CS 5460/6460
Operating Systems

Fall 2009

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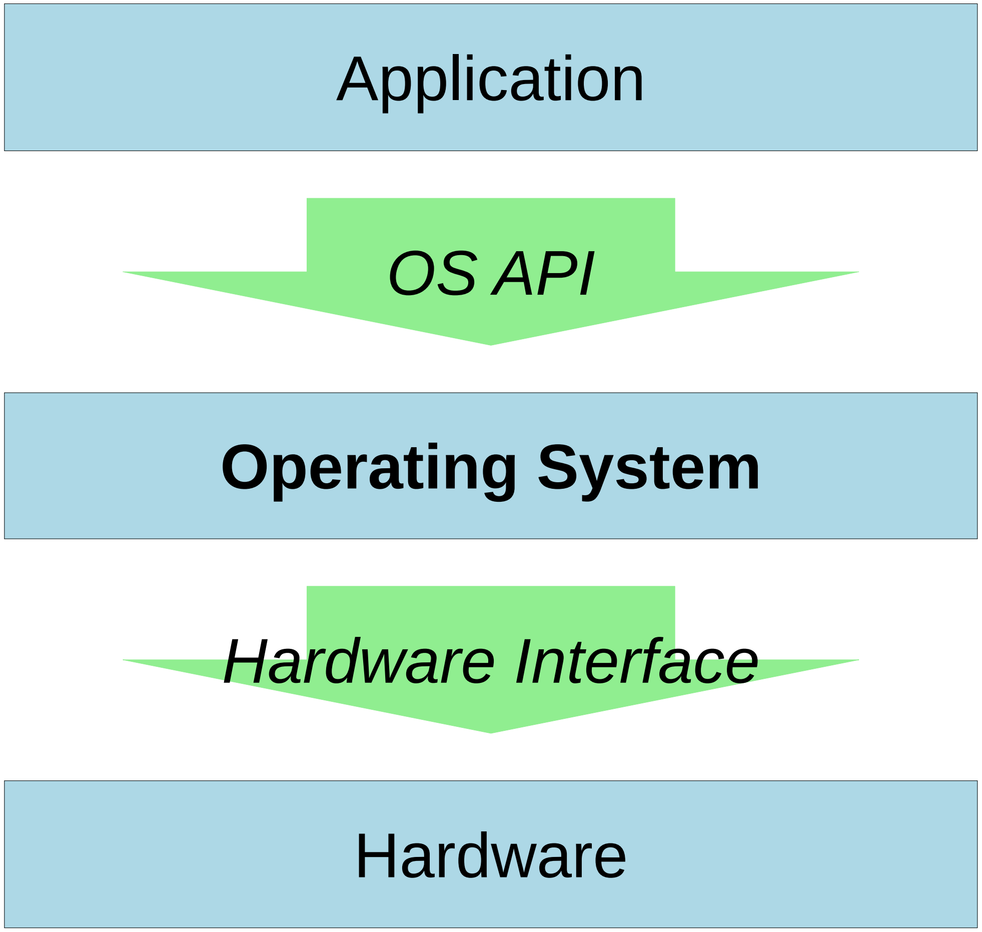
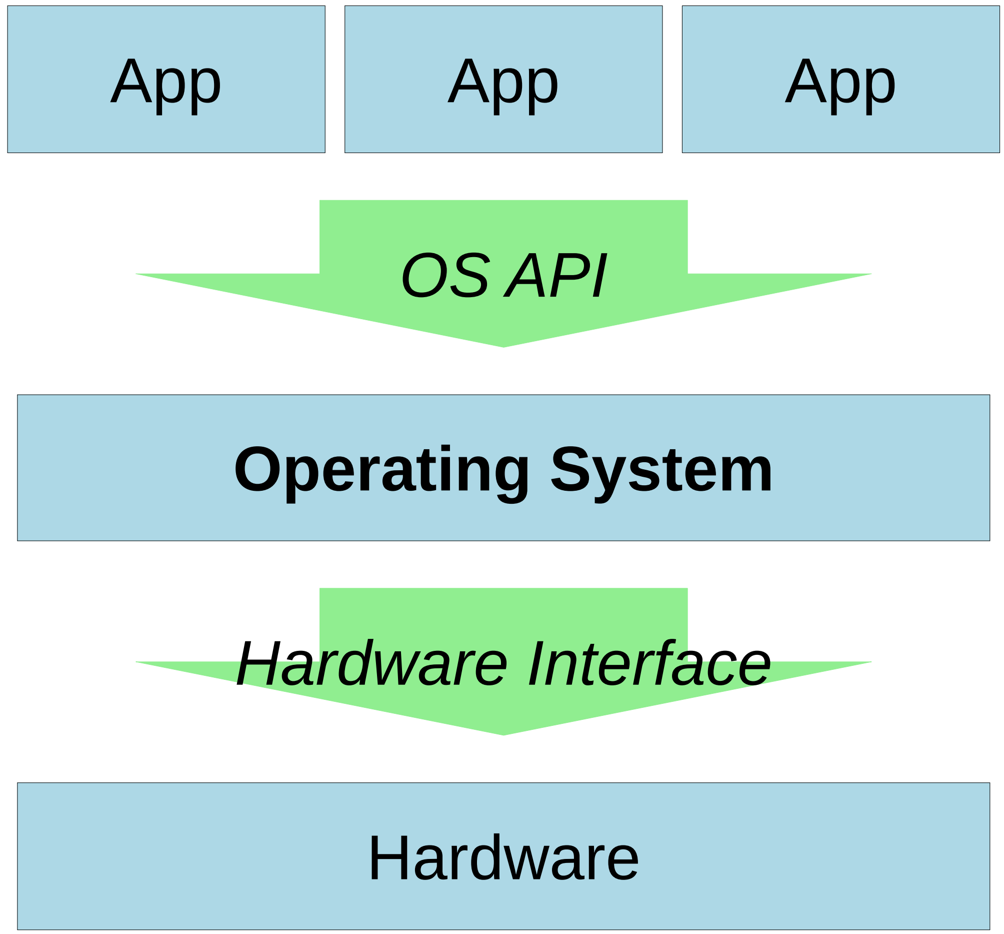
Part I – Course Overview

