Switching Circuits & Logic Design

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Course Info

- Instructor
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- Course webpage
  - http://cc.ee.ntu.edu.tw/~jhjiang/instruction/courses/fall12-ld/ld.html
  - http://media.ee.ntu.edu.tw/courses/ld2012fall/

Textbook

- C. H. Roth, Jr. *Fundamentals of Logic Design*, 6th edition, Cengage Learning, 2009.

Schedule

- 09/13 §1 Introduction, Number Systems and Conversion
- 09/14,20 §2 Boolean Algebra
- 09/21 §3 Boolean Algebra (Continued)
- 09/27,28 §4 Applications of Boolean Algebra
- 10/04,05 §5 Karnaugh Maps
- 10/11,12 §7 Multi-Level Gate Circuits
- 10/18 Quiz 1 (§1~§5)
- 10/19,25 §8 Combinational Circuit Design
- 10/26,11/1 §9 Multiplexers, Decoders, and PLDs
- 11/02 Verilog: Combinational Circuits
- 11/08 --
- 11/09 Midterm Exam

Schedule (cont'd)

- 11/15 -- (University Anniversary)
- 11/16 §11 Latches and Flip-Flops
- 11/22,23 §12 Registers and Counters
- 11/29,30 §13 Analysis of Clocked Sequential Circuits
- 12/6,7 §14 Derivation of State Graphs and Tables
- 12/13 Quiz 2 (§11~§13)
- 12/14 §15 Reduction of State Tables (§15.1~2)
- 12/20,21 §16 Sequential Circuit Design (§16.1~4)
- 12/27,28 §18 Ckts for Arithmetic Operations (§18.1~2)
- 01/03,04 Supplementary Materials
- 01/10 --
- 01/11 Final Exam

Grading

- Raw score
  - Homework 18%
  - Quiz 1 4%
  - Midterm 35%
  - Quiz 2 6%
  - Final 35%
  - Participation 2%
- Final letter grade
  - Grade on a curve based on the raw scores
  - A+: within top 8% among the total student body of four classes

Policies

- Homework assignments due before lecture
  - 14:10-14:20 on Thursday or 15:20-15:30 on Friday
    - Late homework penalty: -33 per day
  - Plagiarism strongly prohibited
    - No borrowing
    - Discussions are strongly encouraged, but solutions need to be written down independently

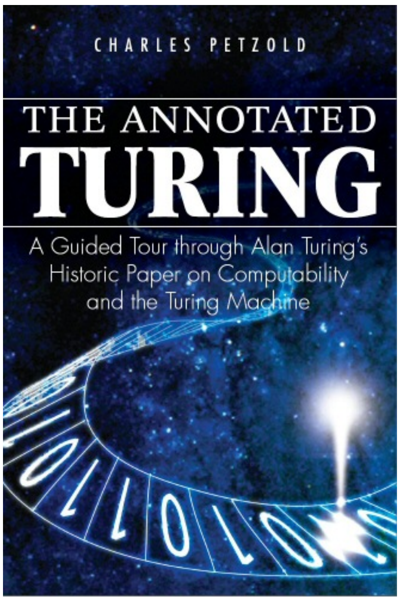
§0 Introduction

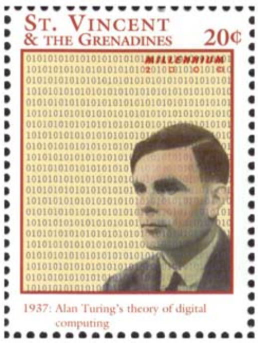
Good Old Days of Computation

Babbage's difference engine (1822)
powered by cranking a handle

Good Old Days of Computation

Computability and the Turing machine
Alan Turing
Cambridge, UK (1937)





Book cover: Wiley (2008)

Good Old Days of Computation

- ENIAC (1946)
  - First general purpose (Turing-complete) electronic computer
  - Vacuum-tube based implementation

