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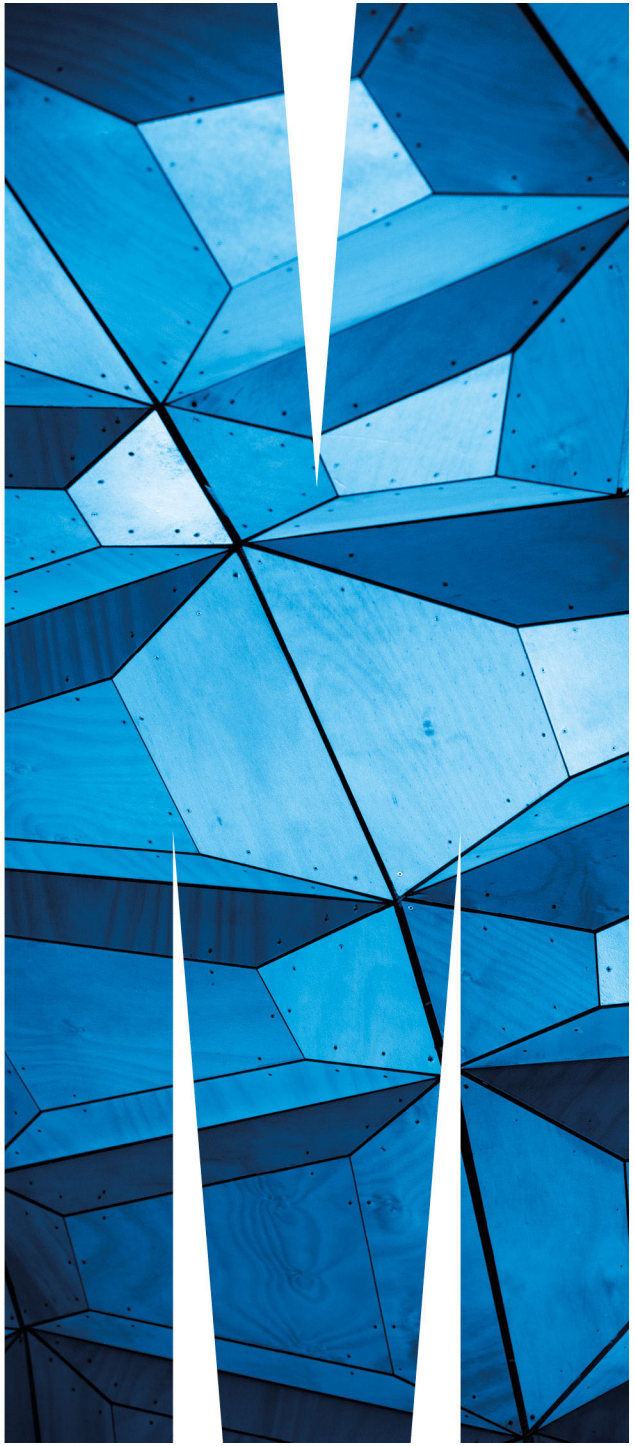


FIT2100 Semester 2 2020

Lecture 2:
Operating System Overview

(Reading: Stallings, Chapter 2)

WEEK 2

GROUP OF EIGHT AUSTRALIA

Lecture 2: Learning Outcomes

- Upon the completion of this lecture, you should be able to:
  - Understand the objectives and functions of an operating system (OS)
  - Discuss the evolution of operating systems from simple batch systems to modern complex systems
  - Discuss the key design areas of modern operating systems
  - Understand (at basic level) the OS architecture of Unix/Linux*

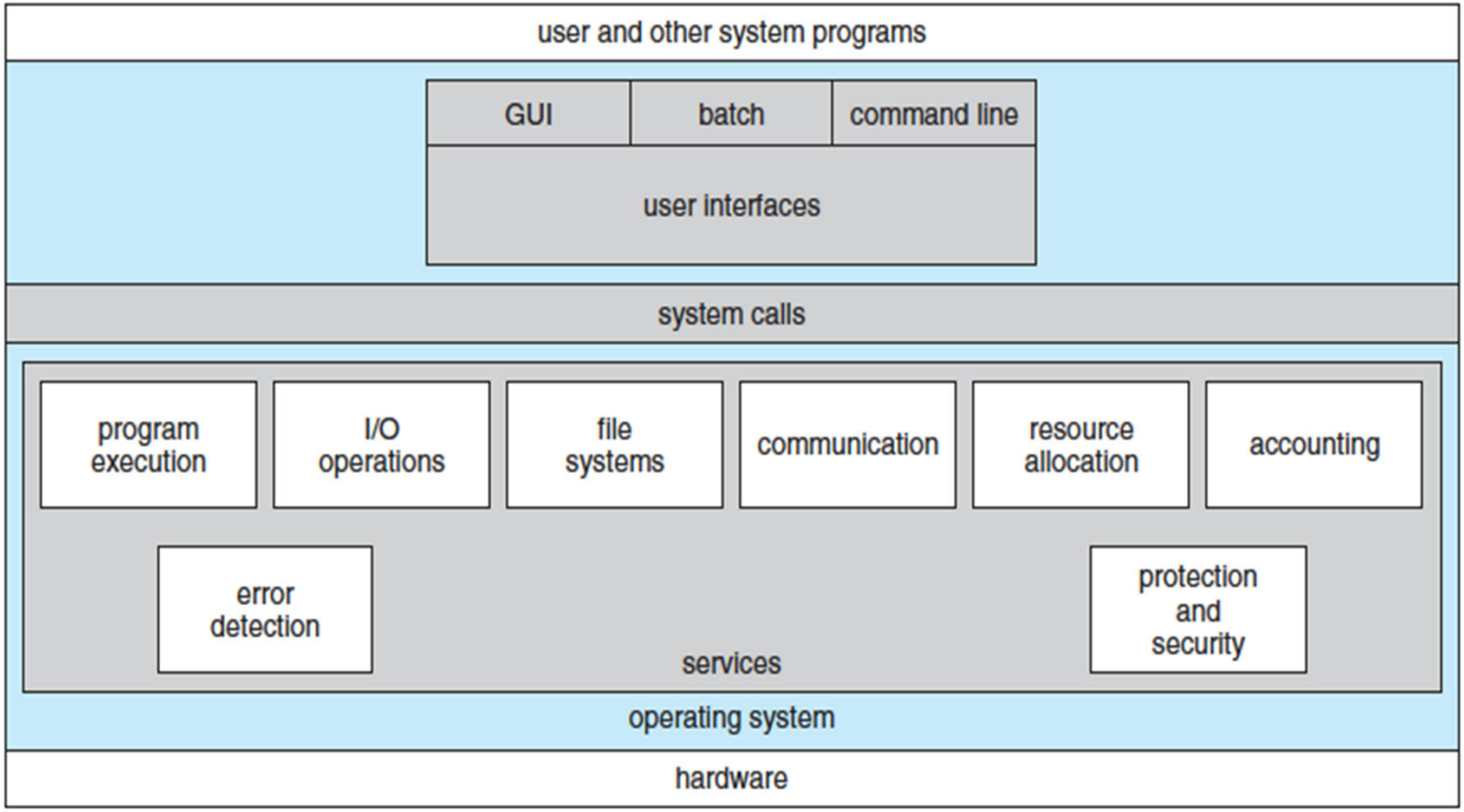
*Reading from Stallings Chapter 2 (2.8-2.10)

What is an operating system?

Operating System

- A program that controls the execution of application programs
- An interface between applications and hardware
- Main objectives of an operating system:
  - Convenience
  - Efficiency
  - Ability to evolve

Operating System Services: High Level View



[Source: Silberschatz et al., Chapter 2, 9th Edition]

Typical Operating System Services

- User interface
- Program execution
- Program development
- Access I/O devices
- Controlled access to files
- System access
- Error detection and response
- Communication
- Protection and security
- Accounting/auditing

What is a system call?

- A way to access OS services directly
  - A set of library functions in C
  - CPU jumps to OS code to carry out the service directly
  - Examples: **read(), write(), open(), close(), fork(),** …
    - You will understand these after working with them in labs in the next few weeks
  - Access files, execute programs, etc.
- Primitive building blocks for more advanced functionality
  - The ‘deepest’ way to access the OS
  - More advanced (high-level) functions are built on top.

EXAMPLE – How does a Python program open files?

- If you write a program in Python to open a file…
  - The Python program runs in an interpreter
  - …the Python interpreter is written in C
  - …the interpreter interprets your code and then calls the **open()** function to access the OS service.
- *Most* software that runs on your PC makes use of C library functions deep down somewhere.

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What is the role of an operating system?

