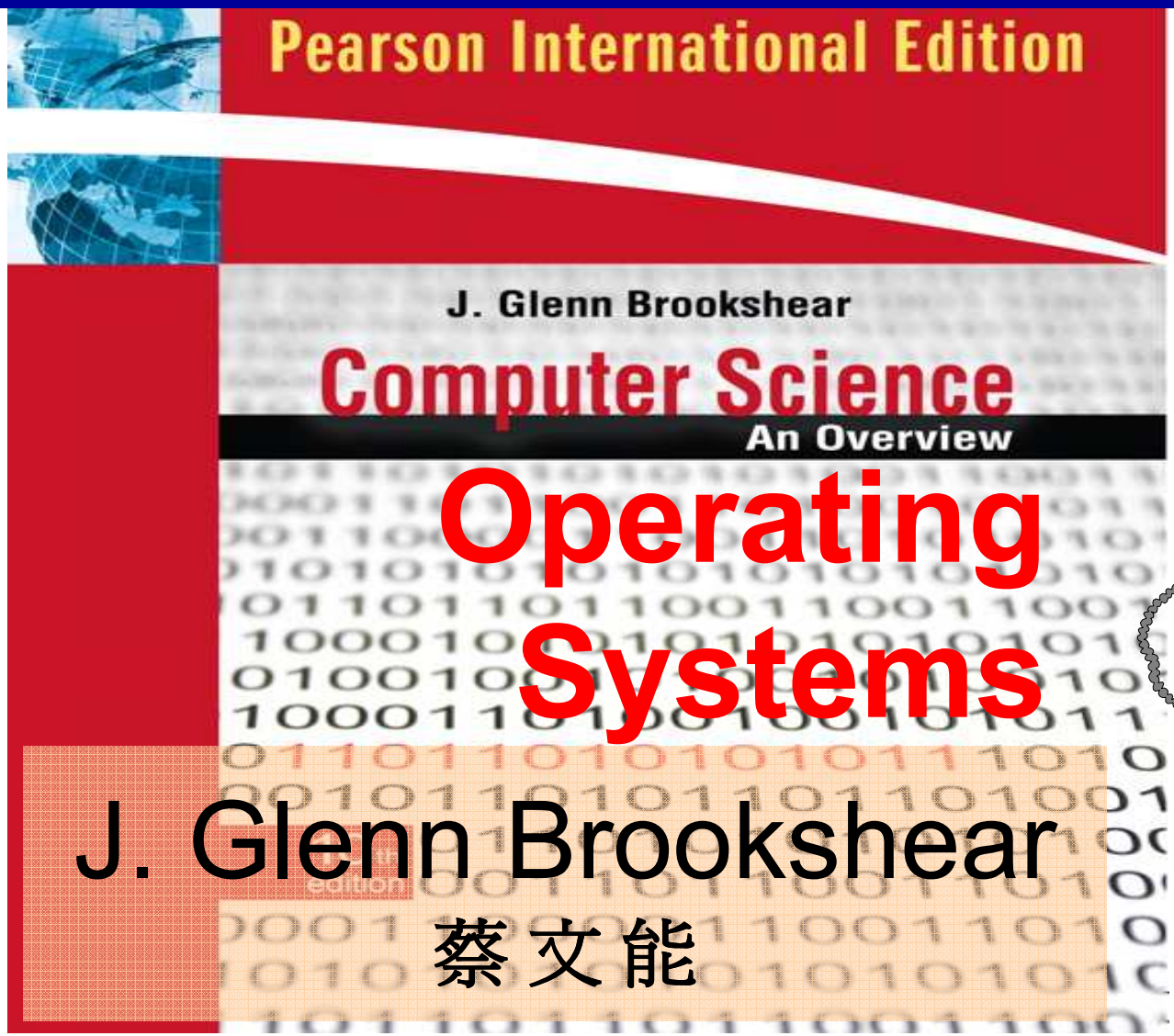
Chapter 3



Operating Systems

J. Glenn Brookshear
蔡文能

Agenda

- **Review of the Computer Architecture**
  - **The central processing unit.**
  - **Instructions & The stored-program concept.**
  - **Program execution.**
- **The Computer Software**
  - **Application** Software
  - **System** Software
    - The Operating Systems : Kernel + Shell(s)
    - Utility Software
- The booting process (開機過程)
- Competition among Processes
  - **Critical** Sections and **Dead Lock**

傷腦筋的 頭字語 (Acronym)

- **ENIAC -- 1946/02/14**
  - Electronic Numerical Integrator And Computer (Calculator ?)

http://en.wikipedia.org/wiki/ENIAC

- **IBM**
  - I Believe Money
  - International Big Mouth (OOP 的 櫻櫻美代子)
  - International Business Machine
- **IDF**
  - I Don't Fly
  - I Don't Fight
  - I Do Fly , I Do Fight
- **CS**
  - Computer Science
  - Counter Strike ☺
- **OOP**
  - Object Oriented Programming
  - Office Of President

http://www.oop.gov.tw

- ICQ (I Seek You)

TLA : Three Letter Acronym

Measuring Memory Capacity

Km = 千米=公里

- **Kilobyte:** 2^{10} bytes = 1024 bytes
  - Example: 3 KB = 3 times1024 bytes
  - Sometimes “kibi” rather than “kilo”
- **Megabyte:** 2^{20} bytes = 1,048,576 bytes
  - Example: 3 MB = 3 x 1,048,576 bytes
  - Sometimes “megi” rather than “mega”
- **Gigabyte:** 2^{30} bytes = 1,073,741,824 bytes = **10^9 bytes**
  - Example: 3 GB = 3 x 1,073,741,824 bytes
  - Sometimes “gigi” rather than “giga”

硬碟容量 1.5TB ?

通訊頻寬 20Gbps ?

- Tera = 1024 Giga = **10^{12}**
- Peta = 1024 Tera = **10^{15}**
- Exa = 1024 Peta = **10^{18}**

- Zeta = 1024 Exa = 10^{21}
- Yotta = 1024 Zeta = 10^{24}

http://en.wikipedia.org/wiki/Exa-

μs = micro second

760 *mm* Hg (Atmospheric pressure)

- ***d*** = **deci** = 10^{-1}
- ***c*** = **centi** = 10^{-2}
- ***m*** = **milli** = 10^{-3}
- ***μ*** = **micro** = 10^{-6}
- ***n*** = **nano** = 10^{-9}
- ***p*** = **pico** = 10^{-12}

- *f* = femto = 10^{-15}
- *a* = atto = 10^{-18}
- *z* = zepto = 10^{-21}
- *y* = yocto = 10^{-24}

cm = 公分=厘米

nano second 奈秒 = 10^{-9} 秒

mm = 毫米

pico second 披秒 = 10^{-12} 秒

nm = 奈米

http://en.wikipedia.org/wiki/Exa-

The Frequencies of Various Wireless Media

Ultraviolet : 0.75P ~30PHz ; 10nm ~ 400nm
Infrared light : 1T~430THz; 0.7~300micrometers

Frequency (H_z)

10^{16}
10^{15}
10^{14}
10^{13}
10^{12}
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
10^{2}
10^{1}

X rays, gamma rays
Ultraviolet light
Visible light
Infrared light

紫外線

紅外線

Millimeter waves

Microwaves
UHF television
VHF television
VHF TV (high band)
FM radio
VHF TV (low band)
Short-wave radio
AM radio

毫米波

Very Low Frequency

微波

極超高頻 SHF Super High Frequency, 頻率範圍 3GHz~30GHz.

超高頻 UHF Ultra High Frequency, 頻率範圍 300MHz~3000MHz.

極高頻 VHF Very High Frequency, 頻率範圍 30MHz~300MHz.

高頻HF High Frequency, 頻率範圍 3MHz~30MHz.

Electromagnetic Spectrum

waveLength * frequency = Light Speed = 299,792,458 m/second ($3*10^8$米/秒)

Y= γ =Gamma rays
HX = Hard X-Rays
SX = Soft X-Rays
EUV = Extreme UltraViolet
NUV = Near UltraViolet
NIR = Near Infrared
MIR = Mid Infrared
FIR = Far Infrared
EHF= Extremely High Freq.
SHF= Super High Freq.
UHF= Ultra High Freq.
VHF= Very High Freq
High / Medium / Low Freq.
VLF= Very Low Frequency
VF/ULF= Voice Frequency
SLF= Super Low Frequency
ELF= Extremely low freq.

