INEL-6080
VLSI Systems Design

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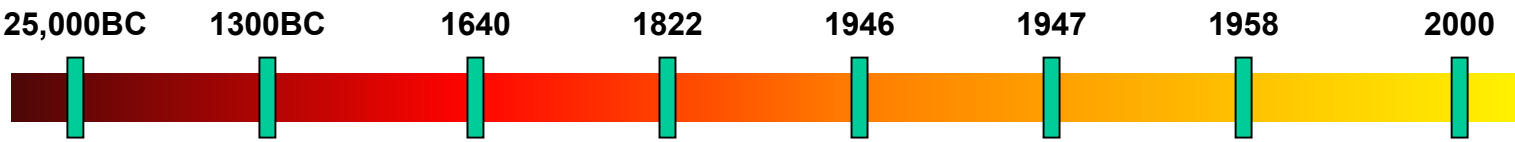
Lecture 1

Introduction

HISTORICAL PERSPECTIVE

Computational Devices

- The idea of developing computing devices is certainly not new
- A few chronological examples show the idea is as old as humanity



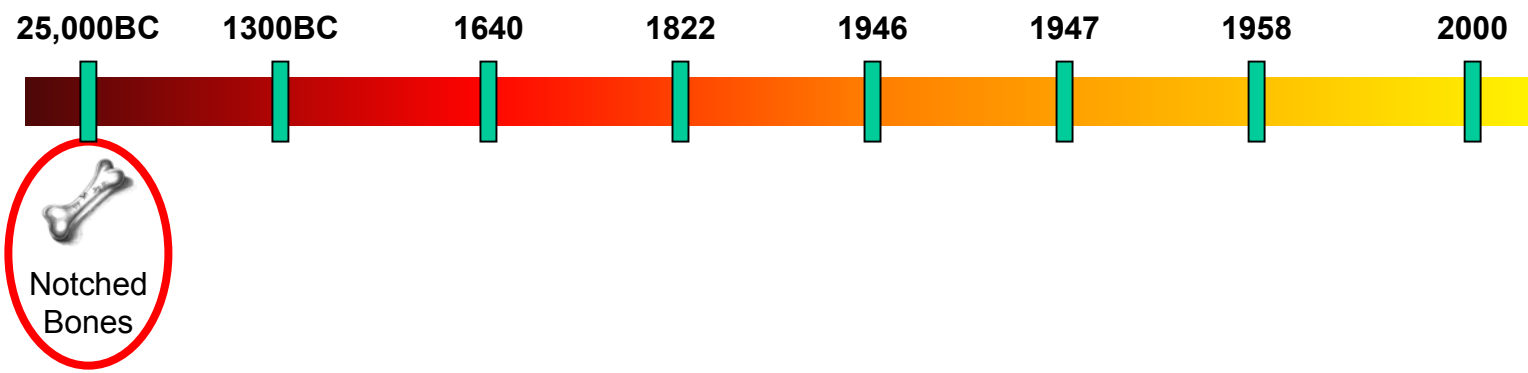
HISTORICAL PERSPECTIVE

25,000BC: Notched Bones

The Ishango Bone

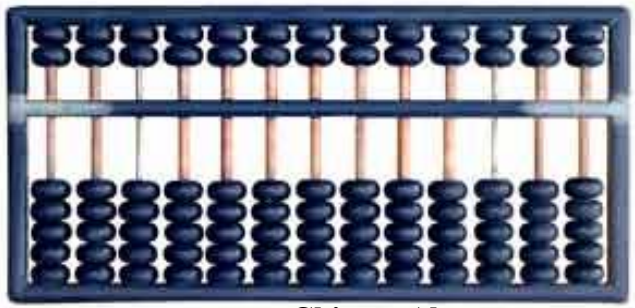
The Venus of Laussel

- The Ishango Bones
  - Notched bone from Congo, Africa. 25,000 to 20,000 BC
  - The markings represent a six-month lunar calendar
  - Believed to be used to compute women's menstrual cycle



