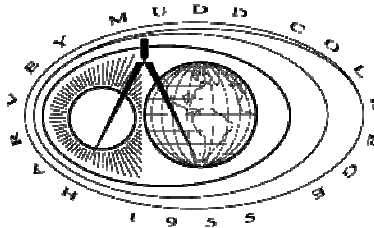


Introduction to CMOS VLSI Design

Lecture 22: Case Study: Intel Processors

David Harris



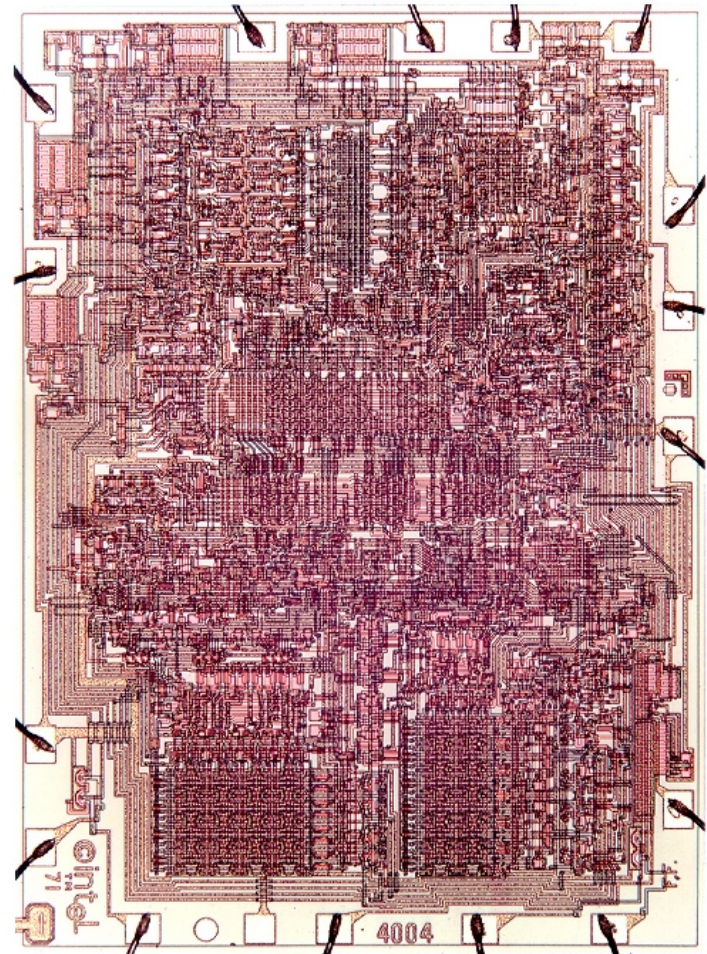
Harvey Mudd College
Spring 2004

Outline

- Evolution of Intel Microprocessors
 - Scaling from 4004 to Pentium 4
 - Courtesy of Intel Museum

