



# How to streamline your life (lessons from computer architecture).

COS 116

4/1/2008

Instructor: Sanjeev Arora

# Lesson 1: Caching

(and the 80-20 rule)



Customer Rating



4.7 out of 5

## **XPS 420**

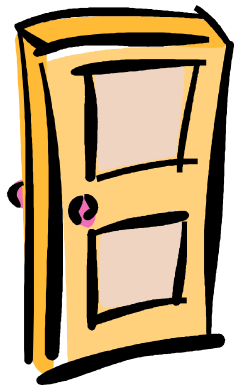
Intel® Core™2 Q6600

Quad-Core (8MB L2

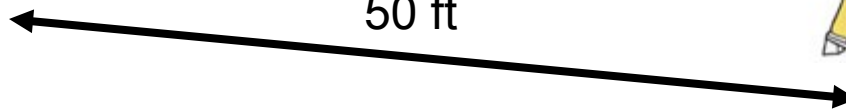
cache, 2.4GHz, 1066FSB)

# The Tired Librarian

Reserves



50 ft



- 1000 checkouts/returns per day
- Distance covered =  $50 \times 2 \times 1000 = 100,000$  feet  
~ 20 miles
- Please help!!!

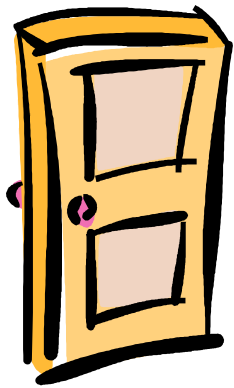


# 80-20 “Rule”

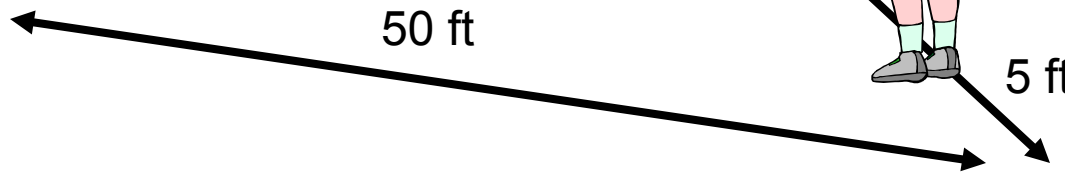
- Pareto [1906]: 20% of the people own 80% of the wealth
- Juran [1930's]: 20% of the organization does 80% of the work

# Better Arrangement

Reserves



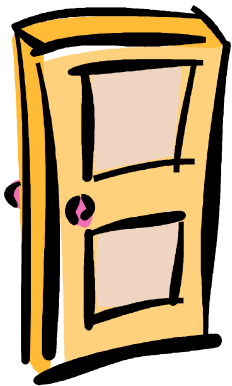
“Most popular” shelf:  
20% most popular  
books



- Distance covered per day?

# Even better arrangement?

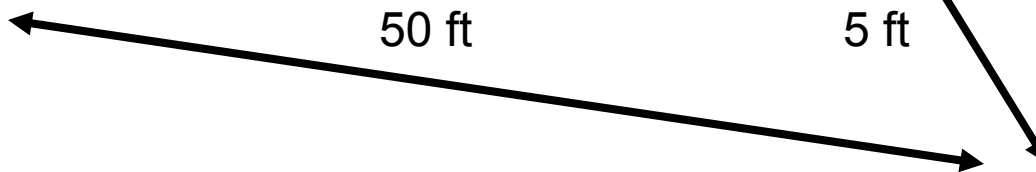
Reserves



“Most popular” shelf:  
20% most popular  
books



Top 4%



- Distance covered per day?



## Discussion Time

- Is the librarian's problem solved?

# How to predict the 20% most popular books for next day?

- In general, no easy solution
- In practice, use rules of thumb
  - Example: “Least Recently Used”. When you need to create space on the desk (or shelf), move out the book that was used least recently
  - Many others (LRU is computationally expensive)



# New and improved



**XPS 600**  
Raw Power Unleashed

**+ SPECIAL OFFERS**

**- Processor**

Intel® Pentium® 4 Processor  
640 with HT (3.20GHz, 800  
FSB, 2MB L2 cache) up to  
Pentium® Extreme Edition Dual  
Core

**- Operating System**

Genuine Windows® XP Media  
Center Edition 2005



**XPS 200**  
Small, But Mighty

**SPECIAL OFFERS**

**Processor**

Intel® Pentium® 4 Processor  
with Hyper-Threading  
Technology - 600 Sequence -  
up to 650 (3.40GHz, 800MHz  
FSB, 2MB Cache).

