CSE 4217
VLSI Design

Introduction

WHAT IS VLSI

- In 1958, first integrated circuit flip-flop with **two** transistors. (LOL! Only two!!)

- In 2008, Intel's Itanium microprocessor contained more than **2 billion** transistors. (What!!)
- A 16 Gb Flash memory contained more than **4 billion** transistors. (OK! ▮▮)

- So, growth rate of 53% over 50 years!

So… VLSI is about integrating "transistors and whatever…."

LEVELS OF INTEGRATION

- Different levels of integration.
  - SSI
  - MSI
  - LSI
  - VLSI
  - VVLSI or ULSI

- Levels depend on number of transistors and logic gates

Name	Signification	Year	Transistors number[19]	Logic gates number[20]
SSI	*small-scale integration*	1964	1 to 10	1 to 12
MSI	*medium-scale integration*	1968	10 to 500	13 to 99
LSI	*large-scale integration*	1971	500 to 20,000	100 to 9,999
VLSI	*very large-scale integration*	1980	20,000 to 1,000,000	10,000 to 99,999
ULSI	*ultra-large-scale integration*	1984	1,000,000 and more	100,000 and more

MOORE'S LAW

- In the 1960s Gordon Moore predicted that the number of transistors that could be manufactured on a chip would grow exponentially.
- His prediction, now known as Moore's Law.
- Moore's ultimate prediction was that **transistor count would double every two years**, an estimate that has held up remarkably well.
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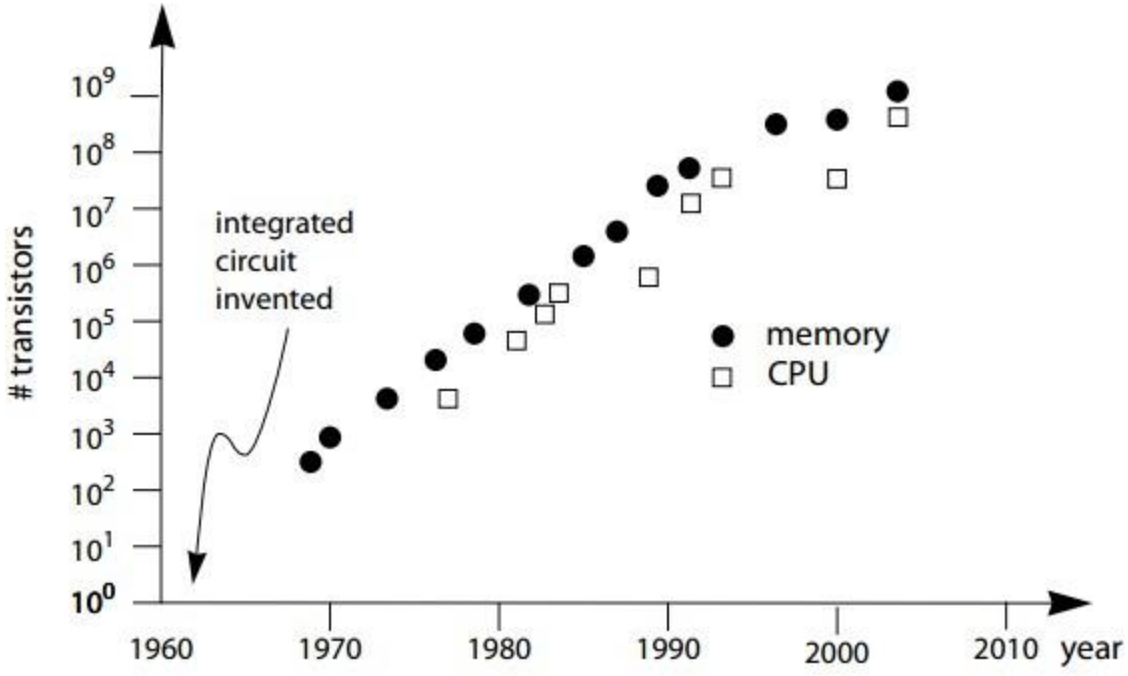
MOORE'S LAW



Moore's Law (Figure 1-3).