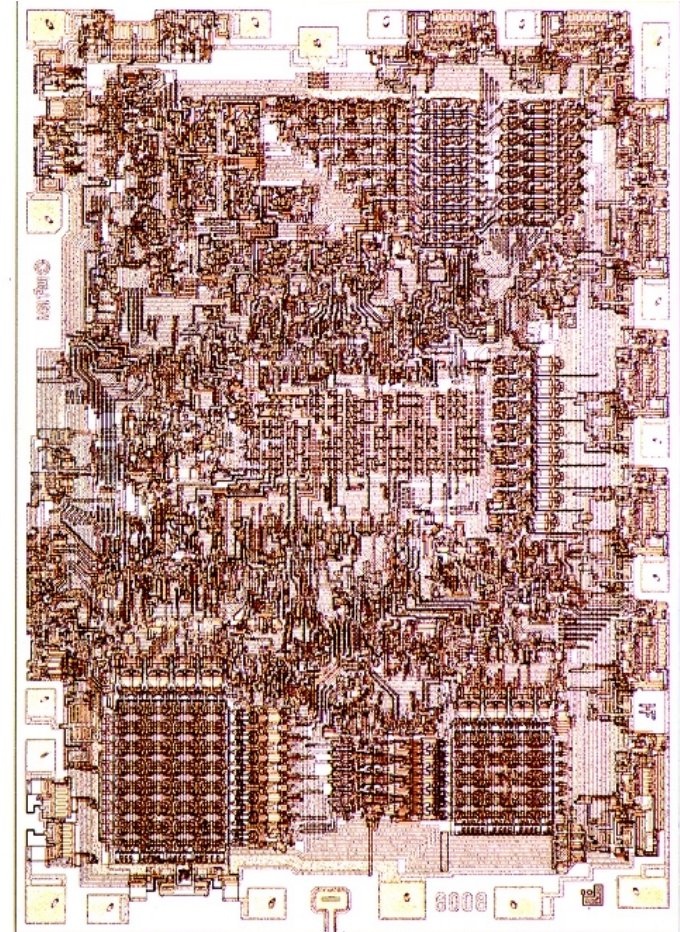
4004

- ❑ First microprocessor (1971)
 - For Busicom calculator
- ❑ Characteristics
 - 10 μm process
 - 2300 transistors
 - 400 – 800 kHz
 - 4-bit word size
 - 16-pin DIP package
- ❑ Masks hand cut from Rubylith
 - Drawn with color pencils
 - 1 metal, 1 poly (jumpers)
 - Diagonal lines (!)



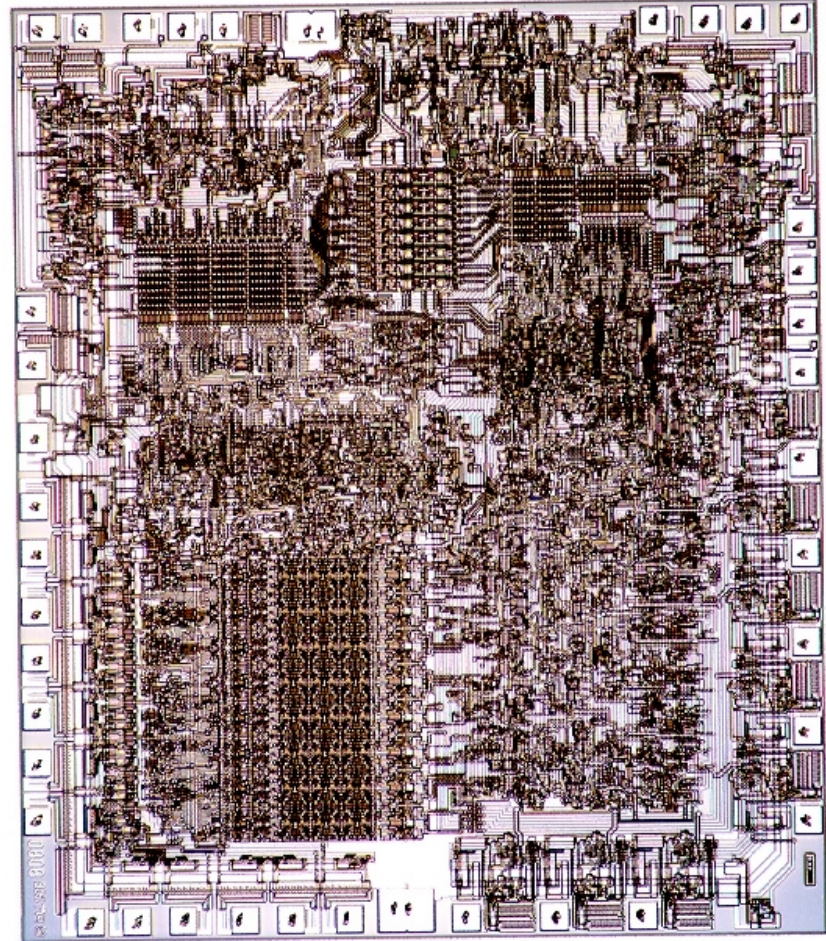
8008

- ❑ 8-bit follow-on (1972)
 - Dumb terminals
- ❑ Characteristics
 - 10 μm process
 - 3500 transistors
 - 500 – 800 kHz
 - 8-bit word size
 - 18-pin DIP package
- ❑ Note 8-bit datapaths
 - Individual transistors visible