**Operating System**

Genuine Windows® XP Media  
Center Edition 2005

X  
TI

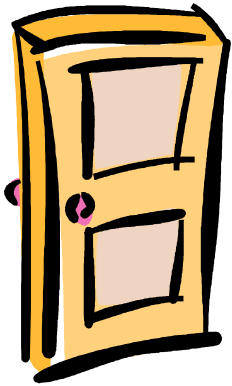
# Connection to Computer Organization

- Speed vs cost of various memories

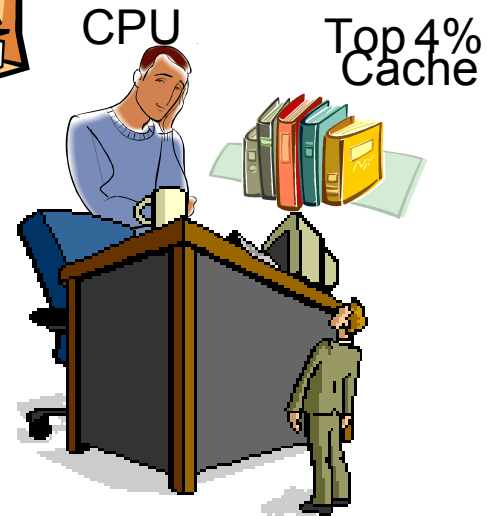
	Cost: \$ / GB	Speed: GB/s
Hard drive	0.50	1
RAM	100	5
On-chip memory for CPU (L2 Cache)	40000	15

# Computer ~~Librarian~~ arrangement

Disks  
Reserves



“Most popular” shelf:  
20% most popular  
books    Memory



Often, today's computers have even more levels of caching



# Moral

- Performance:

- Speed is close to that of fastest memory (cache)
- Overall capacity is that of largest memory (disk)

# Question



- How does the same program (.exe file) run on different PCs with different memory configurations?
- Answer: “Virtual Memory”
  - All programs live a fiction: allowed to pretend it has  $2^{64}$  bytes of memory
  - Illusion is preserved by hardware

# Goodbye Lenin

"The German Democratic Republic lives on – in 79 m<sup>2</sup>!"

*(Die DDR lebt weiter – auf 79 qm!)*



# Virtual Memory

## ■ Program's view:

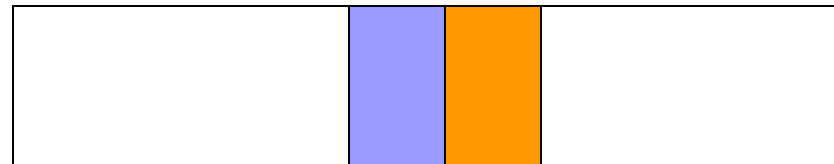
Powerpoint



Memory:

Lec15.ppt

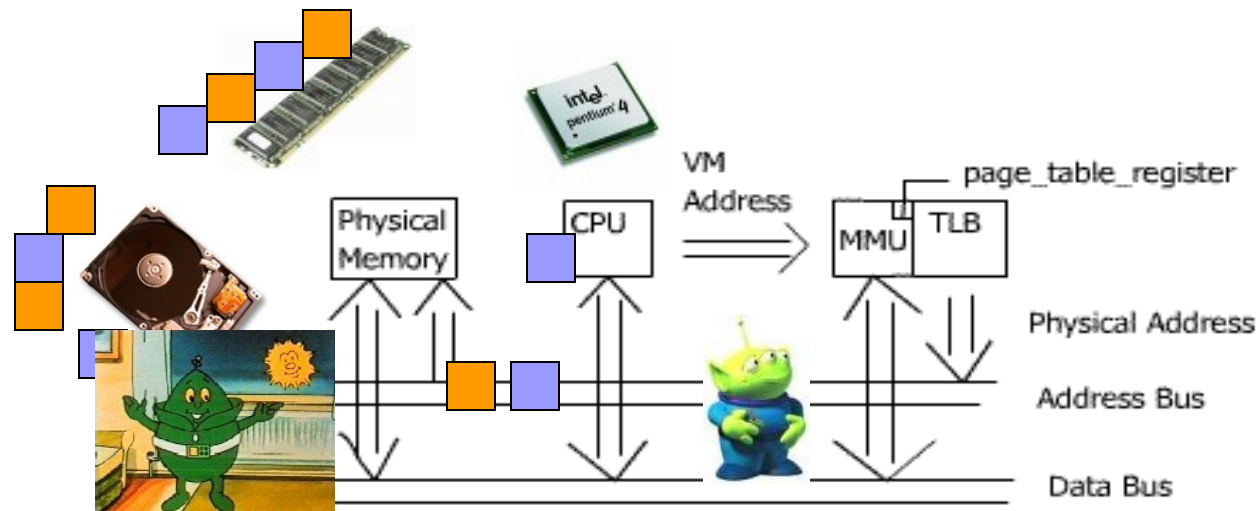
P ≠ NP.ppt



Address 0

Address  $2^{64} - 1$

## ■ Underlying truth:



# Lesson 2: Multitasking

- “The Multitasking Generation”





# An Evening's Tasks for a Gen-M'er

- Homework
- Listen to music
- Instant Messaging
- Call Mom (goes to bed by 11 PM!)
- Answer phone
- Read a bit more of Joyce's *Ulysses*
- Watch the Daily Show
- How do you do it all?



