Digital Systems I

EEC 18

Lecture 1

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Thursday, September 23, 2021

Today

- Course details
  - Lab, Policies, Schedule (web page)
  - Course objective and strategies
- My background
- Chapter 1
  - Digital systems
  - Number systems
  - Binary (base 2) arithmetic
- Chapter 2
  - Boolean algebra

Teaching Assistants

- Terry O'Neill
  Tue lab

- Satyabrata Sarangi
  Wed lab

- Contact information is on the course web page

Course Workload

- 5 unit course
  - 18 "chapters" in 20 lectures
- New way of thinking of things will take some effort
  - Algebra: use variables
  - Calculus: no concrete solutions for indefinite integrals
  - Boolean algebra, binary math
    - Not only $a + b$, but also a AND b, a XOR b, …
    - $1 + 1 = 1$
    - $3 + 6 = -7$
- Passing this course requires significant effort and time
  - (Students that have already taken ECS 154A typically find the first part of the quarter very slow but later parts challenging)

Lectures and Labs

- Lectures
  - By zoom, links are on canvas
  - All lectures and exams
- Labs
  - In person
  - Wear masks at all times
    - cover your nose and mouth
    - the university takes this very seriously
  - Follow all instructions from your TA
  - https://campusready.ucdavis.edu/instructors

Student Responsibilities

Students are expected to:

- **Monitor your symptoms** and stay home if you are feeling sick. Take the Daily Symptom Survey to access campus facilities.
- **Be fully vaccinated before the start of classes** or hold an approved exception for religious or medical reasons. Additional time is granted to students who will have had no access to a vaccine before arriving on campus.
- **Wear face coverings indoors and in mass transit.** Unvaccinated students must also wear face coverings outdoors in crowded places.
- **Test regularly as directed by campus guidelines.** Testing is available at the ARC Testing Kiosk in Davis and at the Administrative Services Building in Sacramento. Students will face disciplinary action if they are out-of-date with testing requirements.
- **Eat only in designated areas and never in classrooms.** Students may remove their masks very briefly to drink while in class.

Lectures

- Ask questions at any time
  - Please raise your hand
  - Ask a question at any pause (zoom)
- Be respectful of others
  - Hold conversations outside of class
  - Silence phones
  - Sit in the back if you come in late or need to leave early

Course Communication

- In class during lecture
- Canvas announcements → Email
  - Time-critical announcements only
- Web page
  - Primary source of course information
- Office hours
  - Posted on the course web page
  - Let me know by the second lecture if you have a conflict
- Please see me (or TA) in person or by zoom with questions rather than email

My Teaching Philosophy

- Primary goal (mine and yours):

  Learn digital system design well

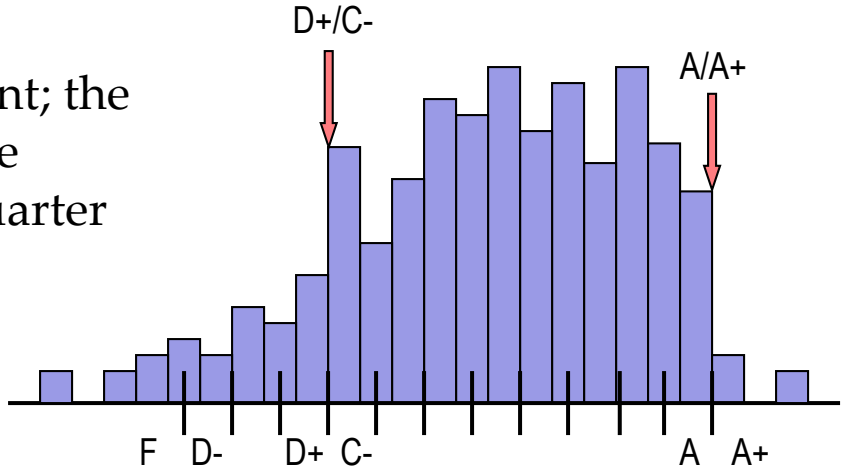
- Achieve this through:
  - Reading textbook
    - Objectives, Study Guide, Reading, Problems
    - Book is very complete, designed for self-study
  - Lectures
  - Solving problems on paper (homework)
  - Solving problems and building things in lab
  - Discussions with other students, TAs, myself

