第1章 计算机设计基础

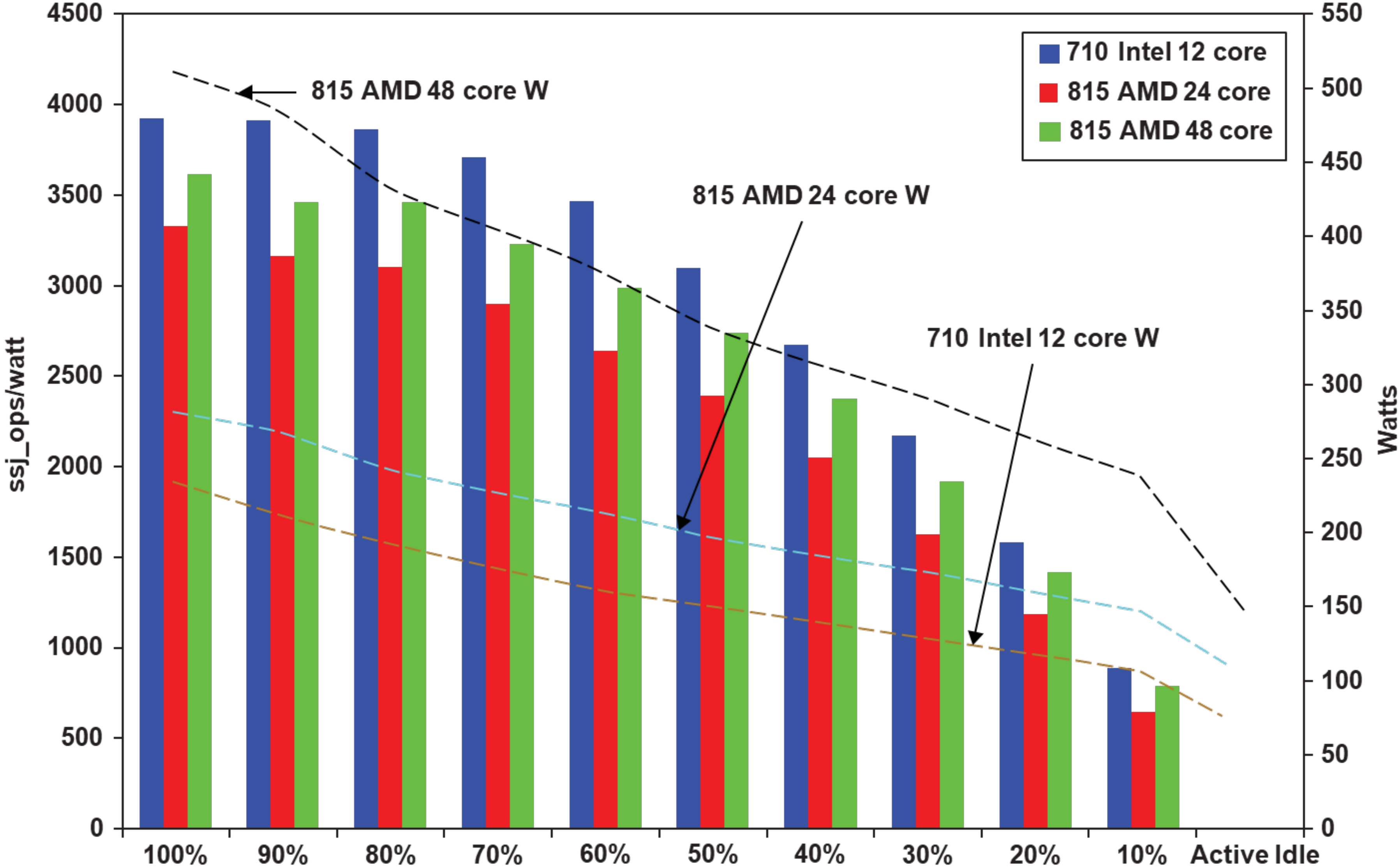
1.10 综合：性能和性价比

桌面系统的性能和性价比

价格差异大的因素

- 不同级别的可扩展性
- 更便宜的磁盘和存储器
- 不同CPU的价格
- 软件差异
- 低端系统在风扇、电源、支持芯片套件方面，使用PC 商品化的配件
- 商品化

Figure 1.19 SPEC Power Benchmark



- **Power consumption of server at different workload levels**
  - ssj_ops: server side Java operations

SPEC Power Benchmark

- **Power consumption of server at different workload levels**
  - ssj_ops: server side Java operations
  - Performance: ssj_ops/sec
  - Power: Watts (Joules/sec)

$$\text{Overall ssj\_ops per Watt} = \left(\sum_{i=0}^{10} \text{ssj\_ops}_i\right) \Bigg/ \left(\sum_{i=0}^{10} \text{power}_i\right)$$

