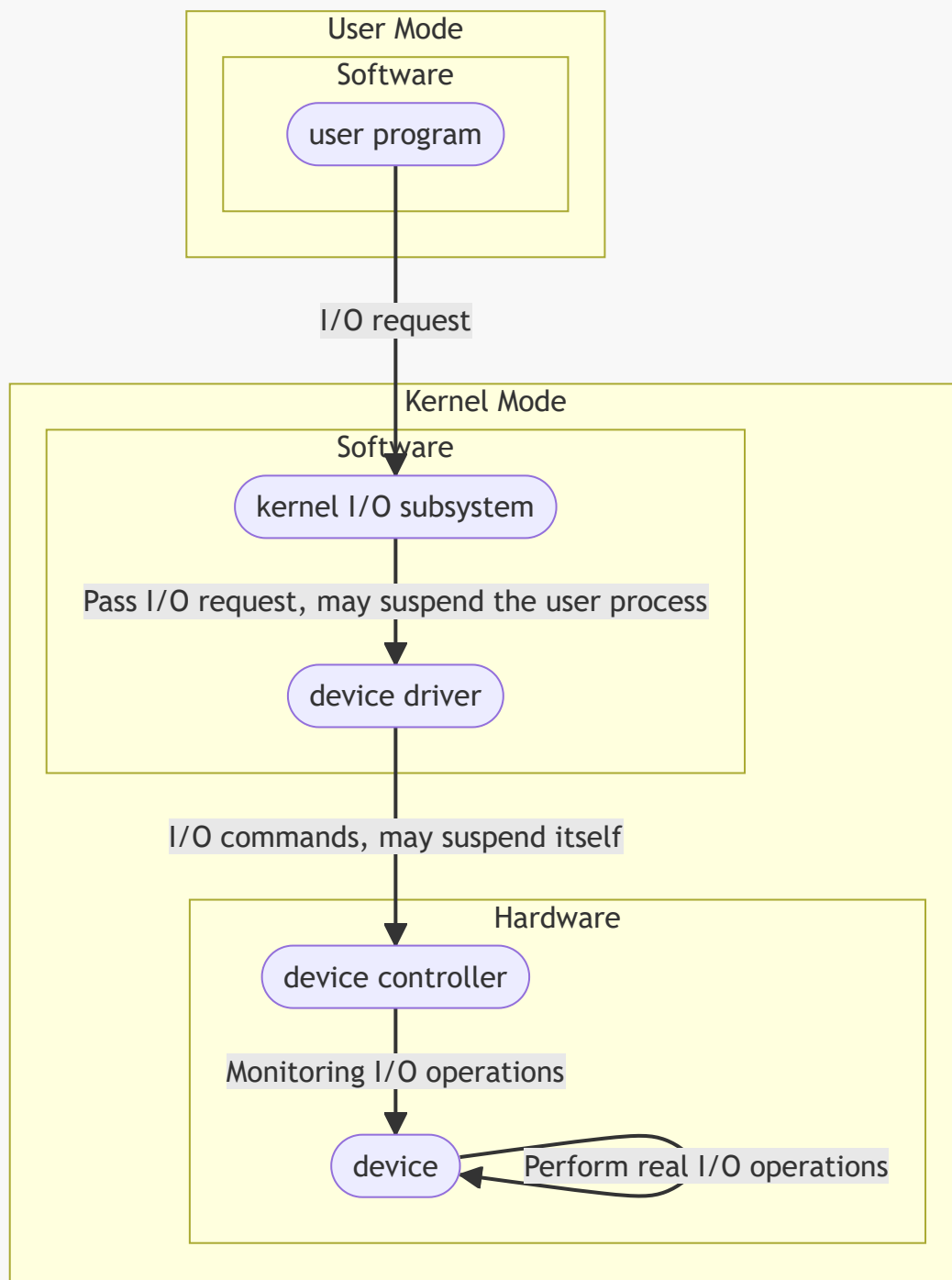


CH1 OS system types

CH2 I/O operations, Hardware resource protection



- I/O operations
 - Polling I/O
 - **byte**-transfer
 - Interrupted I/O

- sense interrupt-request line **before** Instruction Fetch
 - device controller raises an interrupt by asserting a signal on the interrupt-request line
- DMA(Direct Memory Access)
 - **block**-transfer
- Nonblocking and Asynchronous I/O
 - Blocking=Synchronous
 - process suspended until I/O complete
 - Synchronous
 - Nonblocking
 - I/O call returns as much as available
 - returns quickly with count of bytes read or written
 - Asynchronous
 - process runs while I/O executes
 - I/O subsystem signals process when I/O complete
- Hardware Resource Protection
 - infrastructure
 - Dual mode operation
 - user mode
 - kernel mode
 - Privileged Instruction
 - executed only in kernel mode
 - e.g. the instr. to switch to kernle mode, I/O instr., disable interrupts, clear memory, modify the base/limit registers, modify the value of timer for cpu
 - Hardware Resource Protection
 - I/O protection
 - purpose: 防止user process誤用I/O devices, 降低使用I/O devices複雜度
 - mechanism: all I/O instr. are set as "privileged instr.", so they can be executed only in kernel mode
 - Memory protection
 - purpose: 防止user process非法存取其他process or kernel memory area
 - mechanism: modify the base/limit registers must be privileged instrucion
 - CPU protection
 - purpose: we must ensure that the os maintains control over the CPU. We can't allow a user program to get stuck in an infinite loop or to fail to call system services and never return control to the os
 - mechanism: modify the value of timer for cpu must be privileged instrucion

CH3 System call, OS structures, Virtualization

- system call
 - parameters passing of system call
 - registers
 - memory
 - stack

- mechanism
 - how
 - use time to be cpu protection
- policy
 - what
 - determin MAX cpu time quantumn
