第1章 计算机设计基础

1.1 引言
1.2 计算机的分类
1.3 计算机系统结构定义和计算机的设计任务
1.4 实现技术的趋势
1.5 集成电路功耗的趋势
1.6 成本的趋势
1.7 可靠性
1.8 测量、报告和总结计算机性能
1.9 计算机设计的量化原则
1.10 综合：性能和性价比

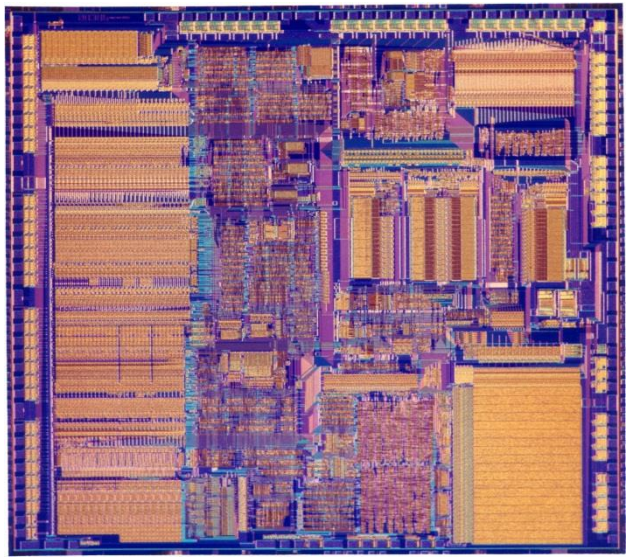
1.5 集成电路功耗（power）的趋势

- 功耗对芯片的规模也提出了挑战
  - 第1个微处理器：1/10watt -->

    2GHz P4：135watt
- 技术挑战：
  - 分配功率
  - 散热
  - 避免过热点

晶体管数量：以下P4是386的200倍

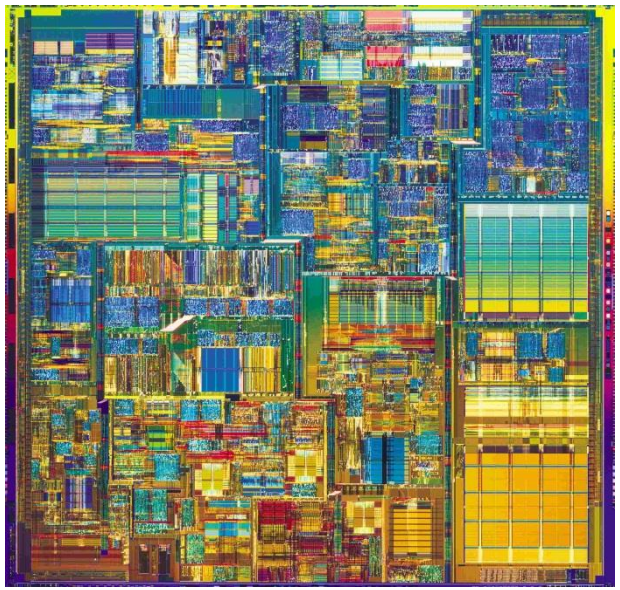
386 Processor



May 1986
16 MHz core
275,000 1.5µ transistors
1.2 SPECint2000

17 Years
200x
200x/11x
1000x

Pentium® 4 Processor



August 27, 2003
3.2 GHz core
55 Million 0.13µ transistors
1249 SPECint2000

两个概念

- **动态功率: 开关晶体管产生的功耗**
  - **Power $_{dynamic}$ = ½ *Capacitive load * Voltage^2 * Frequency switched**
  - **Energy $_{dynamic}$ = Capacitive load * Voltage^2**
- **静态功率: 晶体管在关闭时漏电产生的功耗**
  - **Power $_{static}$ = current static * Voltage**

Example

- **Some microprocessors today are designed to have adjustable voltage, so a 15% reduction in voltage may result in a 15% reduction in frequency. What would be the impact on dynamic energy and on dynamic power?**

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- **Answer:**

Since the capacitance is unchanged, the answer for energy is the ratio of the voltages since the capacitance is unchanged:

$$\frac{Energy_{new}}{Energy_{old}} = \frac{(Voltage * 0.85)^2}{Voltage^2} = 0.85^2 = 0.72$$

thereby reducing energy to about 72% of the original. For power, we add the ratio of the frequencies

$$\frac{Power_{new}}{Powery_{old}} = 0.72 * \frac{(Frequency\ switched * 0.85)}{Frequency\ switched} = 0.61$$

shrinking power to about 61% of the original.