The Role of an OS

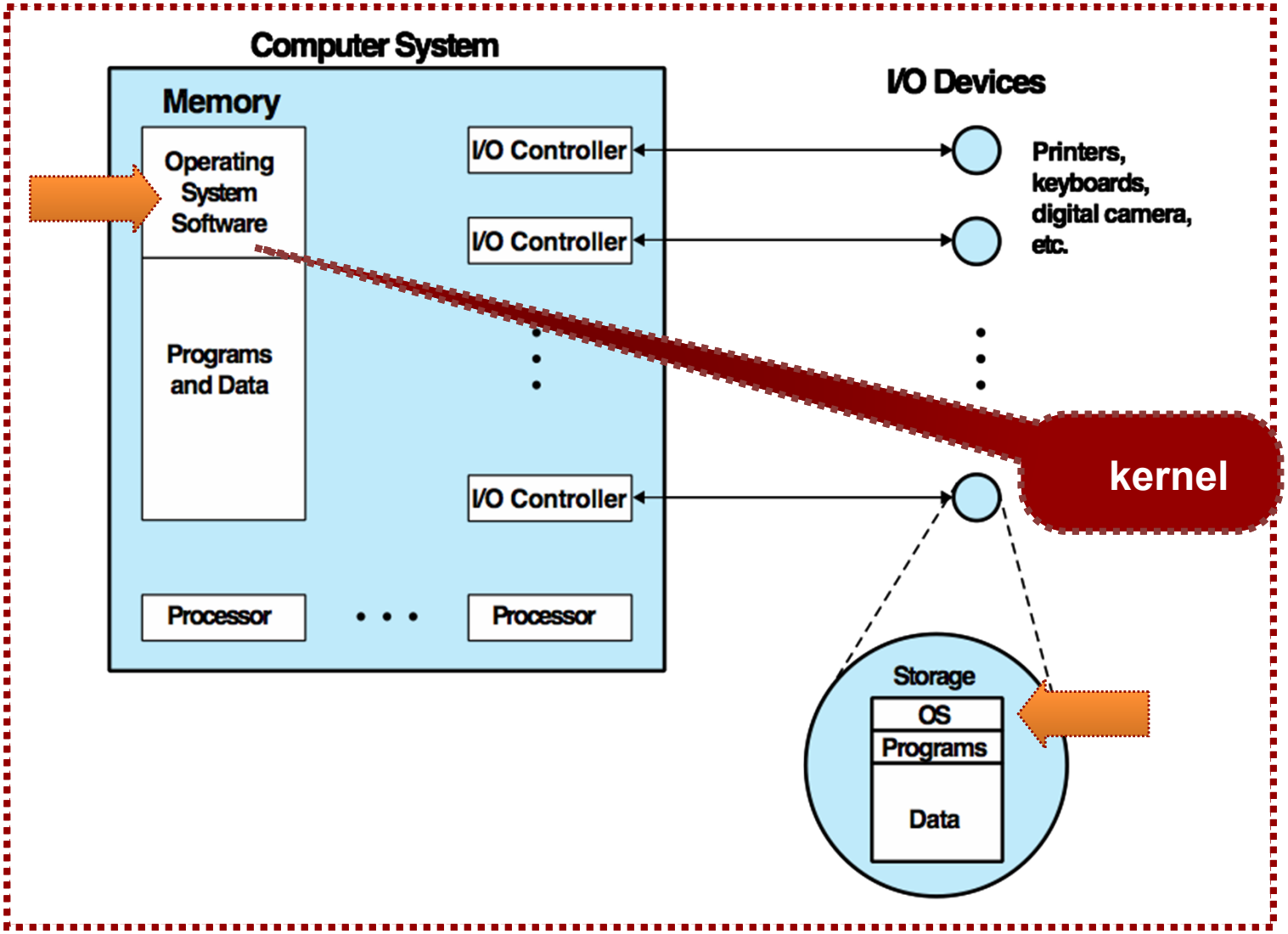
- A computer is a set of resources for the movement, storage, and processing of data
- OS is responsible for managing computer resources
- OS is in control of the computer's basic functions

Operating System: As Software

- OS functions in the same way as ordinary computer software
- Program, or suite of programs, executed by the processor
- Frequently relinquishes control and must depend on the processor to allow it to regain control

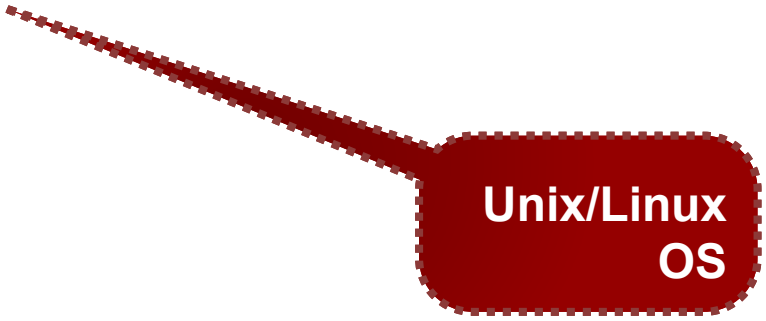
OS provides instructions to the processor and directs the processor in terms of the use of other system resources and the timing of execution for other programs.

Operating Systems: As Resource Manager



Operating System: Other Terms

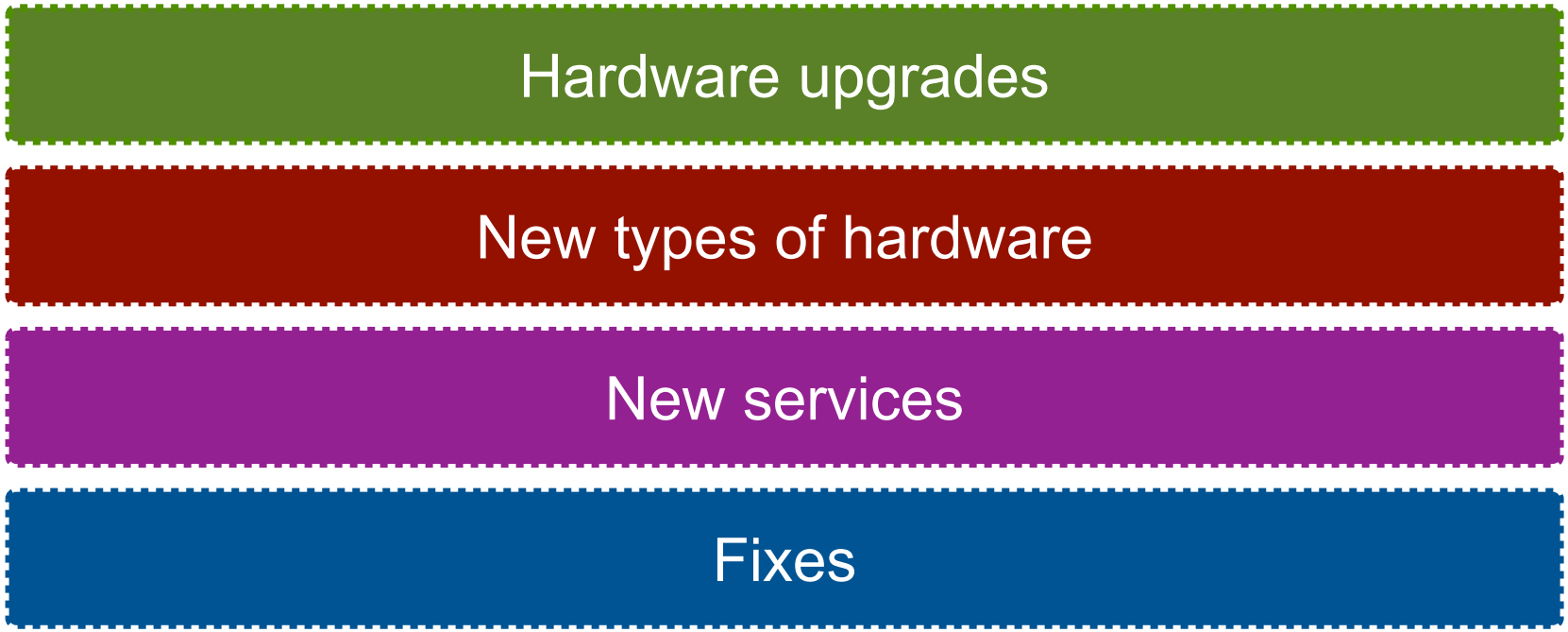
- Resource allocator:
  - Manages and allocates resources to programs
- Control program:
  - Controls the execution of user programs and operation of I/O devices
- Kernel:
  - The one program running at all times (all else being application programs)