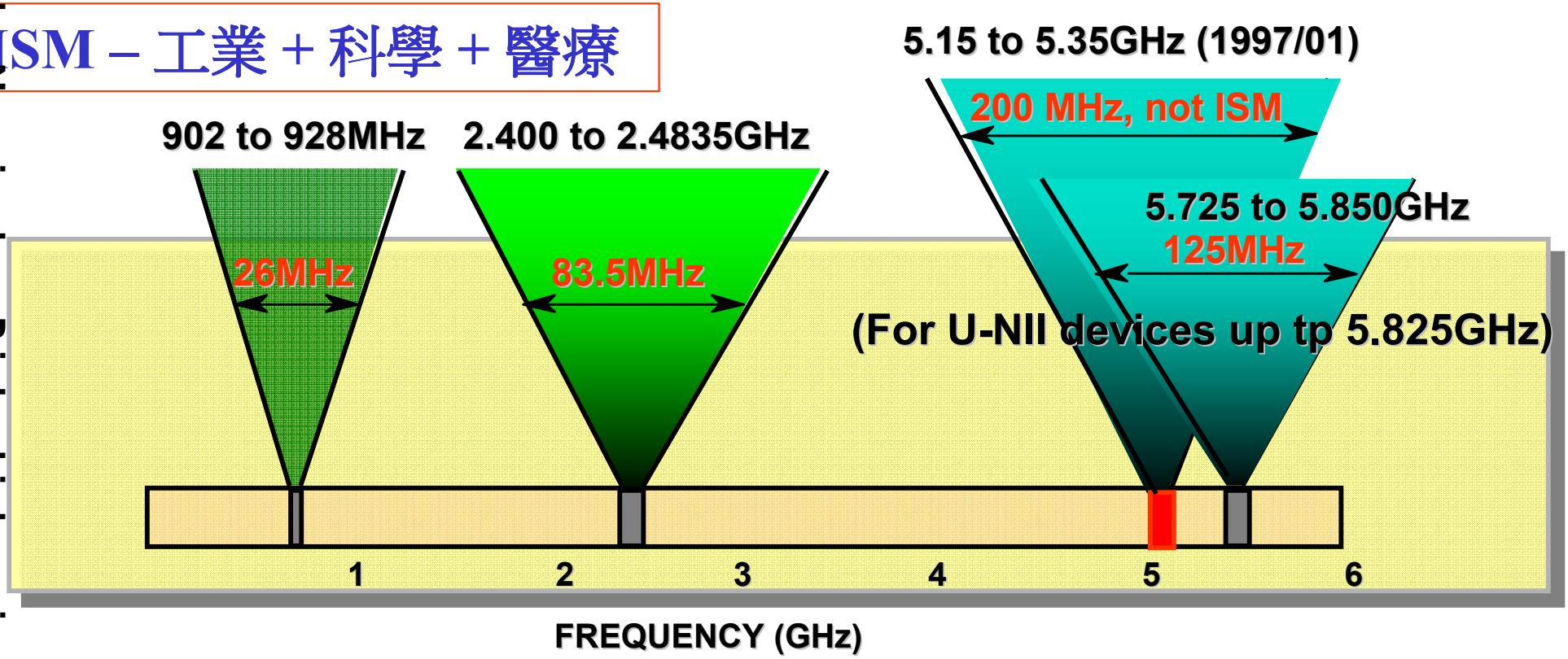
CLASS	FREQUENCY	WAVELENGTH	ENERGY
Y	300 EHz	1 pm	1.24 MeV
HX	30 EHz	10 pm	124 keV
	3 EHz	100 pm	12.4 keV
SX	300 PHz	1 nm	1.24 keV
	30 PHz	10 nm	124 eV
EUV	3 PHz	100 nm	12.4 eV
NUV	300 THz	1 μm	1.24 eV
NIR	30 THz	10 μm	124 meV
MIR	3 THz	100 μm	12.4 meV
FIR	300 GHz	1 mm	1.24 meV
EHF	30 GHz	1 cm	124 μeV
SHF	3 GHz	1 dm	12.4 μeV
UHF	300 MHz	1 m	1.24 μeV
VHF	30 MHz	10 m	124 neV
HF	3 MHz	100 m	12.4 neV
MF	300 kHz	1 km	1.24 neV
LF	30 kHz	10 km	124 peV
VLF	3 kHz	100 km	12.4 peV
VF/ULF	300 Hz	1 Mm	1.24 peV
SLF	30 Hz	10 Mm	124 feV
ELF	3 Hz	100 Mm	12.4 feV

Source: http://en.wikipedia.org

Industrial, Scientific and Medical (ISM) Bands

http://www.fcc.gov/Bureaus/Engineering_Technology/Orders/1997/fcc97005.pdf

ISM – 工業 + 科學 + 醫療



- UNLICENSED OPERATION GOVERNED BY FCC DOCUMENT 15.247, PART 15
- SPREAD SPECTRUM ALLOWED TO MINIMIZE INTERFERENCE
- 2.4GHz ISM BAND
  - More Bandwidth to Support Higher Data Rates and Number of Channels
  - Available Worldwide
  - Good Balance of Equipment Performance and Cost Compared with 5.725GHz Band
  - IEEE 802.11 Global WLAN Standard

UNII : Unlicensed National Information Infrastructure

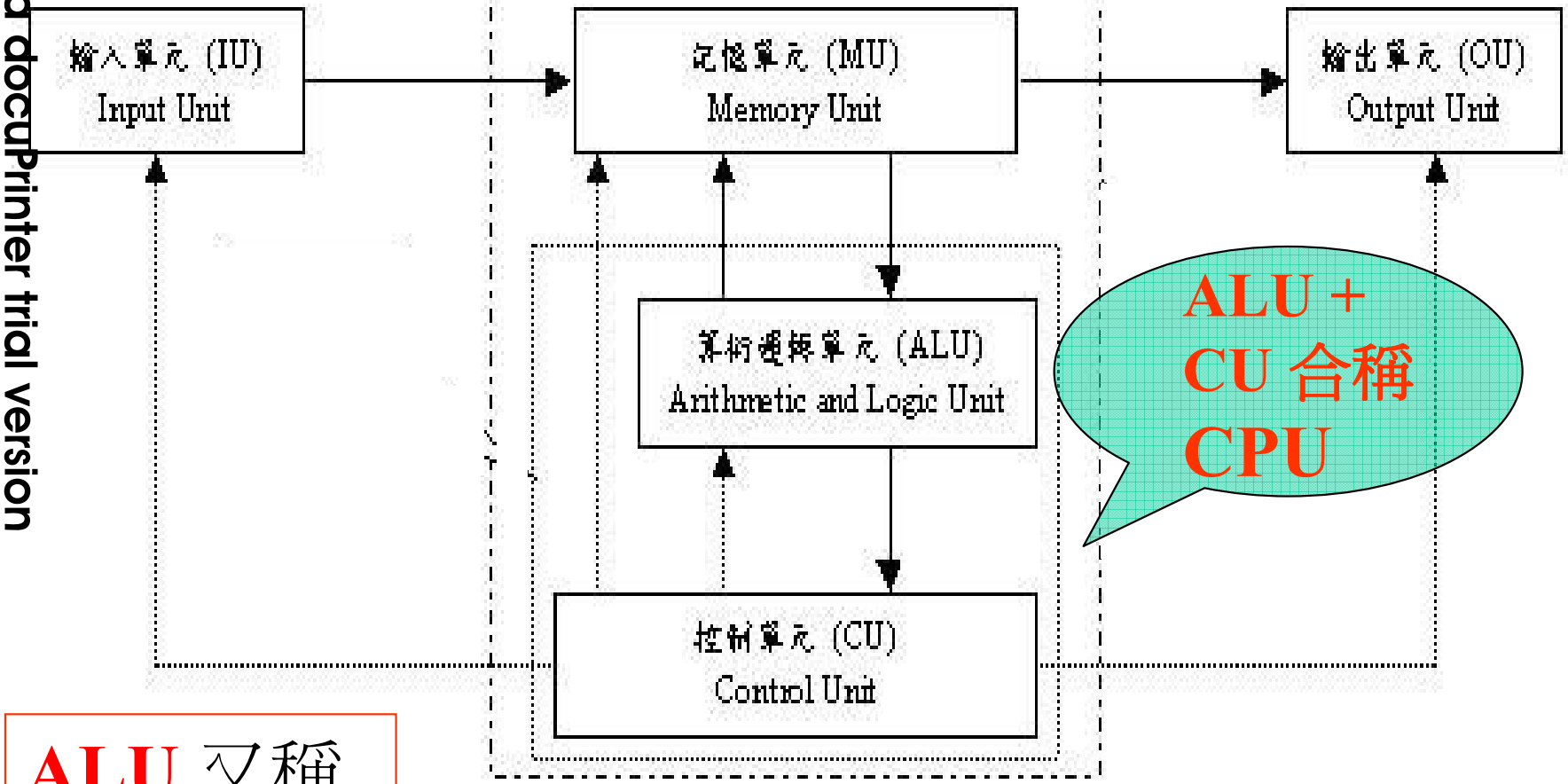
電腦硬體五大單元

計算 2+3=?

人會如何做?

電腦如何做?