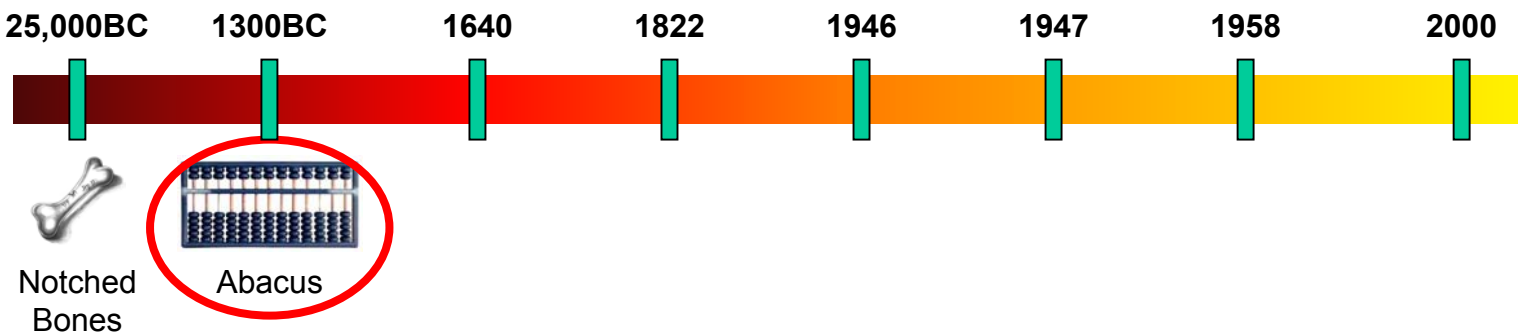
HISTORICAL PERSPECTIVE

1300BC: Abacus



Chinese Abacus

- Abacus
  - Originally invented by the Babylonians between 1,000BC and 500BC
  - Chinese Abacus (Ming Dynasty: 1368-1636)
  - Addition, Subtraction, Multiplication, and Division

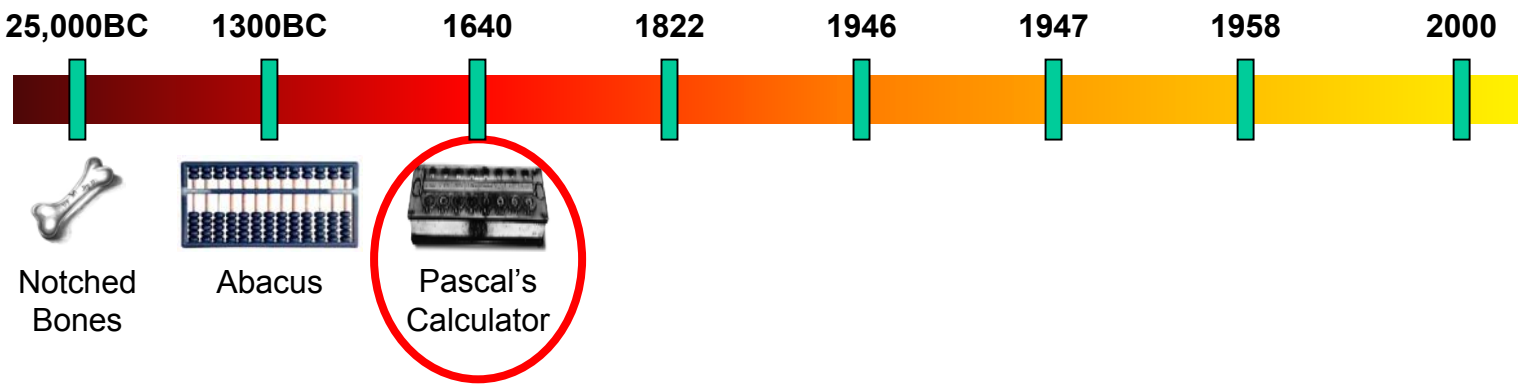


HISTORICAL PERSPECTIVE

1640: Pascal's Calculator

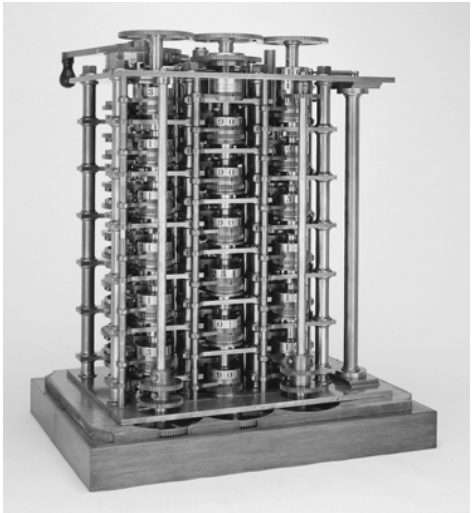
Pascal's Calculator

- Pascal's Calculator (1640)
  - First operational calculating machine
  - Addition and Subtraction
  - Multiplication and division implemented by a series of additions or subtractions