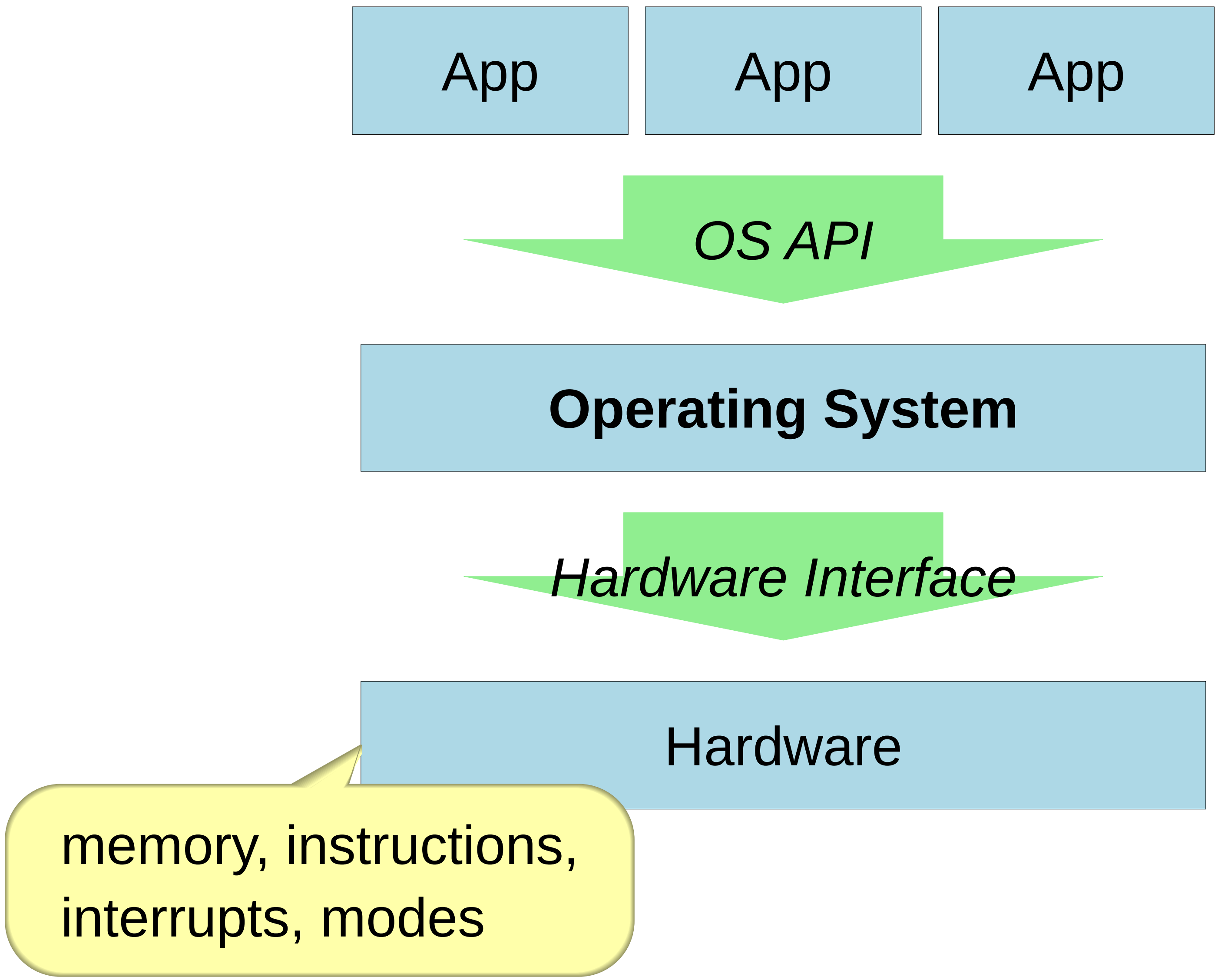
Operating Systems



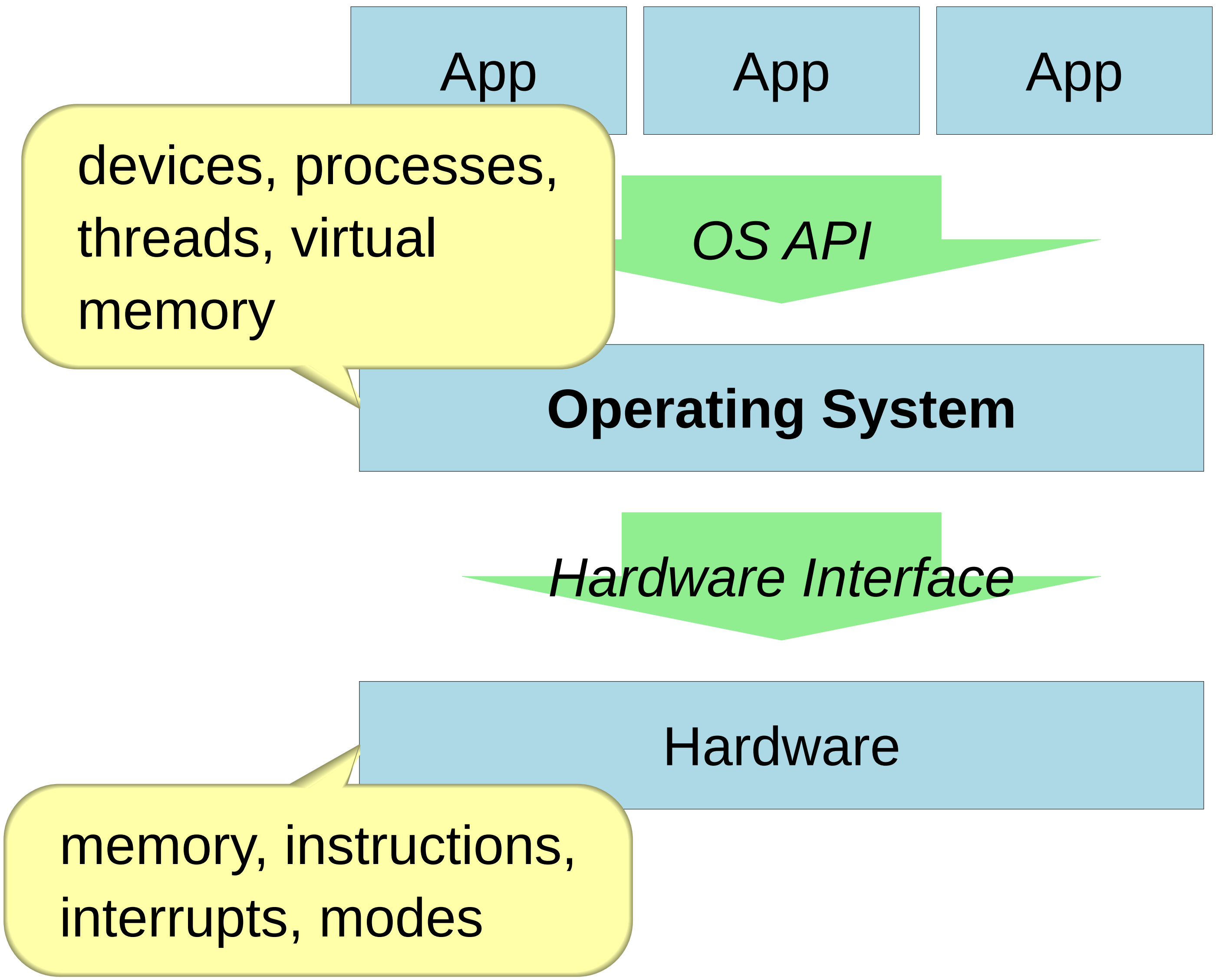