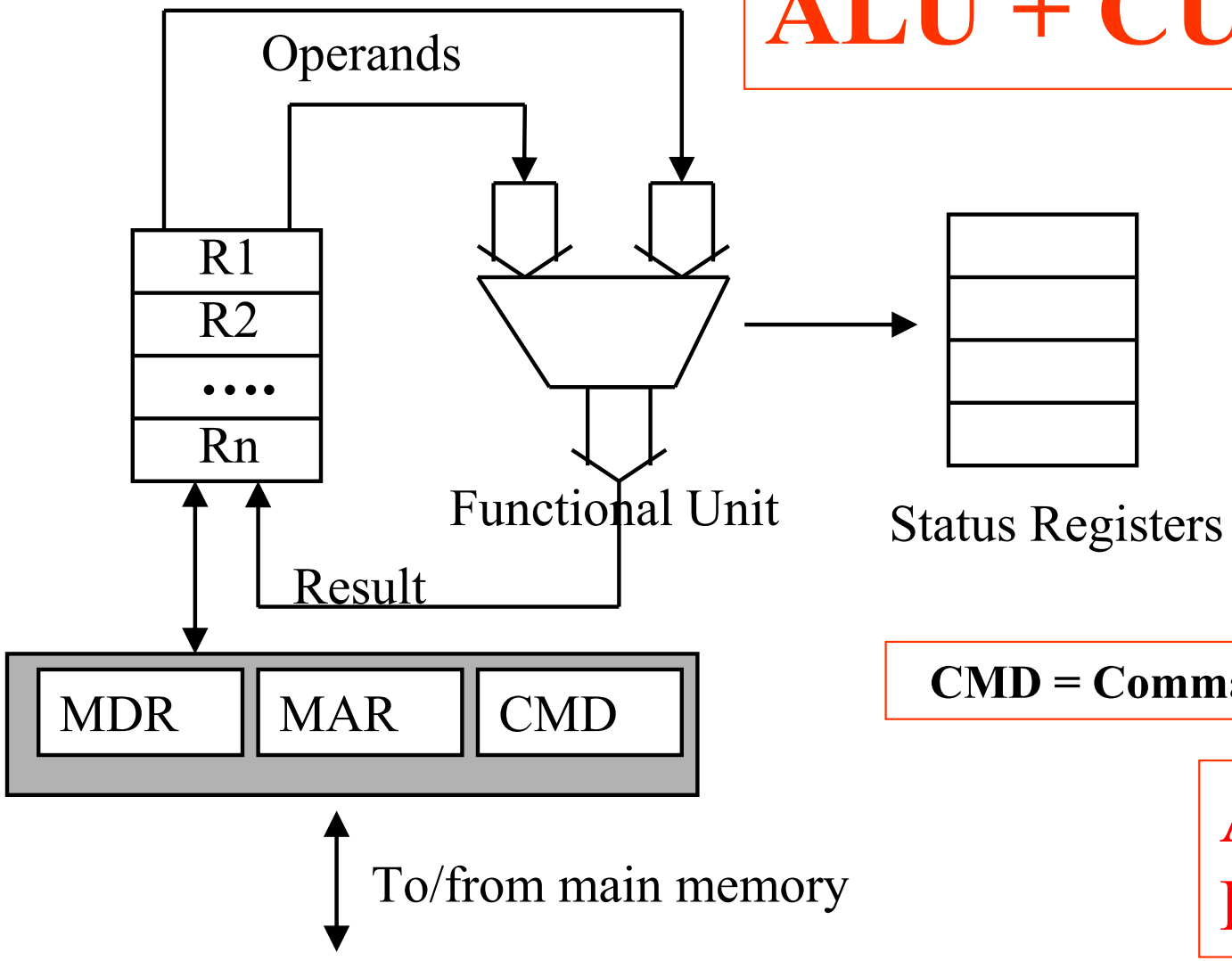
單晶片微電腦 = CPU + Memory



ALU 又稱 Data Path

The ALU = Arithmetic & Logic Unit

ALU + CU = CPU



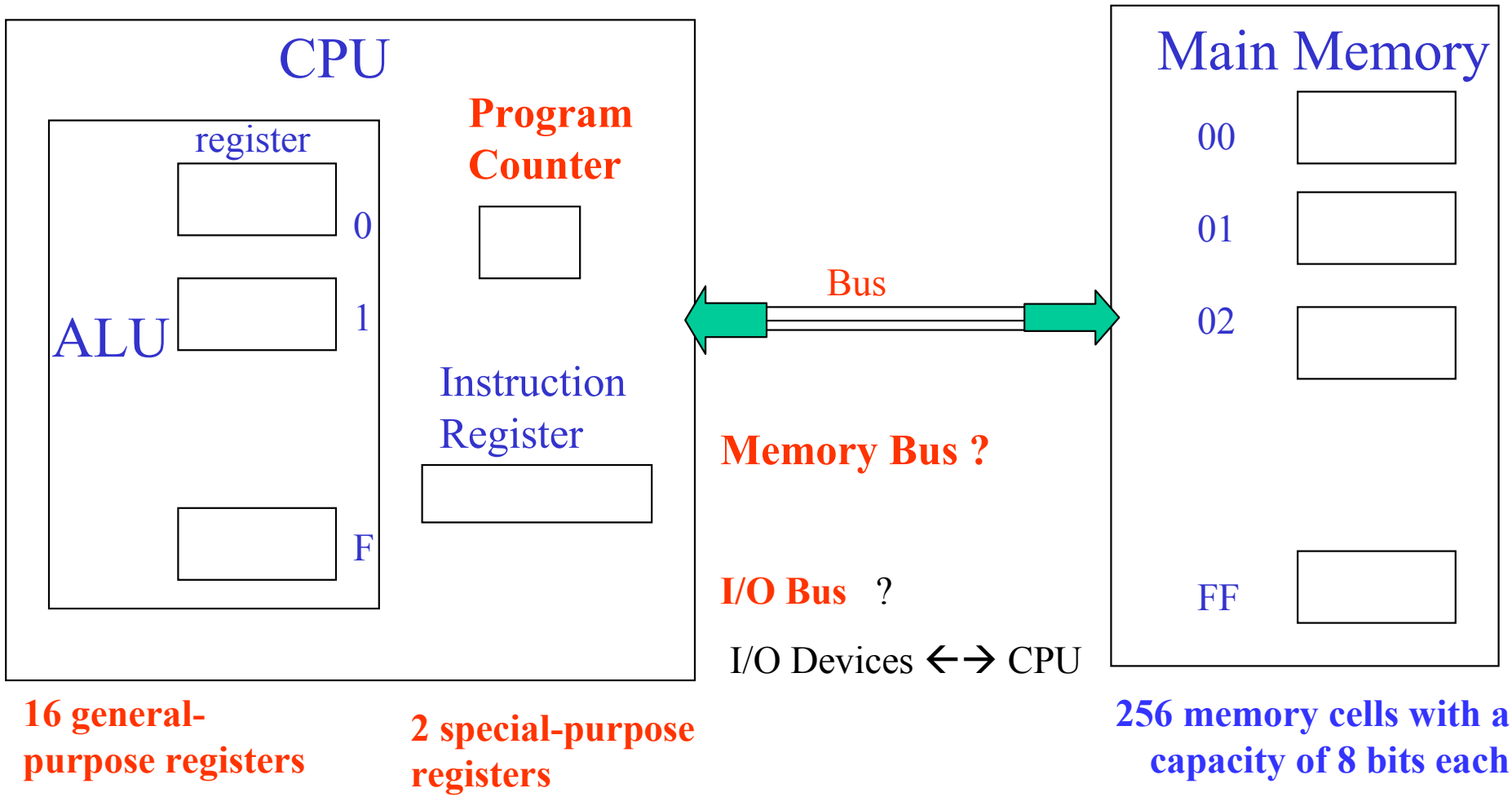
CMD = Command OP code

ALU 又稱
Data Path

MDR = Memory Data Register

MAR = Memory Address Register

The architecture of a sample machine



Program Counter (**Instruction Pointer**) address of next instruction to be executed

Instruction Register hold instruction being executed

Stack Pointer (這假想電腦沒有; 現代CPU都有) **point to top of the STACK in memory**

Machine Instrugctions 1/3

Data transfer Movement of data from one location to another

LOAD	fill a register with contents of a memory cell
LOADI	fill a register with constant in the instruction Immediately
STORE	transfer contents of a register to a memory cell
Move	transfer cpntents of a register to another register

Arithmetic/Logic

Arithmetic operations ADD, FADD

Logic operations OR, AND, XOR

ROTATE

FLAGs: …condition code..
Negative Zero V Carry
Sign Zero Overflow C

Control direct execution of program

JUMP direct control unit to execute an instruction other than the next one

Unconditional	Skip to step 5
Conditional	If resulting value is 0, then skip to step 5

電腦有左邊這些指令就夠用了

Machine Instructions 2/3

Example for a conditional JUMP Division

1- LOAD a register R1 with a value from memory
2- LOAD register R2 with another value from memory
3- If contents of R2 is zero, JUMP to step 6

4- Divide contents of R1 by contents of R2, result stored in R3
5- STORE the content of R3 into memory
6- STOP

Example: Avoid from dividing by zero using conditional JUMP

Machine Instructions 3/3

The Instructions of a sample machine

Op-Code	Operand	Assembly Language
1	RXY	LOAD R, XY ; Load the Register R with data in memory XY
2	RXY	LOADI R, XY ; Load the constant XY into Register R
3	RXY	STORE R, XY ; Store the data in Register R into memory XY
4	0RS	MOVE R, S ; copy R to S
5	RST	ADD R, S, T ; R = S + T
6	RST	FADD R, S, T ; floating Add
7	RST	OR R, S, T ; R = S or T
8	RST	AND R, S, T ; R = S and T
9	RST	XOR R, S, T ; R = S xor T
A	R0X	ROTR R, X ; Rotate the Register R to the Right X times
B	RXY	JUMP R, XY ; goto XY if [Register R] == [R0]
C	000	HALT

How to do a **Subtraction**?

Computer-Peripheral Communication protocols

電腦週邊設備

Parallel communications.
- Centronics
- Internal bus: rates measured in Mbps

Bit per second

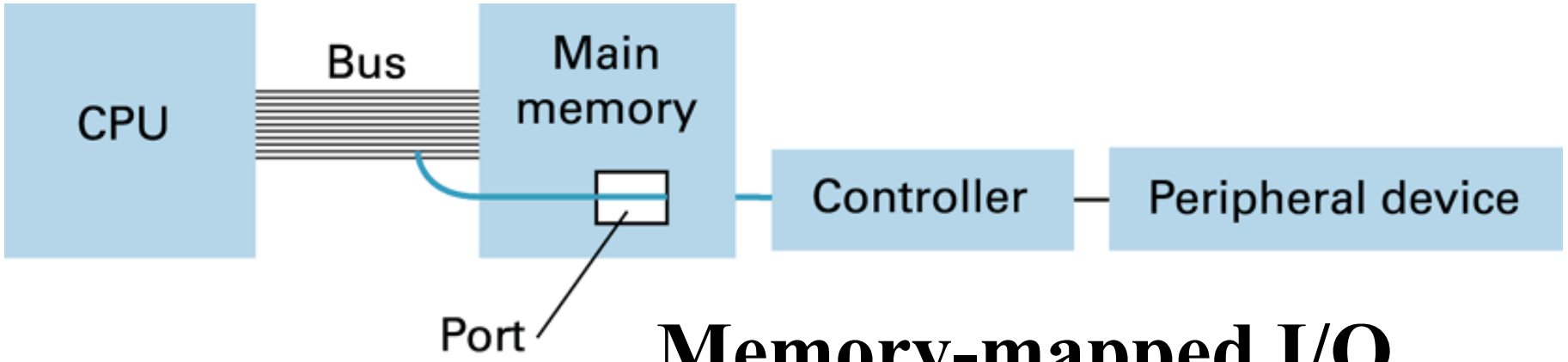
Serial communication
- RS232 - 300 bps ~ 115 Kbps
- RS422/485 , IEEE488
- USB (Universal Serial Bus)
  - USB1.1 - 2Mbsp ~ 12Mbps
  - USB2.0 - 480Mbps
- IEEE 1394 (FireWire™) (400mbps)
- Telephone line: Kbps; Mbps (xDSL)
- Coaxial cable (第四台用的即是其一) – 10Base2, 10Base5
- Twisted Pair (use RJ45接頭Plugs) – 100BaseT, 1000BaseT, 10000BaseT
  - Cat 3 (10Mbps), Cat 5 (100Mpbs), Cat 6 (1Gbps), Cat 7 (10Gbps)
- Optic fiber: near Gbps

2S 1P ?

