tuesday on SystemVerilog.
- HW8: due this Friday.
- HW9: Released this week. Due next Friday.
- FPGA Lab:
  - 5/2 Mon Final Project checkoff
- ASIC Lab
  - 5/6 Friday Final Presentation
- Final: 5/12 3-6pm



- Course Recap
- What's Next

# EECS Circuits/Computer Hardware Course Flow Map



# CS152/252 – Computer Architecture and Engineering

- Some have taken before EECS151
  - Taught only in Spring
- (More) advanced topics in computer architecture:
  - Superscalar,
  - out-of-order machines,
  - vectors,
  - GPUs,
  - multithreading,
  - memory hierarchy

# EECS251B – Advanced Digital Circuits

- Starts with modern SoC Design
- A deeper dive into technology, devices and models
- Variability and a case study of large SRAM arrays
- Most of the class is low-power design and power management
- ASIC projects

# Building Complete SoCs

- Design and simulate complete prototype systems

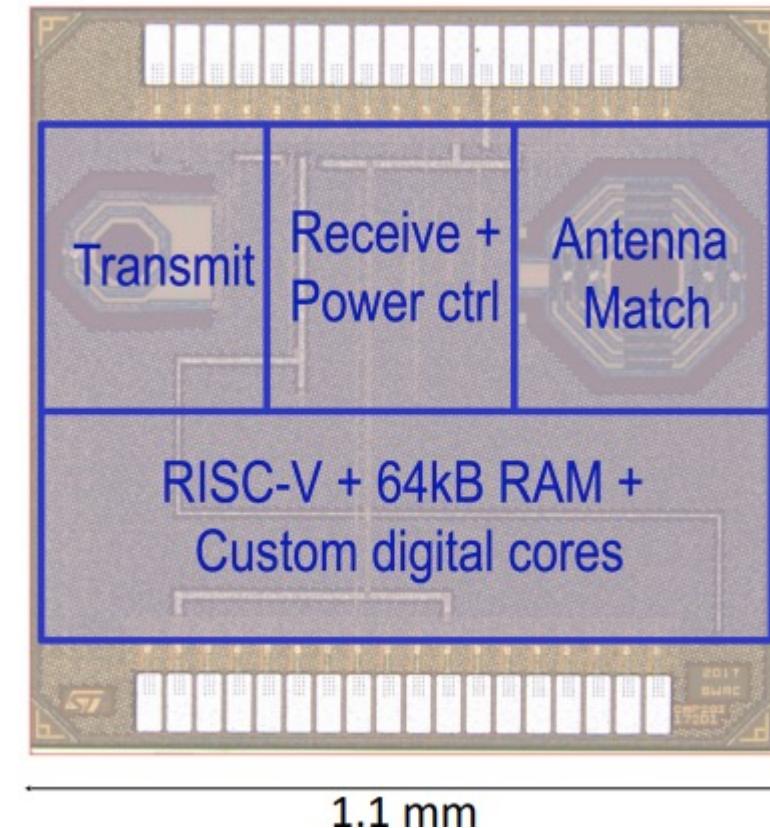


# EE290C/CS294 – Advanced Topics Classes

- Targeting graduate students
- But often advanced undergrads can take them as well
- EE290-2: Hardware for Machine Learning, Spring 2021
  - Instructor: Sophia Shao
    - <https://inst.eecs.berkeley.edu/~ee290-2/>
  - Goals:
    - What is **hardware for machine learning?**
    - What are the **technical challenges** we need to solve?
    - What **research infrastructure** is needed to enable studies?
    - What **new opportunities** can we unlock for the future ML hardware?
  - Invited guest lectures from Google, Facebook, Microsoft, MLPerf, and more...

# EECS194/290C: The Tapeout Class!

- Design a complete system on a chip
  - Microprocessor + memory
  - 2.4 GHz radio
  - Analog support (ADC, bandgap, temp sensor, PoR, ...)
- “Tape out” – send it for fabrication at TSMC
- Real-world experience
  - Fight with your friends over interfaces, real estate
  - “Mostly correct” doesn’t cut it
- + The Bring-up Class in Fall



# Digital Systems/Computer Architecture Research

- Exploring new areas by using high productivity design
- Research opportunities in:
  - High-performance microprocessor design
  - Domain-specific architectures
    - Machine learning and emerging applications
  - Hardware-software co-design
    - Improved performance and efficiency
  - High-productive hardware design and verification
    - Tools to improve the productivity of hardware designers

# Time to become a modern Renaissance Person

- Modern hardware designers need to understand more than just hardware.
  - Driving applications, e.g., ML
  - Compiler
  - Operating system
  - Computer architecture
  - Digital/Analog circuit design
  - Devices
- Willing to break abstractions.
  - Time for vertically integrated ideas!



*Getty Images*

# Architecture is a reflection of time.

- Computing system evolves with the demand of applications and the behaviors of underlying technologies.
- Be brave: build hardware that reflects your time!
- *“A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die and a new generation grows up that is familiar with it.”* Max Planck



By Benh LIEU SONG (Flickr) -  
Louvre Courtyard, Looking West,  
CC BY-SA 4.0

# Architecture is a conversation with space.

- Computing system also becomes increasingly spatially-distributed.
  - From Skyscrapers to Hutongs
- Be considerate: understand your neighbors as yourself.
- *If you know the enemy and know yourself, you need not fear the result of a hundred battles. If you know yourself but not the enemy, for every victory gained you will also suffer a defeat. If you know neither the enemy nor yourself, you will succumb in every battle.* Sun Tzu, The Art of War.



Wang Family Compound

# Thanks to the GSIs!



Alisha Menon  
(FPGA Lab)



Dima Nikiforov  
(Discussion,  
ASIC Lab)



Seah Kim  
(FPGA Lab)



Yikuan Chen  
(Discussion,  
FPGA Lab)

# Thanks to all of you!

- It's a challenging course in a challenging semester.
  - Worked nearly as hard as you did 😊
  - Thanks all of you for working with us to put this course together!
- We had a lot of fun!
- Hope you had too!
- Stay Curious. Stay Optimistic!