Operating Systems



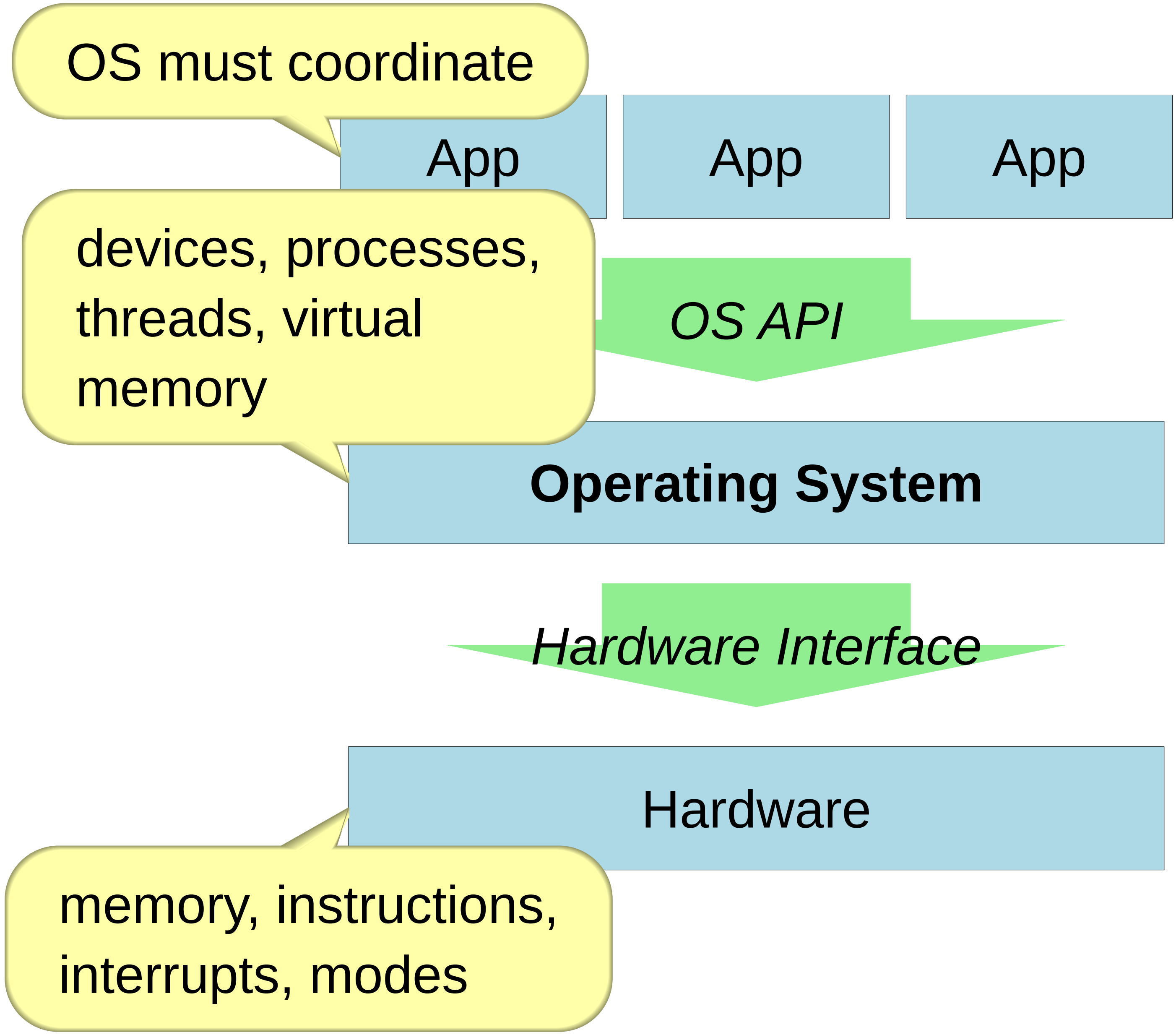