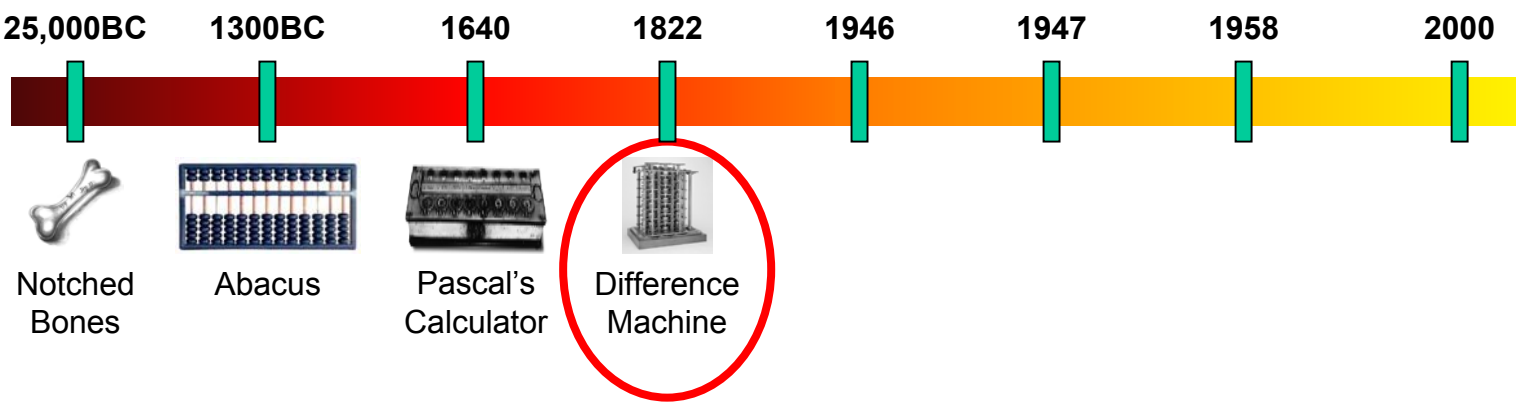
HISTORICAL PERSPECTIVE

1822: Difference Engine



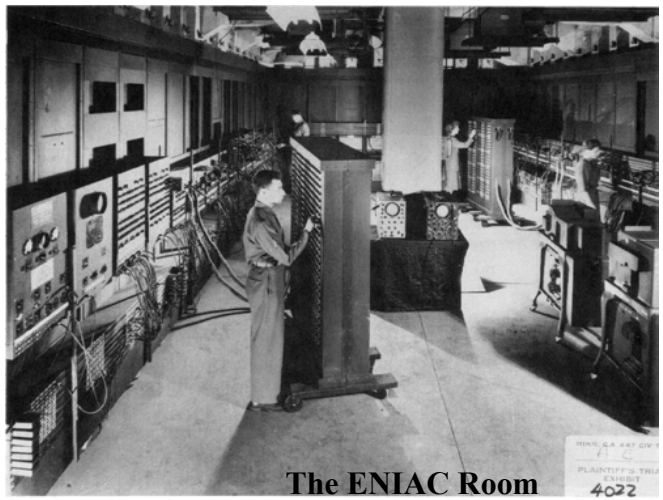
Part of Babbage's Difference Engine

- Babbage's Difference Engine (1822)
  - Considered the 1st computing engine
  - 25,000 mechanical parts
  - Cost: £17,470
  - Based on decimal system
  - Add, Sub, Mult, Div, Sqr, Log, Exp, to 31 digits

