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Operating System Overview

COMP3231/COMP9201 Operating Systems

2005/S2

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Why Study Operating Systems?

Look "under the hood" to understand how computer systems work

- ➜ Understand some of the tradeoffs in systems design
- ➜ Understand what makes a "good" system
- ➜ Embedded system: special-purpose OS tightly coupled to application software
- ➜ Understand why a program that looks alright might be badly broken

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Example 1: Displaying Time of Day

```
#include <timer.h>
void ShowTime (void) {
    int hour, mins, secs;

    hour = Timer.hour;
    mins = Timer.mins;
    secs = Timer.secs;

    printf("time = %02d:%02d:%02d\n",
           hour, mins, secs);
}
```

Where is the problem?

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Example 2: Initialising an Array

```
void ResetArray (int array[10000][10000]) {
    int i, j;

    for (i=0; i<10000; i++) {
        for (j=0; j<10000; j++) {
            array[i][j] = 0;
            /* OR array[j][i] = 0 ??? */
        }
    }
}
```

What difference does it make?

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Example 3: Password Verification

```
int CheckPassword (char *given, char *passwd) {
    int i;

    for (i=0; i<14; i++) {
        if (passwd[i] != given[i]) {
            return EXIT_FAILURE;
        }
    }
    return EXIT_SUCCESS;
}
```

What is the problem?

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What are the objectives of an Operating System?

➜ convenience & abstraction

- the OS should facilitate the task of application and system programmer
- hardware details should be hidden, uniform interface for different I/O devices provided

➜ efficiency

should take up few resources, make good use of resources, and be fast

➜ protection

fairness, security, safety

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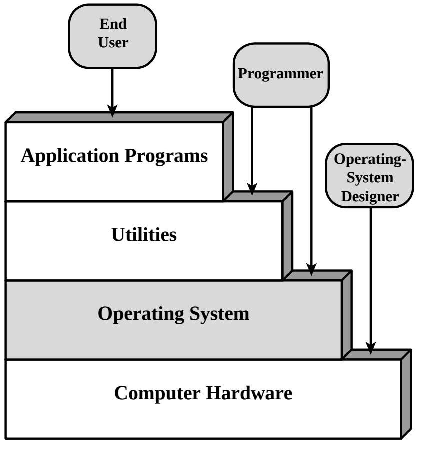
Layers of Computer System



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Services Provided by the Operating System

➜ Program execution

- load instructions and data into main memory
- initialise I/O devices, etc

➜ Access to I/O devices

- provides a uniform interface for various devices

➜ Controlled access to files

- abstracts over structure of data on I/O device
- provides protection mechanisms

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Services Provided by the Operating System

- ➜ System access: provides protection of
  - data
  - system resources; and
  - resolves access conflicts
- ➜ Program development
  - Editors, compilers, and debuggers: not part of the core, but usually supplied with the OS.

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Services Provided by the Operating System

- ➜ Error detection and response

  Possible errors:

  - internal and external hardware errors
    - memory error
    - device failure
  - software errors
    - arithmetic overflow
    - access forbidden memory locations
  - operating system cannot grant request of application

  the OS has to

  - clear error condition
  - minimise effect on other applications

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Services Provided by the Operating System

- ➜ Accounting
  - collect statistics
  - monitor performance
  - used to anticipate future enhancements
  - used for billing users

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Operating System

The operating system controls the

- movement, storage, and processing of data

but it is not always 'in control':

- ➜ functions same way as ordinary computer software
  - it is just a program (or a set of programs) that is executed
  - relinquishes control of the processor to execute other programs
  - must depend on the processor to regain control

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Kernel

- Portion of operating system that is running in privileged (or "kernel" or "supervisor") mode
- Usually resident in main memory
- Implements protection
- Contains fundamental functionality required to implement other services
- Also called the nucleus or supervisor

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Evolution of an Operating System

OS have to evolve over time because of

- hardware upgrades and new types of hardware
- changing performance and costs leading to changing trade-offs
  - hardware gets cheaper, bigger, faster
  - people get more expensive
- New services
  - graphical user interfaces
  - file systems
- Fixes

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Evolution of Operating Systems

Serial Processing: late 1940s to mid 1950s

- No operating system
- Machines run from a console with display lights and toggle switches, input device, and printer
- Manual schedule
- Setup for each user included
  - loading the compiler, source program,
  - saving compiled program,
  - loading and linking

Improvements: libraries of common functions, linkers, loaders, compilers, debuggers available to all users.