2S 1P 4USB ?

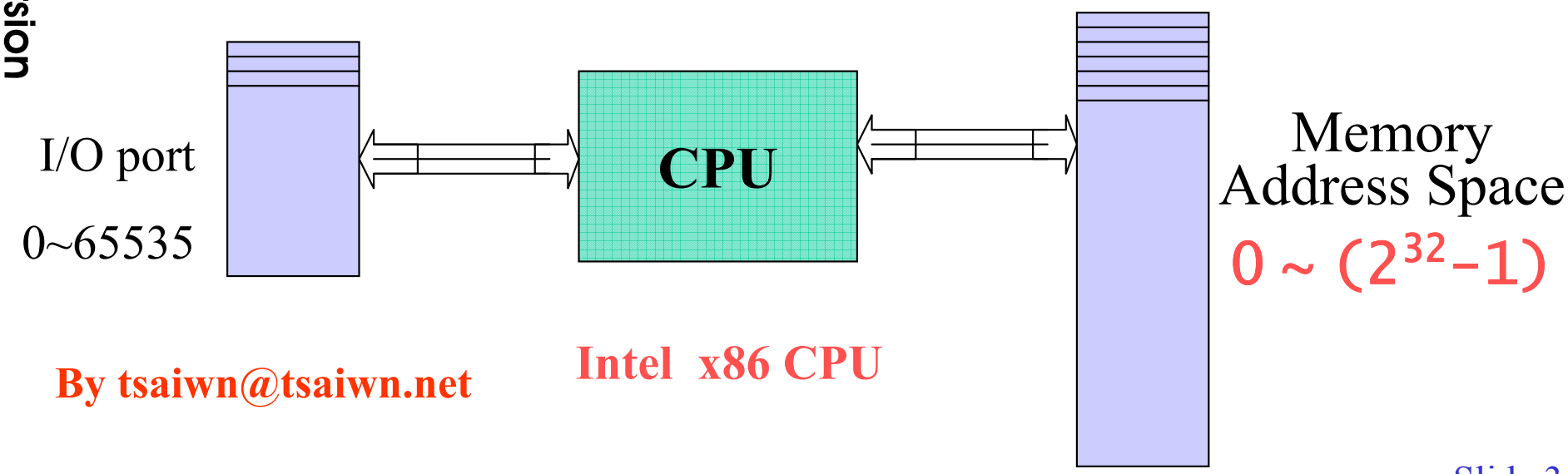
tsaiwn@tsaiwn.net

Figure 2.14: A conceptual representation of memory-mapped I/O



Memory-mapped I/O

Some CPU has no I/O Ports



By tsaiwn@tsaiwn.net

Intel x86 CPU

計算機架構 (Architecture)

- CISC Complex Instruction Set Computer
  - 例如： Intel x86, DEC VAX
- RISC Reduced Instruction Set Computer
  - 例如： IBM RISC6000, SUN SPARK, SGI MIPS
- Parallel Processing
  - Pipeline -- 提高 throughput
  - Multiprocessor machine多處理單元
    - SISD, MIMD, SIMD (page 107, text book)

Computer **Architecture** : **What** ?

Computer Organization : How ?

Stored-Program Concept

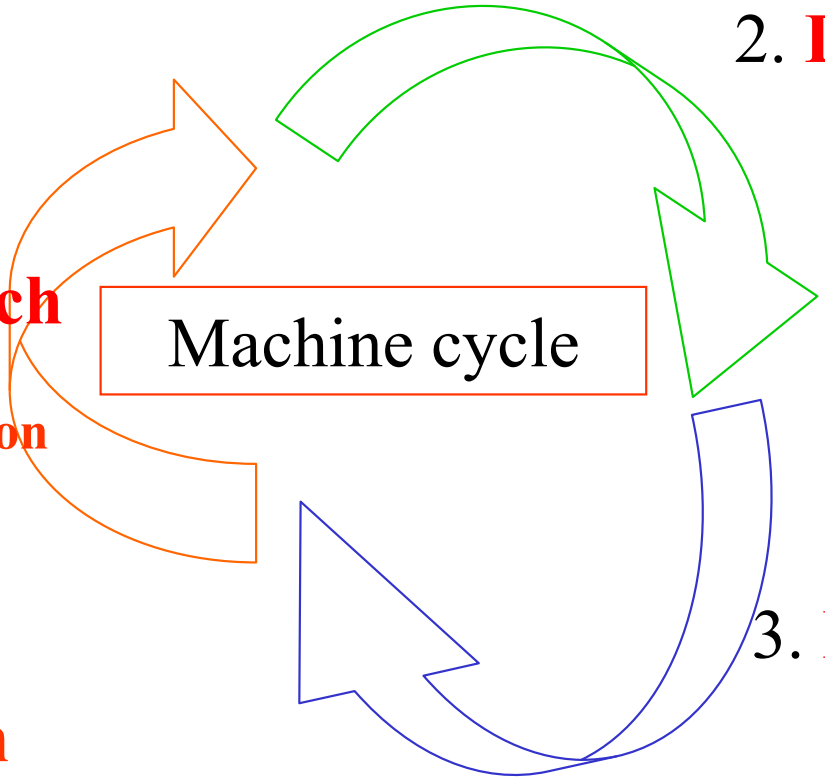
- In early computing, the program is built into the control unit as a part of the machine. The user rewires the control unit to adapt different programs.
- Program (instructions) stored in memory instead of being built into the control unit as part of the machine
- A computer's program can be changed merely by changing the contents of the computer's memory instead of rewiring the control unit
- A machine recognizes a bit pattern as representing a specific instruction
- Instruction consists of two parts

Op-code (operation code)	operand(s) field(s)

- STORE operands would be
  - ✓Register containing data to be stored
  - ✓Address of memory cell to receive data

Program Execution(The machine cycle)

JUMP Instruction **B258**$_{16}$



1.**Fetch**

Retrieve next instruction from memory (as per program counter) and then

increment program counter

2. **Decode**

Decode bit pattern in instruction register

3. **Execute**

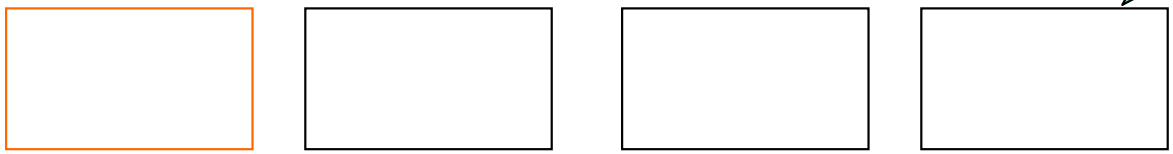
Perform action requested by instruction in the instruction register

The composition of an instruction

Instruction Format

半個 Byte
稱爲
1個 Nibble

Instruction consists of 4 hex digits (2 bytes)