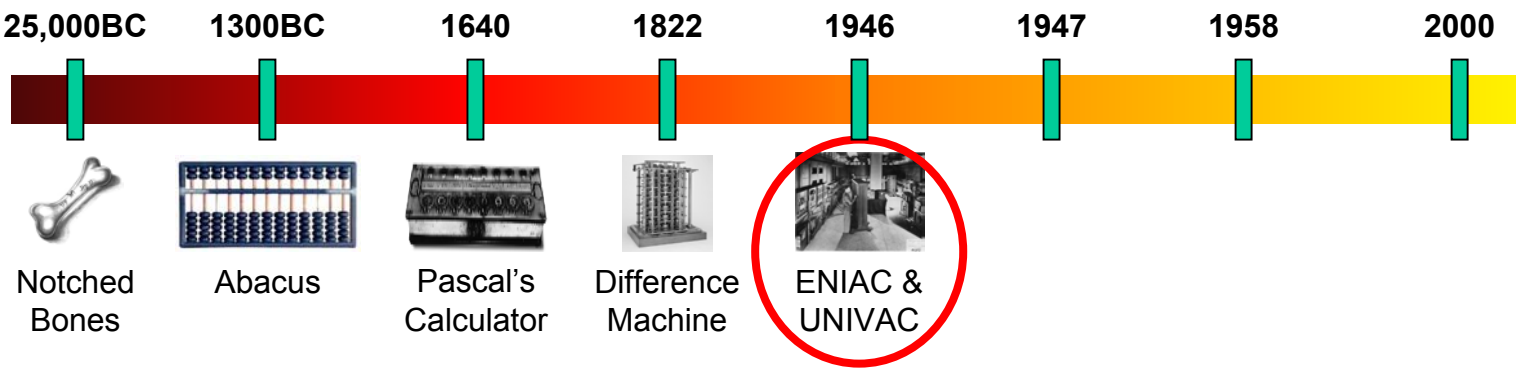


HISTORICAL PERSPECTIVE

1946: ENIAC & UNIVAC

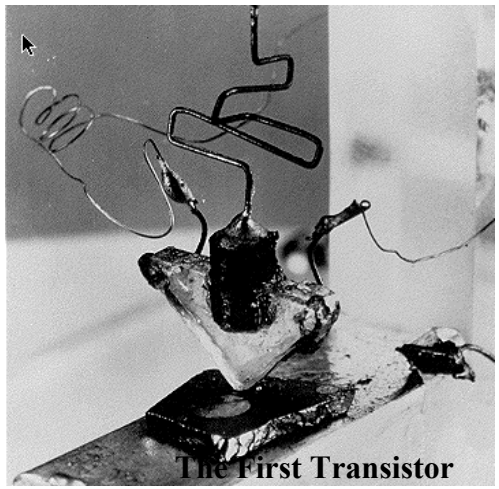


- Electronic Numerical Integrator and Computer (ENIAC)
  - First general-purpose computer
  - 1,000 square feet of area
  - 30 tons of weigh:
    - 18,000 vacuum tubes
    - 150 kilowatts of power
  - Performed 5000 additions/sec
  - Burned 50 tubes/day

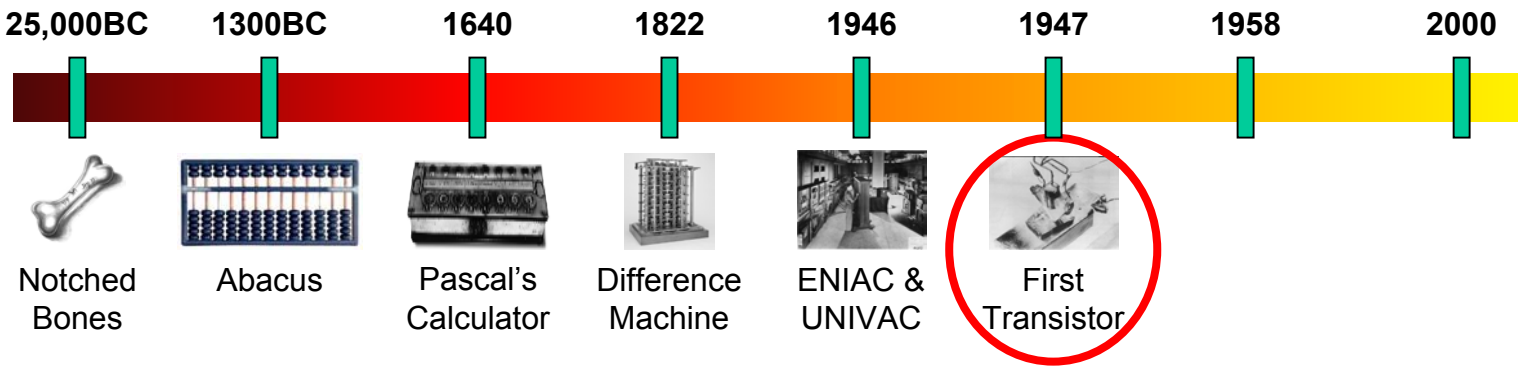


HISTORICAL PERSPECTIVE

1947: First Transistor

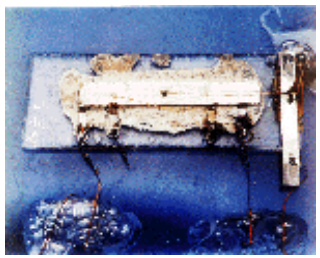


- Point-contact germanium transistor (Brattain & Bardeen) - 1947
- Bipolar junction transistor (Shockley) - 1949
- Field effect transistor (MOS FET) (Hofstain & Heiman) - 1962
  - First patent in 1926 (Lilienfeld)
- By 1960 all new computers used transistors

