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

COS 116, Spring 2010

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Lesson 1: Caching

(and the 80-20 rule)

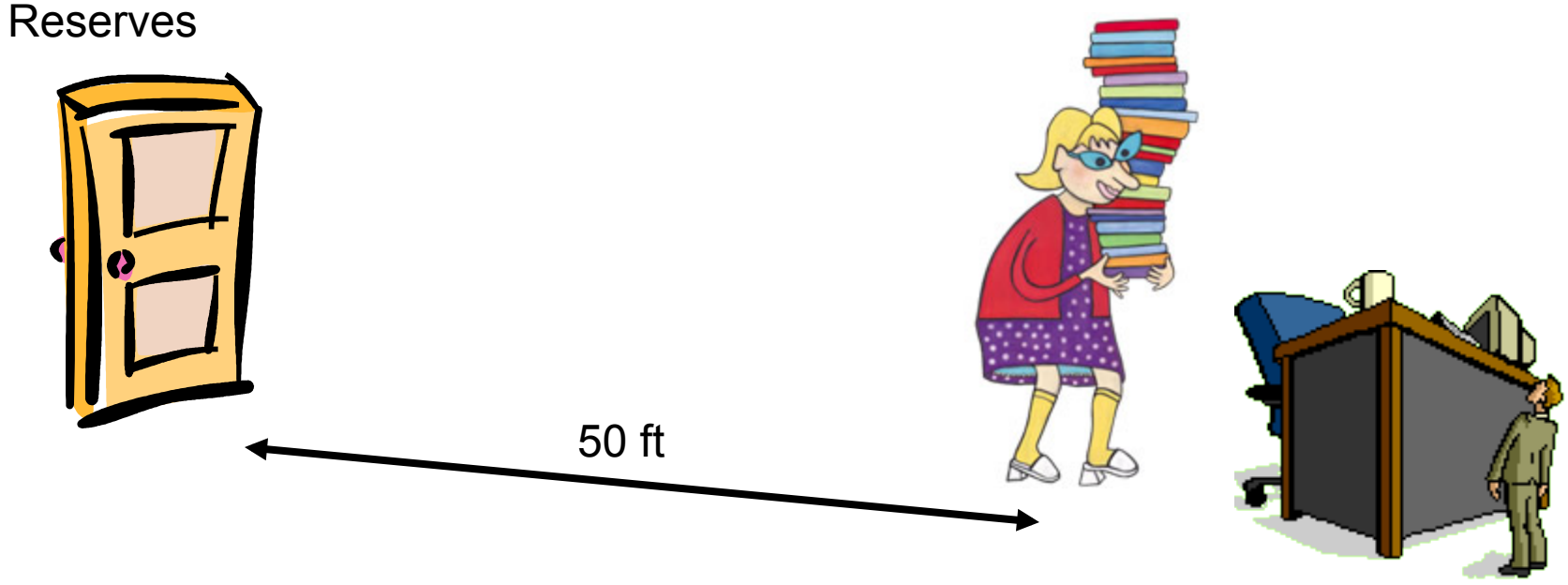
Customer Rating

4.7 out of 5

XPS 420

Intel® Core™2 Q6600 Quad-Core (8MB L2 cache, 2.4GHz, 1066FSB)