Op-code **Operand Fields**

1347_{16} LOAD register 3 with contents of the memory cell at address 47_{16}

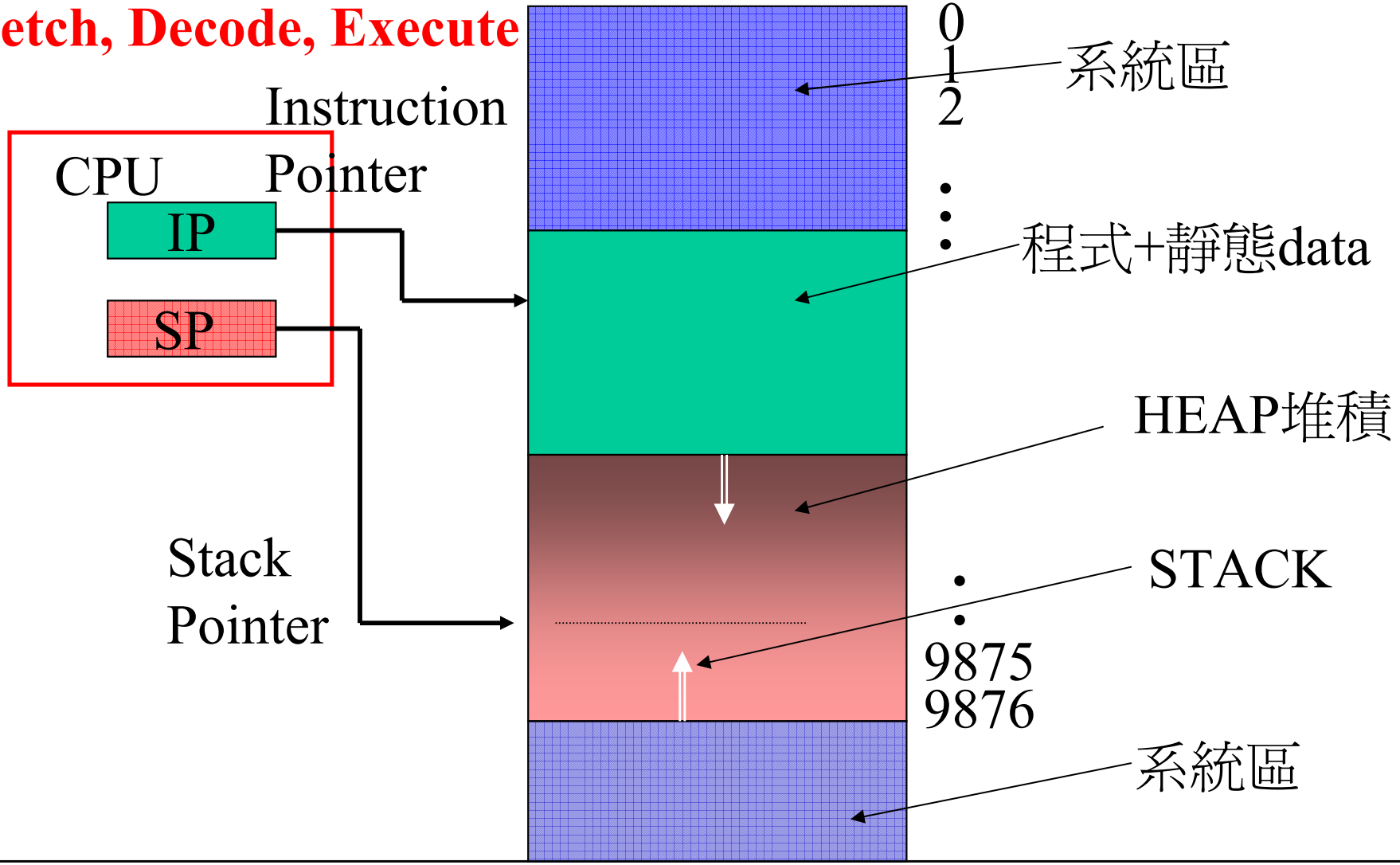
Textual representation might be “LOAD R3,47”

$B258_{16}$

JUMP to instruction at address 58_{16} if **contents of register 2 is the same as register 0**

電腦如何運作? How it works?

- Auto 變數就是沒寫 static 的 Local 變數



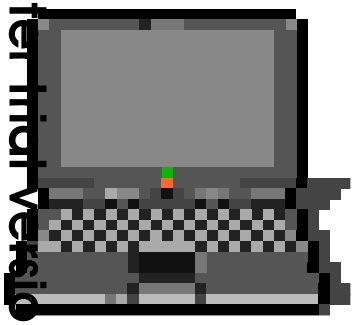
Auto 變數佔用STACK區memory

Software(軟體) --電腦的靈魂

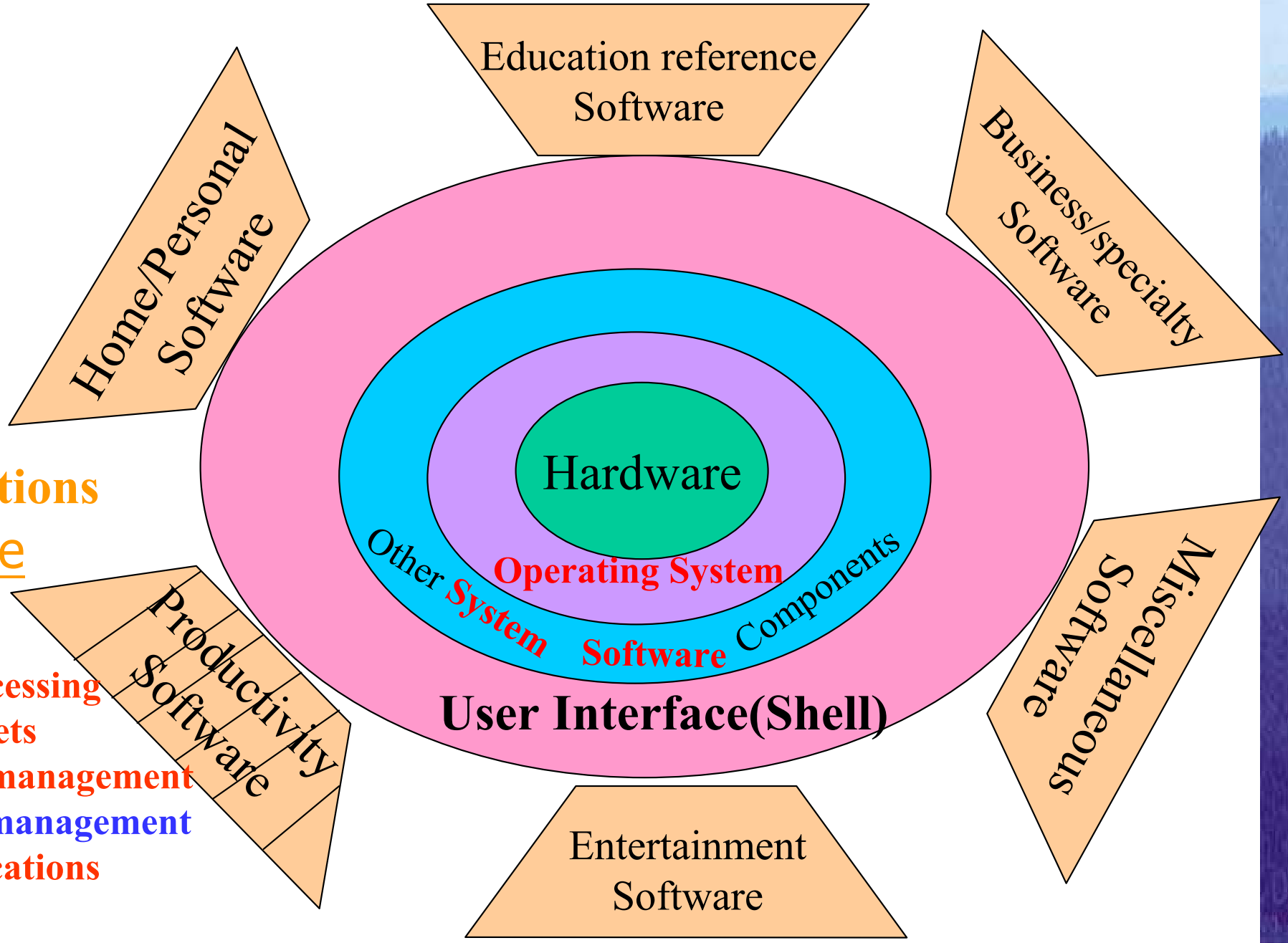
- **Operating Systems (OS)**
  - Kernel (核心, 直接控制硬體的一些程式)
    - OS components
  - Shell (又稱 Command Interpreter 命令解譯器)
- Programming languages
  - **Algorithms** + Data Structures = **Programs**
  - **Compiler vs. Interpreter**
- Software engineering Tools
- **D**ata **B**ase **M**anagement **S**ystem (**DBMS**)

Web Applications

Computer Applications



硬體軟體蔥皮圖



Applications Software

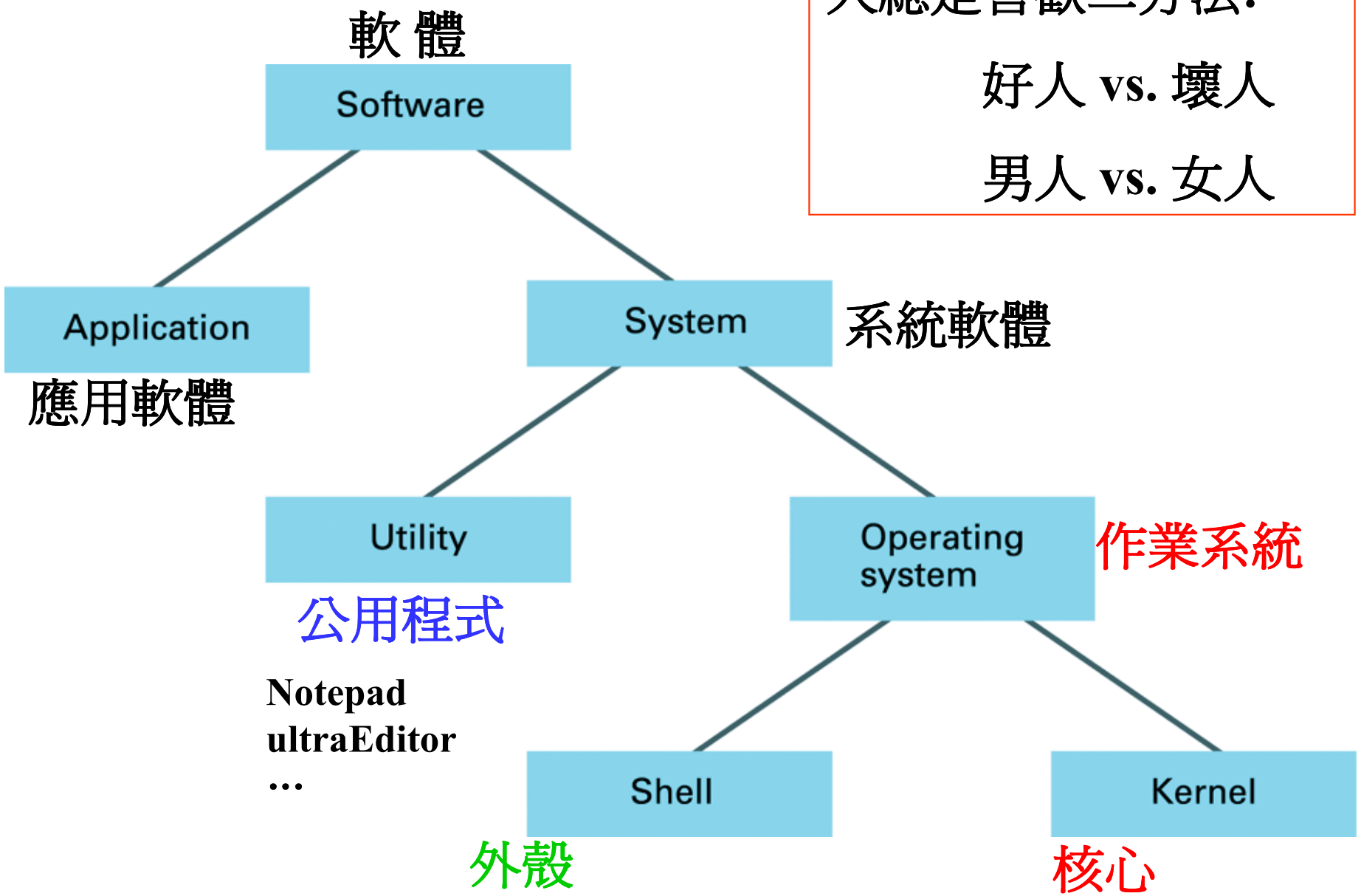
Word Processing
Spreadsheets
Financial management
Database management
Communications
Suites
Browsers