- Monolithic kernel
 - Linux
 - UNIX
 - Solaris
 - Windows
- Microkernel
 - Mach
- Modules(loadable kernel modules(LKMs))
 - Linux
 - Solaris(先鋒)
 - UNIX
 - MacOS
 - Windows
- Hybrid system
 - Linux
 - Solaris
 - Windows
 - MacOS
 - iOS
 - Android
- Virtual Machine
 - Host
 - Vitual Machine Manager(VMM)
 - Guest
 - different types
 - type 2 use mode
 - type 1 OS(kernel mode)
 - type 0 HardWare
 - implementation of VMMS
 - Pure VM
 - Paravirtualization
 - Programming-environment virtualization

- Java Virtual Machine(JVM)
- Emulators
- Application containment
 - container
- Cloud Computing
 - Software as a Service(SaaS)
 - office365, salesforce, gmail, google drive, dropbox,...
 - Platform as a Service(PaaS)
 - 金流API, 物流API, 地圖API,...
 - Infrastructure as a Service(IaaS)
 - AWS, Azure,...

CH4 Process Management, Thread Management

Process

process state diagram

- New
- Ready
- Running
- Waiting
- Terminal

PCB

1.Process state 2.Program counter 3.CPU registers 4.CPU-scheduling information 5.Memory-management information 6.Accounting information 7.I/O status information (8.Process ID)

scheduler 之種類

- Long-Term scheduler
 - Batch system採用
 - Real-time system, Time-sharing system不採用
- Medium-Term scheduler
- Short-Term scheduler

scheduling criteria

- CPU utilization
- Throughput
- Turnaround time
- Waiting time
- Response time

CPU Scheduling Algorithm

- **FCFS**

- SJF
 - Non-preemptive SJF->**SJF**
 - Preemptive SJF->**SRJF**
- **RR**
- **priority**
 - aging
- **multilevel queues**
- **multilevel feedback queues**

Multiple-Processor scheduling

- ASMP(沒什麼好設計的)
- SMP
 - load balancing
 - push migration
 - pull migration
 - processor affinity
 - soft affinity
 - hard affinity

Real-Time system scheduling

若有Priority Inversion,用Priority Inheritance解決

- Hard real-time(preemptive kernel)
 - Rate-Monotonic scheduling
 - EDF scheduling
- Soft real-time(preemptive kernel)
 - 不提供aging