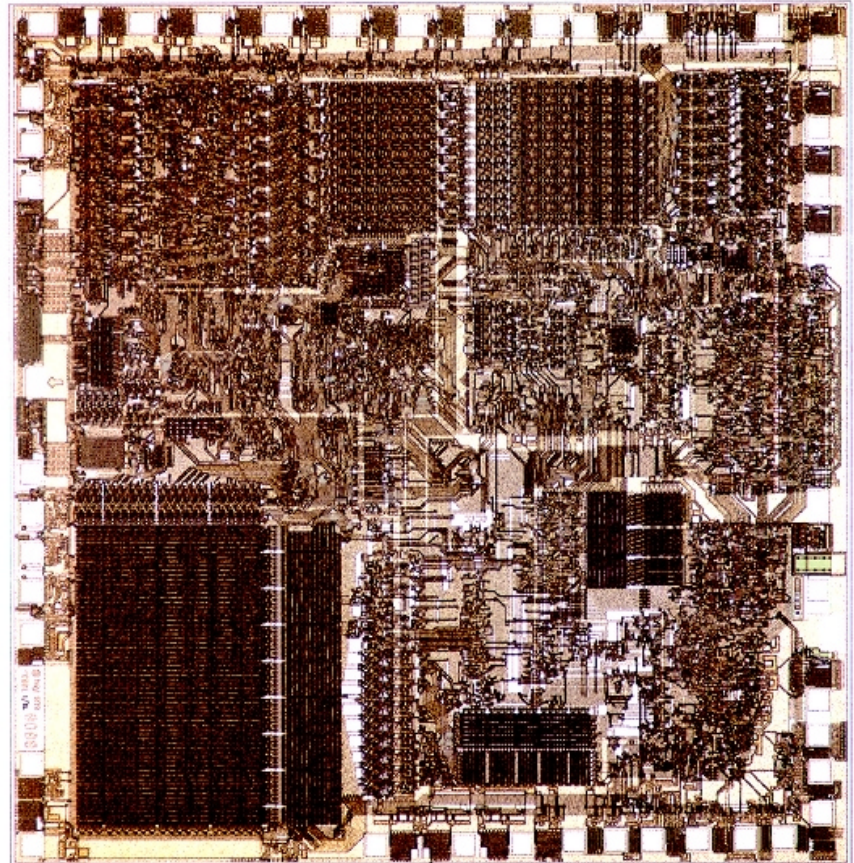
8080

- ❑ 16-bit address bus (1974)
 - Used in Altair computer
 - (early hobbyist PC)
- ❑ Characteristics
 - 6 μm process
 - 4500 transistors
 - 2 MHz
 - 8-bit word size
 - 40-pin DIP package