Operating Systems



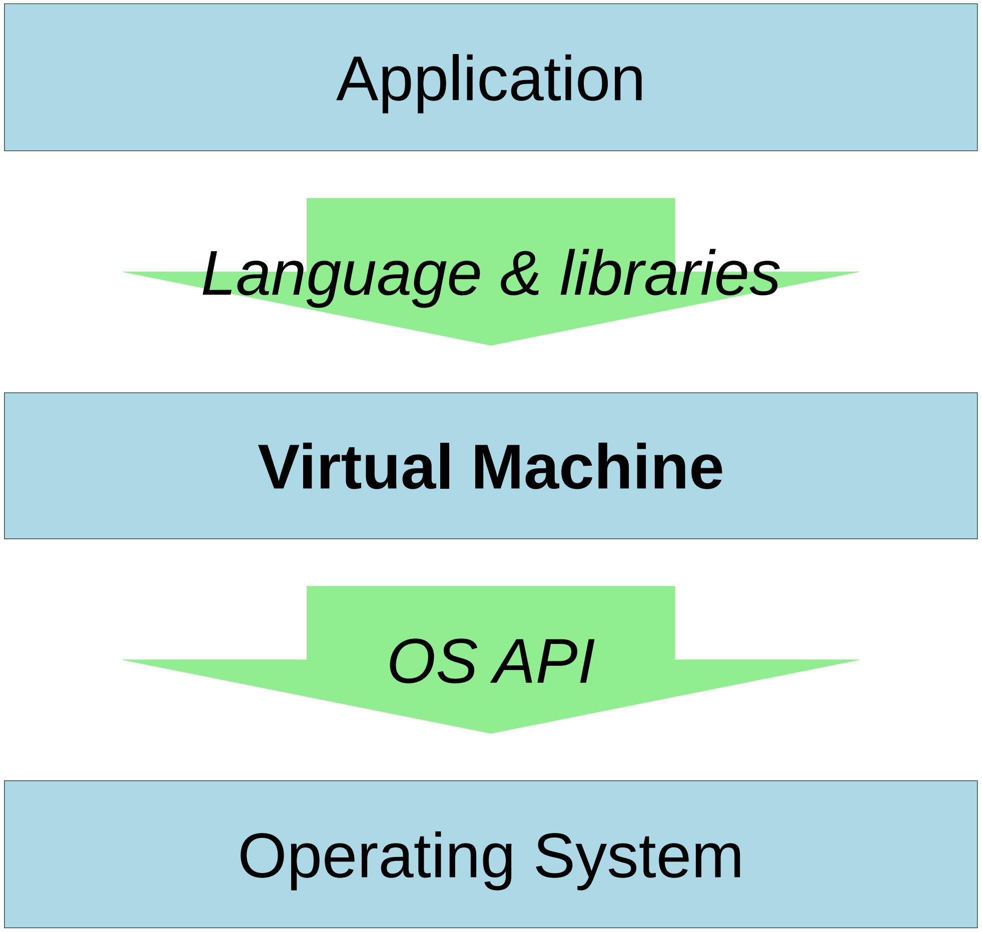
Operating Systems