USE OF TRANSISTORS

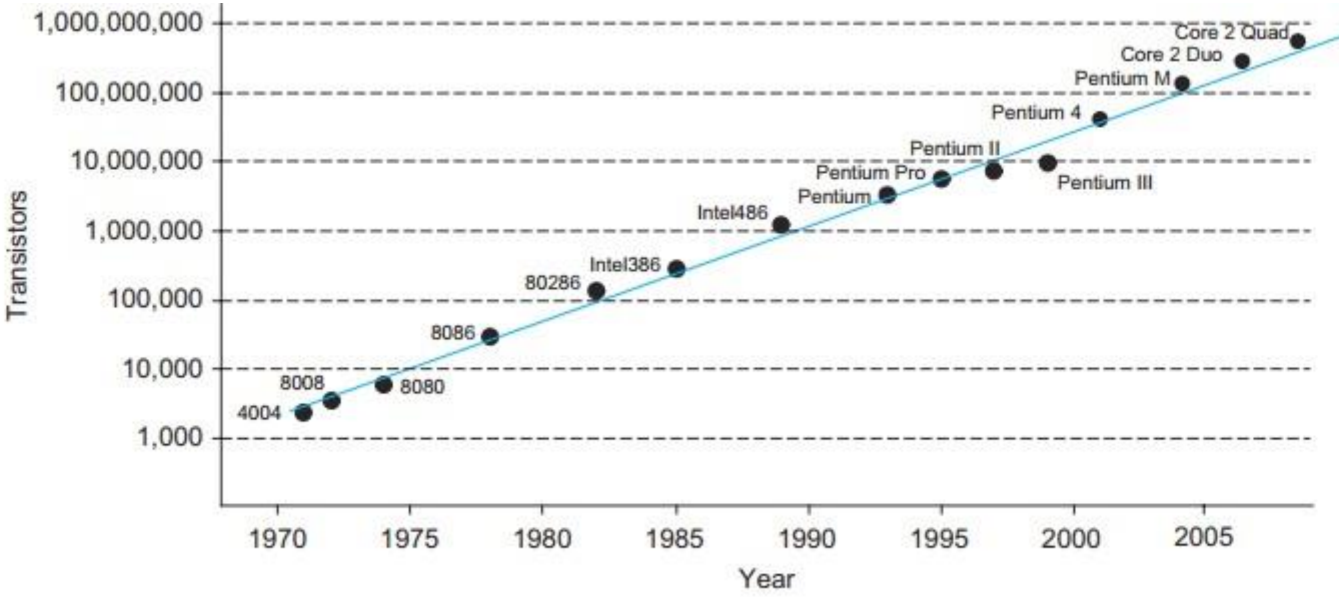


FIGURE 1.4 Transistors in Intel microprocessors [Intel10]

microprocessor	date of introduction	# transistors
80286	2/82	134,000
80386	10/85	275,000
80486	4/89	1,200,000
Intel Pentium™	3/93	3,100,000
Intel Pentium Pro™	11/95	5,500,000
Intel Pentium II™	1997	7,500,000
Intel Pentium III™	1999	9,500,000
Intel Pentium 4™	2000	42,000,000
Intel Itanium™	2001	25,000,000
Intel Itanium 2™	2003	220,000,000
Intel Itanium 2™ (9 MB cache)	2004	592,000,000

DENNARD’S SCALING LAW

- As transistors **shrink, they become faster, consume less power, and are cheaper to manufacture.** – known as Dennard’s Scaling Law.

- Intel microprocessor clock frequencies have doubled roughly every 34 months. This was performance measurement at first.
- Presently, the performance is driven by the number of cores on a chip rather than by the clock.
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FEATURE SIZE

- The feature size of a CMOS manufacturing process refers to the **minimum dimension of a transistor that can be reliably built.**
  - In 1971, The 4004 had feature size 10 um.
  - In 2008, Core 2 Duo had feature size 45 nm.