Threads

- private
 - program counter
 - CPU registers set
 - stack
 - local variables
 - thread ID
- shared
 - code section
 - data section(global data)
 - heap
 - static local variables
 - other OS resources(open files, signals, I/O resources,etc.)
- Benefits

- **responsiveness**
- **resource sharing**
- **economy**
- **scalability**(utilization of multiprocessors architecture)
- Thread management
 - user thread
 - provide a library entirely in user space with no kernel support
 - implement a kernel-level library supported directly by the OS
 - kernel thread
- multithreading models
 - Many-to-One model
 - One-to-One model
 - Many-to-Many model
- 2 strategies of creating multiple threads
 - Asynchronous threading(父,兒之thread concurrently execute)
 - Synchronous threading(父thread要等兒thread做完)
- Pthreads library
 - Pthreads is a specification
 - Run on UNIX
 - Can't run on windows os

CH5 Deadlock Management

- necessary conditions
 - **mutual excludation**
 - **hold and wait**
 - **no preemption**
 - **circular wait**
- resource-allocation graph
 - no cycle, no deadlock
 - 有cycle不一定有deadlock
 - if every resource only has exactly one instance, 有cycle就有deadlock
- methods for handling deadlocks
 - **deadlock prevent**
 - 破除mutual excludation條件(辦不到)
 - 破除hold and wait條件
 - 破除no preemption條件
 - 破除circular wait條件: resource ordering
 - **deadlock avoidance**

- banker's algorithm($O(n^2m)$,n: process,m: resource)
- if system consisting of **m** resources of the same type with **n** processes running in the system
 - $1 \leq MAX_i \leq m$
 - $\sum_{i=1}^n MAX_i < n + m$
- **deadlock detection and recovery**
 - detect it, and recover(允許系統進入deadlock)
 - detection algorithm($O(n^2m)$,n: process,m: resource)
- **ignore deadlock**
- Recovery from deadlock
 - process and thread termination
 - abort all deadlocked processes
 - abort one process at a time until the deadlock cycle is eliminated(盲目地砍一個)
 - resource preemption

CH6 Process Synchronization, IPC(InterProcess Communication)

- synchronization: process因某些事情之發生 or 不發生,而被迫停頓,要等其他process do something 之後,才可往下進行.
 - Producer-Consumer problem
 - Readers/Writers problem
 - First variation
 - Second variation
 - The Sleeping barber problem
 - The dinning philosophers problem
- 執行中程式可有兩種型態:
 - independent processes
 - 我的結果不會影響你,你的結果不會影響我
 - cooperation processes
 - 有某種程度的資訊交換
 - 允許process cooperation之理由
 - information sharing
 - computation speedup
 - modularity
- 2 fundamental models of IPC
 - **Shared Memory**
 - **Message Passing**

Shared Memory

- Race Condition problem

- several processes access and manipulate the same data concurrently and the outcome of the execution depends on the particular order in which the access takes place.
- resolve race condition problem 2 strategy

- **disable interrupt**

- **critical section design**

- 每個process內,access shared data之程式碼片段稱為critical section
- c.s.須滿足3性質
 - mutual exclusion
 - progress
 - bounded waiting
- critical section是要設計Entry section以及Exit section

```
while(true){
    Entry section;
    C.S.
    Exit section;
    R.S.
}
```

- 程式語言level
 - monitor
- OS SW tools(sys. call)level
 - mutex lock, semaphore
- 基礎
 - C.S. design
 - SW solution
 - peterson solution
 - HW support
 - memory barriers
 - test&set(&lock)
 - compare&set(&lock,0,1)
 - 非C.S. design
 - disable interrupt

- **peterson solution**

Pi	Pj
while(true){	while(true){
flag[i]=true; /*表明有意*/	flag[j]=true; /*表明有意*/
turn=j; /*禮讓對方*/	turn=i; /*禮讓對方*/
while(flag[j] && turn==j);	while(flag[i] && turn==i);
/*當對方有意且權杖在對方身上,則我等 */	/*當對方有意且權杖在對方身上,則我等 */
C.S.	C.S.

flag[i]=false; /*手放下*/	flag[j]=false; /*手放下*/
R.S.	R.S.
}	}

- **memory barriers**

```
Pi
while(true){
    turn=j; /*禮讓對方*/
    memory_barrier();
    flag[i]=true; /*表明有意*/
    C.S.
    flag[i]=false; /*手放下*/
    R.S.
}
```