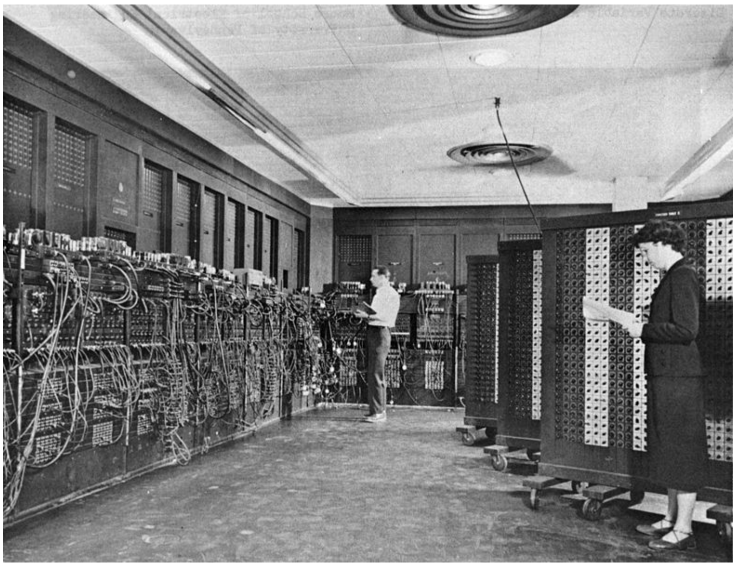


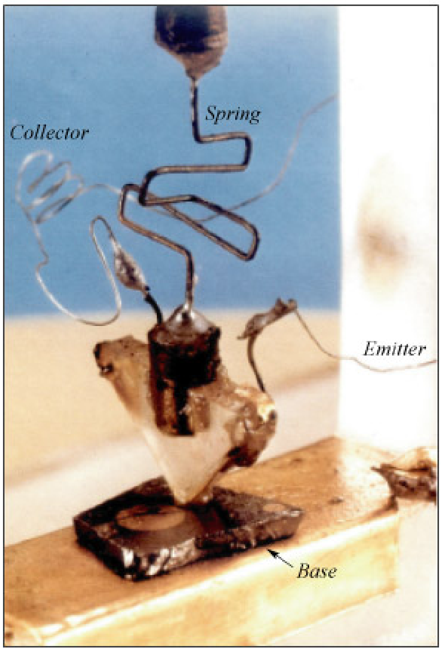
Photo: US Army, Roth audio

Good Old Days of Computation

The first point contact transistor

William Schockley, John Bardeen, and Walter Brattain

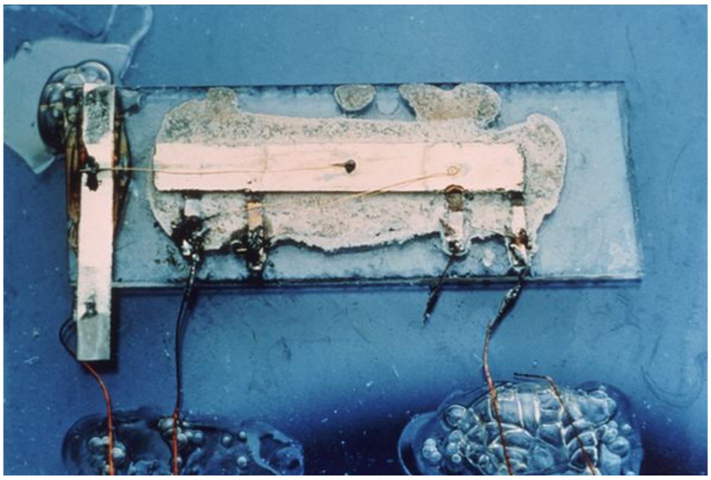
Bell Laboratories, Murray Hill, New Jersey (1947)



Photos: Lucent Technologies

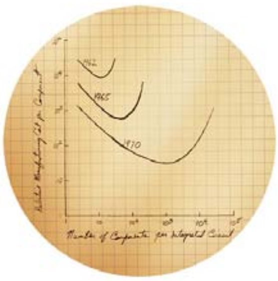
Good Old Days of Computation

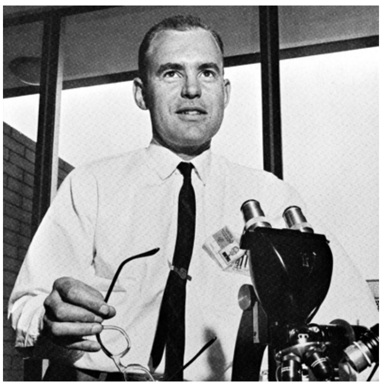
The first integrated circuit
Jack Kilby
Texas Instruments, Texas (1958)