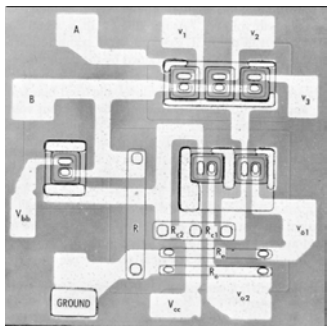


HISTORICAL PERSPECTIVE

1958: First Integrated Circuit

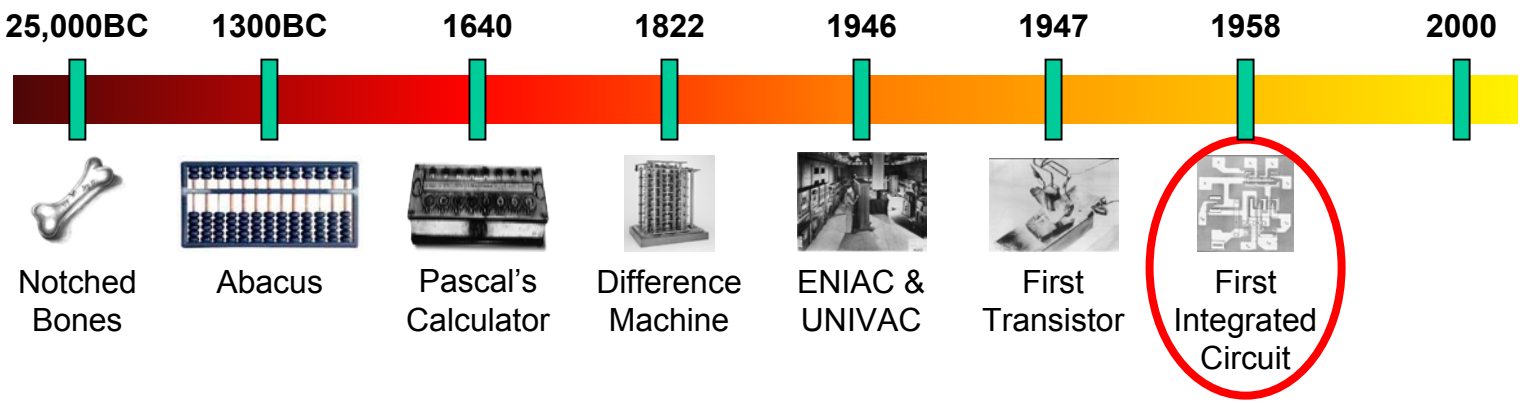


The First Integrated Circuit



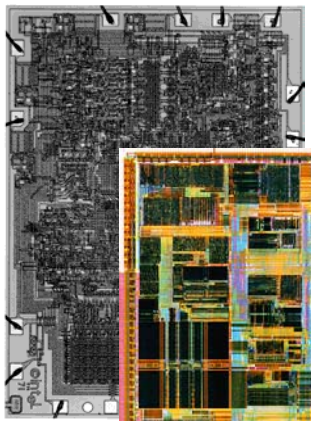
1966 bipolar ECL Gate

- 1958 Jack Kilby at Texas Instruments integrated multiple components onto a single semiconductor piece
  - A phase shift oscillator
- 1961 Fairchild and TI fabricate first commercial digital IC
- 1970 Fairchild introduced the first 256-bit static RAM