Grading Philosophy

- Grading serves two main purposes:
  1. Motivate you to do the work required to learn
     - Reading textbook (quizzes)
     - Lectures (quizzes)
     - Solving problems in homework (exams)
     - Solving problems in labs (lab grading, exams)
     - Discussions with others
  2. Give others an indication of how well you know the material

Letter Grade Assignments

- I assign a letter grade only for the final course grade
- You can see score statistics for each graded item on Canvas
- I look at the final exams and course record of the class and assign two key dividing points: the A/A+ and D+/C- boundaries, and assign course grades from there using equally-sized intervals
  - No required numbers of any particular letter grades
  - Absolute scores are not important; the boundaries shift according to the difficulty of the exams in any quarter
  - In fact, easy exams cause large grade drops for small errors
  - Ignore any letter grades you might see on canvas



(not actual grade data)

Working With Others

- Collaboration
  - Asking questions and explaining principles produces better work and dramatically increases learning
  - Working with others
    - Do homework and prelabs with classmates nearby
    - Ask each other questions, help each other—regarding **principles,** and **approaches to solving** only
  - See *Course Collaboration Policy* on web page
- Dishonesty
  - Copying produces similar work, stunts learning, is not fair to honest students, and is not allowed in this course
    - Students engaged in dishonest work will be referred to Student Judicial Affairs
    - I will try to keep in-class exams honest
    - Steps will be taken to keep out of class work honest

Penalties for Violating the *Policy on Student Conduct and Discipline*

- Penalties
  - Minimum penalty: meetings with SJA officer, zero grade on work, record with SJA
  - Permanent **F** grade on your transcript, no credit for the class
  - One to three quarter suspension from the university
  - Permanent dismissal from all ten campuses of the University of California. Permanent notation on your transcript.

Penalties for Violating the *Policy on Student Conduct and Discipline*

- Several perspectives
  - Personal — obvious reasons
  - ECE and UCD — (especially for those inclined to share work with someone doing poorly in class) Cheating harms our major and university's reputation among employers who interview our graduates.
- In summary: The purpose of the penalties and me mentioning them is so that no one will get one!!! Don't do anything that violates the Policy on Student Conduct!

Penalties for Violating the *Policy on Student Conduct and Discipline*

- Typical scenario:
  - Someone shares code/design with another
  - They get caught
  - The "Copier" feels terrible guilt for causing a friend to get a zero
  - The "Sharer" deeply regrets sharing resulting in a zero when he/she should have had a full score

Cheating Websites
chegg, coursehero, etc.

- The university has recently taken a very strong stand against paying for work (2-quarter suspension for first offense last year)
- Key take-away messages:
  - Do not post assignments
  - Of course do not use any unpermitted outside material in work you submit
  - Of course do not post solutions
  - Two students did last year and got caught!!!

Submitting Work

- Unless announced otherwise, materials due must be submitted through canvas as instructed
- Only pdf format
  - It greatly simplifies grading
- Homework drop box on the second floor of Kemper