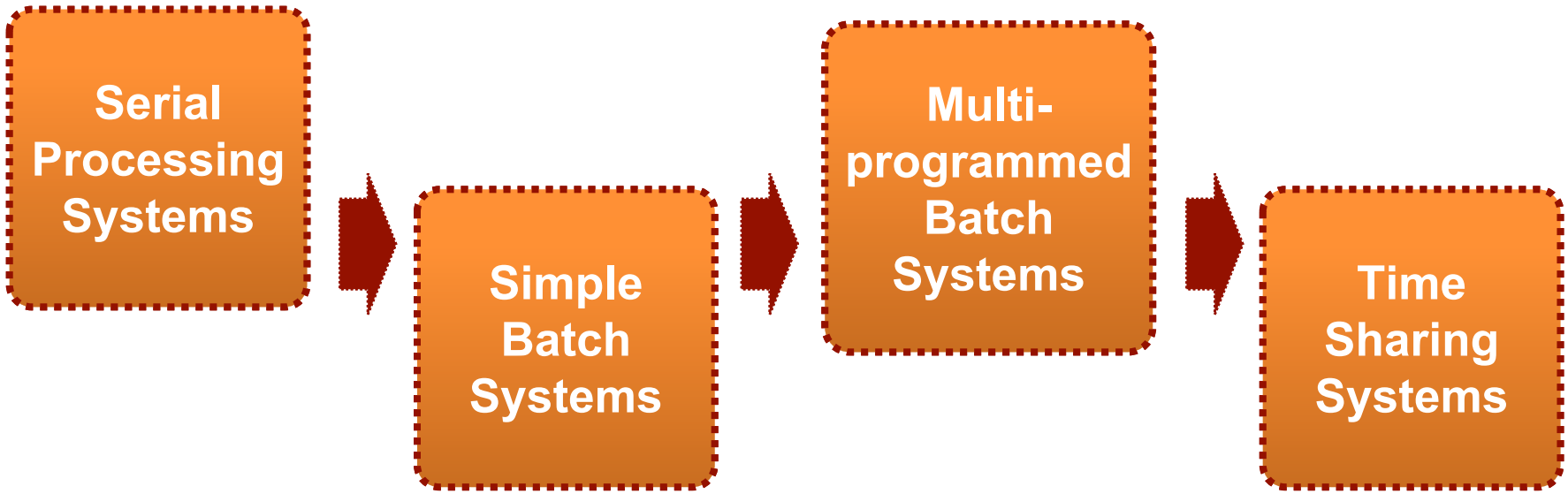
The evolution of operating systems

The Evolution of Operating Systems

- A major OS will evolve over time for a number of reasons:



The Evolution of Operating Systems



Serial Processing

Earliest Computers

- No operating system
  - Programmers interacted directly with the computer hardware
- Computers ran from a console with display lights, toggle switches, some form of input device, and a printer
- Users have access to the computer in "series"

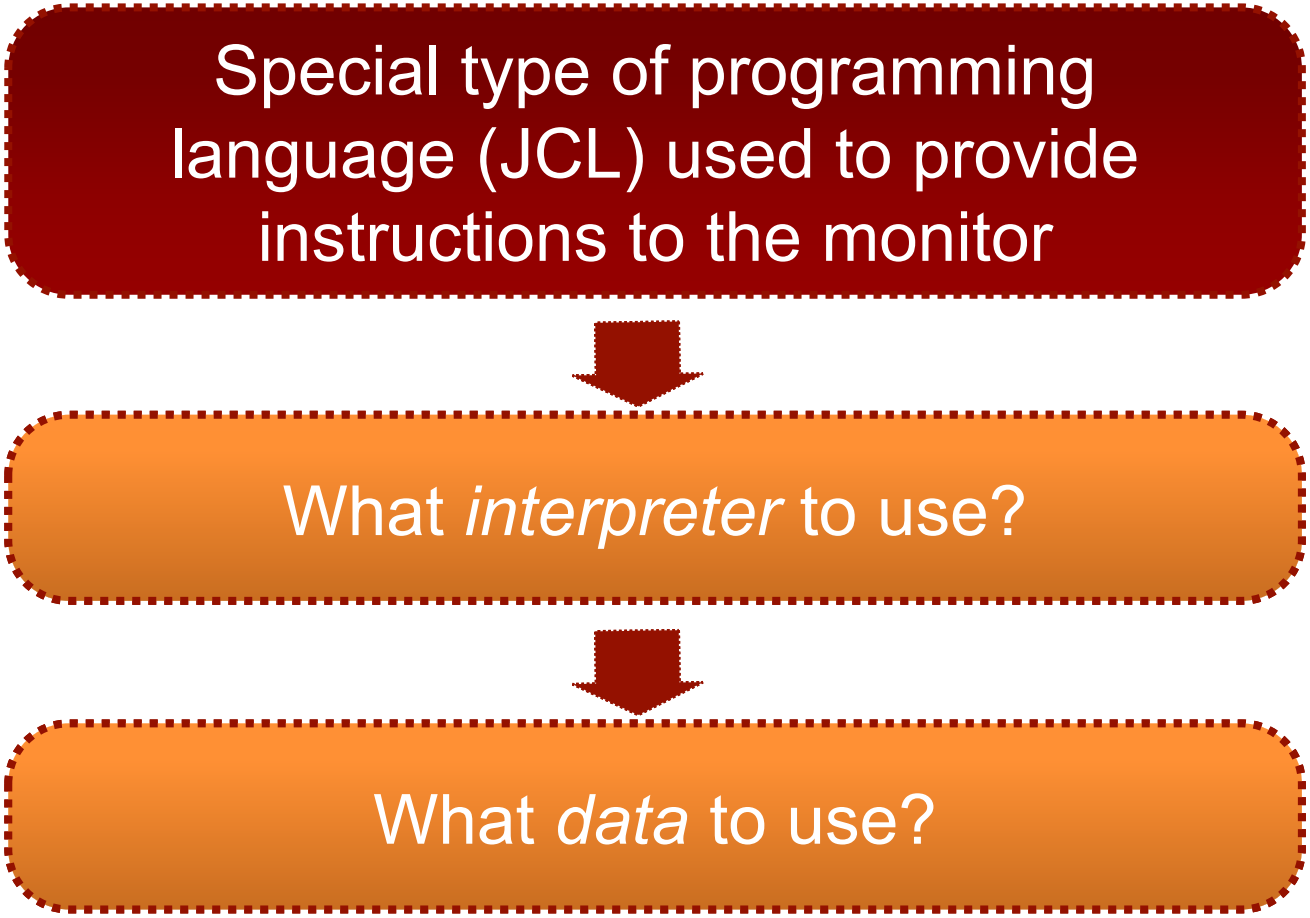
Problems

- Scheduling
  - Most installations used a hardcopy sign-up sheet to reserve computer time
  - Time allocations could run short or long, resulting in wasted computer time
- Setup time
  - A considerable amount of time was spent just on setting up a program (or a job) for execution

Simple Batch Systems

- Important to maximise processor utilisation
  - Early computers were very *expensive*
- The concept of "monitor":
  - Users no longer have direct access to the processor
  - Jobs are submitted to a computer *operator* who batches them together and places them on an input device
  - Program branches back to the monitor when finished

Simple Batch Systems: Job Scheduling



Simple Batch Systems: Modes of Operation

User Mode

- User program executes in user mode
- Certain areas of memory are protected from user access
- Certain instructions may not be executed

Kernel Mode

- Monitor executes in kernel mode
- Privileged instructions may be executed
- Protected areas of memory may be accessed

Simple Batch Systems: Overhead?

- Processor time alternates between execution of user programs and execution of the monitor
- Sacrifices:
  - Some main memory is given over to the monitor
  - Some processor time is consumed by the monitor
- Despite overhead, the simple batch system improves utilisation of the computer

Multi-programmed Batch Systems

- Processor is often idle:
  - Even with automatic job sequencing
  - I/O devices are slower as compared to processor

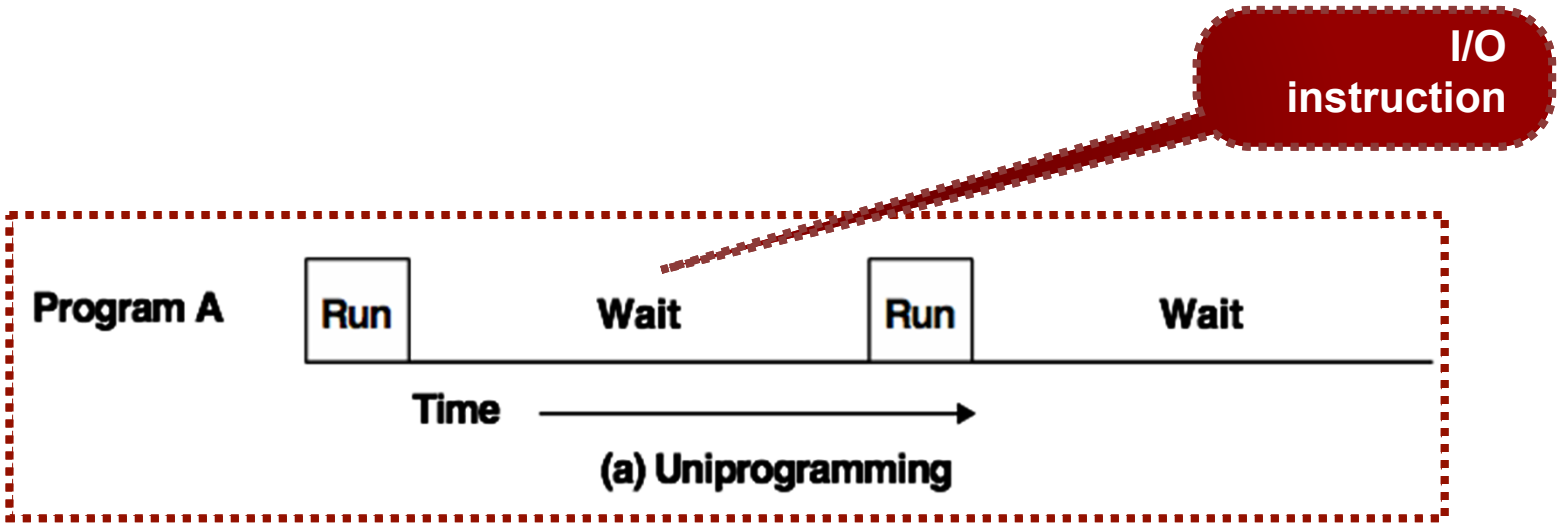
- Example: system utilisation

Read one record from file	15 μs
Execute 100 instructions	1 μs
Write one record to file	15 μs
TOTAL	31 μs