经验法则

- 电压减少10%
- 频率减少10%

=>

- 功率减少30%
- 性能减少< 10%

Rule of Thumb

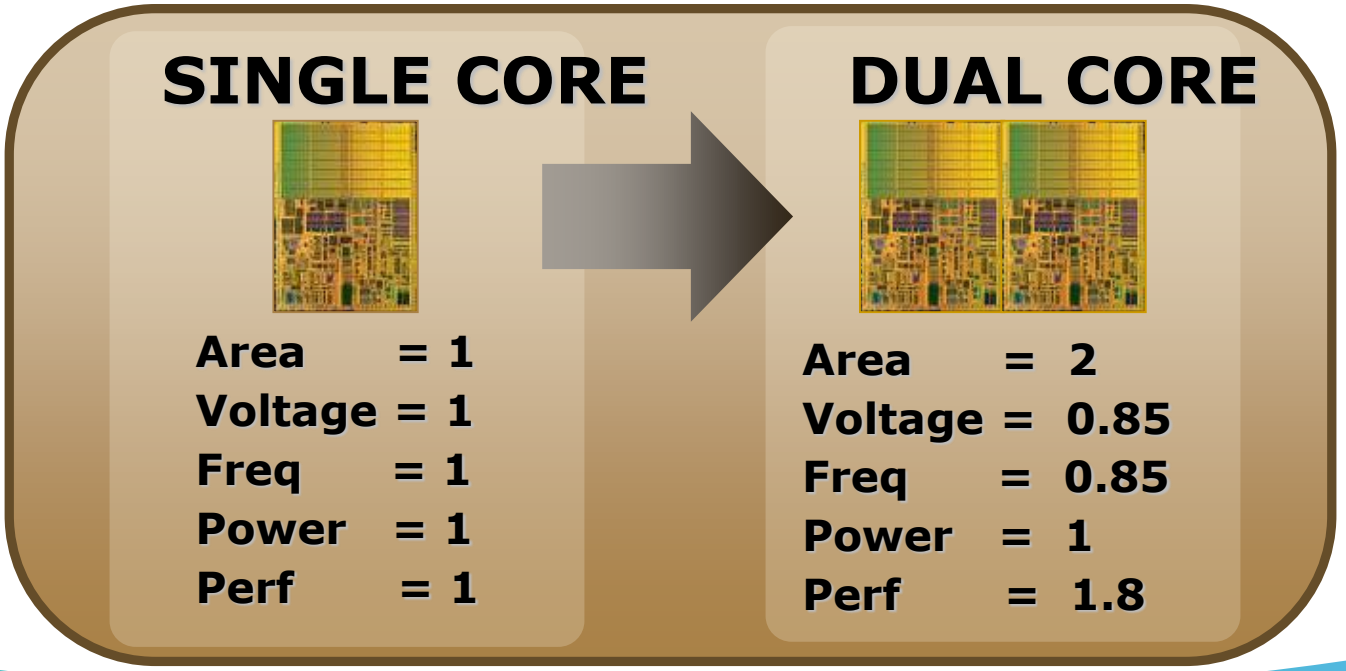
Voltage	Frequency	Power	Performance
1%	1%	3%	0.66%