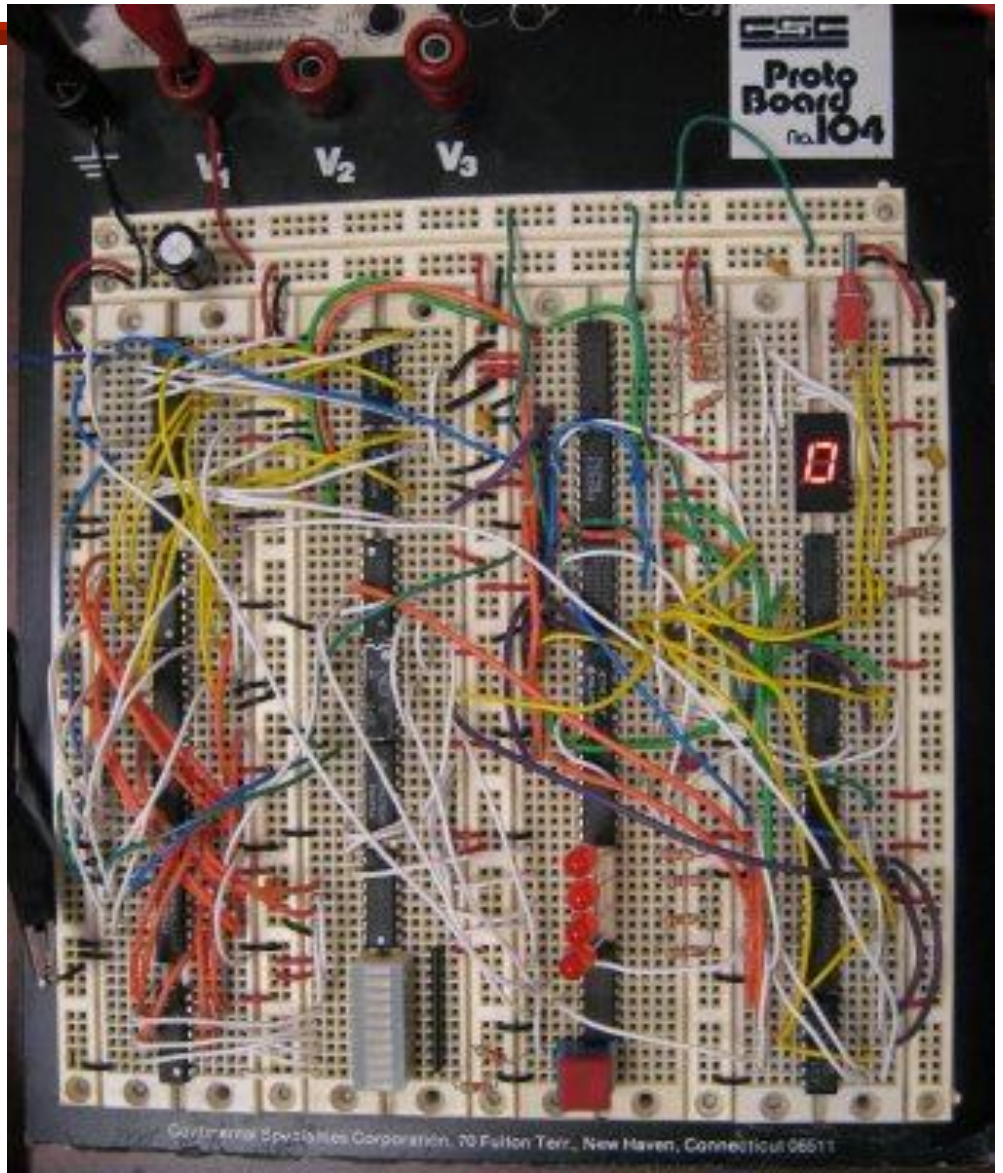
Course Web Page

`http://www.ece.ucdavis.edu/~bbaas/18/`

- This link is posted on the canvas home page

Lab Items NOT To Buy

- Four-module-wide protoboard

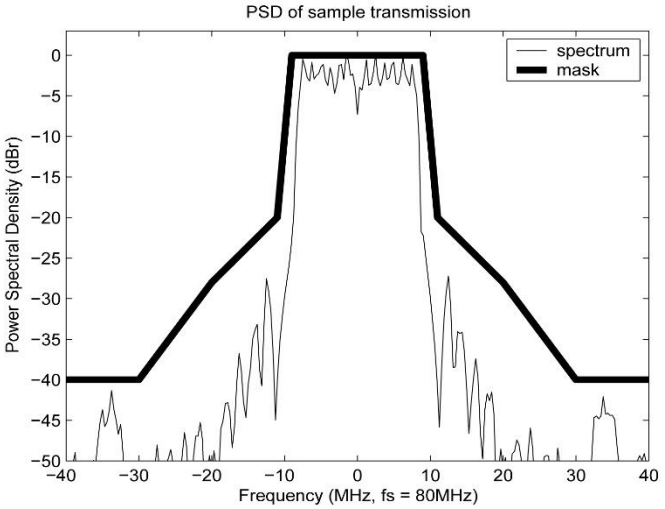


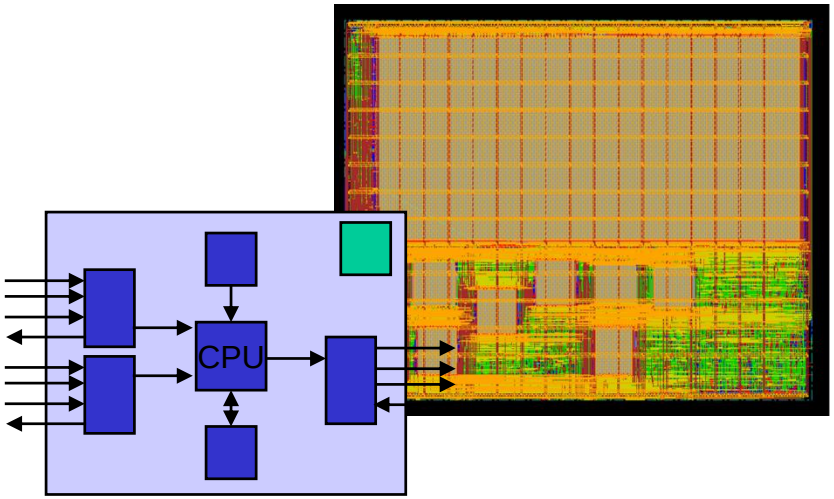
My Background

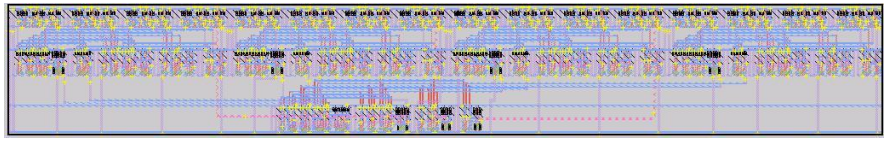
- My education
  - Westmont College — Physics
  - Cal Poly, San Luis Obispo — Mechanical/Electrical Engineering
  - Stanford — Electrical Engineering
- My research
  - VLSI (chip) design
  - Processor architectures
  - Digital signal processing (DSP) algorithms
- Work experience
  - Mechanical engineering internships
  - Hewlett-Packard, Computer Systems Division
  - Atheros Communications

Areas of Research

- Processor architectures
  - Programmable
  - Special-purpose
- DSP algorithms
- Circuits
- VLSI design
- Software tools and applications







$$G_c(m,n) = \alpha(m)\sum_{i=0}^{N-1}[\alpha(n)\sum_{k=0}^{N-1} g(i,k)\cos\frac{\pi(2k+1)n}{2N}]\cos\frac{\pi(2i+1)m}{2N}$$

Advancing CMOS Technologies

- Moore's "Law" (Observation) was made in 1965 and notes that transistor density ~doubles every year (every 1.5 years now)
- "Cramming more components onto integrated circuits," Gordon Moore, *Electronics,* April 19, 1965.

The experts look ahead

Cramming more components onto integrated circuits

With unit cost falling as the number of components per circuit rises, by 1975 economics may dictate squeezing as many as 65,000 components on a single silicon chip

By Gordon E. Moore

Director, Research and Development Laboratories, Fairchild Semiconductor division of Fairchild Camera and Instrument Corp.

The future of integrated electronics is the future of electronics itself. The advantages of integration will bring about a proliferation of electronics, pushing this science into many new areas.

Integrated circuits will lead to such wonders as home computers—or at least terminals connected to a central computer—automatic controls for automobiles, and personal portable communications equipment. The electronic wristwatch needs only a display to be feasible today.

But the biggest potential lies in the production of large systems. In telephone communications, integrated circuits in digital filters will separate channels on multiplex equipment. Integrated circuits will also switch telephone circuits and perform data processing.

Computers will be more powerful, and will be organized in completely different ways. For example, memories built of integrated electronics may be distributed throughout the machine instead of being concentrated in a central unit. In addition, the improved reliability made possible by integrated circuits will allow the construction of larger processing units. Machines similar to those in existence today will be built at lower costs and with faster turn-around.

Present and future

By integrated electronics, I mean all the various technologies which are referred to as microelectronics today as well as any additional ones that result in electronics functions supplied to the user as irreducible units. These technologies were first investigated in the late 1950's. The object was to miniaturize electronics equipment to include increasingly complex electronic functions in limited space with minimum weight. Several approaches evolved, including microassembly techniques for individual components, thin-film structures and semiconductor integrated circuits.