- Obviously, this scaling cannot go on forever because **transistors cannot be smaller than atoms.**
- Dennard scaling has already begun to slow.
- By the 45 nm generation, designers are having to **make trade-offs between improving power and improving delay.**

FEATURE SIZE

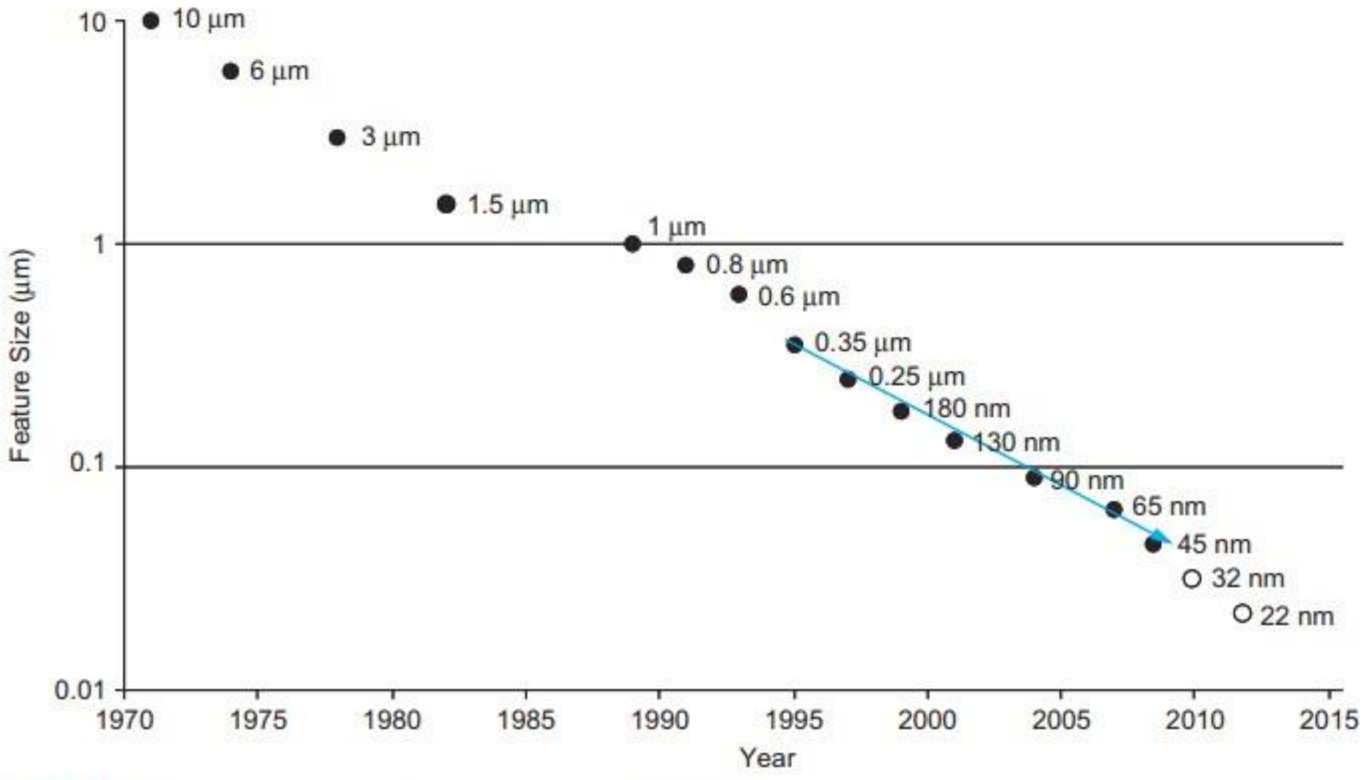

FIGURE 1.6 Process generations. Future predictions from [SIA2007].

WHY VLSI?

- **Smaller Physical Size**
- **Lower Power Consumption**
  - Replacing a handful of standard parts with a single chip reduces total power consumption.
  - Ripple effect:
    - less power consumption means less heat, a fan may no longer be necessary.
    - a simpler cabinet with less shielding for electromagnetic shielding may be feasible.

- **Reduced Cost**
  - Reducing the number of components, the power supply requirements, cabinet costs, and so on, will inevitably reduce system cost.
  - Ripple effect:
    - the cost of a system built from custom ICs can be less, even though the individual ICs cost more than the standard parts they replace.