计算机系统结构

1.9 计算机系统评价

冯 丹

武汉光电国家研究中心
华中科技大学计算机科学与技术学院

1. 计算机系统设计的四个要素

- （1）性能（快！）
- （2）成本
- （3）能耗
- （4）可靠性

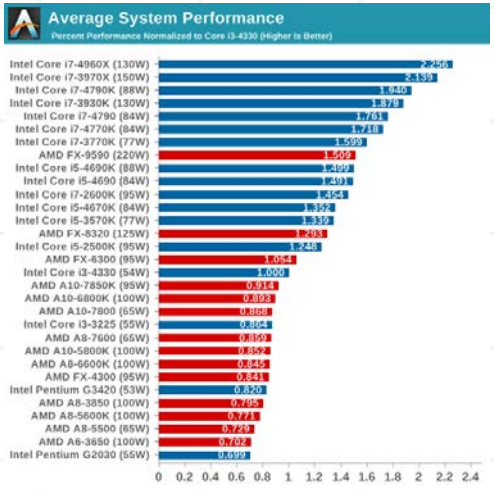
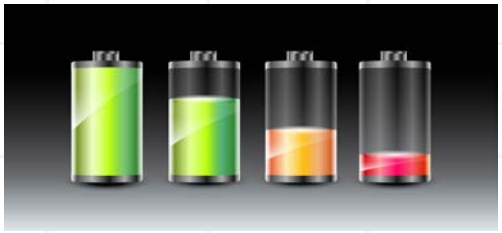
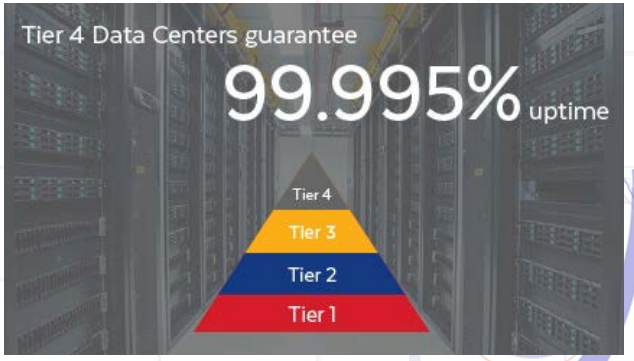


Figure 6: Bill of Materials for a Typical Desktop PC (Estimated)

Component	Cost Range		% of Total	
Monitor	$61 -	$113	16.1% -	15.0%
CPU	40 -	164	10.7% -	21.7%
Hard Disk Drive	54 -	95	14.3% -	12.6%
DRAM	14 -	25	3.6% -	3.4%
Power source / casing	33 -	54	8.7% -	7.1%
Chipset (data processing / ASP)	25 -	44	6.7% -	5.8%
Connectors	19 -	26	4.9% -	3.4%
Circuit Board	6 -	7	1.6% -	1.0%
Optical drive	21 -	79	5.6% -	10.5%
Keyboard	4 -	6	1.1% -	0.8%
Others	5 -	16	1.5%	2.2%
Software	75 -	75	19.9% -	9.9%
Warranty	20 -	50	5.3% -	6.6%
Total	$376 -	$754		