- **test&set(&lock),compare&set(&lock,0,1)**

- 是CPU特殊指令

```
boolean test_and_set(boolean *target){
    boolean ret=*target;
    *target=false;
    return ret;
}
```

```
int CAS(int *value, int expected, int new_value){
    int temp=*value;
    if(*value==expected)
        *value=new_value;
    return temp;
}
```

- test&set,CAS用於critical section problem

```
while(true){
    waiting[i]=true;
    key=true;
    while(waiting[i] && key)
        key=test_and_set(&lock); or key=CAS(&lock,0,1); //決一死戰,誰先搶到,誰
    先win
    waiting[i]=false; //Pi不用等了,可進入C.S.
    C.S.
    j=(i+1)%n;
    while(j!=i && !waiting[j]) //找出下一個想進入C.S.之process j
}
```

```

    j=(j+1)%n;
    if(j==i)//此時無人想進入C.S.
        lock=false;//鑰匙掛高空,等人去搶
    else//Pj像進入C.S.
        waiting[j]=false;//Pj不用等了,可進入C.S.,此時lock為true
    R.S.
}

```

- **mutex lock**

```

while(true){
    acquire lock;
    C.S.
    release lock;
    R.S.
}

```

- a mutex lock透過boolean variable: available,用以指示the lock is available or not.
- 提供兩個atomic operations:
 - acquire()

```

acquire(){
    while(!available);//if lock被取走就卡
    available=false;//lock被Pi取走
}

```

- release()

```

release(){
    available=true;
}

```

- 利用cpu硬體指令完成mutex lock

```

typedef struct{
    int available;//0->lock is available,1->lock is unavailable
}lock;

lock mutex;
//使用CAS製作acquire
void acquire(lock *mutex){
    while(CAS(&mutex->available,0,1)!=0);
    return;
}

```

```

}
//使用test_and_set製作acquire
void acquire(lock *mutex){
    while(test_and_set(&mutex->available)!=0);
    return;
}
void release(lock *mutex){
    mutex->available=0;
    return;
}

```

- **semaphore**

- semaphore is a data type based on int
- semaphore只能透過兩個atomic operation來存取
 - wait() or P()

```

wait(s){
    while(s<=0);
    s--;
}

```

- signal() or V()

```

signal(s){
    s++;
}

```

- 用於C.S. design

```

semaphore mutex=1;
Pi
wait(mutex);
C.S.
signale(mutex);
R.S.

```

- **monitor**

- a monitor type is a ADT(Abstract Data Type),想像成class,包含三部分
 - 共享變數宣告
 - a set of programmer-defined operations
 - 初始區
- monitor本身已保證了互斥性質

- the monitor construct ensures that only **one** procss at a time is **active** within the monitor
 - 如此保證了monitor內的shared variables不會發生race condition problem
- 代表programmer無需煩惱race condition problem,只需專心解決synchronization
- condition變數
 - 為了讓programmer可以用monitor解決synchronization problem,需提供一種特殊形態變數,即condition type variables
 - 宣告格式:


```
condition x,y;
```
 - 此變數只有兩種operation提供呼叫:
 - x.wait()
 - 類似block() sys. call
 - x.signal()
 - 類似wakeup() sys. call
 - default is FIFO Queue

liveness (是一個好性質,但沒考過)

- system 必須滿足確保processes make progress during their execution life cycle

Message Passing IPC

- 無須共享相同的位址空間,在分散式系統中特別有用.
- 兩個processes要溝通,步驟如下:
 - 建立communication link
 - messages 相互傳輸
 - 傳輸完畢, release communication link
- OS提供至少兩種system calls
 - send(message)
 - receive(message)
- messages sent by a process can be either **fixed** or **variable** in size.
- message passing
 - direct communication
 - symmetric
 - 收送雙方皆須相互指名對方process ID才能建立通訊鏈結
 - send(Q, message)
 - receive(P, message)
 - asymmetric(跟e-mail很像)