Percent CPU Utilization $= \frac{1}{31} = 0.032 = 3.2\%$

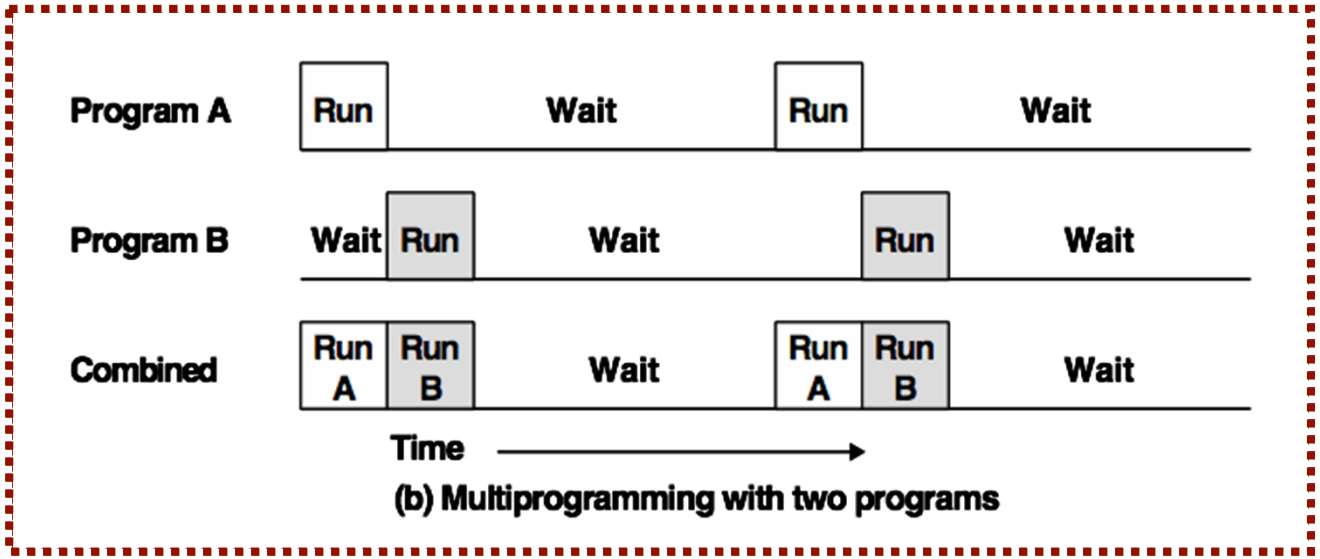
Uniprogramming

- The processor spends a certain amount of time executing, until it reaches an I/O instruction
- It must then wait until that I/O instruction concludes before proceeding



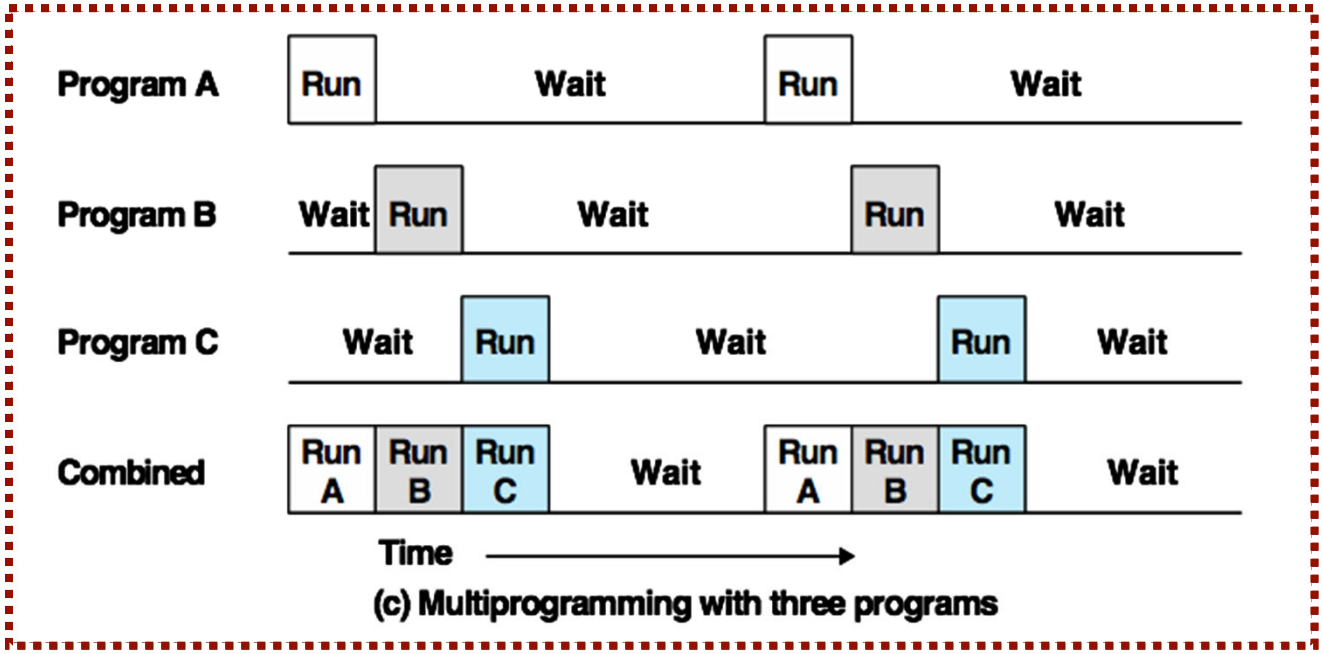
Multiprogramming: Two Programs

- When one job needs to wait for I/O, the processor can switch to the other job, which is likely not waiting for I/O



Multiprogramming: Three Programs

- Memory is expanded to hold three, four, or more programs and switch among all of them
- The concept of "multitasking"

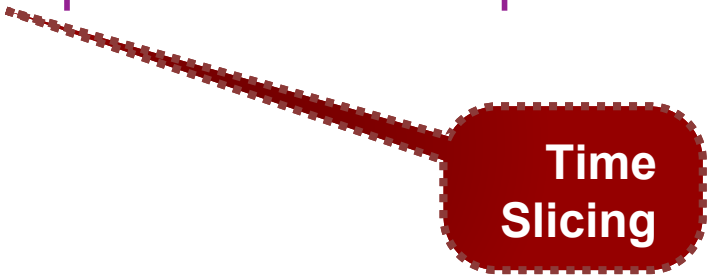


Multiprogramming: Example

	JOB1	JOB2	JOB3
Type of job	Heavy compute	Heavy I/O	Heavy I/O
Duration	5 min	15 min	10 min
Memory required	50 M	100 M	75 M
Need disk?	No	No	Yes
Need terminal?	No	Yes	No
Need printer?	No	No	Yes

Time-Sharing Systems

- Can be used to handle multiple interactive jobs
- Processor time is shared among multiple users
- Principle objective is to minimise response time
- Multiple users simultaneously access the system through terminals, with the OS interleaving the execution of each user program in a short burst or quantum of computation



What have been some major advances in OS development?