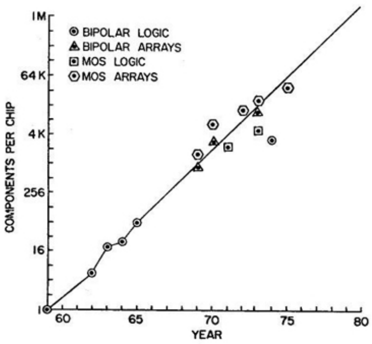
Photos: Texas Instructments

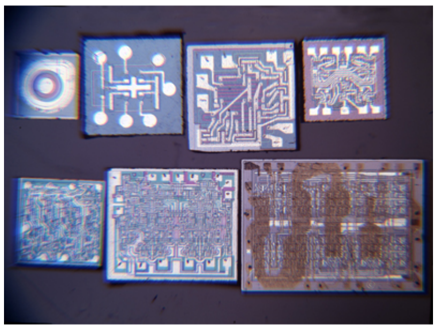
Roadmap of VLSI Design

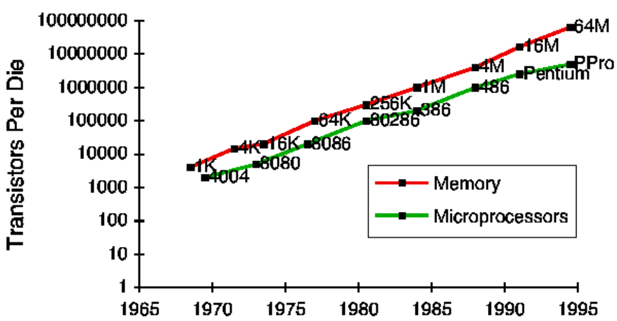




Gordon Moore at Fairchild (1962)