The Tired Librarian

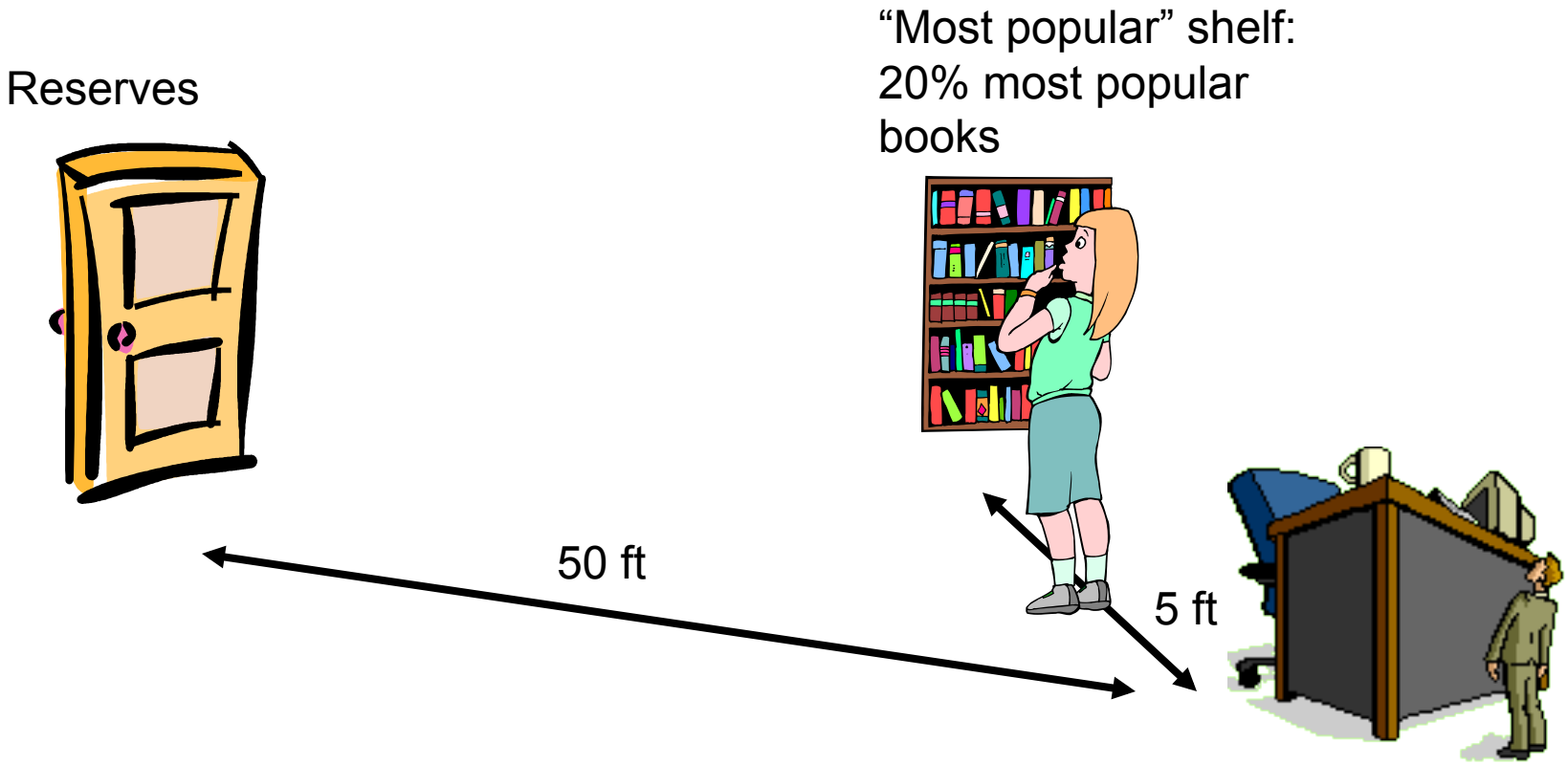


- 1000 checkouts/returns per day
- Distance covered = 50 x 2 x 1000 = 100,000 feet ~ 20 miles
- Please help!!!

80-20 “Rule”