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Evolution of Operating Systems

Simple Batch Systems: mid 1950s, by GM for IBM 701

- The monitor controls the execution of programs:
  - it batches jobs together
  - the program branches back to monitor when finished
  - resident monitor is in main memory and available for execution
- Instructions to monitor via Job Control Language (JCL)
  - the monitor contains a JCL interpreter
  - each job includes instructions in JCL to tell the monitor
    - what compiler to use
    - what data to use
  - predecessor of shell

Monitor takes up main memory and CPU time but improves utilization of computer

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Hardware Features

New hardware features support development of OS features

- ➜ Memory protection
  - do not allow the memory area containing the monitor to be altered
- ➜ Timer
  - prevents a job from monopolizing the system
- ➜ Privileged instructions
  - for example, I/O instructions
- ➜ Interrupts
  - relinquishing control to and gaining control from user program

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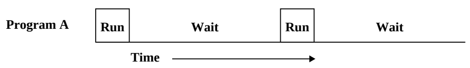
Uniprogramming

Problem:

- ➜ Processor must wait for I/O instruction to complete before preceding
- ➜ I/O instructions are very slow compared to computations



Solution: Interleave the execution of multiple jobs!

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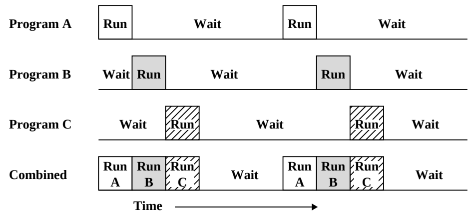
Multiprogramming

When one job needs to wait for I/O, the processor can switch to the other job

- ➜ Increased throughput
- ➜ Increased utilisation



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Example

	Job 1	Job 2	Job 3
Type of Job	CPU bound	I/O bound	I/O bound
Duration	5 min	15 min	10 min
Memory req't	50k	100k	80k
Disk?	No	No	Yes
Terminal?	No	Yes	No
Printer?	No	No	Yes

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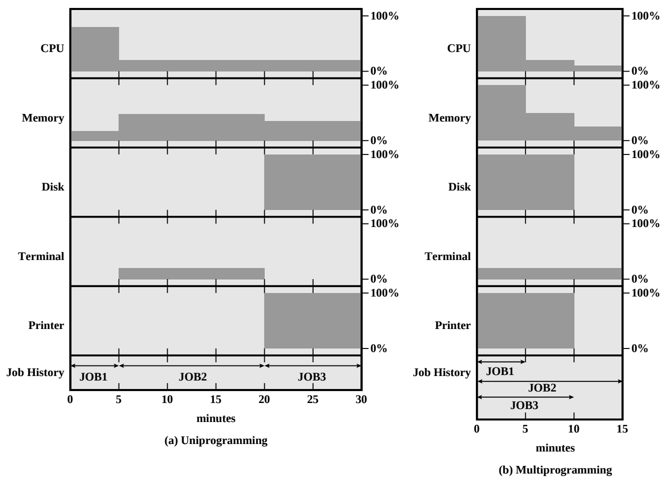

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Effects of Multiprogramming

	Uniprogramming	Multi-programming
Processor utilis.	22%	43%
Memory utilis.	30%	67%
Disk utils.	33%	67%
Printer utilis.	33%	67%
Elapsed time	30 min	15 min
Throughput	6 jobs/h	12 jobs/h
mean resp. time	18 min	10 min

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Time Sharing

Batch multiprogramming improves the utilisation of static jobs, but what about interactive jobs?

- ➜ Using multiprogramming to handle multiple interactive jobs
- ➜ Processor's time is shared among multiple users
- ➜ Multiple users simultaneously access the system through terminals

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Batch Multiprogramming versus Time Sharing

Different requirements for interactive execution

	Batch Multiprogramming	**Time Sharing**
Principal objective	Maximise CPU utilisation	Minimise response time
Control	JCL with job	Interactive commands

One of the first systems: Compatible Time-Sharing System (CTSS), 1961, IBM 709 & IBM 7094

- ➜ a system clock creates interrupts in regular intervals
- ➜ system switches to a new user
- ➜ old user's program and data saved to disk

PRIMITIVE TIME SHARING (CTSS)

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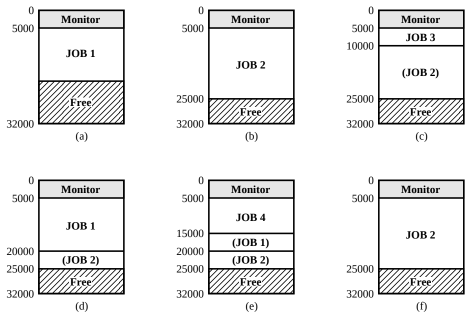
Job1:	15,000	Job3:	5000
Job2:	20,000	Job4:	10,000



PROCESSES

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➜ Problems occurring in multiprogramming batch systems, time-sharing systems required a closer look at "jobs".

➜ What exactly is a Process?

Exact definition is differs from to textbook to textbook:

✶ A program in execution

✶ An instance of a program running on a computer

✶ A unit of execution characterised by

- a single, sequential thread of execution
- a current state
- an associated set of system resources (memory, devices, files)

We define a Process to be an unit of resource ownership

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The OS has to

➜ Load the executable from hard disk to main memory

➜ Keep track of the states of every process currently executed

➜ Make sure

- no process monopolises the CPU
- no process starves
- interactive processes are responsive