Operating Systems



Virtual Machines



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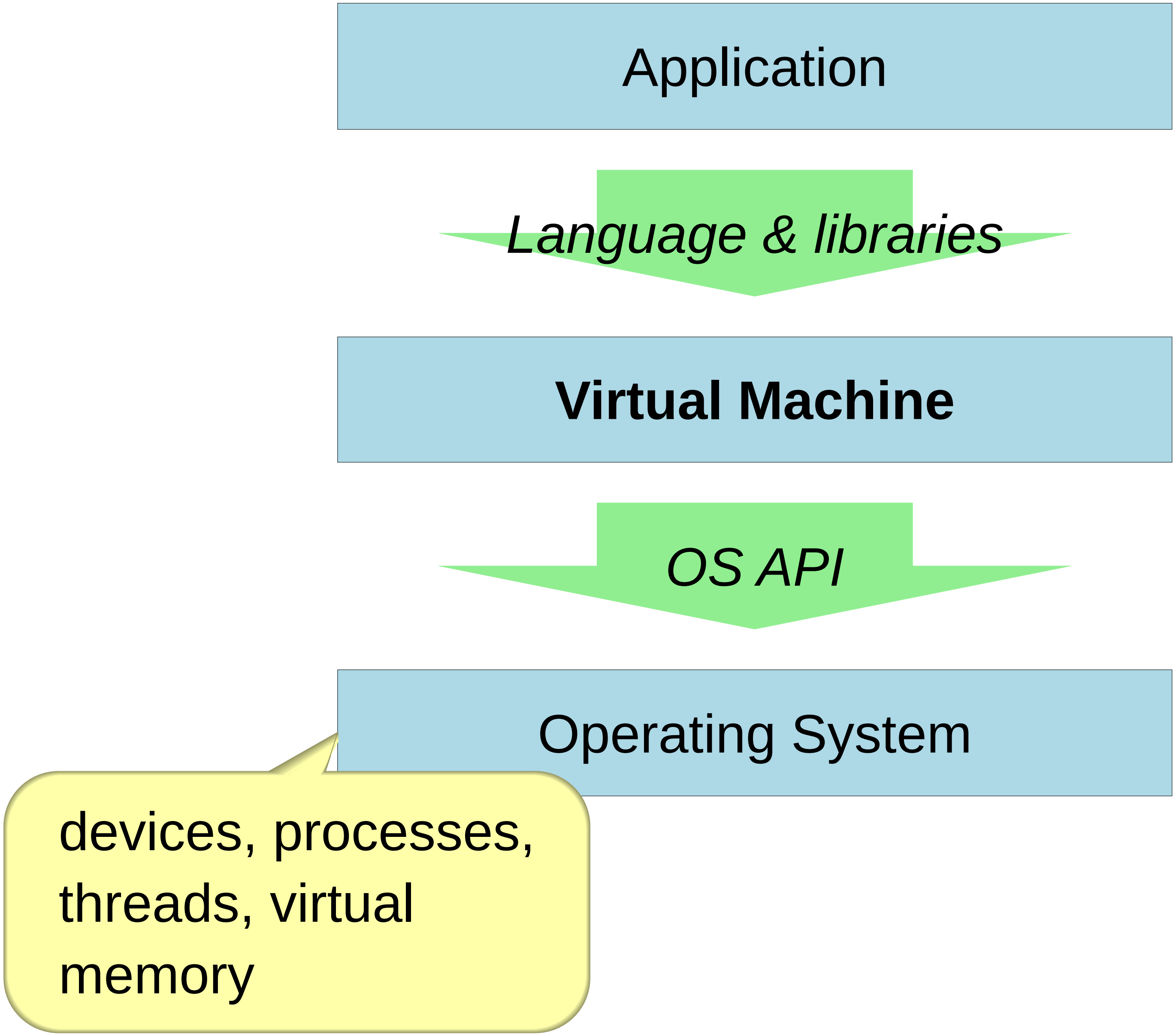
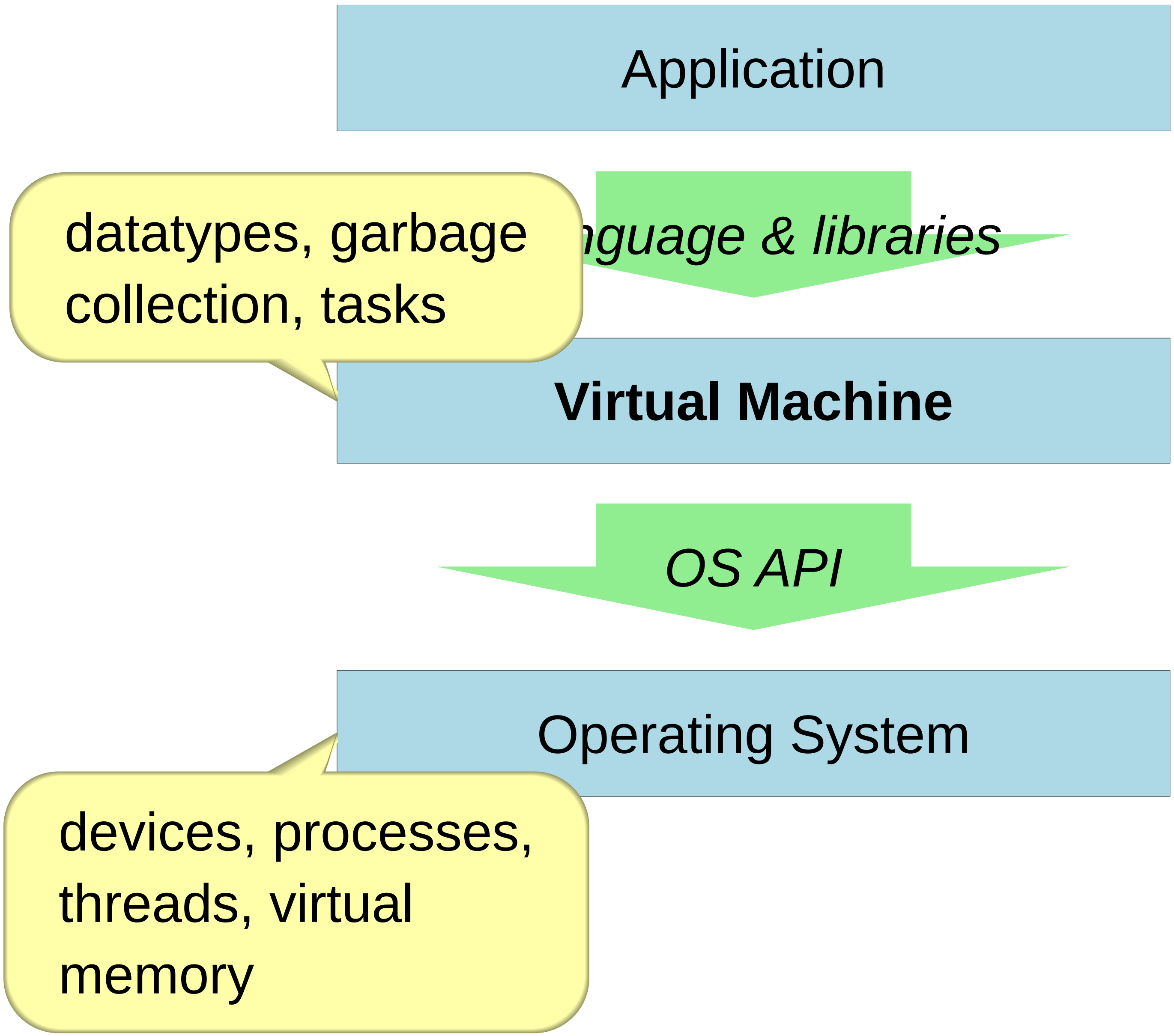