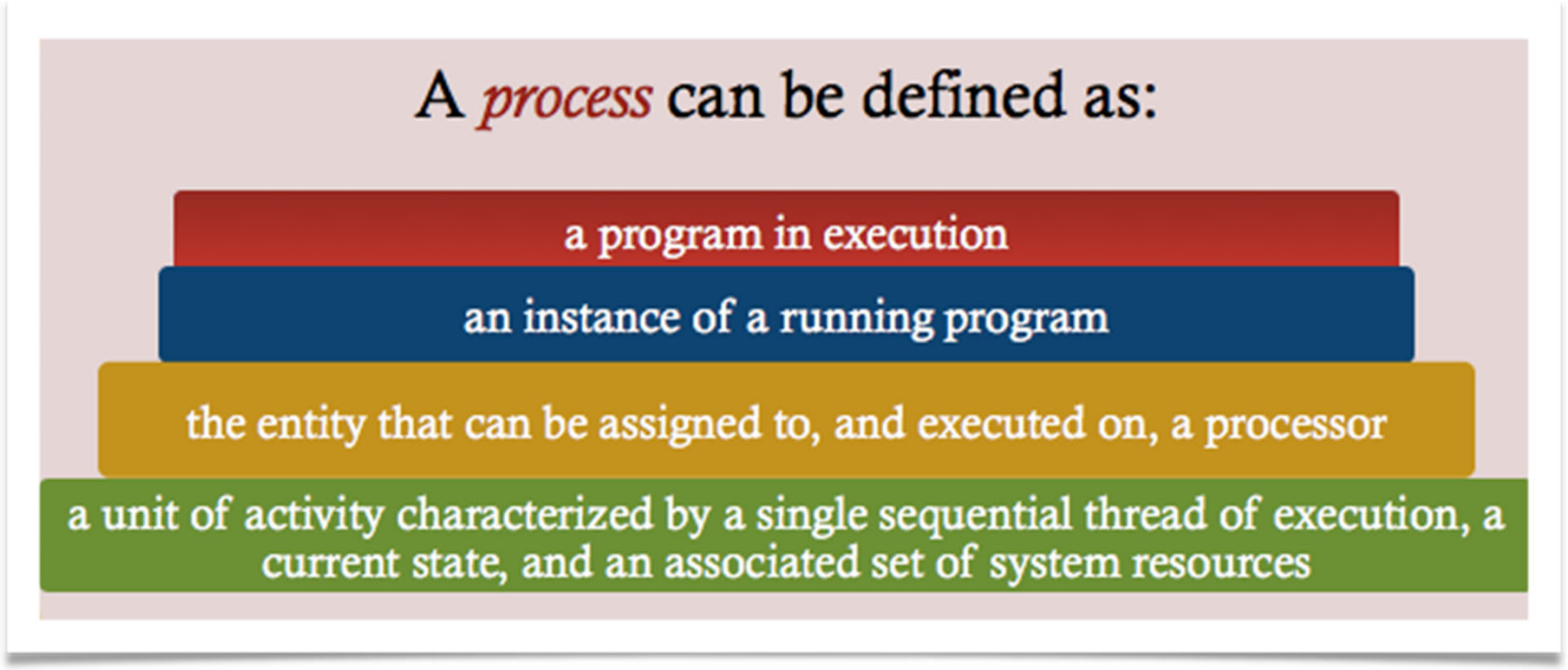
Major Achievements

- Major advances in OS development:

  - Processes
  - Memory management
  - Information protection and security
  - Scheduling and resource management

The Concept of Process

- Fundamental to the structure of operating system



Development of the Concept of Process

Three major lines of computer system development that created problems in timing and synchronisation:

- Multiprogramming batch operation:
  - Processor is switched among the various programs residing in main memory
- General purpose time sharing:
  - Be responsive to the individual users but be able to support many users simultaneously
- Real-time transaction processing systems:
  - A number of users are entering queries or updates against a database

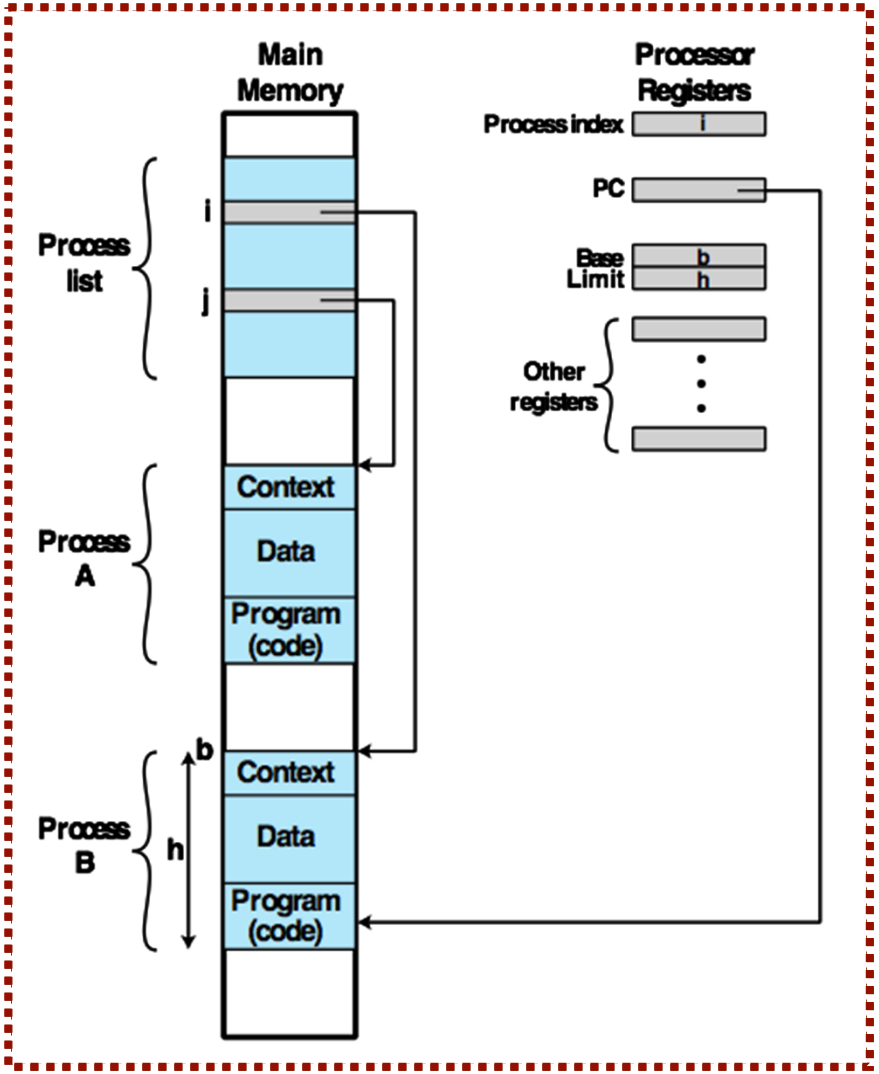
Process: Three Key Components

- An executable program
- Associated data needed by the program (e.g. variables, work space, buffers, etc.)
- Execution context (or process state) of the program

- The execution context is essential as it includes:
  - the internal data by which the OS is able to supervise and control the process
  - the contents of the various process registers
  - other information (e.g. the priority of the process; whether the process is waiting for the completion of a particular I/O event)

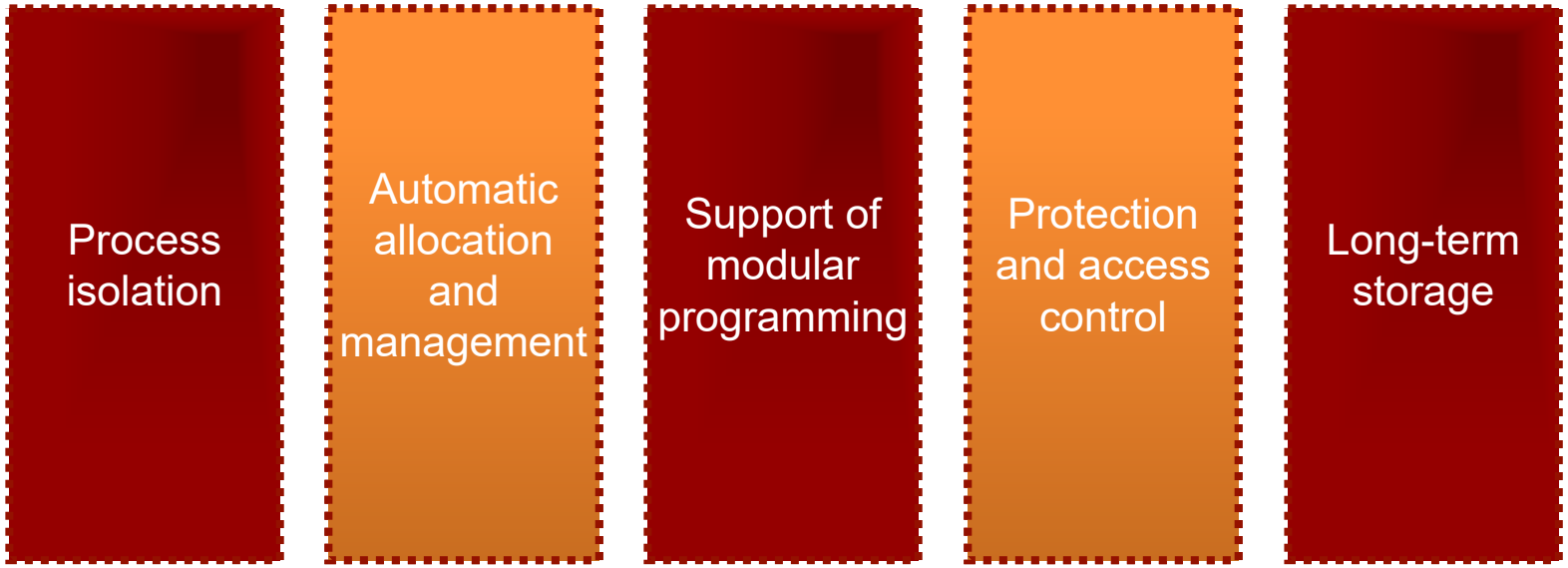
Process Management

- The process is realised as a data structure.
- The entire state of the process at any instant is contained in its context.
- New features can be designed and incorporated into the OS — by expanding the context to include any new information needed to support the features.



