Title: Mommy, Daddy, Why is My New Laptop So Dog Slow?! or Recent Trends in Systems Research

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Outline
- Problem motivation
- How computers work today
- Some history
- What can you do?
- What are computer scientists doing?
- The future

Motivation
- Computers “become” slower over time
- Money spent ineffectively
- Power consumption
- E-waste

How a Computer System Works
0. User clicks on “paper.doc”
1. Find file on disk
2. Copy file into memory
3. Copy part of file into CPU
4. Present result to user

Show-n-Tell: CPU
- Speed: 1000 MHz
- Internal memory: 256 KB
- Speed to memory bus: 133 MHz

Show-n-Tell: CPU Heat Sink
- Note: modern faster CPUs require an ever larger CPU fan
Show-n-Tell: Main Memory
Common name: Dynamic Random Access Memory (DRAM)

Typical memory sizes today: 4-16 GB (Giga Bytes), or billion characters
Typical memory speeds: micro-seconds (millions of operations per second)

Show-n-Tell: Flash Memory

Major advantage: persistent (non-volatile) memory
Typical flash memory sizes today: 1GB–1024GB (Giga Bytes), or billion characters
Typical flash speeds: between DRAM and hard disks
Lifetime: only thousands/millions of writes
Performance depends on fullness, age, and internal processes (GC, defrag)

Show-n-Tell: Hard Disk

Typical disk sizes today: 1-6 TB (Giga Bytes), or billion characters
Typical disk speeds: milli-seconds (thousands of operations per second)

The Storage Hierarchy Pyramid

Smaller, faster, more expensive
Bigger, slower, cheaper

Moore’s Law
"Transistor density doubles every 18-24 months" (c. 1965)

Kryder’s Law
"Magnetic storage density doubles annually" (c. 1995)
Moore’s vs. Kryder’s Law

- Transistor Density
- Hard Disk Density

CPU/Memory doubling every 1.5–2 years

Hard disk speed lagging behind!

How Computers REALLY Work (1)

Scenario 1: CPU and memory are large and fast enough.

How Computers REALLY Work (2)

Scenario 2: CPU too small.
Memory is large enough.

How Computers REALLY Work (3)

Scenario 3: CPU and memory are BOTH too small.

The Perfect Storm

- Disk sizes getting larger the fastest
- CPU/Memory getting larger/faster
  - But lagging behind disk-size growth rates
- Disk speeds lagging far behind the rest
- Software getting larger
  - Fills disks to capacity
  - Software updates & system service packs
- E.g., anti-virus/spyware scanners
  - How long to scan a 500GB disk?

Buying a New Computer (1)

- Given a fixed budget, spend your $$$ on the following, by importance:
  1. More main memory (2–8 GB+)
    - Try to keep a free memory upgrade slot
  2. Larger CPU caches
  3. Faster disks (SSD)

Caveat: may increase power consumption
Buying a New Computer (2)

- Where to cut back on (if fixed budget):
  1. Don’t get the fastest CPU (in MHz)
     - E.g., get a 2.8GHz instead of a 3.2GHz
  2. You may skip on multi-core CPUs
     - Extra “brains” but share same CPU cache
  3. Consider a smaller disk

Recommend: avoid “canned” solutions

Ongoing Comp. Sci. Research

- How to use multi-core CPUs effectively?
  - Trade CPU for reduced I/O?
  - How to reduce the need to go to disk?
    - Compressing data (spare CPU cores)
    - Prediction/AI algorithms, prefetch disk data
  - Use new storage devices
    - E.g., FLASH memory

Show-n-Tell: Flash Memory

- Major advantage: persistent (non-volatile) memory
- USB port
- Typical flash memory sizes today: 128MB–4GB (Giga Bytes), or billion characters
- Typical flash speeds: between DRAM and hard disks
- Lifetime: only millions of writes

The Future of FLASH Memory

- Intermediate cache between main memory and hard disks
- Reliability
  - Distribute writes evenly across device
- Staging device inside hard disks
  - Hybrid disks
- Replace spinning disks
  - Solid State Disks (SSDs)
    - MacBook Air (2008)

Computer Power Use

- Energy savings trails off everything
  - Small percentage improvements annually
- Energy consumption secondary design consideration:
  - Idle laptop: 20–30 Watts
  - Idle workstation: 60–80 Watts
  - Idle server: 200+ Watts
“Green” Research

- Turn off components automatically
  - Without annoying users
- Better hardware components
  - Without slowing down the system
- Use FLASH to store data
  - Lower costs, improve reliability
- Lightweight software
  - Without reduced functionality

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Q&A

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Today’s Storage Hierarchy Pyramid

Smaller, faster, more expensive

- CPU speed
- Memory speed

10,000 to 100,000 slower!

Bigger, slower, cheaper

- Hard Disk speed
- Memory size
- CPU size