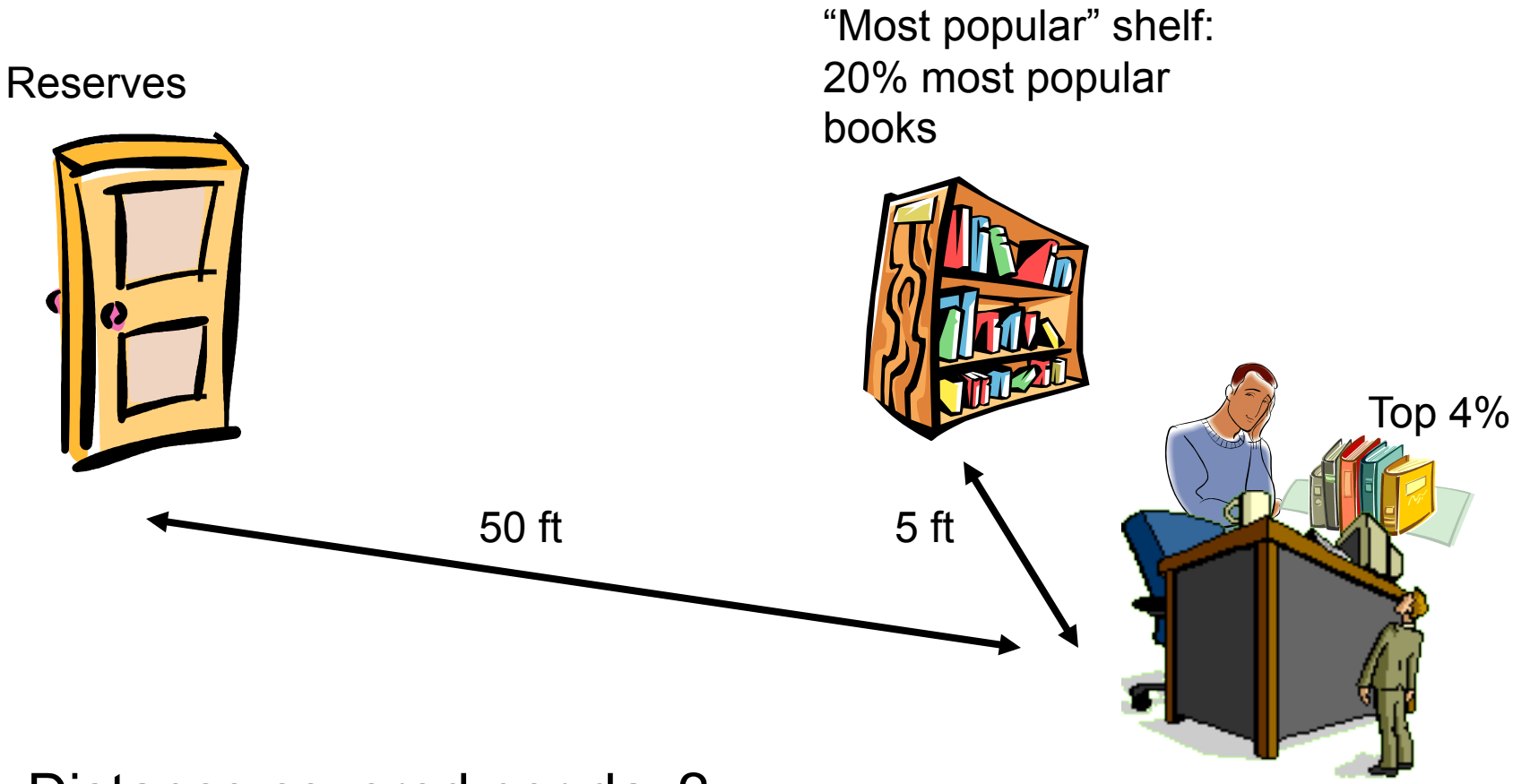
- Pareto [1906]: 20% of the people own 80% of the wealth
- Juran [1930’s]: 20% of the organization does 80% of the work

Better Arrangement



- Distance covered per day?

Even better arrangement?



- 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

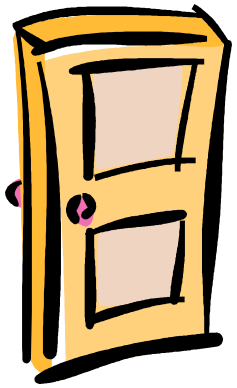
Connection to Computer Organization

- Speed vs cost of various memories

	Cost: $ / GB	Speed: GB/s
Hard drive	0.10	0.1
Flash (e.g., SSD, USB stick)	2	0.25
RAM	10	10
On-chip memory for CPU (L2 Cache)	40000	20

Computer ~~Librarian~~ arrangement

Rest of Disk



"Most popular" shelf: 20% most popular books

Memory

CPU

Top 4% Cache

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)

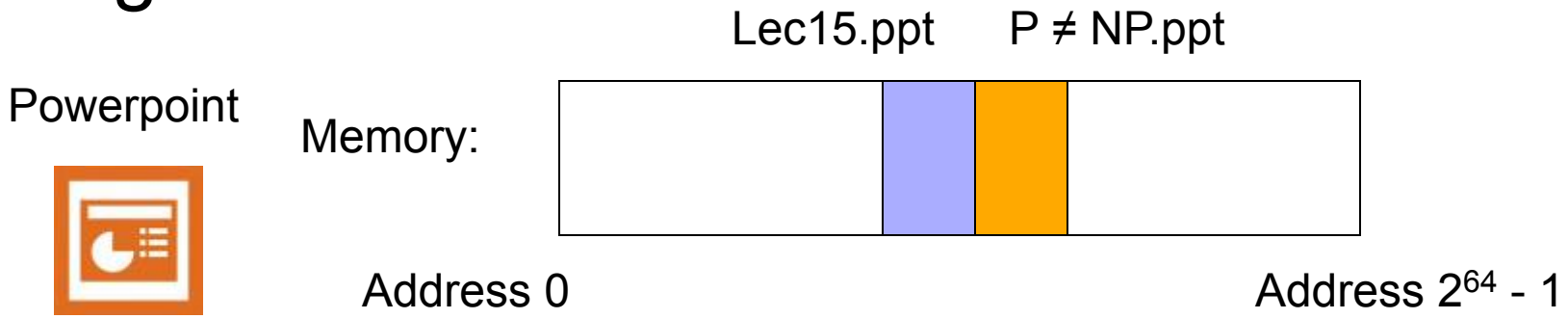
Question

- How does the same program (.exe file) run on different PCs with different memory configurations?