Memory Management

- Principal storage management responsibilities of OS:



- Can be achieved using virtual memory and file system facilities

Information Protection and Security

- The nature of the threat that concerns an organisation will vary greatly depending on the circumstances
- The concern involves controlling access to computer systems and the information stored in the systems
- Main issues:
  - Availability
  - Confidentiality
  - Data integrity
  - Authenticity

Scheduling and Resource Management

- Key responsibilities of an OS: managing various system resources (main memory, I/O devices, processors)
- Resource allocation and scheduling policies must consider:
  - Fairness: equal and fair access to resources by competing processes
  - Differential responsiveness: discriminate among different classes of processes
  - Efficiency: maximise throughput and minimise response time; accomodate as many users as possible

OS Architecture

- Demands on operating systems require new approaches to organising the OS architecture

Different approaches and design elements have been tried:

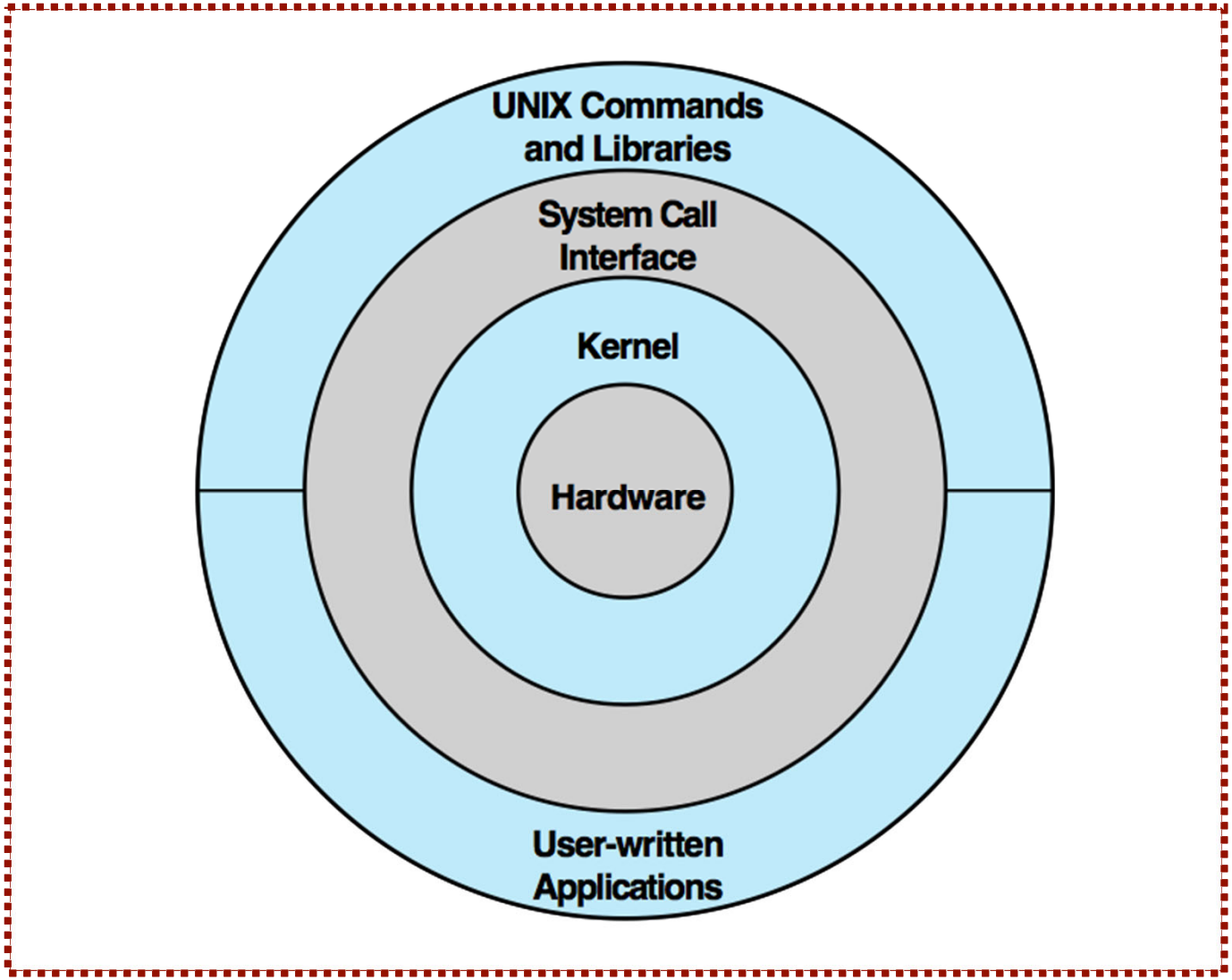
- microkernel architecture
- multithreading
- symmetric multiprocessing
- distributed operating systems
- object-oriented design

OS architecture for Unix/Linux

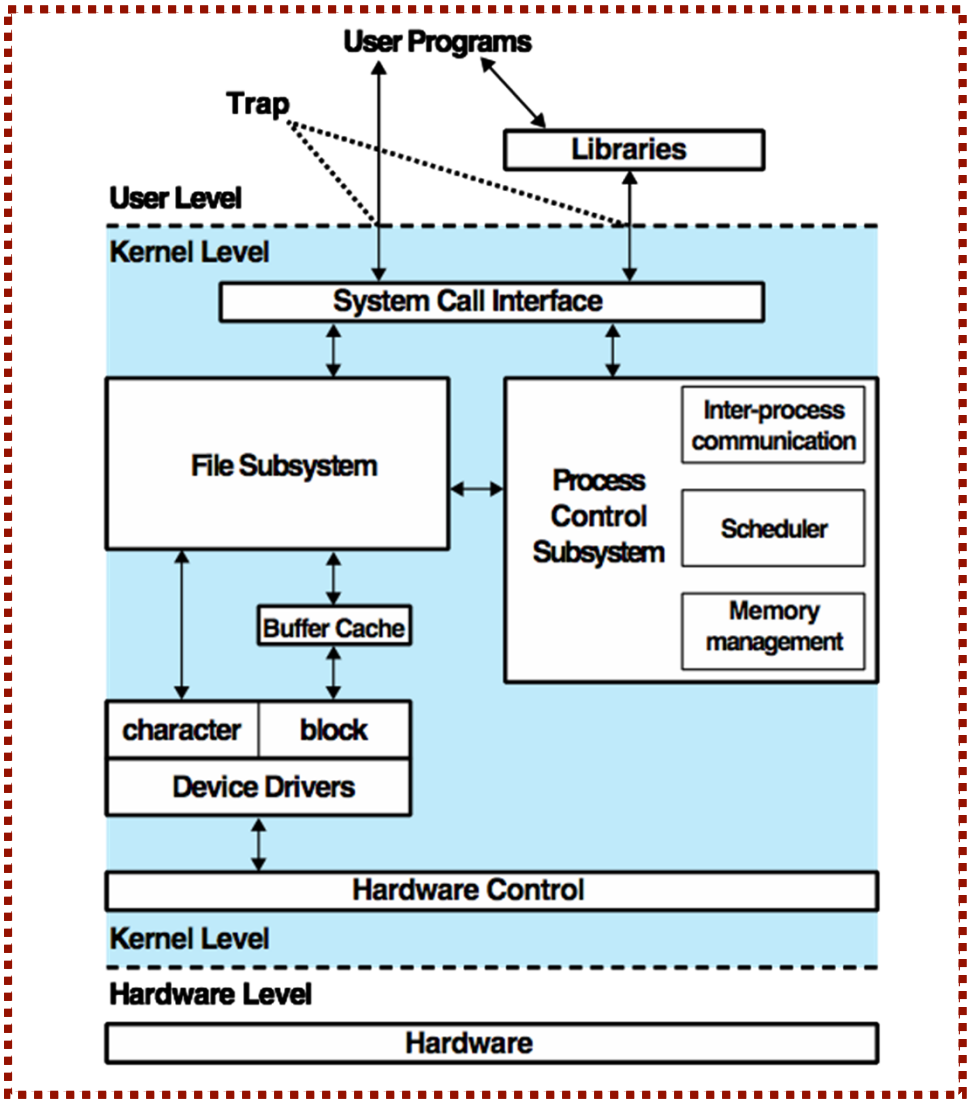
Traditional Unix Systems

- Developed at Bell Labs and became operational on a PDP-7 in 1970
  - Incorporated many ideas from Multics (and also CTSS)
  - PDP-11 was a milestone because it first showed that UNIX would be an OS for all computers
- Next milestone was rewriting UNIX in the programming language C
  - Demonstrated the advantages of using a high-level language for system code
- Described in a technical journal for the first time in 1974
- First widely available version outside Bell Labs was Version 6 in 1976
  - V*ersion 7* released in 1978 is the ancestor of most modern UNIX systems
- Commercially marketed as Unix System III and Unix System V
- Most important of the non-AT&T systems was Unix BSD