Figure 3.3: Software classification

人總是喜歡二分法:

好人 vs. 壞人

男人 vs. 女人



Types of software

- Applications software (應用軟體)
  - Performs tasks specific to the machine's utilization.
  - Generally transportable (即容易換到別的系統)
- System Software (系統軟體)
  - Performs tasks common to computer systems in general
  - Startup Software (Bootstrap Loader)
    - ✓**POST**- Power On Self Test
    - ✓**BIOS**- Basic Input/Output System (Subroutines)
  - Operating Systems vary based on the hardware they're used on
  - Utility Software – 公用程式 / 工具軟體

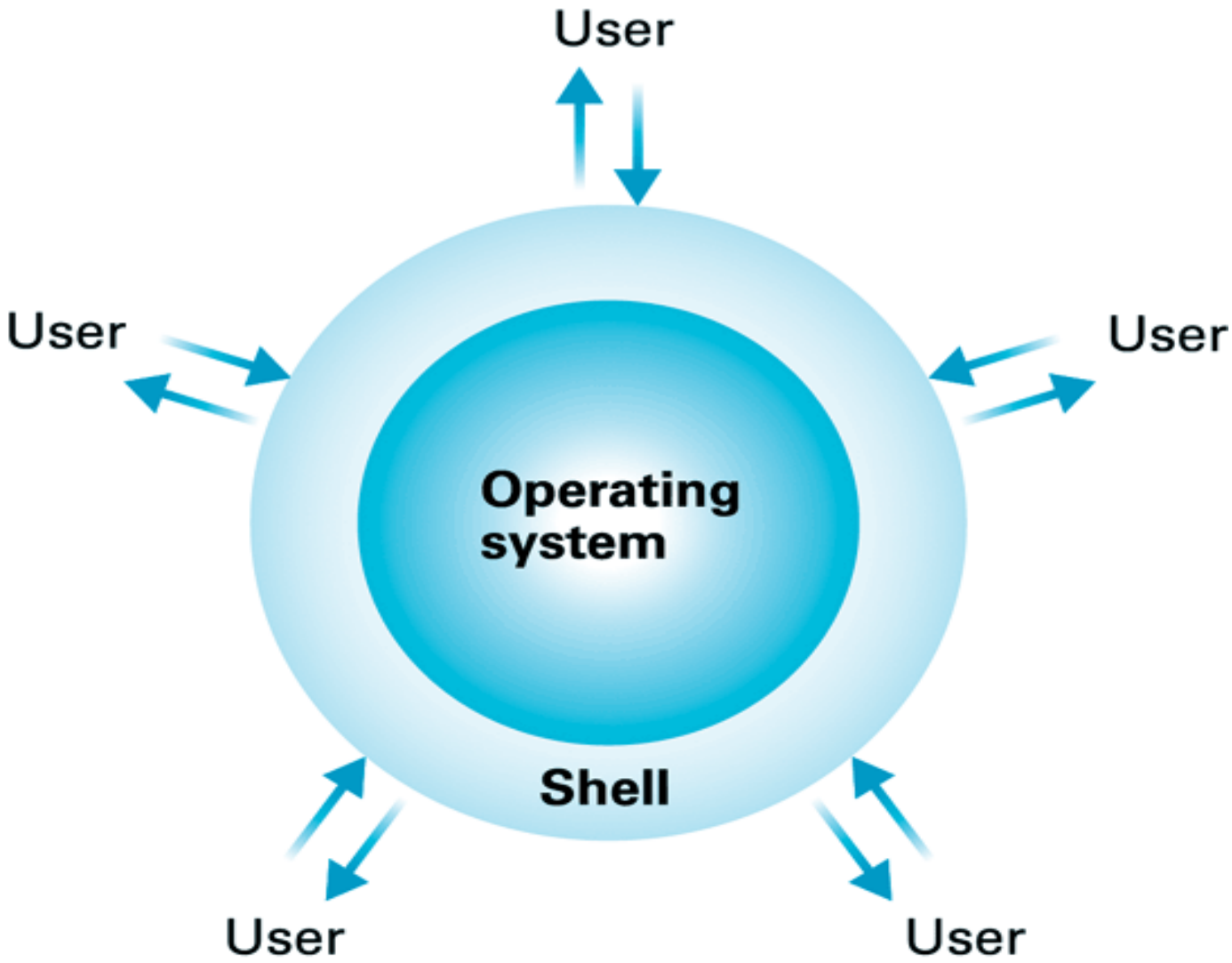
Types of System Software

- ✓ Operating System (**OS**)
  - ➢ **Shell (also known as Command Interpreter)**
  - ➢ **Kernel**
- ✓ **Utility** software
  - – Kind of System Software
  - – providing fundamental activities, yet not included with OS
  - – "extend" the **OS**

❖ **What is the difference between them?**

- – Distinction between applications and **utilities** is often vague (不明確的, 不清楚的)
- – Distinction between **OS** and **utilities** is also vague

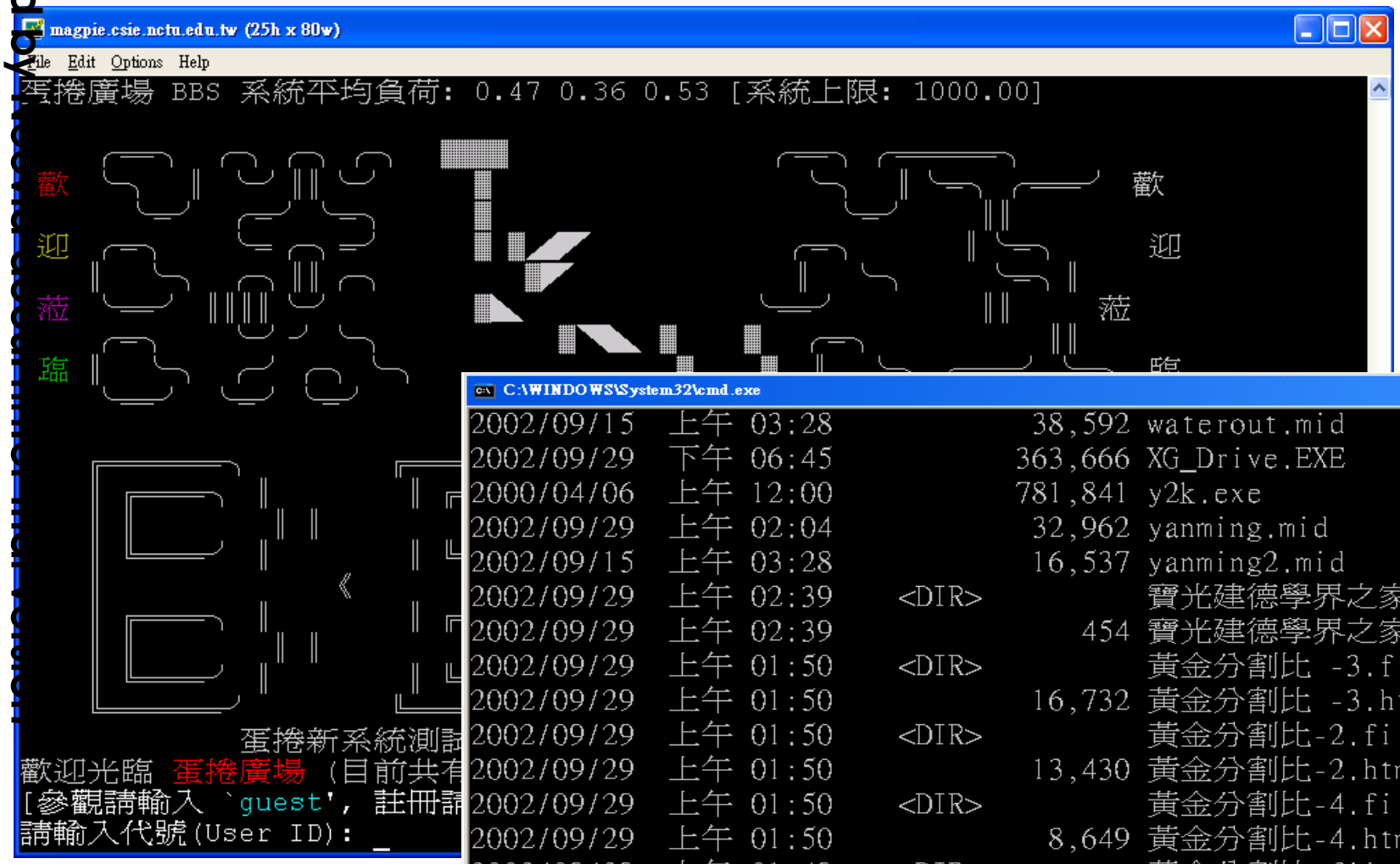
Figure 3.4: The **shell** as an interface between users and the operating system



More About Shell

- Also known as Command Interpreter
- Types of shell
  - Command driven
  - Menu driven (restricted shell)
  - GUI (Graphical User Interface)

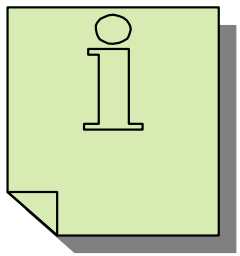
Command Shell examples



Graphical Shell

GUI – (pronounced "goo-ee")

- The Graphical User Interface – features of the GUI…
- Users work with on-screen pictures called icons and with menus rather than keyed-in.