Reference :
Computer Organization and Design: The Hardware / Software Interface (MIPS 5e)

SPECpower_ssj2008 for Xeon X5650

Target Load %	Performance (ssj_ops)	Average Power (watts)
100%	865,618	258
90%	786,688	242
80%	698,051	224
70%	607,826	204
60%	521,391	185
50%	436,757	170
40%	345,919	157
30%	262,071	146
20%	176,061	135
10%	86,784	121
0%	0	80
Overall Sum	4,787,166	1922
$\sum$ssj_ops / $\sum$power =		2490

ssj_ops: server side Java operations

Reference :
Computer Organization and Design: The Hardware / Software Interface (MIPS 5e)

易犯的错误和谬误

- 易犯的错误（Pitfall）：
  - 错误地认为指数增长定律一直有效。

易犯的错误（Pitfall）

- 忽视Amdahl's Law的性能改进极限。
- **Pitfall: Expecting the improvement of one aspect of a computer to increase overall performance by an amount proportional to the size of the improvement.**

$$T_{\text{improved}} = \frac{T_{\text{affected}}}{\text{improvement factor}} + T_{\text{unaffected}}$$

- **Example: multiply accounts for 80s/100s**
  - **How much improvement in multiply performance to get 5× overall?**

$$20 = \frac{80}{n} + 20$$

  - **Can't be done!**

- **Corollary: make the common case fast**

Pitfall

- **Pitfall: Using a subset of the performance equations as a performance metric.**
- **We should not predict performance based on simply one of clock rate, instruction count, or CPI. Another common mistake is to use only two of the three factors to compare performance. Although using two of the three factors may be valid in a limited context, the concept is also easily misused.**

Pitfall: MIPS as a Performance Metric

- **MIPS: Millions of Instructions Per Second**
  - Doesn't account for
    - Differences in ISAs between computers
    - Differences in complexity between instructions

$$\text{MIPS} = \frac{\text{Instruction count}}{\text{Execution time} \times 10^6}$$

$$= \frac{\text{Instruction count}}{\dfrac{\text{Instruction count} \times \text{CPI}}{\text{Clock rate}} \times 10^6} = \frac{\text{Clock rate}}{\text{CPI} \times 10^6}$$

  - **CPI varies between programs on a given CPU**

❖ 谬误：多处理器是万能钥匙

* ILP实现到达极限，2005生产一芯多核
* 多核简化并行编程，生产简单

硬件提升程序运行速度的时代结束了，需要程序员提高自己程序的并行度。

Fallacy

- ***Hardware enhancements that increase performance improve energy efficiency or are at worst energy neutral.***能够提高性能的硬件改进也可以提高能效，至少不会增加能耗。

Esmaeilzadeh et al. [2011] measured SPEC2006 on just one core of a 2.67 GHz Intel Core i7 using Turbo mode. Performance increased by a factor of 1.07 when the clock rate increased to 2.94 GHz (or a factor of 1.10), but the i7 used a factor of 1.37 more joules and a factor of 1.47 more watt-hours!

Fallacy

- **Fallacy: Designing for performance and designing for energy efficiency are unrelated goals.**

Fallacy: Low Power at Idle

- **Fallacy: Computers at low utilization use little power.**
- **Look back at i7 power benchmark**
  - At 100% load: 258W
  - At 50% load: 170W (66%)
  - At 10% load: 121W (47%)
- **Google data center**
  - Mostly operates at 10% – 50% load
  - At 100% load less than 1% of the time
- **Consider designing processors to make power proportional to load**

Fallacy

- ***Benchmarks remain valid indefinitely.***基准测试永远有效。

Amazingly, almost 70% of all programs from SPEC2000 or earlier were dropped from the next release.

易犯的错误和谬误

- **易犯的错误（Pitfall）：**
  - **因为故障概率低，所以就不会发生：应当**确保所有组件都有冗余，使单一组件故障不会导致整个系统宕机。

Fallacy

- ***The rated mean time to failure of disks is 1,200,000 hours or almost 137 years, so disks practically never fail.***磁盘的额定平均无故障时间为1200 000小时，差不多是137年，所以磁盘实际上永远不会发生故障。

Assume 1000 disks with a 1,200,000-hour MTTF and that the disks are used 24 hours a day. If you replaced failed disks with a new one having the same reliability characteristics, the number that would fail in a year (8760 hours) is

$$Failed\ disks = \frac{Number\ of\ disks * Time\ period}{MTTF} = \frac{1000\ disks * 8760\ hours/disk}{1{,}200{,}000\ hours/failure} = 7.3$$