Source: Gartner and Barclays Research

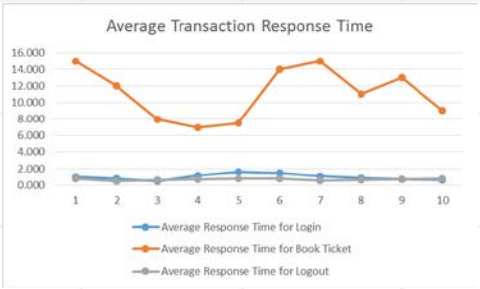


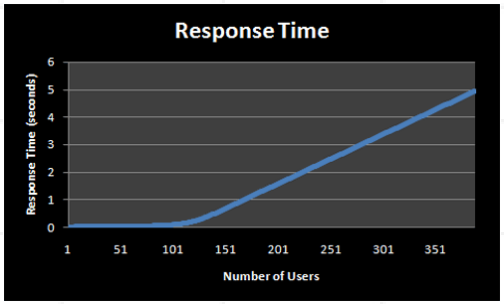


2. 性能

- **1. 性能评价指标：响应时间、吞吐率**
- （1）响应时间（response time）：完成一个任务的全部时间

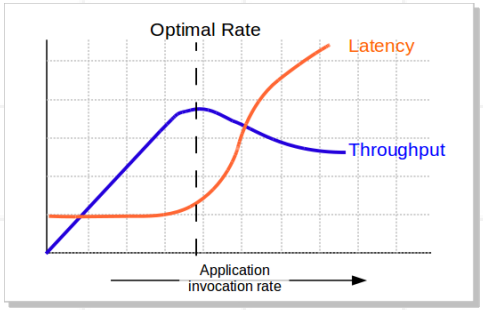
  用户角度

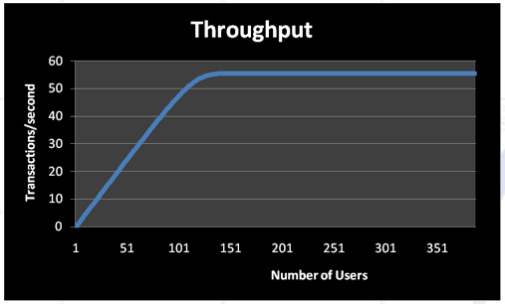




- （2）吞吐率（throughput）：单位时间内完成的任务数

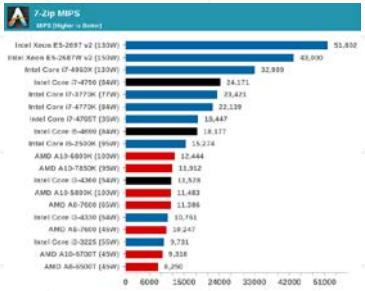
  管理员角度

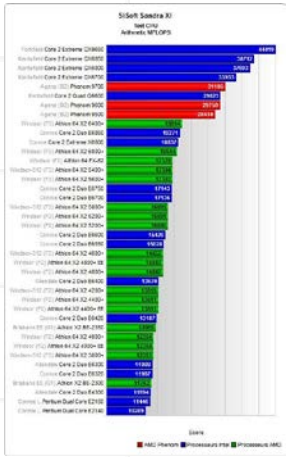




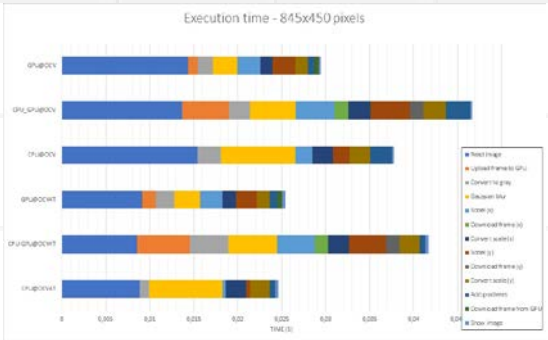
2. 性能

- 2. 其他性能评价指标
- (1) $MIPS = \dfrac{\text{指令条数}}{\text{执行时间}\times 10^6} = \dfrac{f}{CPI \times 10^6}$





- (2) 程序执行时间Te = $\dfrac{\text{指令条数}}{MIPS \times 10^6}$



- (3) $MFLOPS = \dfrac{\text{程序中的浮点操作数}}{\text{执行时间}\times 10^6}$

The only consistent and reliable measure of performance is the execution time of real programs!----D.A.Patterson

2. 性能

- **3. 基准测试程序（Benchmark）**
- （1）实际应用程序
- （2）修正（或脚本化）的应用程序
- （3）核心测试程序
- （4）小测试程序
- （5）合成测试程序
- **4. 基准测试程序套件（Benchmark Suites）**
- SPEC89, SPEC92, SPEC2006, SPEC2017