单核与双核功耗/性能比较

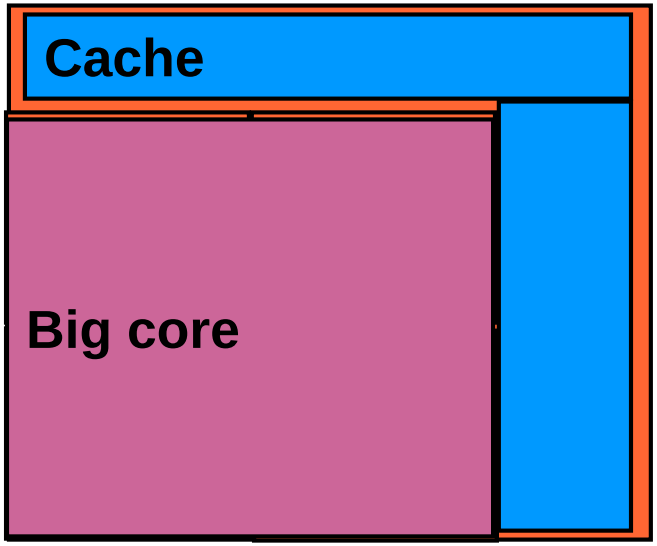
经验法则

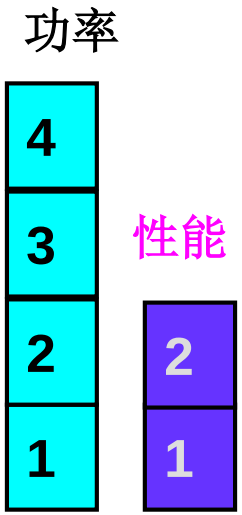
A 15% Reduction In Voltage Yields

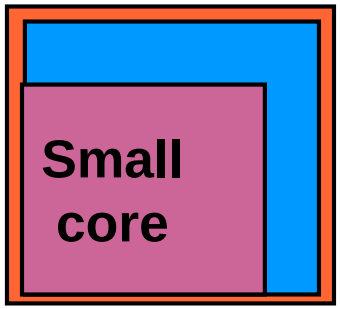
Frequency Reduction	Power Reduction	Performance Reduction
15%	45%	10%

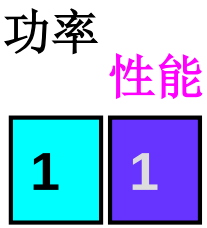


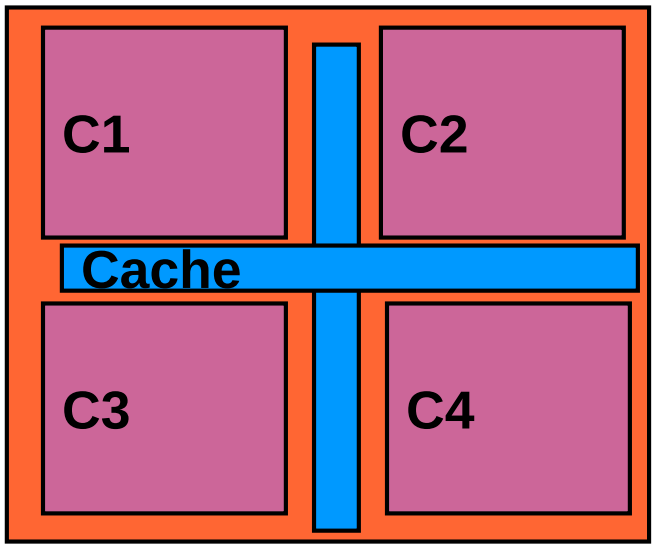
对于多核，每瓦提供更多性能

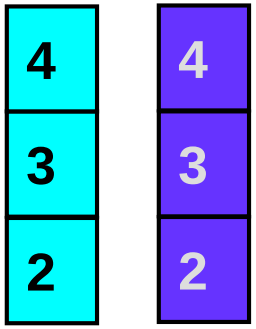












功耗 与 面积成正比

单核性能与面积增加倍数的一半成正比

多核有更高的功率利用率

- Intel i7处理器平均功耗为45瓦。
- 基于ARM的片上系统（其中包括图形处理器）的功耗最大瞬间峰值大约是3瓦。

Exercise 1.4

Figure 1.23 presents the power consumption of several computer system components.

a. Assuming the maximum load for each component, and a power supply efficiency of 80%, what wattage must the server's power supply deliver to a system with an Intel Pentium 4 chip, 2 GB 240-pin Kingston DRAM, and one 7200 rpm hard drive?

b. How much power will the 7200 rpm disk drive consume if it is idle roughly 60% of the time?

c. Given that the time to read data of a 7200 rpm disk drive will be roughly 75% of a 5400 rpm disk, at what idle time of the 7200 rpm disk will the power consumption be equal, on average, for the two disks?

Component type	Product	Performance	Power
Processor	Sun Niagara 8-core	1.2 GHz	72–79 W peak
	Intel Pentium 4	2 GHz	48.9–66 W
DRAM	Kingston X64C3AD2 1 GB	184-pin	3.7 W
	Kingston D2N3 1 GB	240-pin	2.3 W
Hard drive	DiamondMax 16	5400 rpm	7.0 W read/seek, 2.9 Widle
	DiamondMax 9	7200 rpm	7.9 W read/seek, 4.0 Widle

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$$0.80 * x = 66 + 2 * 2.3 + 7.9$$

$$x = 99$$

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0.6 * 4 W + 0.4 * 7.9 = 5.56

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Solve the following four equations:
seek7200 =0 .75 * seek5400
seek7200 + idle7200 = 1.0
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seek7200 * 7.9 + idle7200 * 4 = seek5400 * 7 + idle5400 * 2.9

idle7200 = 29.8%

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