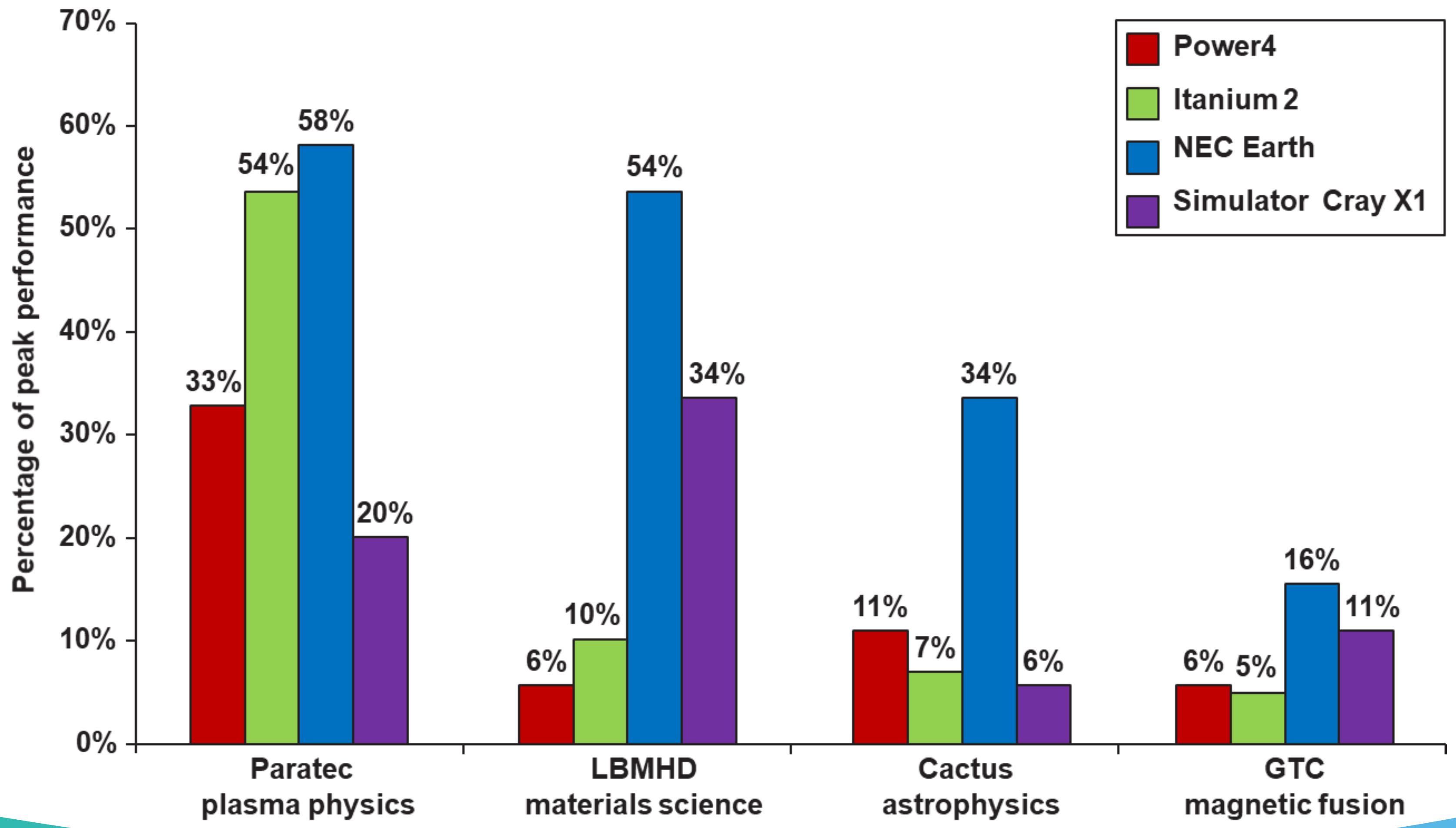
易犯的错误和谬误

- 易犯的错误（Pitfall）：
  - **故障检测会降低可用性：**这种易犯错误在于检测了错误却没有提供纠正错误的机制。

Fallacy

- ***Peak performance tracks observed performance.*峰值性能能够一直被观察到。**

The only universally true definition of peak performance is "the performance level a computer is guaranteed not to exceed." Figure 1.20 shows the percentage of peak performance for four programs on four multiprocessors. It varies from 5% to 58%.



第1章 小结

- 分类： **Flynn’s** 分类，市场分类
- 系统结构的原始定义和现在的定义
- 实现技术、功耗、成本、可靠性
- 性能评价指标：CPU时间
- 性能评价方法：基准测试程序，SPEC测试程序集及指标（ SPEC Ratio）
- 量化：Amdahl定律，CPU时间计算