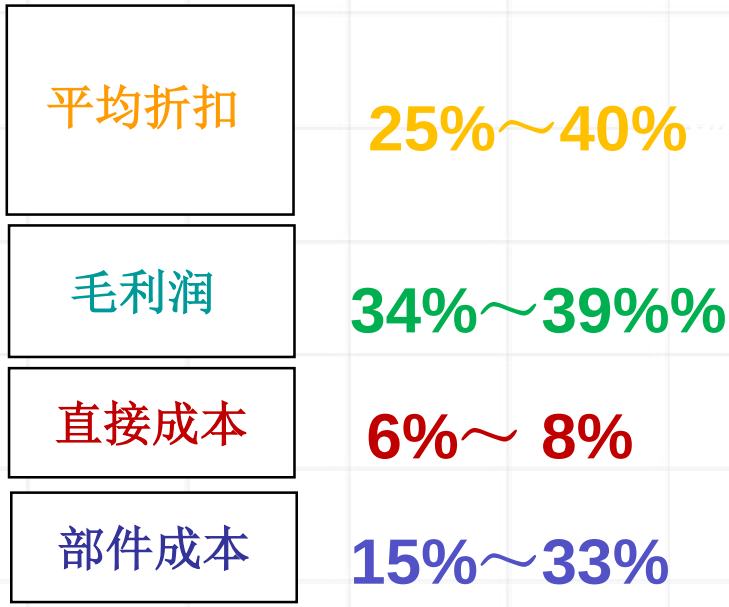
Short Tag	Suite	Contents	Metrics	How many copies? What do Higher Scores Mean?
intspeed	SPECspeed®2017 Integer	10 integer benchmarks	SPECspeed2017_int_base SPECspeed2017_int_peak	SPECspeed suites always run one copy of each benchmark. Higher scores indicate that less time is needed.
fpspeed	SPECspeed®2017 Floating Point	10 floating point benchmarks	SPECspeed2017_fp_base SPECspeed2017_fp_peak	
intrate	SPECrate®2017 Integer	10 integer benchmarks	SPECrate2017_int_base SPECrate2017_int_peak	SPECrate suites run multiple concurrent copies of each benchmark. The tester selects how many. Higher scores indicate more *throughput* (work per unit of time).
fprate	SPECrate®2017 Floating Point	13 floating point benchmarks	SPECrate2017_fp_base SPECrate2017_fp_peak	