What does Shell can do?

- Read Command from the user and take some action(s)
  - ➢Internal commands (and the Aliases)
  - ➢External commands
    - **Current directory ?**
      - **Unix vs. DOS/Windows ?**
    - **Path**
      - **Command path**
      - **Data path**

OS can have many different Shells

- Defines interface between OS and users
  - Windows GUI
  - UNIX command line (Command driven)
  - UNIX users can choose among a variety of shells
    - sh is the "Borne shell"
    - csh is the "C shell" (因語法像 C; by Berkeley Univ.)
    - tcsh is an enhanced "C shell"
    - **ksh is the "Korn shell"**
    - bash is "Borne Again Shell"
  - **Shell programming (Batch file/Script file)**

The Operating System Kernel

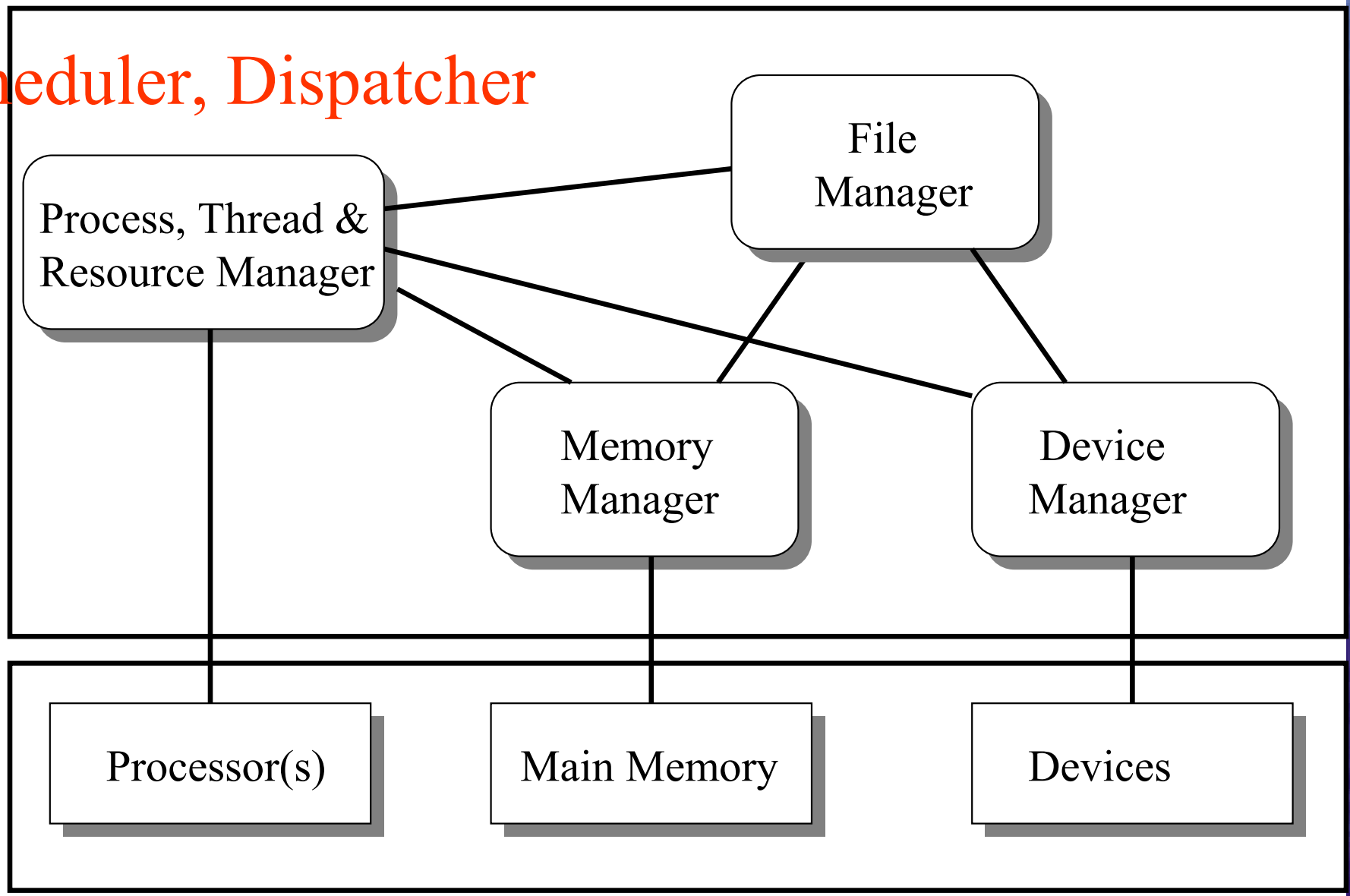
The internal part of the OS is often called the Kernel .

- Resident in memory, running in privileged mode
- System calls offer general purpose **services**
- Controls and mediates access to **hardware**
- Schedules / allocates system **resources**:
  - CPU, memory, disk, devices, etc.
- **Event driven**:
  - Responds to user requests for service (system calls)
  - Attends interrupts and exceptions
  - **Context switch** at quantum time expiration

OS Kernel Components (1/2)

- Kernel Components
  1) **File Manager** -- manages mass storage
  2) **Memory Manager** -- manages main memory
  3) **Device Drivers** -- communicate with peripherals
  4) **Scheduler**-- manage processes 排班
  5) **Dispatcher**-- manage processes 指揮
- The **`trap`** instruction is used to switch from **user** to **supervisor** mode, entering the OS

OS Kernel Components (2/2)



File Manager : OS Component 1/5

- Maintains information about the files that are available on the system
- Where files are located in mass storage, their size and type and their protections, what part of mass storage is available
- Files usually allowed to be grouped in ***directories*** or ***folders***. Allows hierarchical organization.

Memory Manager : OS Component 2/5

- This unit is responsible for coordinating the use of the machine's main memory.
- It decides what area of memory is to be allocated for a program and it's data
- It allocates and deallocates memory for different programs and always knows what areas are free.

Device Drivers : OS Component 3/5

- **Software to communicate with peripheral devices or controllers**
- Each driver is unique
- Translates general requests into specific steps for that device

- Drive != Driver (車子 != 司機)

不等於

Scheduler : OS Component 4/5

- Maintains a record of processes that are present, adds new processes, removes completed processes
  - memory area(s) assigned
  - priority
  - state of readiness to execute (ready/wait)