Each approach evolved rapidly and converged so that each borrowed techniques from another. Many researchers believe the way of the future to be a combination of the various approaches.

The advocates of semiconductor integrated circuitry are already using the improved characteristics of thin-film resistors by applying such films directly to an active semiconductor substrate. Those advocating a technology based upon films are developing sophisticated techniques for the attachment of active semiconductor devices to the passive film arrays.

Both approaches have worked well and are being used in equipment today.

The author

Dr. Gordon E. Moore is one of the new breed of electronic engineers, schooled in the physical sciences rather than in electronics. He earned a B.S. degree in chemistry from the University of California and a Ph.D. degree in physical chemistry from the California Institute of Technology. He was one of the founders of Fairchild Semiconductor and has been director of the research and development laboratories since 1959.

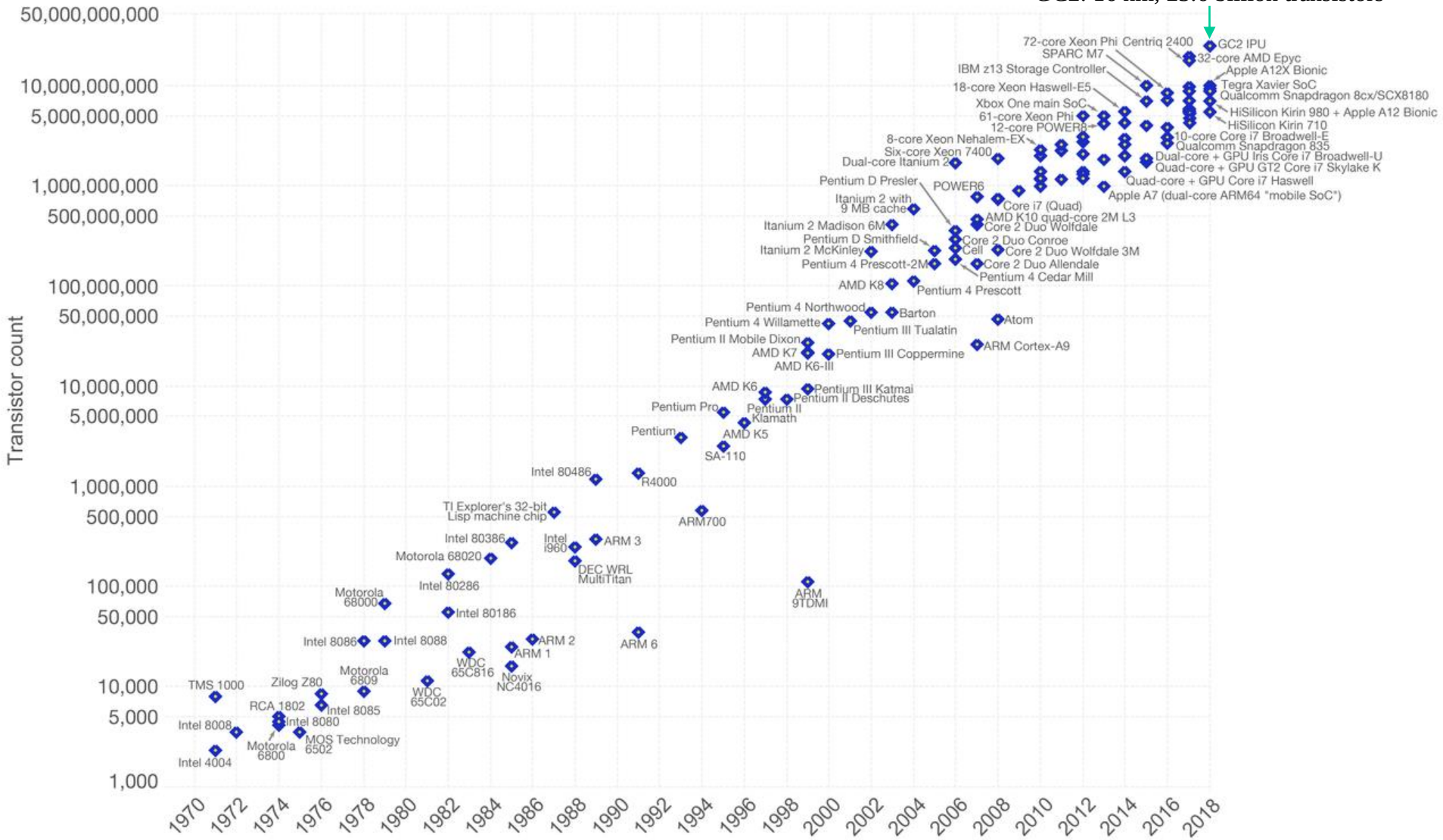
Electronics, Volume 38, Number 8, April 19, 1965

