Operating Systems Structure
Chapter 2

Operating System

- Is a control program that controls the execution of application programs
  - OS must relinquish control to user programs and regain it safely and efficiently
  - Tells the CPU when to execute other pgms
- Is an interface between the user and hardware
- Masks the details of the hardware to application programs
  - Hence OS must deal with hardware details

Services Provided by the OS

- Facilities for Program creation
  - editors, compilers, linkers, and debuggers
- Program execution
  - loading in memory, I/O and file initialization
- Access to I/O and files
  - deals with the specifics of I/O and file formats
- System access
  - Protection in access to resources and data
  - Resolves conflicts for resource contention

Evolution of an Operating System

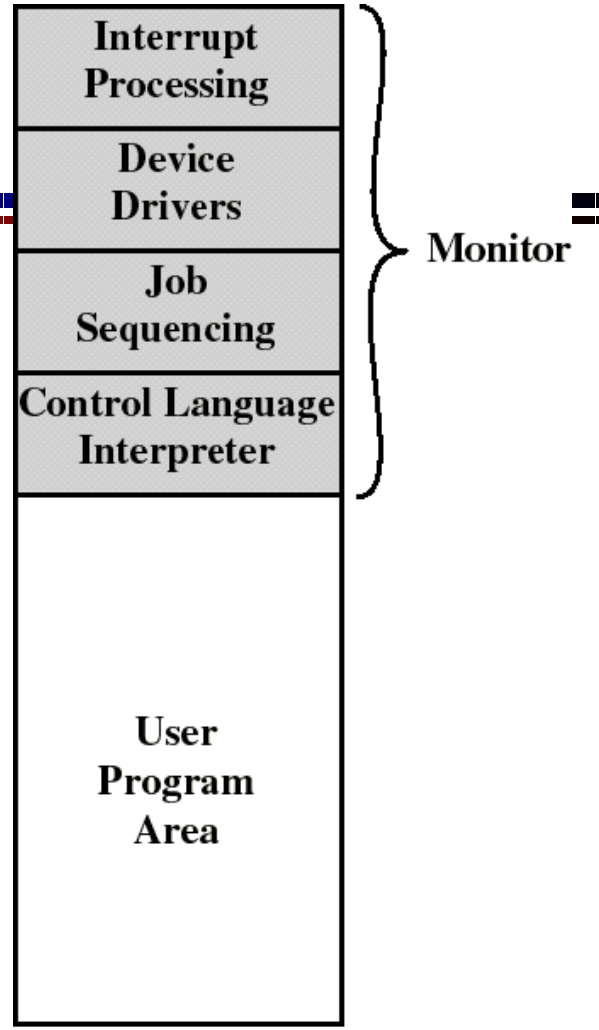
- Must adapt to hardware upgrades and new types of hardware. Examples:
  - Character vs graphic terminals
  - Introduction of paging hardware
- Must offer new services, eg: internet support
- The need to change the OS on regular basis place requirements on it’s design
  - modular construction with clean interfaces
  - object oriented methodology

Simple Batch Systems

- Are the first operating systems (mid-50s)
- The user submit a job (written on card or tape) to a computer operator
- The computer operator place a batch of several jobs on a input device
- A special program, the monitor, manages the execution of each program in the batch
- Resident monitor is in main memory and available for execution
- Monitor utilities are loaded when needed

The Monitor

- Monitor reads jobs one at a time from the input device
- Monitor places a job in the user program area
- A monitor instruction branches to the start of the user program
- Execution of user pgm continues until:
  - end-of-pgm occurs
  - error occurs
- Causes the CPU to fetch its next instruction from Monitor



Memory Layout of Resident Monitor

Job Control Language (JCL)

- Is the language to provide instructions to the monitor
  - what compiler to use
  - what data to use
- Example of job format: ------->>
- $FTN loads the compiler and transfers control to it
- $LOAD loads the object code (in place of compiler)
- $RUN transfers control to user program

```
$JOB
$FTN
. . .
FORTRAN
program
. . .
$LOAD
$RUN
. . .
Data
. . .
$END
```

Job Control Language (JCL)

- Each read instruction (in user pgm) causes one line of input to be read
- Causes (OS) input routine to be invoke
  - checks for not reading a JCL line
  - skip to the next JCL line at completion of user program

Batch OS

- Alternates execution between user program and the monitor program
- Relies on available hardware to effectively alternate execution from various parts of memory

Desirable Hardware Features

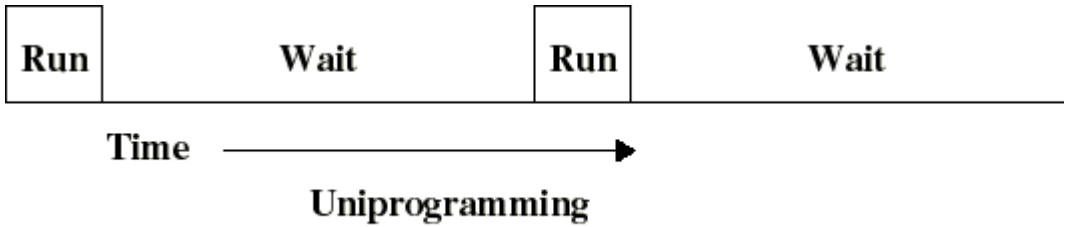
- Memory protection
  - do not allow the memory area containing the monitor to be altered by user programs
- Timer
  - prevents a job from monopolizing the system
  - an interrupt occurs when time expires

Desirable Hardware Features

- Privileged instructions
  - can be executed only by the monitor
  - an interrupt occurs if a program tries these instructions
- Interrupts
  - provides flexibility for relinquishing control to and regaining control from user programs