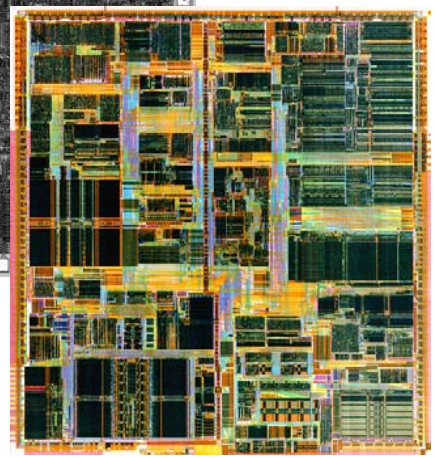


HISTORICAL PERSPECTIVE

The Microprocessor's Era

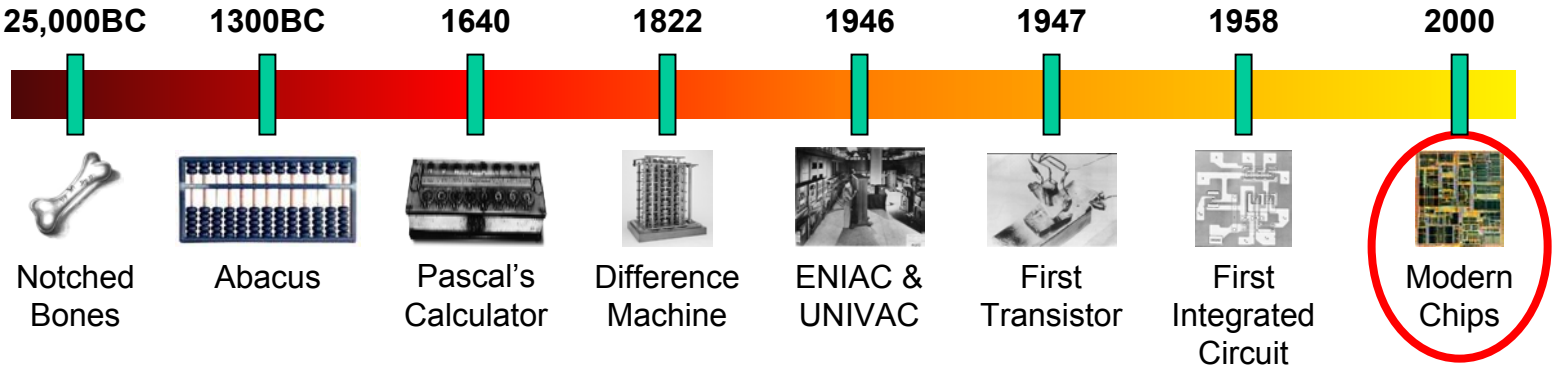


Intel 4004



Intel P4

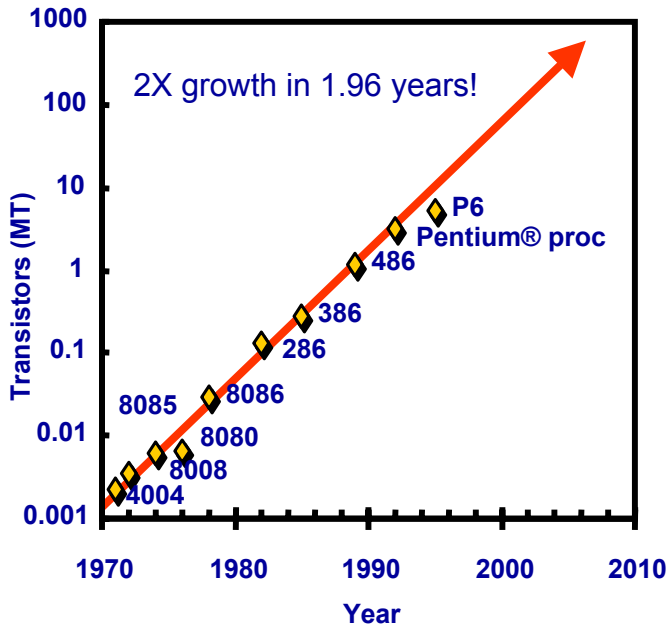
- Modern IC Examples:
  - INTEL 4004 (1971)
    - 1.0 MHz
    - 1K transistors
  - INTEL Pentium 4 (2000)
    - 3.20GHz
    - 60M transistors
    - FXP, FPU, Cache, Pipe

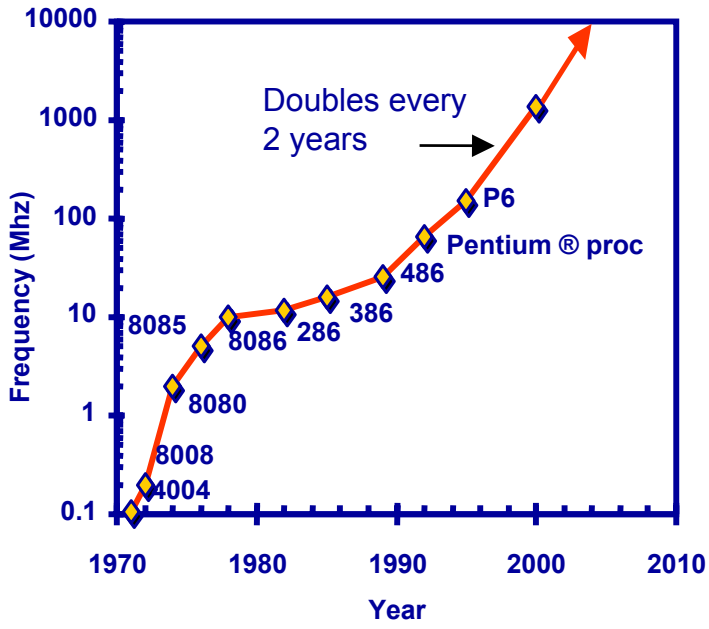


Primary Issues in IC Design

- Integration Density and Performance
- Moore's Law (1965):