Moore's Law – The number of transistors on integrated circuit chips (1971-2018)

Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years. This advancement is important as other aspects of technological progress – such as processing speed or the price of electronic products – are linked to Moore's law.

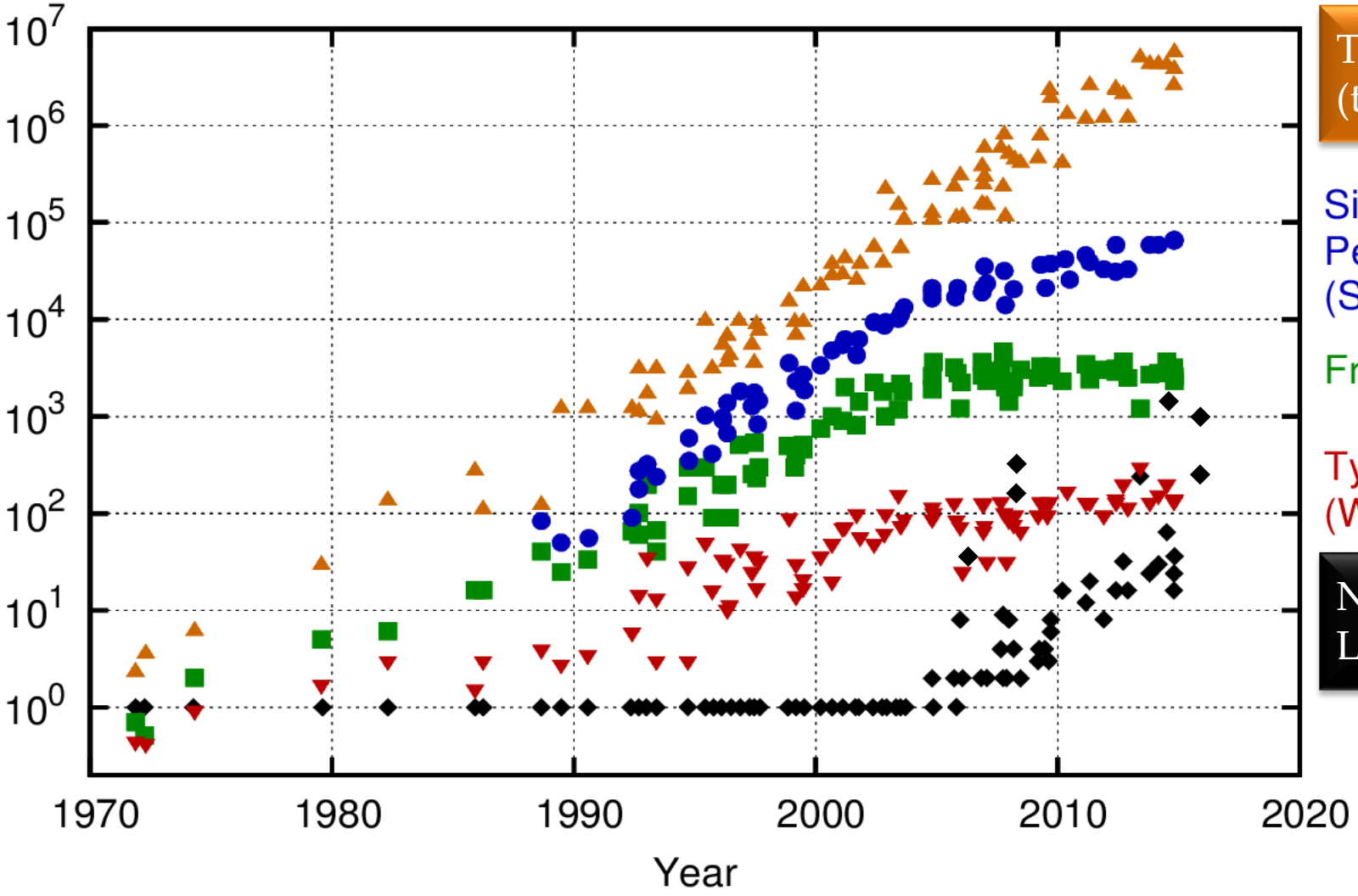
Our World in Data

GC2: 16 nm, 23.6 billion transistors



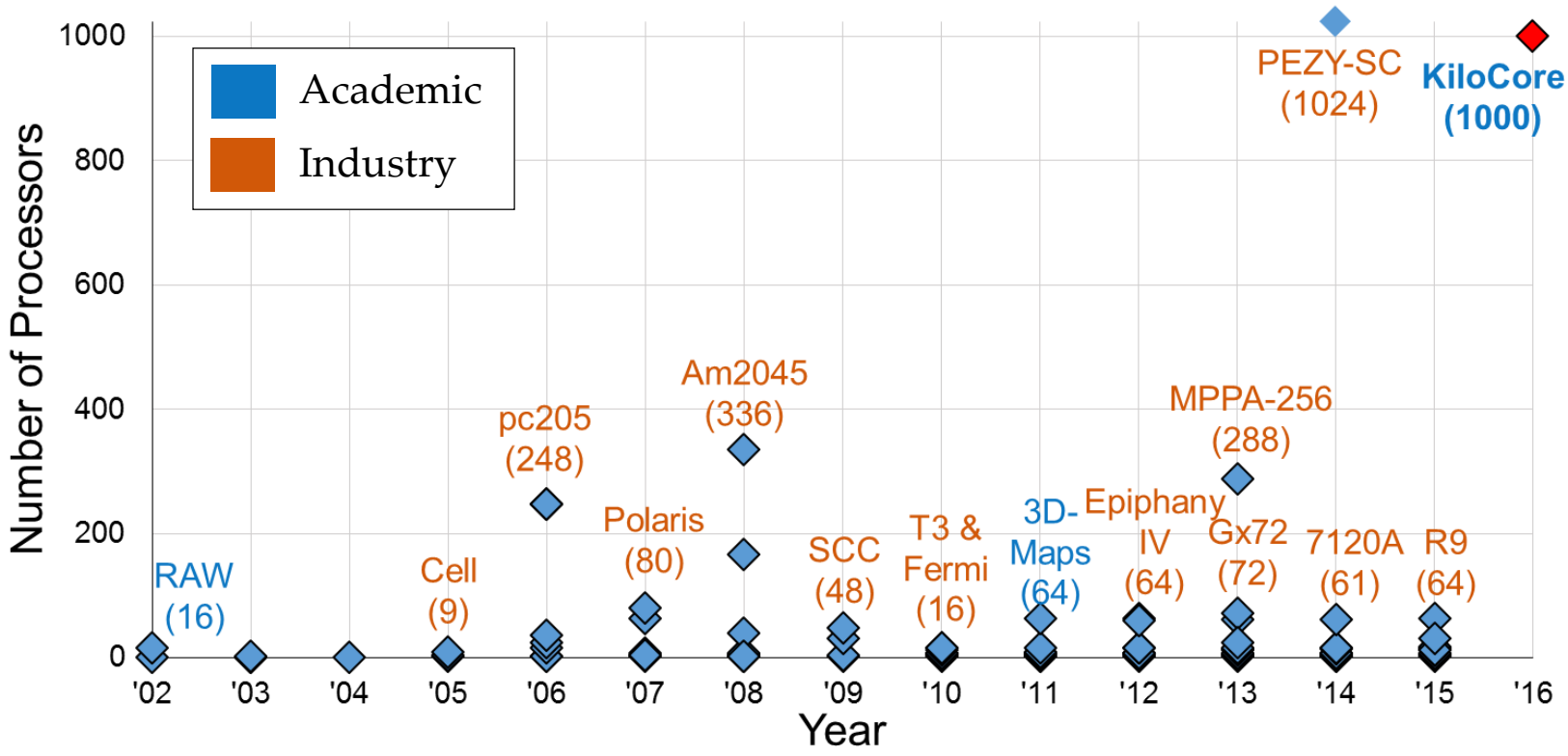
Data source: Wikipedia (https://en.wikipedia.org/wiki/Transistor_count)

The data visualization is available at OurWorldinData.org. There you find more visualizations and research on this topic.