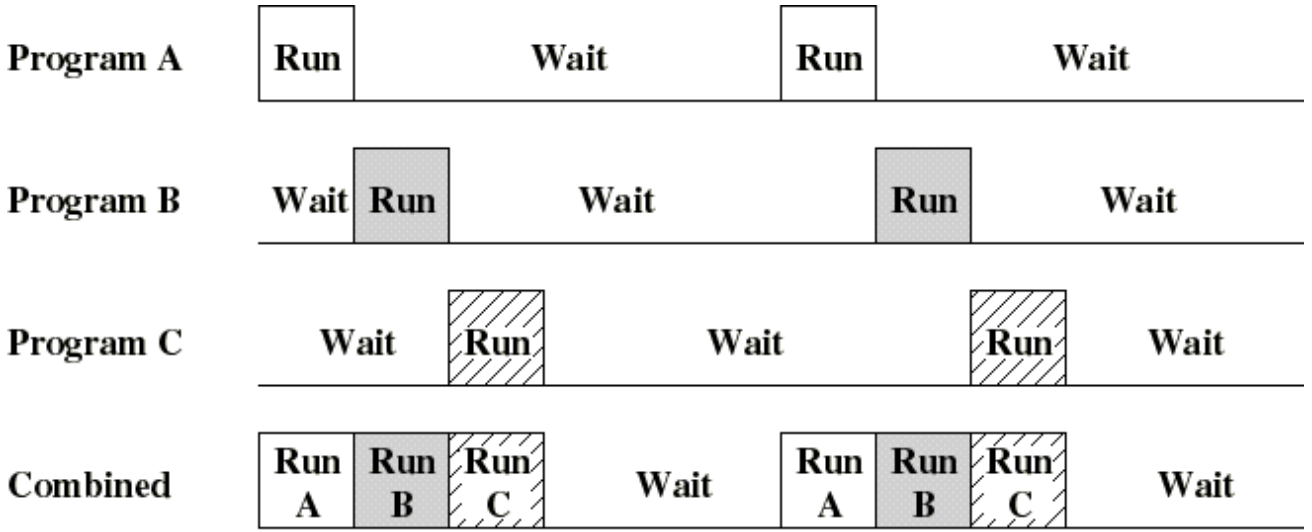
Multiprogrammed Batch Systems

- I/O operations are exceedingly slow (compared to instruction execution)
- A program containing even a very small number of I/O ops, will spend most of its time waiting for them
- Hence: poor CPU usage when only one program is present in memory



Multiprogrammed Batch Systems

- If memory can hold several programs, then CPU can switch to another one whenever a program is awaiting for an I/O to complete
- This is multitasking (multiprogramming)



Multiiprogramming with three programs

Requirements for Multiprogramming

- Hardware support:
  - I/O interrupts and (possibly) DMA
    - in order to execute instructions while I/O device is busy
  - Memory management
    - several ready-to-run jobs must be kept in memory
  - Memory protection (data and programs)
- Software support from the OS:
  - Scheduling (which program is to be run next)
  - To manage resource contention

Example: three jobs are submitted

	JOB1	JOB2	JOB3
Type of job	Heavy compute	Heavy I/O	Heavy I/O
Duration	5 min.	15 min.	10 min.
Memory req.	50K	100 K	80 K
Need disk?	No	No	Yes
Need terminal	No	Yes	No
Need printer?	No	No	Yes

- Almost no contention for resources
- All 3 can run in minimum time in a multitasking environment (assuming JOB2/3 have enough CPU time to keep their I/O operations active)

Advantages of Multiprogramming

	Uniprogramming	Multiprogramming
Processor use	17%	33%
Memory use	33%	67%
Disk use	33%	67%
Printer use	33%	67%
Elapsed time	30 min.	15 min.
Throughput rate	6 jobs/hr	12 jobs/hr
Mean response time	18 min.	10 min.

Time Sharing Systems (TSS)

- Batch multiprogramming does not support interaction with users
- TSS extends multiprogramming to handle multiple interactive jobs
- Processor’s time is shared among multiple users
- Multiple users simultaneously access the system through terminals

Time Sharing Systems (TSS)

- Because of slow human reaction time, a typical user needs 2 sec of processing time per minute
- Then (about) 30 users should be able to share the same system without noticeable delay in the computer reaction time
- The file system must be protected (multiple users…)

System Structure

- Because of it's enormous complexity, we view the OS system as a series of levels
- Each level performs a related subset of functions
- Each level relies on the next lower level to perform more primitive functions
- Well defined interfaces: one level can be modified without affecting other levels
- This decomposes a problem into a number of more manageable sub problems

Monolithic systems

- Monolithic/layered system
- All services provided by the OS
- OS functionality provided by the OS/kernel
- Unix, VMS, Linux
- Features
  - Easy to understand
  - Simplifies construction
  - Careful interface
  - Very rigid

Characteristics of Modern Operating Systems

- New design elements were introduced recently
- In response to new hardware development
  - multiprocessor machines
  - high-speed networks
  - faster processors and larger memory
- In response to new software needs
  - multimedia applications
  - Internet and Web access
  - Client/Server applications

Microkernel architecture

- Support a minimal set of essential functions in the kernel
  - primitive memory management (address space)
  - Interprocess communication (IPC)
  - basic scheduling
- Other OS services are provided by processes running in user mode (servers)
  - device drivers, file system, virtual memory…
- More flexibility, extensibility, portability…
- A performance penalty by replacing service calls with message exchanges between process...

Advantages of kernelized design

- Supports heterogeneity
- Supports flexibility
- Supports extensibility
- Challenge- performance/security