# Scheduler's objectives

- Fairness
- Timeliness
- Critical tasks processed promptly
- Low overhead

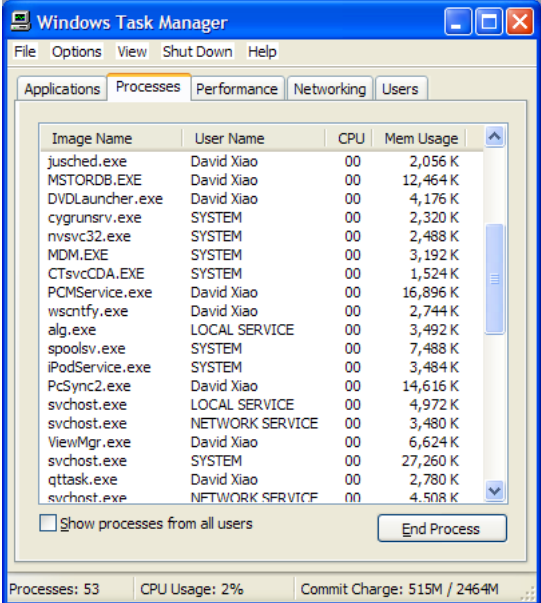


## Discussion Time

How can one achieve these (often conflicting) goals?

# Tasks done by my PC last night

- Word processing
- Play CD
- Download news updates
- Download email
- Run clock
- Hidden tasks: handle network traffic, manage disk and RAM traffic, scheduler, etc.



The screenshot shows the Windows Task Manager window with the 'Processes' tab selected. It displays a list of running processes with columns for Image Name, User Name, CPU usage, and Mem Usage. The status bar at the bottom indicates 53 processes, 2% CPU usage, and a commit charge of 515M / 2464M.

Image Name	User Name	CPU	Mem Usage
jusched.exe	David Xiao	00	2,056 K
MSTORDB.EXE	David Xiao	00	12,464 K
DVDLauncher.exe	David Xiao	00	4,176 K
cygrunsrv.exe	SYSTEM	00	2,320 K
nsvsc32.exe	SYSTEM	00	2,488 K
MDM.EXE	SYSTEM	00	3,192 K
CTsvcCDA.EXE	SYSTEM	00	1,524 K
PCMSservice.exe	David Xiao	00	16,896 K
wscntfy.exe	David Xiao	00	2,744 K
alg.exe	LOCAL SERVICE	00	3,492 K
spoolsv.exe	SYSTEM	00	7,488 K
iPodService.exe	SYSTEM	00	3,484 K
PcSync2.exe	David Xiao	00	14,616 K
svchost.exe	LOCAL SERVICE	00	4,972 K
svchost.exe	NETWORK SERVICE	00	3,480 K
ViewMgr.exe	David Xiao	00	6,624 K
svchost.exe	SYSTEM	00	27,260 K
qttask.exe	David Xiao	00	2,780 K
svchost.exe	NETWORK SERVICE	00	4,508 K

Managed by “Operating System”  
(WinXP, Linux, MacOS, etc.)

# Multitasking versus Parallel Processing

**Multitasking:** A single CPU handles many tasks by switching rapidly among them.

(e.g., all Wintel machines since early 1990s; all Unix machines since the 1970s)

**Parallel Processing:** Multiple CPUs that do the work of a single CPU. (But, 4 CPUs do not necessarily mean 4x speed.)

**XPS 420**

Intel® Core™2 Q6600

Quad-Core (8MB L2

cache, 2.4GHz, 1066FSB)

# The Legal View.....

UNITED STATES DISTRICT COURT  
FOR THE DISTRICT OF COLUMBIA

UNITED STATES OF AMERICA,

Plaintiff

v.

MICROSOFT CORPORATION,

Defendant.

Civil Action No. 98-1232 (CKK)

**FINAL JUDGMENT**  
(November 12, 2002)

WHEREAS, plaintiffs United States of America ("United States") and the States of New York, Ohio, Illinois, Kentucky, Louisiana, Maryland, Michigan, North Carolina and Wisconsin and defendant Microsoft Corporation ("Microsoft"), by their respective attorneys, have consented to the entry of this Final Judgment;

One main point studied by the judge:

What is an OS?