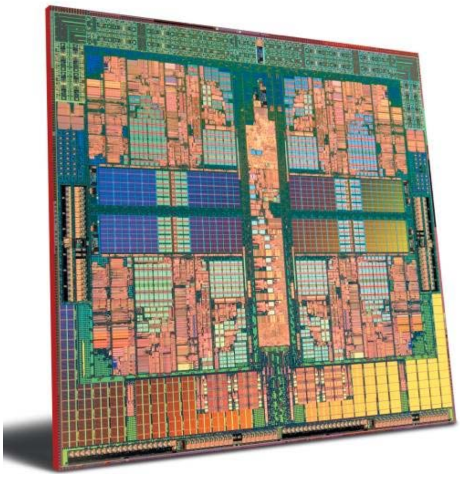




Photos: Intel

VLSI Design Nowadays

MPUs with billions of transistors



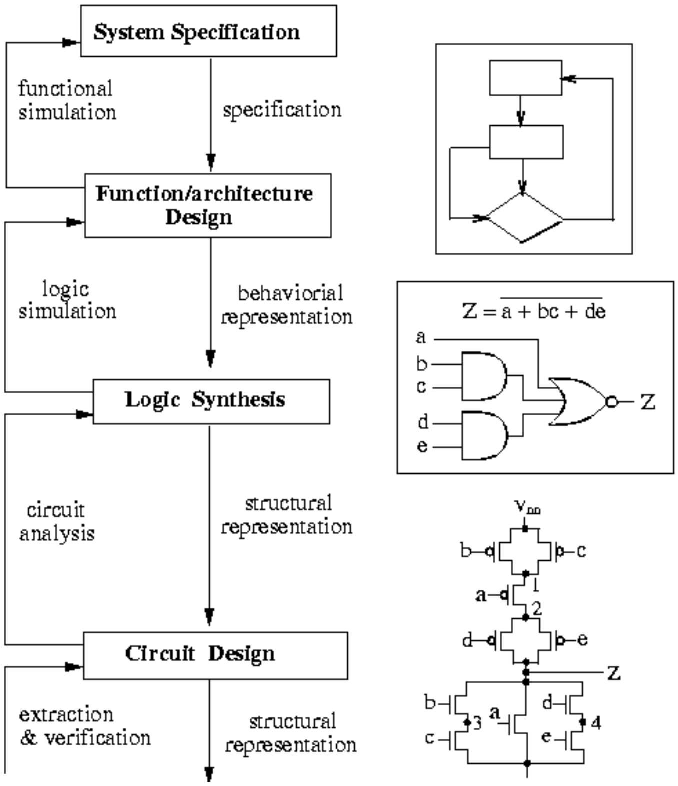
Systems with powerful capabilities

Photo: AMD; Apple

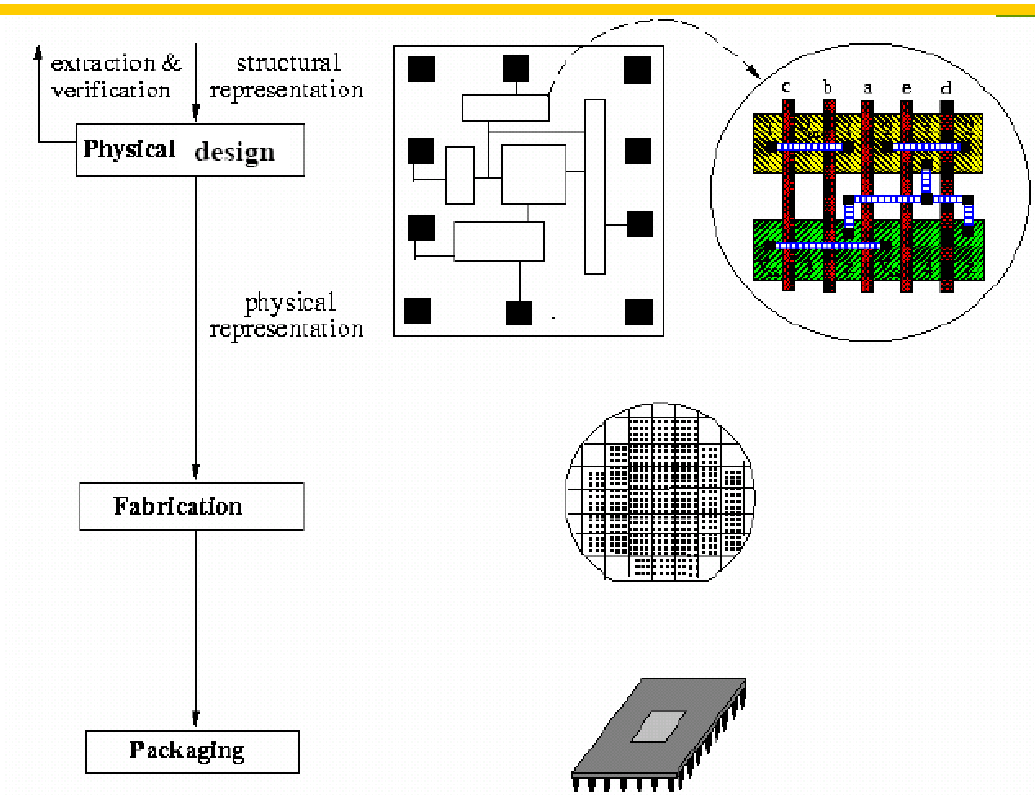
Cope with Complex Designs

- Proper design abstraction
  - E.g., treating digital circuits as switches
- Module-based design
- Design reuse
- Design automation
  - Computer-Aided Design (CAD) tools

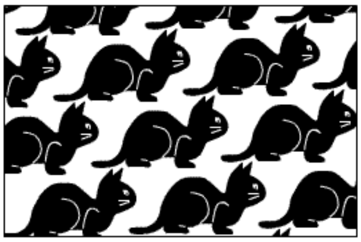
How to Build Digital Electronic Systems?



How to Build Digital Electronic Systems?