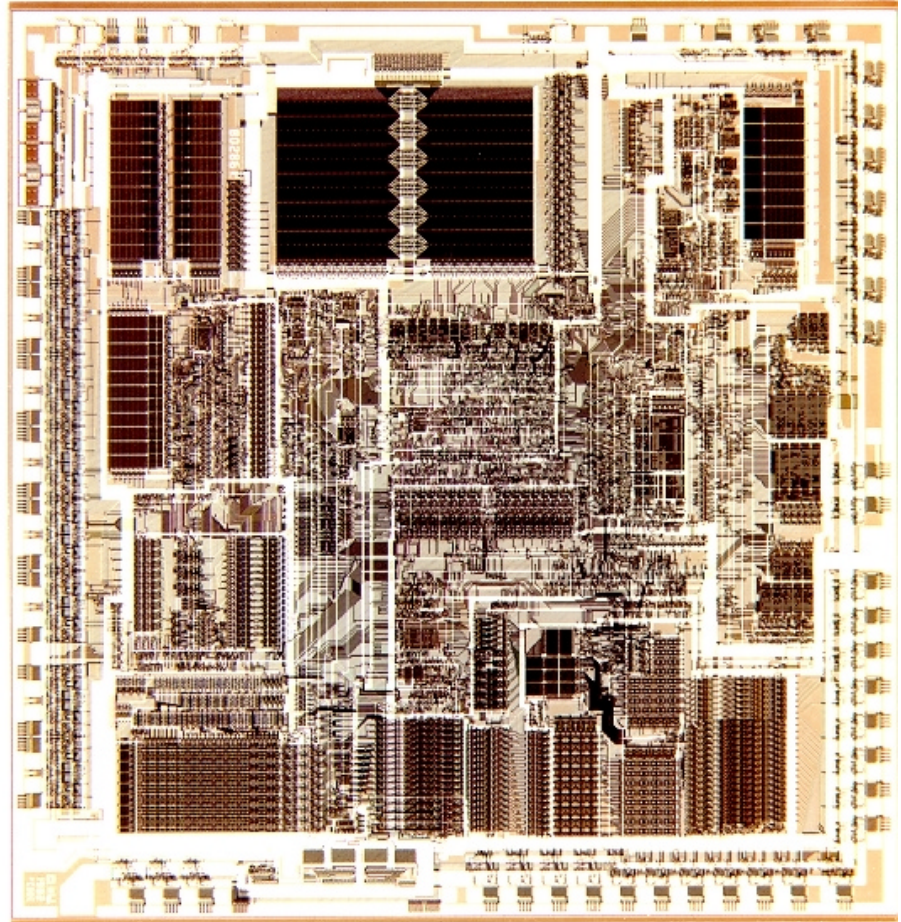
8086 / 8088

- ❑ 16-bit processor (1978-9)
 - IBM PC and PC XT
 - Revolutionary products
 - Introduced x86 ISA
- ❑ Characteristics
 - 3 μm process
 - 29k transistors
 - 5-10 MHz
 - 16-bit word size
 - 40-pin DIP package
- ❑ Microcode ROM