Virtual Machines

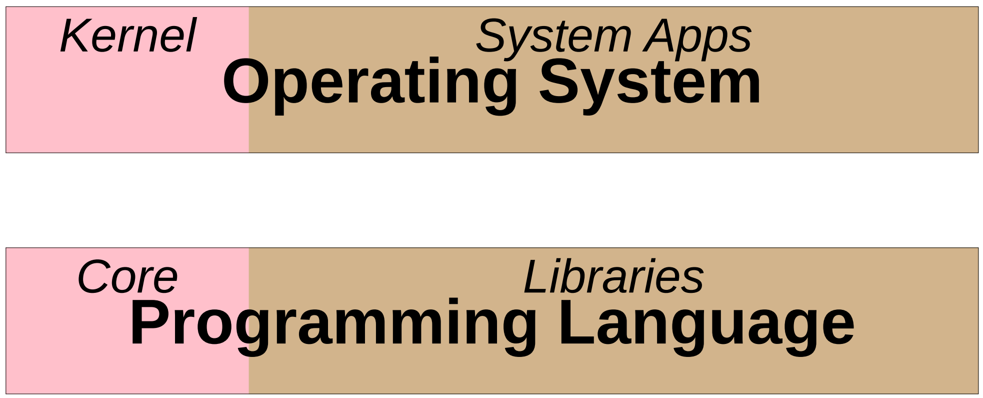


OS vs. Kernel

Operating System

Programming Language

OS vs. Kernel


Kernel
System Apps
Operating System
Core
Libraries
Programming Language

OS Design

- Convenience
- Performance

Why Study OS?