3. 成本

- **售价构成**
- （1）部件成本（Component Costs）
- （2）直接成本（Direct Costs）

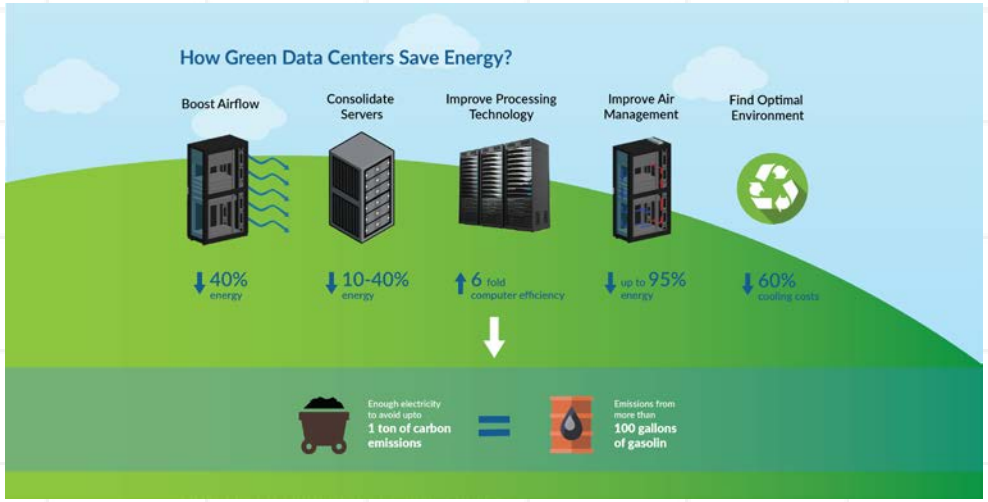
  经常性费用
- （3）毛利润（Gross Margin）

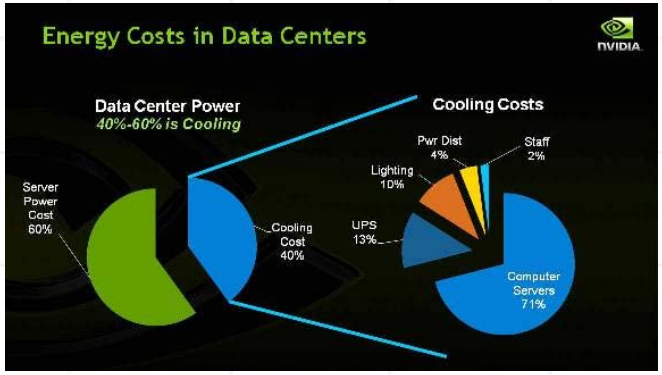
  非经常性费用
- （4）平均折扣（Average Discount）

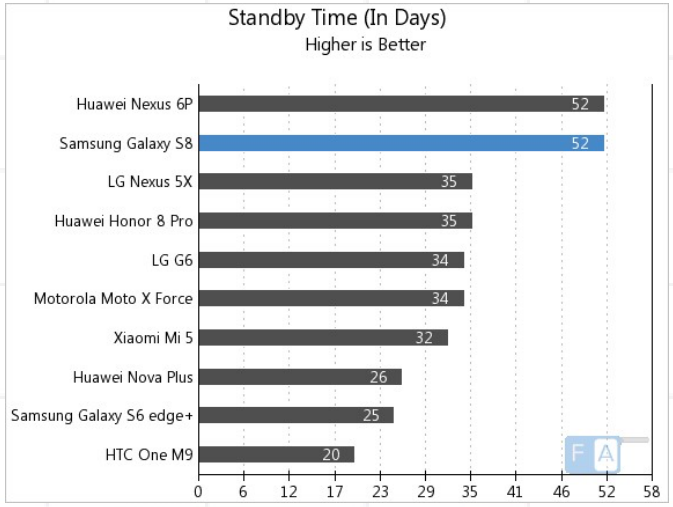


4. 功耗

- **从两个层面考虑功耗**
- （1）云端：电力成本
- （2）终端：待机时间
- 节能降耗：
  - 绿色计算（Green Computing）
  - 绿色数据中心
  - 绿色存储







4. 功耗

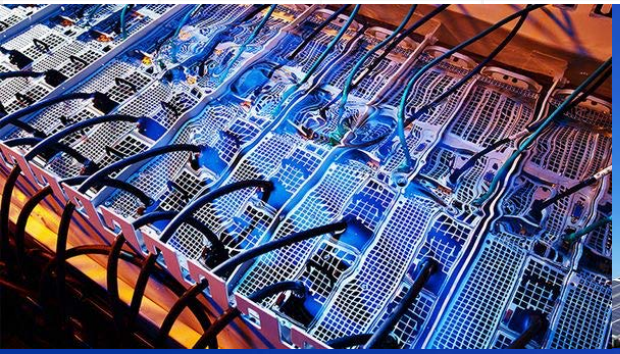
- **功耗问题的解决办法**
- （1）**减小IT设备的功耗**

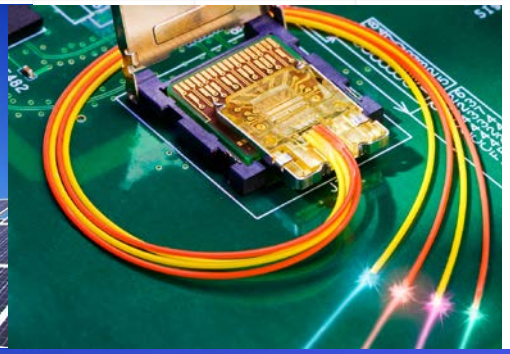
  处理器（发热严重1/3左右）：自适应调频，用低电压器件

  存储器（内存刷新，硬盘转动1/3）：优化刷新，用非易失器件

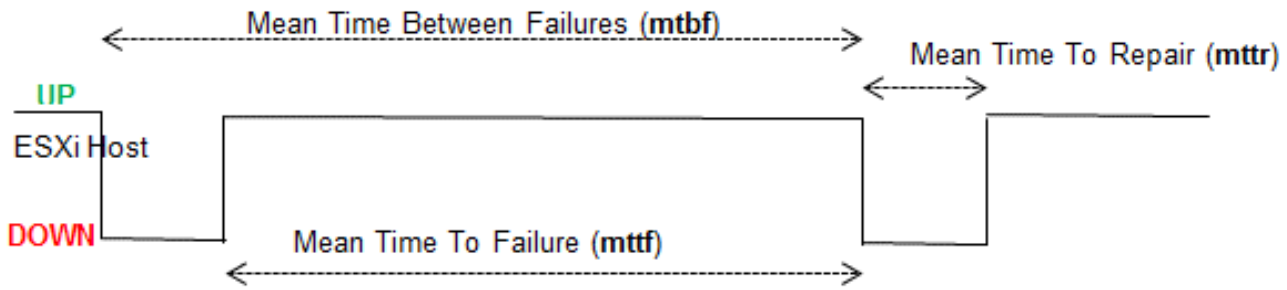
  不同时关闭存储，采用离线存储

  传输网络（数据传输1/3）：用光互联代替电互联
- （2）**减少冷却装置的能耗**
- （3）**采用新能源：太阳能、风能**





5. 可靠性和可用性



- （1）可靠性Reliability——MTTF
- （2）可用性Availability $= \frac{MTTF}{MTTF+MTTR}$
- （3）云中心需要99.9999%以上的可用性