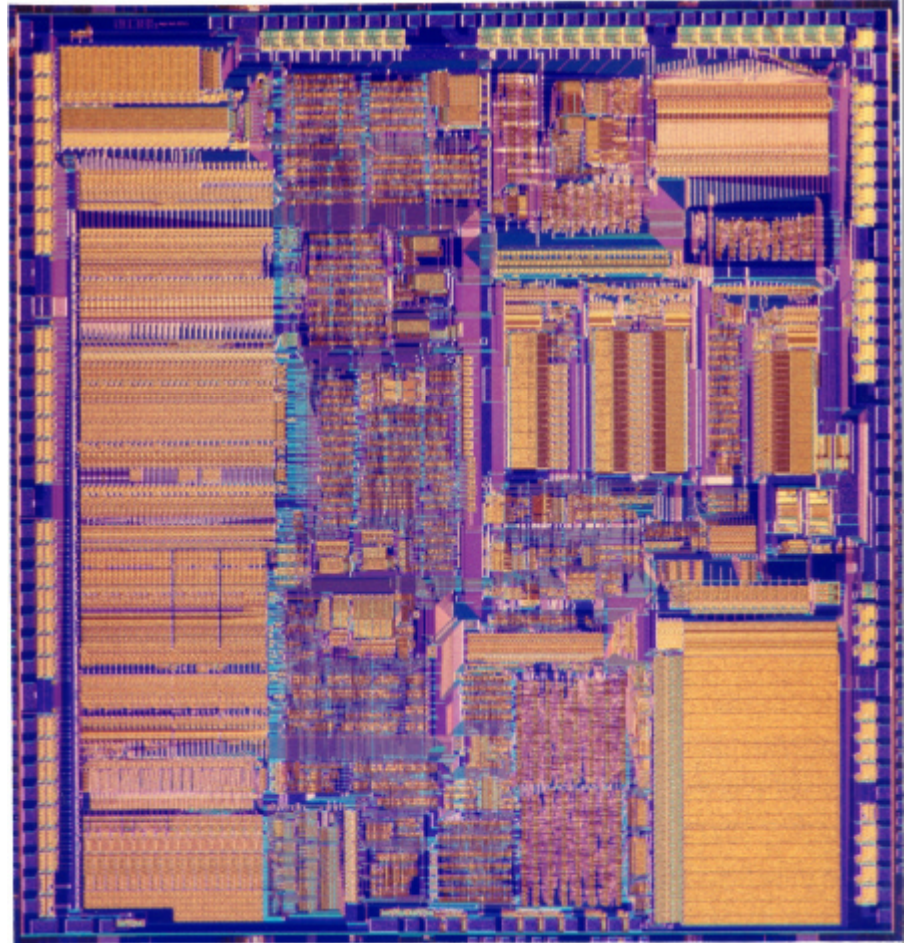
80286

- ❑ Virtual memory (1982)
 - IBM PC AT
- ❑ Characteristics
 - 1.5 μm process
 - 134k transistors
 - 6-12 MHz
 - 16-bit word size
 - 68-pin PGA
- ❑ Regular datapaths and ROMs
Bitslices clearly visible



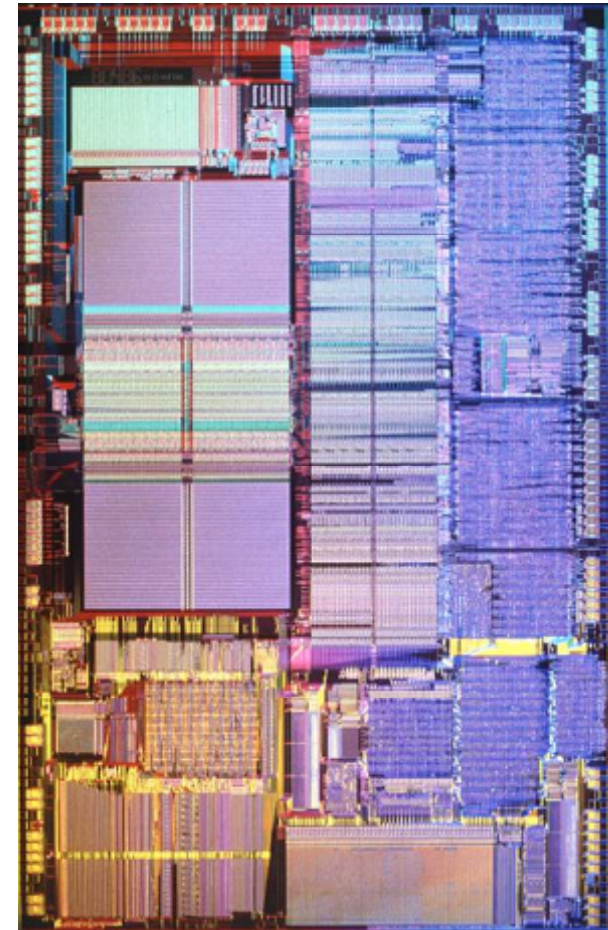
80386

- ❑ 32-bit processor (1985)
 - Modern x86 ISA
- ❑ Characteristics
 - 1.5-1 μm process
 - 275k transistors
 - 16-33 MHz
 - 32-bit word size
 - 100-pin PGA
- ❑ 32-bit datapath,
microcode ROM,
synthesized control