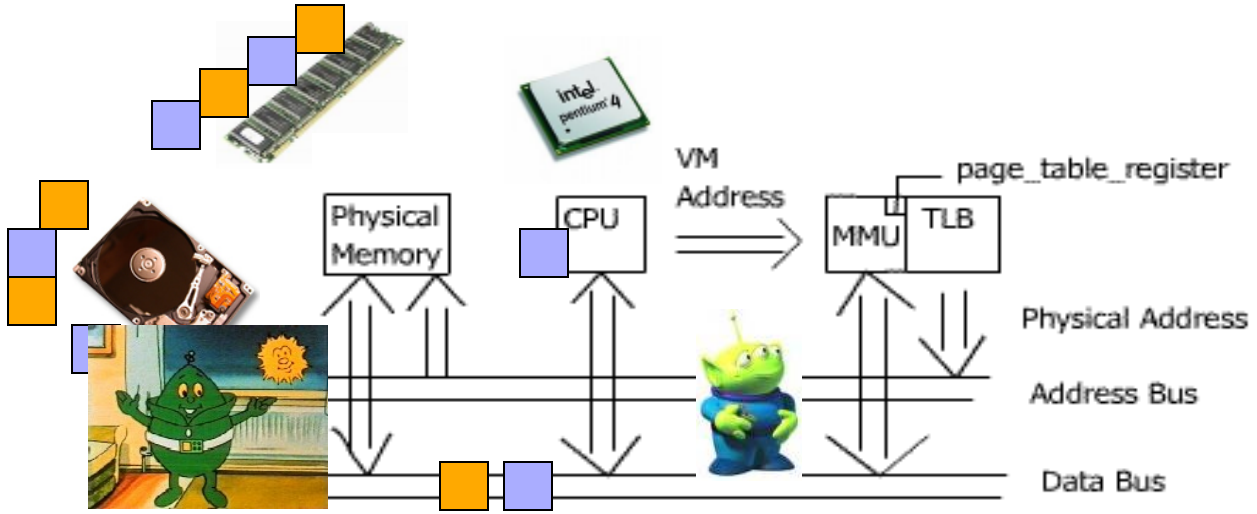
- Answer: “Virtual Memory”
  - All programs live a fiction: allowed to pretend they each have 2^{32} or 2^{64} bytes of memory
  - Illusion is preserved by hardware

Virtual Memory

- Program's view:



- Underlying truth:



Lesson 2: Multitasking

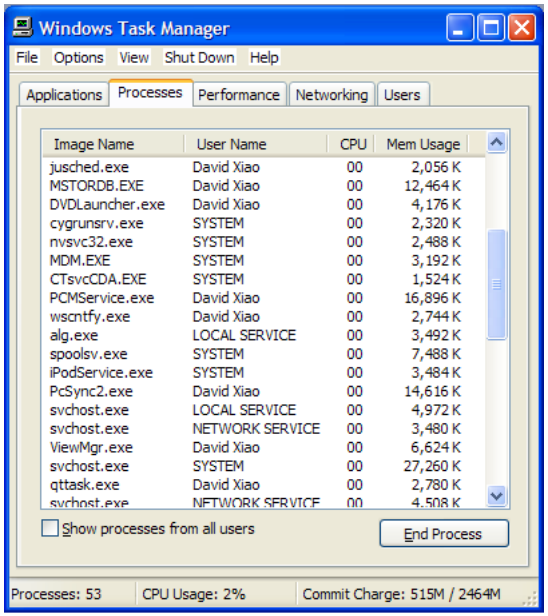
- "The Multitasking Generation"

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?

Tasks done by my PC last night



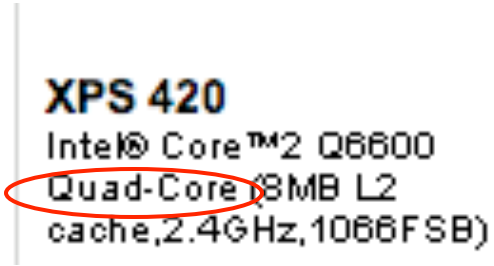
- Word processing
- Play CD
- Download news updates
- Download email
- Run clock
- Hidden tasks: handle network traffic, manage disk and RAM traffic, scheduler, etc.

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.)



Scheduler's objectives

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

How can one achieve these (often conflicting) goals?