Original data up to the year 2010 collected and plotted by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond, and C. Batten
New plot and data collected for 2010-2015 by K. Rupp
New data added by B. Baas

Number of Processors on a Single Die vs. Year



Note: Each processor capable of independent program execution

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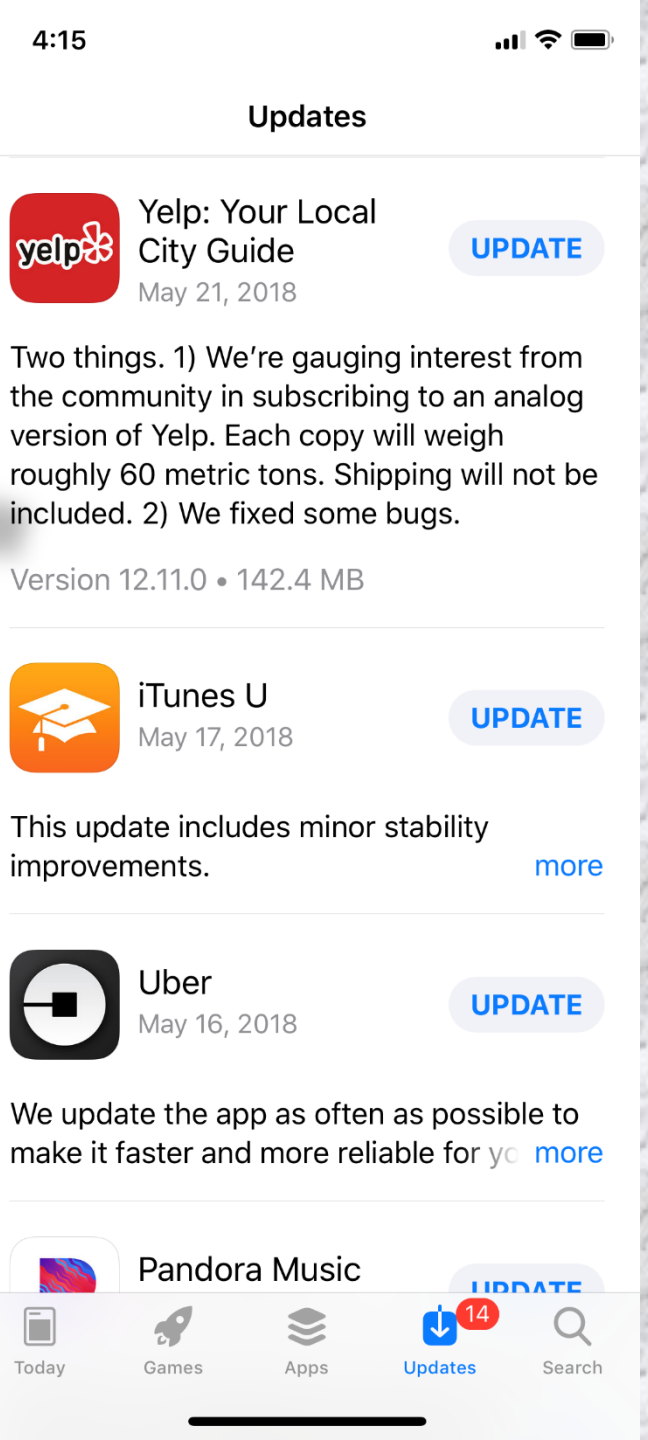
Consumer Products' Trends

- Analog based → Digital based
  - Music records, tapes → CDs, MP3s
  - Video VHS, 8mm → DVD, Blu-ray, H.264, H.265
  - Telephony analog mobile (1G) → digital (4G, LTE,…)
  - Television NTSC/PAL → digital (DVB, ATSC, ISDB, …)
  - Many products use digital data and "speak" digital: computers, networks, digital appliances

Consumer Products' Trends

- Analog based vs. Digital based
  - iphone apps???



Future Applications

- Very limited power budgets
- Require significant digital signal processing