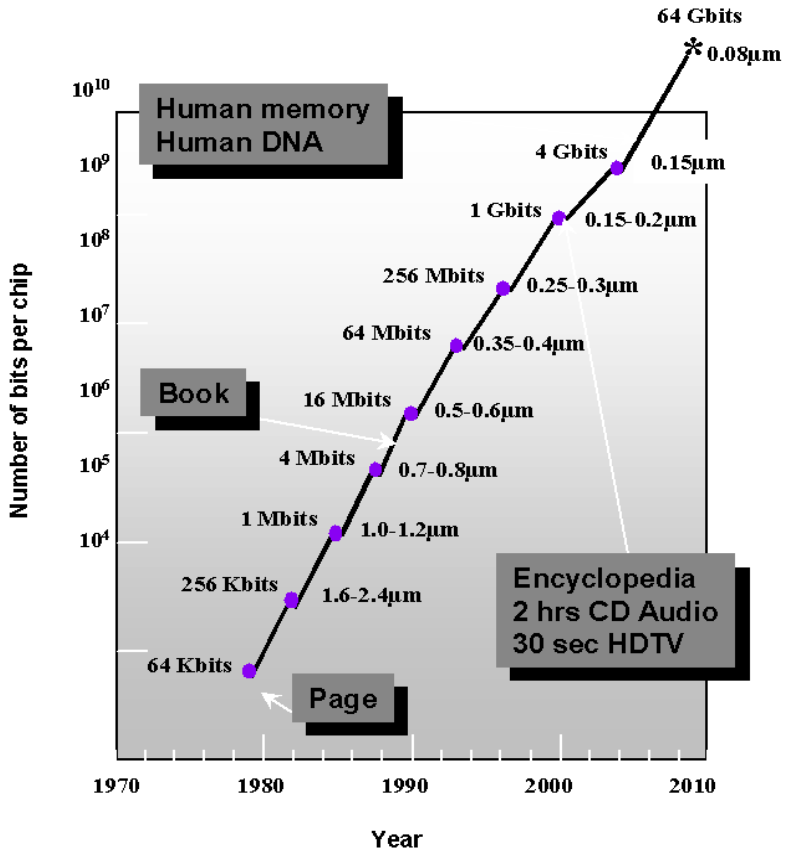
"*Semiconductor technology will double its effectiveness every 18 months*"





IC DESIGN ISSUES

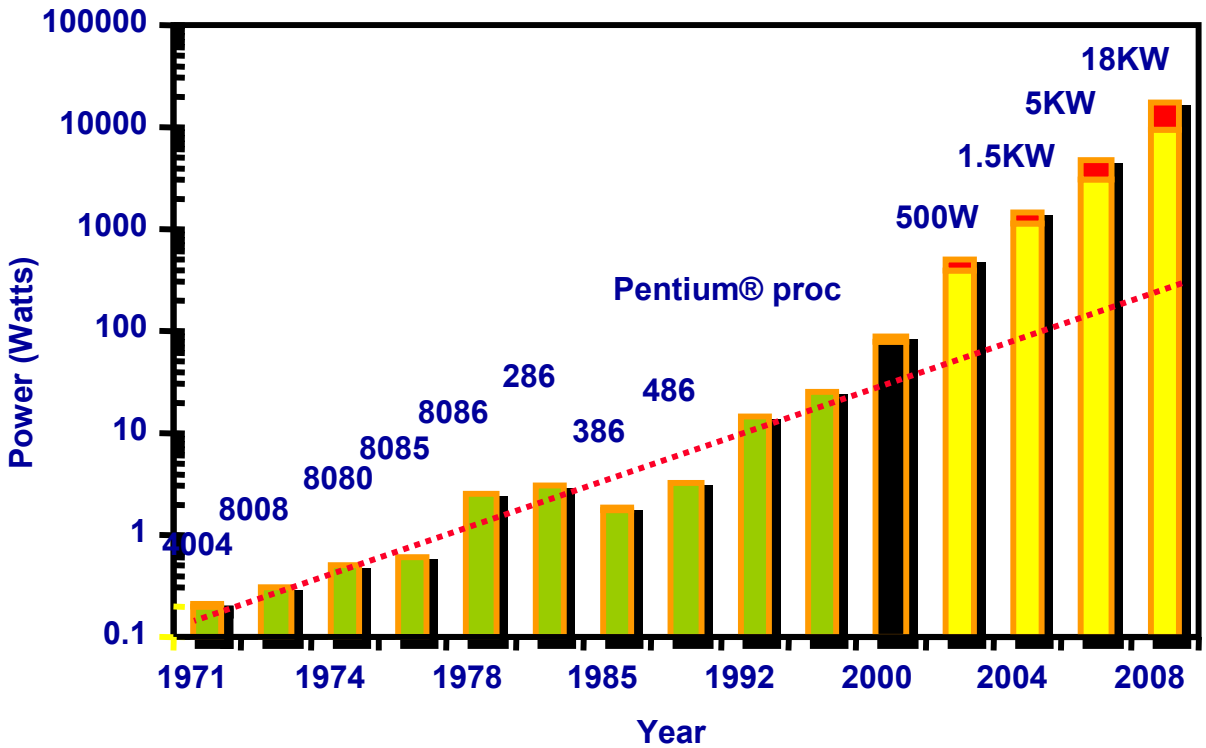
Memory Technology



- Has also followed Moore's Prediction
  - Integration complexity doubles every 1 to 2 years
  - Not expected to slow-down anytime soon
- Another issue has arisen