- Abstractions
  - Many tried and true constructs
- Know your tools
  - Driving a shell
  - Composing and controlling processes
- Know your environment
  - Space of possibilities for applications
  - Performance implications
- Build your own OS/VM?

Prerequisites

- CS 4400 *really is* a prerequisite
- C programming
- General familiarity with Unix-style OSes

Course Details

`http://www.eng.utah.edu/~cs5460/`

Expect about 5 C programming tasks as homework

Example Concepts

Services	Processes
Threads	CPU Scheduling
I/O Redirection	Pipes
Concurrency	Synchronization
Deadlock	Memory Management
Paging	Segmentation
Virtual Memory	Page Replacement
File Systems	I/O Systems
Distributed Systems	Networks
RPC	Distributed Filesystems
Security	Embedded Systems

Part II – OS History

OS History

Phase 1: No or Minimal OS

Hardware: *expensive*

Humans: *cheap*

- One user at a time on the console
- One function at a time (no overlap of computation and I/O)
- User must be on the console to debug

OS History

Phase 2: Batch Processing

Hardware: *expensive* Humans: *cheap*

- Users give their program (on cards or tape) to a human, who then schedules the jobs (e.g., Fortran and Pascal programs)
- OS loads, runs, and dumps user jobs
- Batch processing makes better use of the hardware, but debugging is much more difficult

OS History

Phase 3: Overlap of I/O and Computation

Hardware: *expensive*

Humans: *cheap*

- Buffering and interrupt handling in OS
- Spool jobs on drum
- No protection $\Rightarrow$ One job at a time
- Performance improves, because I/O and processing happen concurrently

OS History

Phase 4: Memory Protection and Relocation

Hardware: *expensive*

Humans: *cheap*

- Multiprogramming — several programs run at the same time
- One job runs until it performs I/O, then another job gets the CPU
- OS decides which spooled jobs to start, protects one program's memory from other programs, decides which process to resume when one gives up the CPU

First OS failures:

- Multics announced in 1963, released in 1969
- OS/360 released with 1000 known bugs

OS History

Phase 5: Interactive Timesharing

Hardware: *cheap*

Humans: *expensive*

- Terminals are cheap
  - All users interact with the system at once, debugging becomes a lot easier, process switching occurs much more frequently
- Memory is cheap — programs and data go on-line
- UNIX simplifies Multics so it can be built
- New OS services: shell, filesystems, rapid process switching, virtual memory

New problems: response time & thrashing

OS History

Phase 6: Personal Computing

Hardware: *very cheap*

Humans: *expensive*

- Computers are cheap, so put one in each terminal
- Make the OS simple (again) by getting rid of support for multiprogramming, concurrency, and protection...
  - Did not really work; e.g., Microsoft had to put all this functionality back into its OS
  - With distributed computing & networking, we still want to share resources, but now we want to share across machines

OS History

Phase 7a: Parallelism

Hardware: *very cheap* Humans: *expensive*

- Increased processing demands lead to parallelism
- In parallel systems, multiple processors are in the same machine, sharing memory, I/O devices, clock, ...
- In distributed systems, multiple processor communicate via network

Advantages: increased performance, increased reliability, sharing of specialized resources

OS History

Phase 7b: Real-Time Systems

Hardware: *very cheap*

Humans: *expensive*

- Computers control physical machines or provide high-quality interaction
  - e.g., virtual reality
- Timing requirements provide deadlines by when tasks must be accomplished
- Hard vs. soft real-time:
  - Hard real-time OS must meet timing requirements (so omit features)
  - Soft real-time OS allows deadlines to be missed

OS History

Phase 7c: Embedded Systems

Hardware: *very, very cheap*   Humans: *expensive*

- Your car may have dozens of processors
- Severe processing constraints $\Rightarrow$ no OS...
- Programmer creates own OS abstractions

History Conclusions

- Different environments demand different designs
- Many abstractions nevertheless work across many environmets