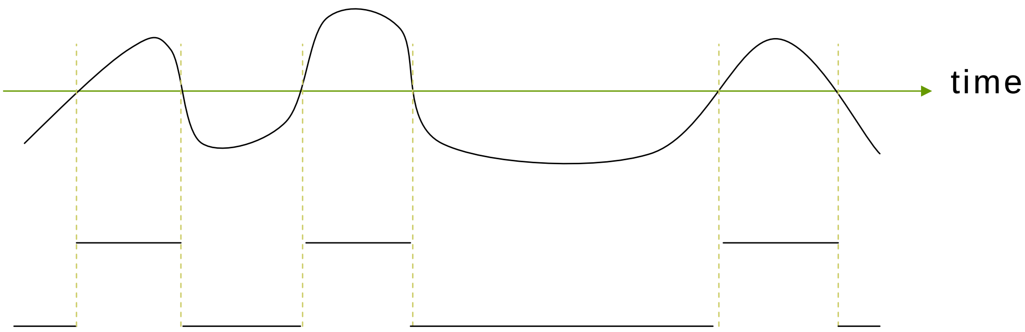
The World of **0** and **1**



People to Know

- George Boole
  - Logic + algebra $\rightarrow$ Boolean algebra
- Claude E. Shannon
  - Boolean algebra $\leftrightarrow$ switching circuits

Digital vs. Analog



Digital vs. Analog

- Digital
  - Discrete in value
  - More artificial

  - Immune to noise
  - Easy error correction
  - Easy precision control
  - Easy design automation

  - Slow computation
- Analog
  - Continuous value
  - Closer to physical world

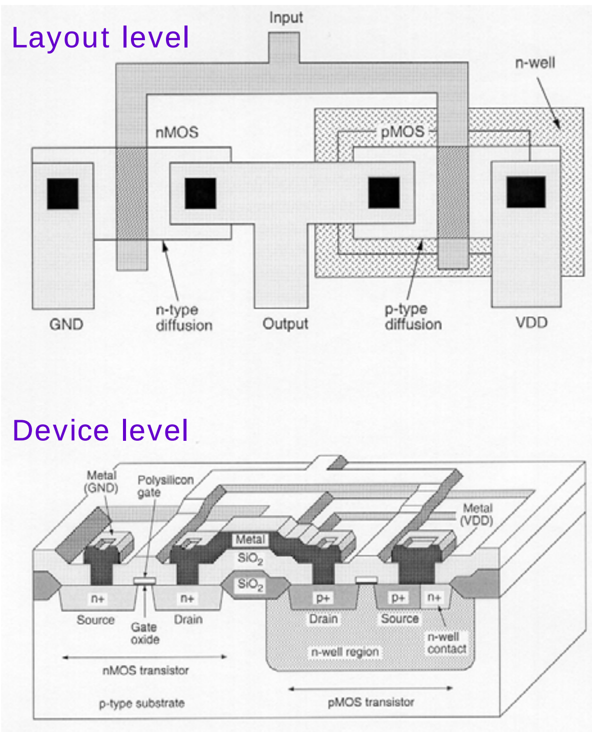
  - Vulnerable to noise
  - Hard error correction
  - Hard precision control
  - Hard design automation

  - Fast computation

Binary vs. Multi-Valued

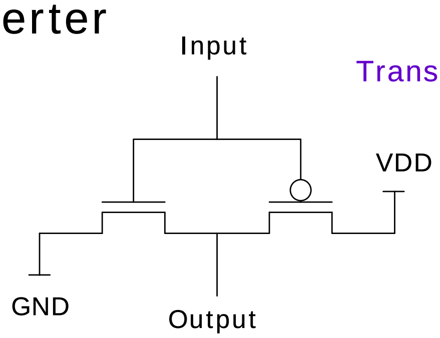
- A digital system can be binary or multi-valued
  - Binary:
    Signals with 2 values, e.g., {on, off}, {0,1},...
  - Multi-valued:
    Signals with > 2 values, e.g., {high, low, medium}, {0,1,2,3}, ...
  - Binary systems are still the most popular design choice
    - Simple and fast operations
    - Higher noise immunity

Digital Circuits and Boolean Algebra

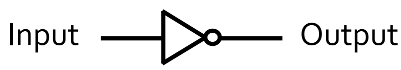


Inverter

Transistor level



Gate level



Input	Output
0	1
1	0

Reference: http://lsmwww.epfl.ch/Education/former/2002-2003/VLSIDesign/ch02/ch02.html

Switching Circuits and Logic Design

- This course is about digital circuit design at the gate level
  - Signals that we encounter are of {0,1} Boolean values
  - We will apply Boolean algebra to logic design
- Other applications
  - Biological network analysis and design
    - Gene regulatory networks can be abstracted as Boolean circuits
  - Non-conventional computation systems
    - E.g., quantum circuit design

Do You Know?

- What does “bit” stand for?
- Who coined the term?