IC DESIGN ISSUES

Power in Microprocessors

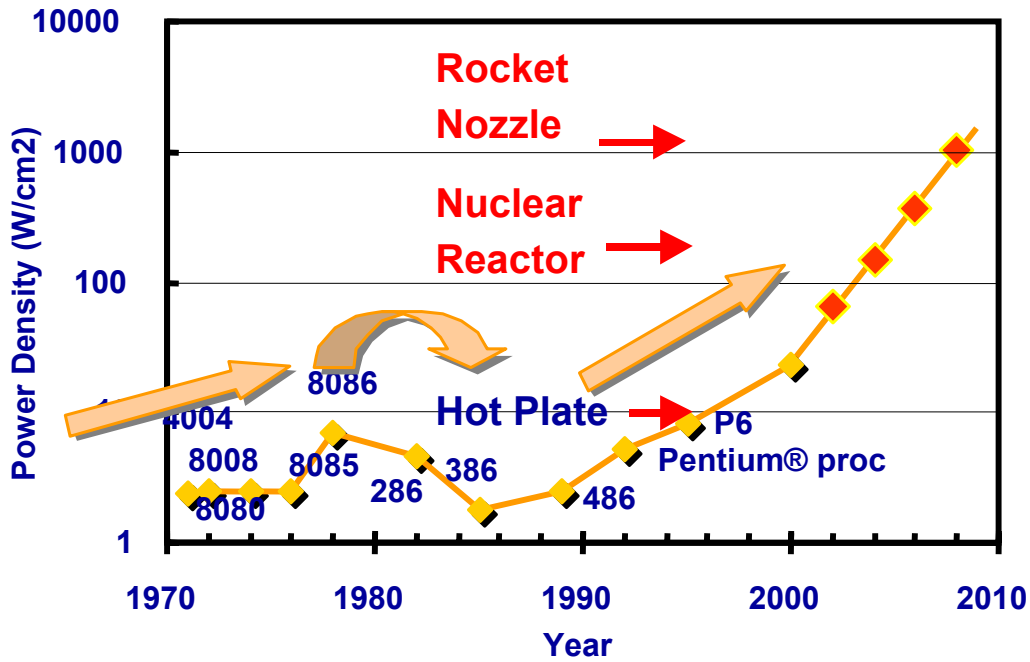


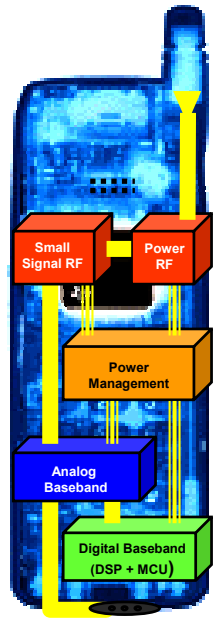
- Power delivery and dissipation could become prohibitive, especially in battery powered devices

IC DESIGN ISSUES

Power Density Problem

Amount of heat in ICs is becoming too high to keep junctions working at low temperature

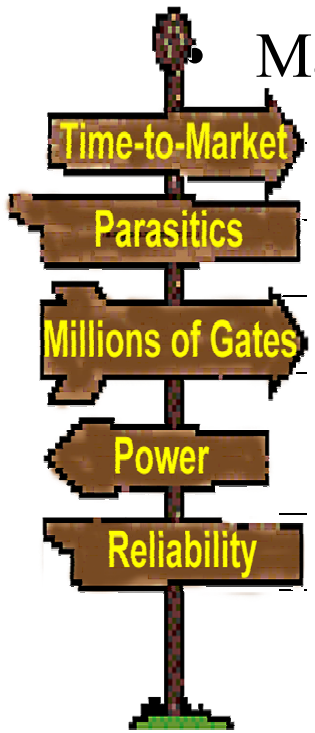




IC DESIGN ISSUES

Design Challenges

- Microscopic Level
  - Size and Performance
  - Power Dissipation
  - Interconnect Parasitics
  - Clock Distribution
  - Noise
  - Testability
  - Reliability
  - Manufacturability



- Macroscopic Level
  - Time-to-market
  - Technological Limits
  - Abstraction-Level
  - Reusability and Portability
  - Intellectual Property
  - Design Predictability