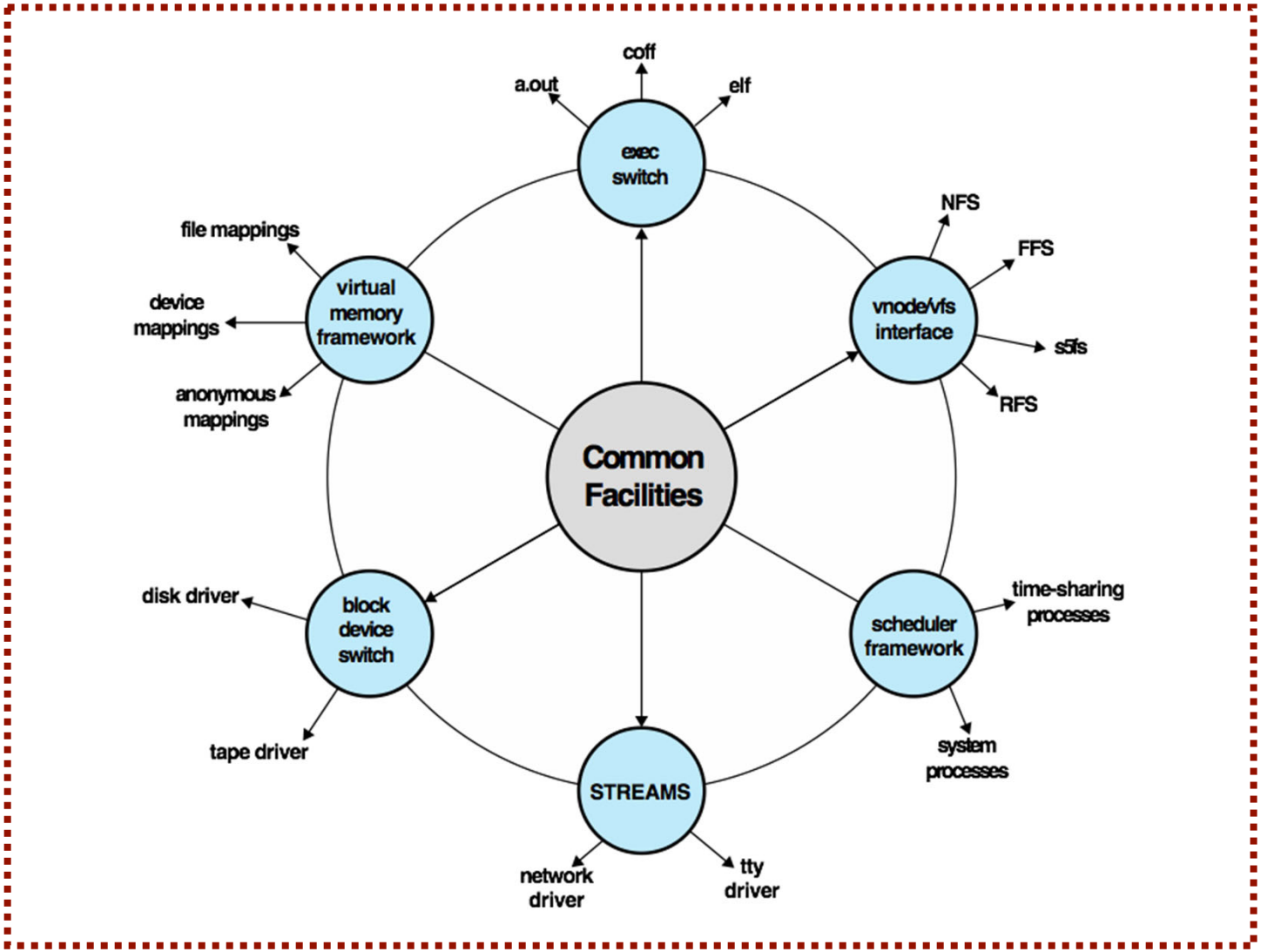
Unix: General Architecture



Unix Kernel: Traditional Architecture



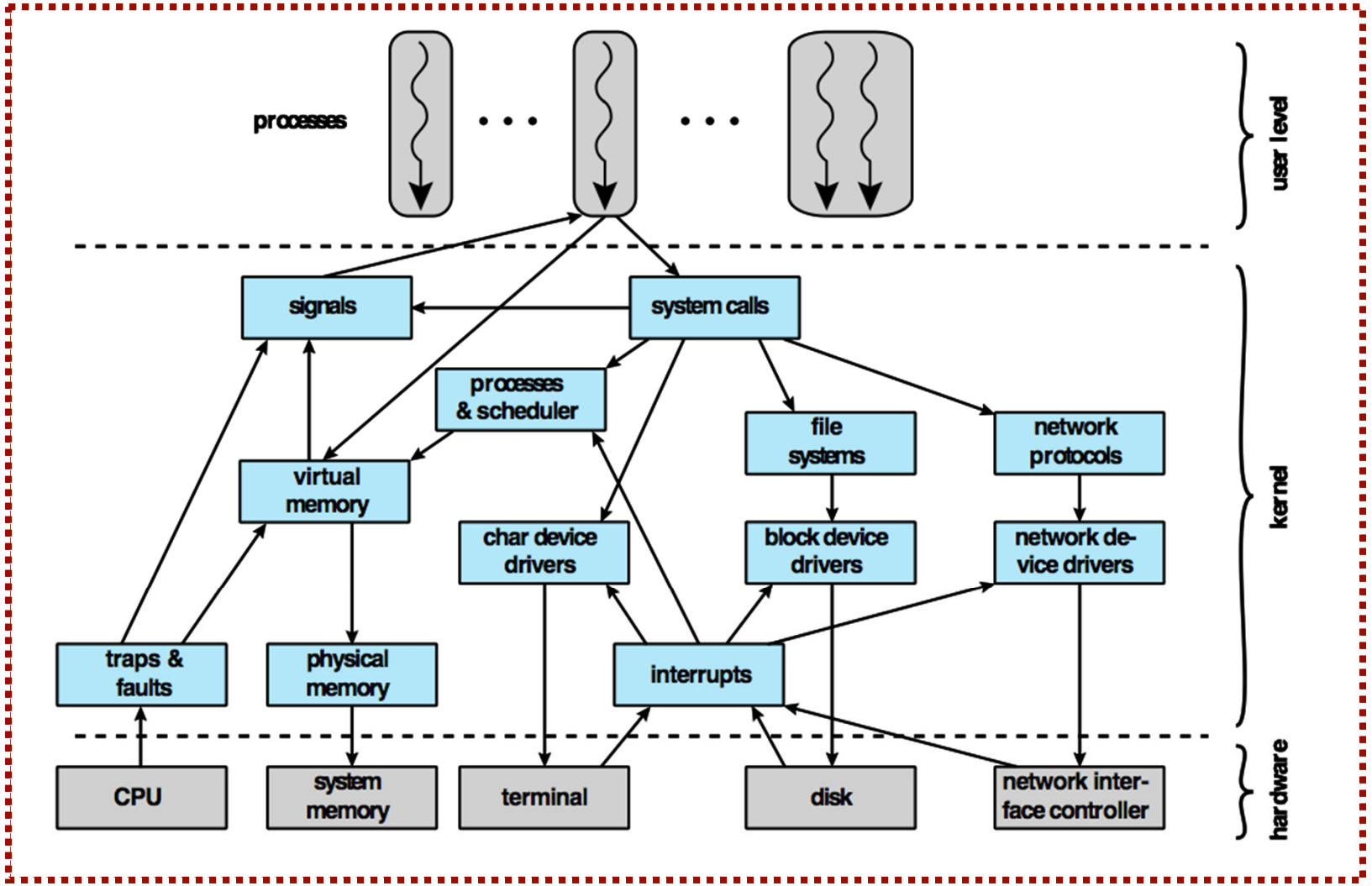
Unix Kernel: Modern Architecture



Linux Systems

- Started out as a UNIX variant for the IBM PC
- Initial version was written by Linus Torvalds — a Finnish student of computer science
- Linux was first posted on the Internet in 1991
- Linux is a full-featured UNIX system that runs on several platforms
- Free and source code is available (GNU Public License)
- Key to success has been the availability of free software packages
- Linux is highly modular and easily configured