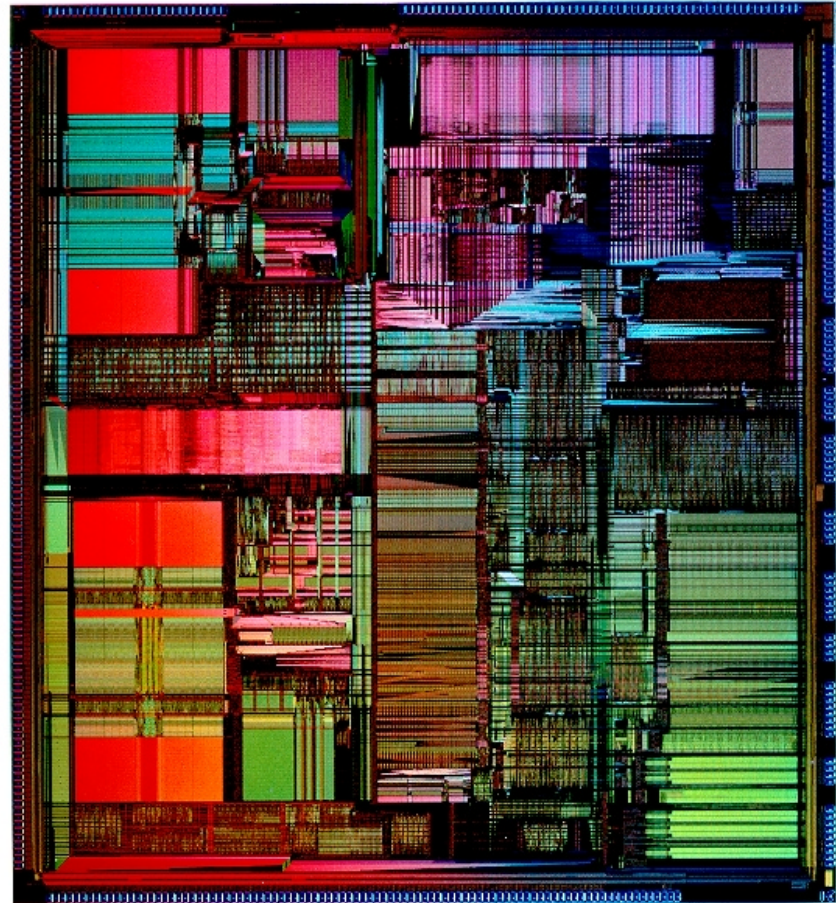
80486

- ❑ Pipelining (1989)
 - Floating point unit
 - 8 KB cache
- ❑ Characteristics
 - 1-0.6 μm process
 - 1.2M transistors
 - 25-100 MHz
 - 32-bit word size
 - 168-pin PGA
- ❑ Cache, Integer datapath, FPU, microcode, synthesized control