- 只有sender需指名recipient的process ID
 - send(Q, message)
 - receive(id, message)
 - indirect communication
 - 收送雙方是透過共享的mailbox來溝通, each mailbox有自己獨一無二的ID
 - send(mailbox, message)
 - receive(mailbox, message)
- synchronization
 - message passing 可以是blocking(synchronous) or nonblocking(asynchronous)
 - Blocking send
 - Nonblocking send
 - Blocking receive
 - Nonblocking receive
 - 如果收送雙方皆是採用Blocking_send()即blocking_receive(),則此同步模式叫:rendezvous
- Buffering(message queue's size)
 - zero capacity
 - also called rendezvous
 - bounded capacity
 - unbounded capacity
 - the sender doesn't have to be blocked

CH7 Main Memory

Binding Time

- compile time
- loading time
- execution time

Memory Management methods in OS

- **Contiguous Memory Allocation**
 - external fragmentation
 - First Fit
 - Best Fit
 - Worst Fit
- **Page**
 - internal fragmentation
 - page table
 - hierarchical paging
 - hashed page table
 - inverted page table
- **Segment**
 - external fragmentation

- Base and Limit
- Paged Segment

CH8 Virtual Memory

- 實現Virtual Memory 技術: Demand Paging -pure demand paging -prepaging

Page Replacement Algorithm(沒有最差，只有最佳)

- **FIFO**(belady's anomaly)
- **OPT**(stack property)
- **LRU**(stack property)
- LRU-approximation(stack property)
 - **Additional reference bits usage**
 - **Second chance**
 - **Enhanced second chance**
- **LFU**(belady's anomaly)
- **MFU**(belady's anomaly)
- **Thrashing**
 - CPU utilization down
 - Paging I/O devices 異常忙碌
 - processes spends more time on paging I/O than normal execution
 - technique to handle Thrashing
 - **decrease multiprogramming degree**(已經thrashing)
 - **page fault frequency control**
 - **working set model**
- Allocation Kernel Memory
 - Buddy system
 - Slab allocation(has no internal,external fragmentation)

CH9 Massive Storage System

Hard Disk

- cylinder
- tracks
- sectors(磁碟控制器控制read,write之基本單位)
- Disk Access Time
 - Seek Time

- Rotational latency
- Transfer Time

Free-Space Management

- Bit vector
- Linked List
 - Grouping
 - Counting

File Allocation Methods

- Contiguous Allocation
- Linked Allocation
 - 變形: FAT
- Indexed Allocation
 - Linked scheme
 - Multilevel index
 - Combined scheme(UNIX i-Node structure)

HDD scheduling(沒有最好與最差之法則)

- **FCFS**
- **SSTF**
- **SCAN**
 - elevator
- **C-SCAN**
- **LOOK**
 - elevator
- **C-LOOK**

RAID

- improvement of reliability via redundancy
 - mirror
 - parity check
- improvement in performance via parallelism
 - data striping
 - bits-level
 - block-level
- RAID0(N部)
 - block-level striping
- RAID1(mirror)(N/2部)

- RAID2(ECC-Error-Correcting Code)
 - 沒有實際產品
- RAID3(ECC-Error-Correcting Code)(N+1部)
 - bit-level striping
 - parity check
- RAID4(ECC-Error-Correcting Code)(N+1部)
 - block-level striping
 - parity check
- RAID5(ECC-Error-Correcting Code)(N+1部)
- RAID6(ECC-Error-Correcting Code)(N+2部)
- RAID1+RAID0(更好)
- RAID0+RAID1

File Directory Structure

- Tree-structured Directory
- Acyclic Graph Directory
- General Graph Directory(允許有cycle)

File Access Control

- Owner, Group, Other
- RWX(Read, Write, eXecute)
- command: `chmod 755 file`

Consistency Semantic

- UNIX semantic
 - 訂票系統
- Session semantic
 - 網站上的檔案提供下載讓user填寫
- Immutable-Shared-Files semantic
 - 總經理公告文件第3009號

NAS(Network-Attached Storage)

- File-based operation
- 會占用網路頻寬

SAN(Storage-Area Network)

- Block-based operation
- private network
- 不佔用一般網路頻寬