Linux: Kernel Components



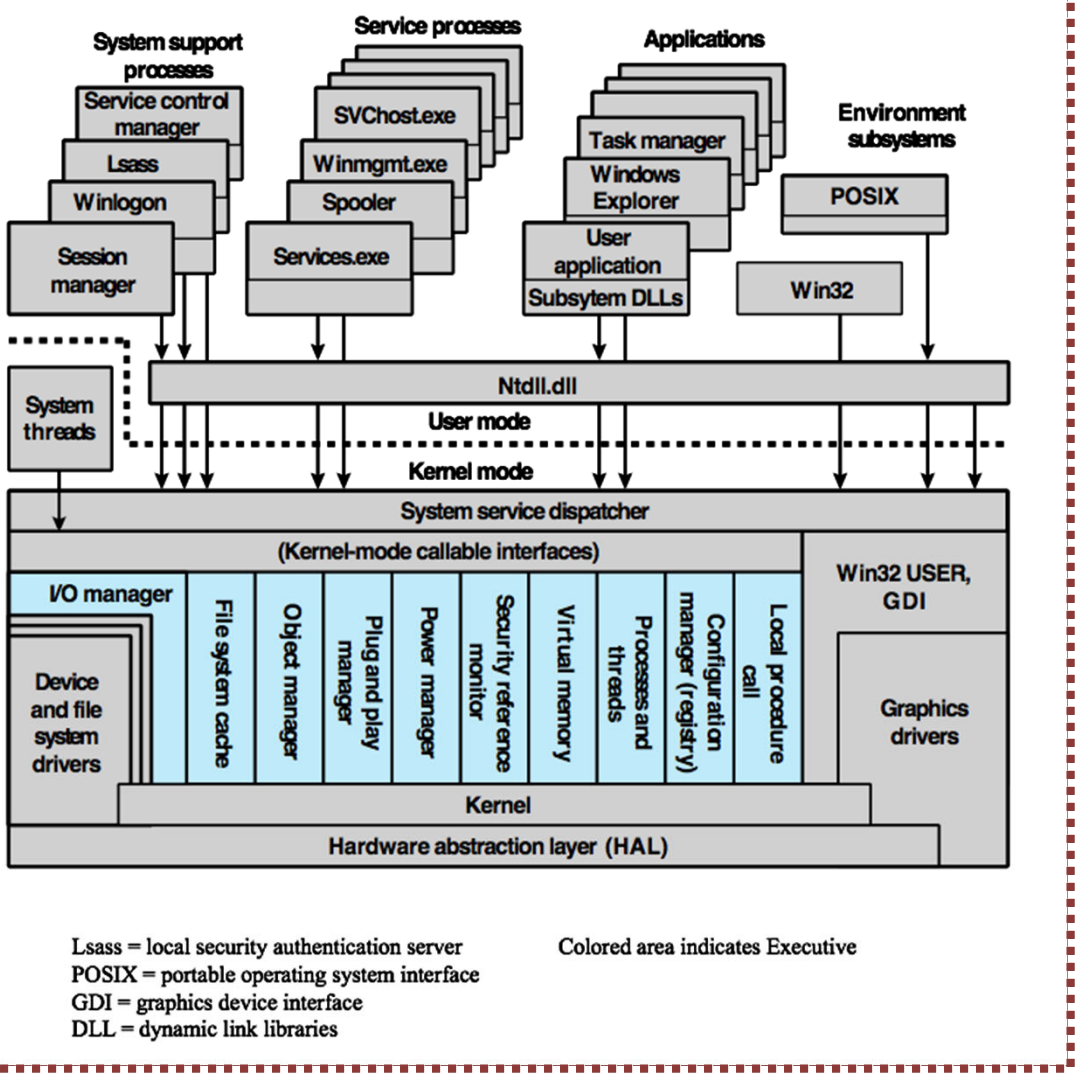
Summary

- So far, we have discussed:
  - Objectives and functions of OS
  - Evolution of operating systems
  - Key design areas of modern OS
  - OS architecture of Unix/Linux
- Reading:
  - Stallings, Chapter 2 (2.1-2.3, 2.8-2.10), 9th/8th Edition
- Next week:
  - External I/O and hard drives

Reminder: The first practical this week.

Supplementary slides

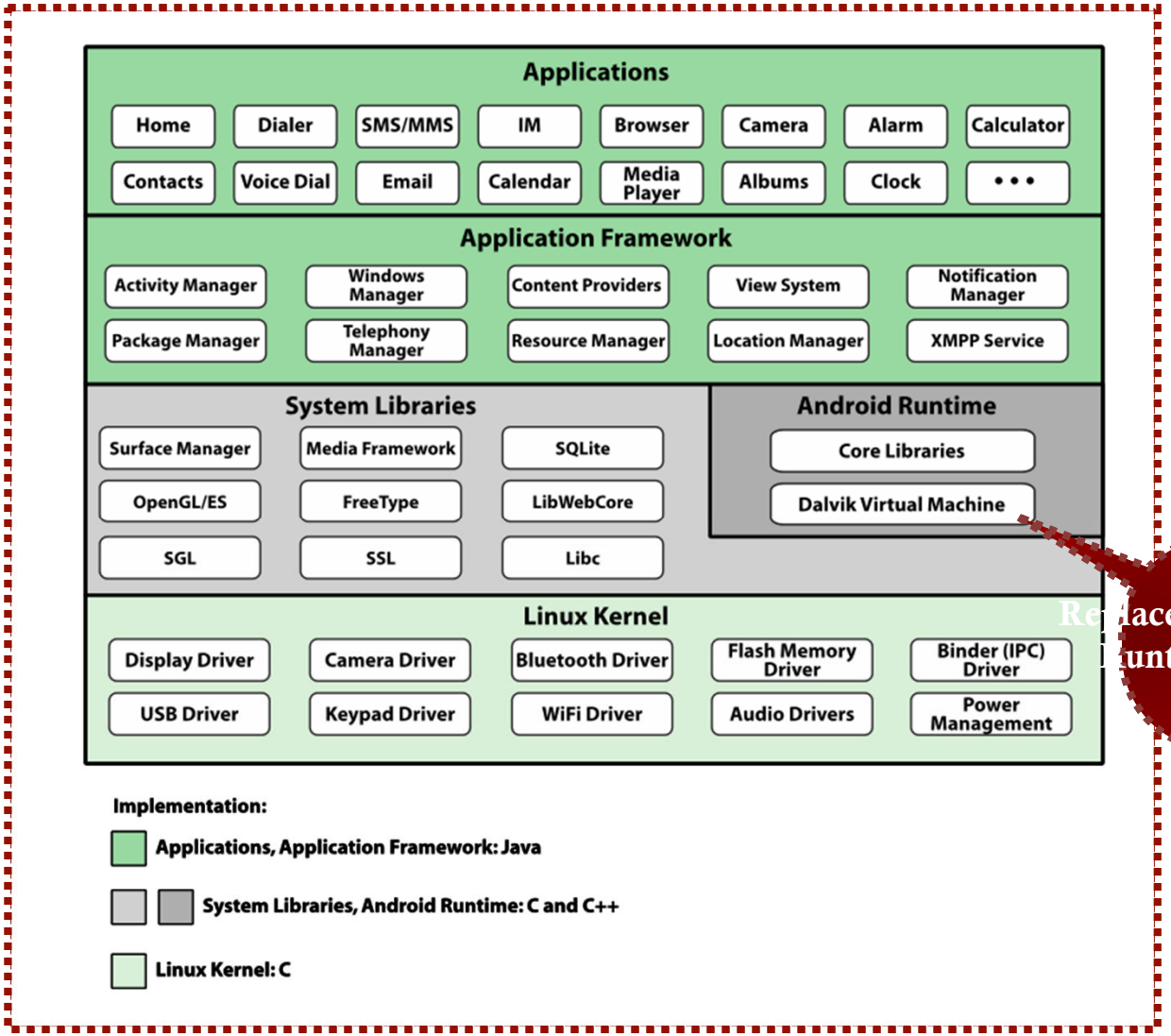
Microsoft Windows: System Architecture



Android OS

- A Linux-based system originally designed for touchscreen mobile devices such as smartphones and tablet computers
- Development was done by Android Inc., which was bought by Google in 2005
- 1st commercial version (Android 1.0) was released in 2008
- Most recent version is Android 9 (Pie)
- The Open Handset Alliance (OHA) was responsible for the Android OS releases as an open platform
- The open-source nature of Android has been the key to its success

Android: Software Architecture



Android: System Architecture