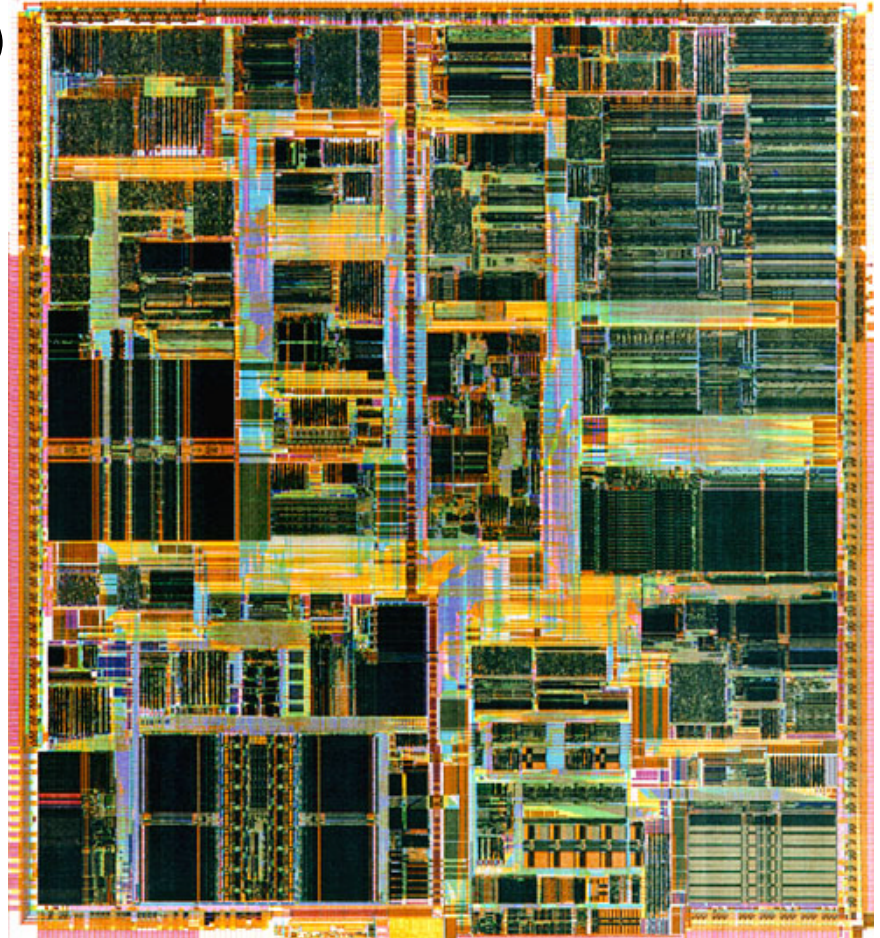
Pentium

- ❑ Superscalar (1993)
 - 2 instructions per cycle
 - Separate 8KB I\$ & D\$
- ❑ Characteristics
 - 0.8-0.35 μm process
 - 3.2M transistors
 - 60-300 MHz
 - 32-bit word size
 - 296-pin PGA
- ❑ Caches, datapath, FPU, control



Pentium Pro / II / III

- ❑ Dynamic execution (1995-9)
 - 3 micro-ops / cycle
 - Out of order execution
 - 16-32 KB I\$ & D\$
 - Multimedia instructions
 - PIII adds 256+ KB L2\$
- ❑ Characteristics
 - 0.6-0.18 μm process
 - 5.5M-28M transistors
 - 166-1000 MHz
 - 32-bit word size
 - MCM / SECC



Pentium 4

- ❑ Deep pipeline (2001)
 - Very fast clock
 - 256-1024 KB L2\$
- ❑ Characteristics
 - 180 – 90 nm process
 - 42-125M transistors
 - 1.4-3.4 GHz
 - 32-bit word size
 - 478-pin PGA
- ❑ Units start to become invisible on this scale



Summary

- ❑ 10^4 increase in transistor count, clock frequency over 30 years!

Table 4.19 History of Intel microprocessors over three decades

Processor	Year	Feature Size (μm)	Transistors	Frequency (MHz)	Word size	Package
4004	1971	10	2.3k	0.75	4	16-pin DIP
8008	1972	10	3.5k	0.5–0.8	8	18-pin DIP
8080	1974	6	6k	2	8	40-pin DIP
8086	1978	3	29k	5–10	16	40-pin DIP
80286	1982	1.5	134k	6–12	16	68-pin PGA
Intel386	1985	1.5–1.0	275k	16–25	32	100-pin PGA
Intel486	1989	1–0.6	1.2M	25–100	32	168-pin PGA
Pentium	1993	0.8–0.35	3.2–4.5M	60–300	32	296-pin PGA
Pentium Pro	1995	0.6–0.35	5.5M	166–200	32	387-pin MCM PGA
Pentium II	1997	0.35–0.25	7.5M	233–450	32	242-pin SECC
Pentium III	1999	0.25–0.18	9.5–28M	450–1000	32	330-pin SECC2
Pentium 4	2001	0.18–0.13	42–55M	1400–3200	32	478-pin PGA