Scheduler == 排班者

Dispatcher : OS Component 5/5

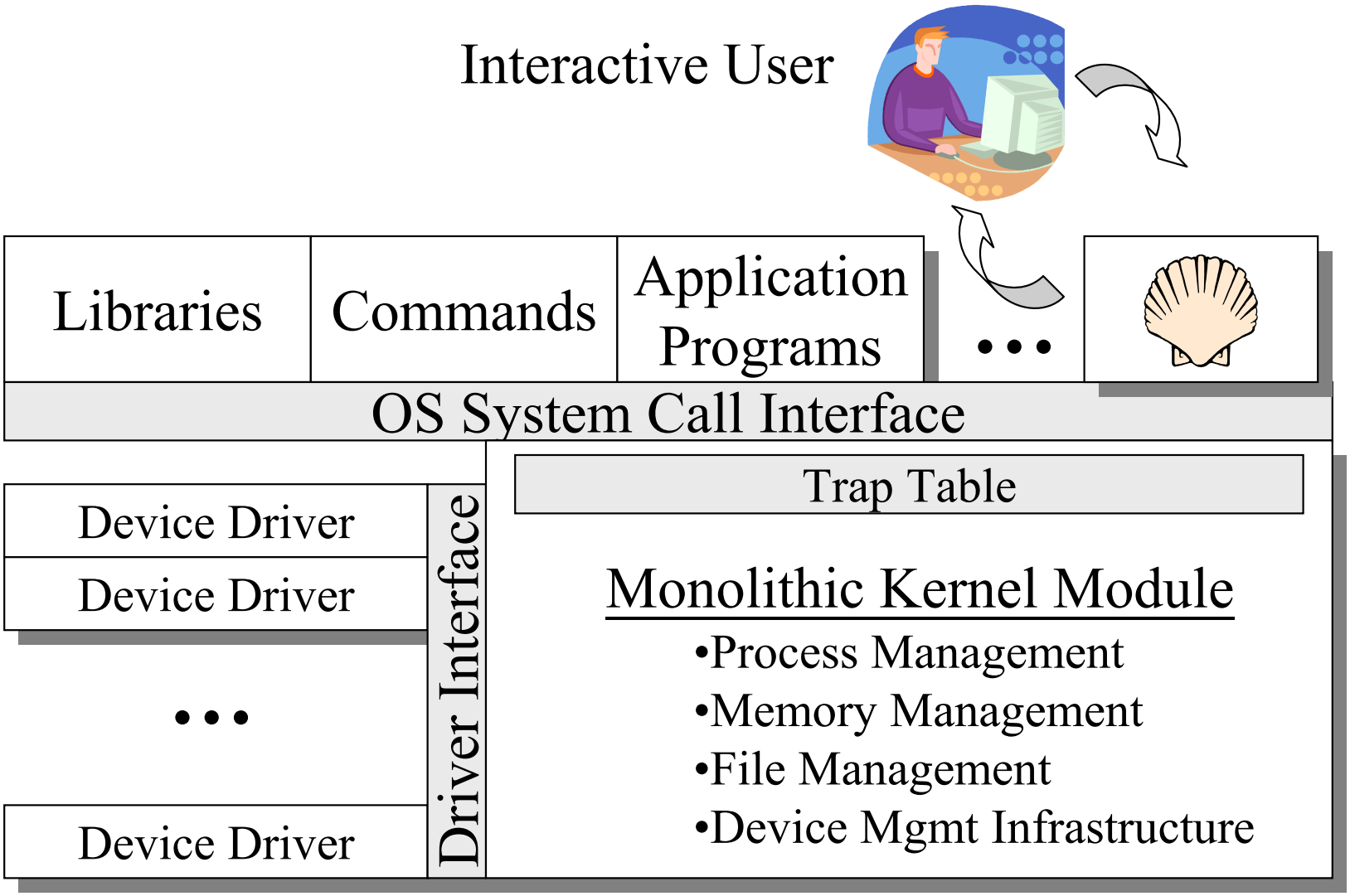
- Ensures that processes that are ready to run are actually executed
- Time is divided into small segments (e.g., 50 ms) called a ***time slice***. (時間片斷)
- When the **time slice** is over, the dispatcher allows scheduler to update process state for each process, then selects the next process (from ready queue) to run.

Dispatcher == 調度指揮官

Process Management

- **A *process* is a program in execution.** A process needs certain resources, including CPU time, memory, files, and I/O devices, to accomplish its task. (正在跑的程式就叫 ***process 行程***)
- The operating system is responsible, through Scheduler and Dispatcher, for the following activities in connection with process management.
  - Process creation and deletion.
  - process suspension and resumption.
  - Provision of mechanisms for:
    - process synchronization
    - process communication

The OS Architecture



More about the OS

- OS History
- OS kernel
- Types of OS
  - Batch vs. Interactive
  - Multi-Programming
  - Time Sharing
  - Real Time Operating System (RTOS)
- Other Topics regarding OS
- OS Loading
  - The Booting process (Bootstrapping)

Early Computing History

- In the 1940s and 1950s, all computers were **personal computers** in the sense that a user would sign up to use the machine and then take over the whole machine for that period.
  - **ENIAC 1946/02/14 於賓州大學**
- The early 1960s were dominated by **batch systems** in which a user would **submit** a job on **punched cards** and wait, usually hours, before any printed **output** appeared on a **printer**.

http://en.wikipedia.org/wiki/ENIAC

MULTICS project in MIT

- To get around this unproductive environment, the concept of **timesharing** was invented by Dartmouth College and M.I.T. (1969)
- The M.I.T system CTSS (Compatible Time Sharing System) was an enormous success.
- M.I.T., Bell Labs, and General Electric created a second generation **timesharing** system named **MULTICS** (**MULT**iplexed **I**nformation and **C**omputing **S**ervice). (1964-1969)

MULTi-user **I**nteractive **C**omputing **S**ystem ?

http://en.wikipedia.org/wiki/MULTICS

http://en.wikipedia.org/wiki/Unix

Early UNIX History (1/4)

- At Bell Labs, **Ken Thompson** decided to write a stripped down version of MULTICS for the very small **PDP-7** minicomputer which he called **UNICS**.
- **Dennis Ritchie**, also at Bell Labs, joined **Thompson** in further developments of what was now called **UNIX**.
- Together they ported the system to the larger and very popular **PDP-11**/20 and PDP-11/45 minicomputers.

PDP-7 → PDP-11　　7-11 ?

http://en.wikipedia.org/wiki/Unix

Early UNIX History (2/4)

- **Thompson** also tried to rewrite the operating system in high level language of his own design which he called **B**., which is a modified version from **BCPL**.
- The B language lacked many features and **Ritchie** decided to design a successor to B which he called **C**.
- **They then rewrote UNIX in the C programming language to aid in portability. (C + Assembly)**

BCPL: Basic Computer Programming Language

BCPL → B → C → C++ → Java → C#

Early UNIX History (3/4)

- In 1974, **Ritchie** and **Thompson** published a paper about UNIX and received the prestigious ACM Turing Award.
- This publication stimulated many universities to request a copies of UNIX.
- Since Bell Labs, part of AT&T, was not allowed to be in the computer business, it licensed UNIX to universities.
- Also, at that time, the PDP-11 series was the workhorse of most computer science departments.
- Result: UNIX was a hit on campus.

http://en.wikipedia.org/wiki/Unix

Early UNIX History (4/4)

- In Version 6, the source code of UNIX was **8200 lines of C** and **900 lines of assembler**.
- The first **portable** version arrived with Version 7 which had **18,800 lines of C** and **2100 lines of assembly instruction**.
- By the 1980s the use of UNIX was widespread with many vendors selling their own versions based on Version 7.

The BSD UNIX

One of the many universities that had received license for UNIX was the **University of California at Berkeley**.

Aided by many government grants, Berkeley released an improved version named **1BSD** (First **Berkeley Software Distribution**)

In subsequent, versions Berkley added many new features including a new visual editor (vi) and a new shell (csh).

csh：通稱 C-Shell, 因其語法很像 **C** 語言

Shell script：就是 BATCH file (批次檔)

System-V vs. BSD-4

- Because of these and other enhancements, many companies based their UNIX on Berkeley's version as opposed to AT&T's so-called System V.
- By the late 1980s, two different and somewhat incompatible versions of UNIX were in widespread use:
  - 4.4 BSD
  - System V release 4. (SVR4)

UNIX Standards (1/3)

- In addition, every vendor added its own nonstandard enhancements.
- In an attempt to unify the troops, the IEEE Standards Board undertook the **POSIX** Project (POS for Portable Operating System) and IX to make it UNIX like.
- POSIX 1003.1 emerged as a common ground standard.
- 1003.1 **is the intersection of System V and BSD. (a feature had to be on both to be included in the standard**)

UNIX Standards (2/3)

- The **POSIX** standard defined a set of library procedures and **systems calls** that all compliant UNIX systems.
- It appeared that the split between System V and BSD had been somewhat dealt with.
- Unfortunately, a funny thing happened on the way back form the standards meeting.

UNIX Standards (3/3)

A group of vendors led by IBM, DEC, Hewlett-Packard, and others formed the OSF (Open Software Foundation) to standardize an enhanced version of UNIX in an attempt to derail AT&T's efforts to regain control of UNIX. (註: DEC 已經倒掉)

AT&T, Sun, UNISYS, Data General, and other companies countered and formed UI (UNIX International) based on System V.

SUN OS (史丹弗大學;Stanford University Network)

- BSD based for version 4.x and before
- SVR4 based for version 5.x (**Solaris** system)

2010/01/27 SUN 已正式被 Oracle 併購@ US$7.4billion

Oracle – 美商甲古文公司 – DBMS leader

Major Unix Flavors

- **First** Edition: Bell Labs, 1969
- BSD1.0: UC, Berkeley, 1977 -- BSD4.6
- System V: 1983 -- SVR1, SVR2, SVR3, SVR4
- **POSIX** standard
- Solaris (Sun OS 5.x)
- AIX (IBM)
- Linux (open source); GNU/Linux
- FreeBSD (open source)

UNIX Like Systems

- In a new trend, UNIX like operating systems began to appear.
- MINIX, by **Andrew Tanenbaum**, used a microkernel design with only **1600 lines of C** and **800 lines of assembler** in its first version.
- **GNU** project started by Richard M. Stallman(RMS) at **1984/01/05**. (announced at **1983/09/27**)
- In 1991, a Finnish student named **Linus Torvalds** released another **UNIX** clone named **Linux** version 0.01. (芬蘭大二學生)

http://en.wikipedia.org/wiki/Richard_Stallman

GNU is Not Unix

- **GNU** is a project started by **Richard M. Stallman** (RMS) to write a completely free implementation of Unix available. (coding begun at 1984/01/05)
- **GNU** stands for "**G**NU is **N**ot **U**nix", which is recursively defining itself.
- Most of Unix has been rewritten by him and his friends.
- Many other software packages have been released for free.
- My favorite linux distribution has over 13,000 packages.

http://www.gnu.org/gnu/thegnuproject.html

Richard M. Stallman (MIT Professor)

Father
of
GNU

Free software according to RMS

- Free software comes with four freedoms
  - The freedom to run the software, for any purpose
  - The freedom to study how the program works, and adapt it to your needs
  - The freedom to redistribute copies so you can help your neighbor
  - The freedom to improve the program, and release your improvements to the public, so that the whole community benefits

RMS -- Richard M.Stallman.

http://en.wikipedia.org/wiki/Richard_Stallman

Linux operating system

- Linux is a monolithic design. (9,300 lines of C and **950 instructions of assembly code in ver. 0.01**)
- Linux quickly grew in size and functionality.
- Version 1, shipped in 1994, contained about **165,000 lines of code**.
- Version 2 in 1996 contained about **470,000 lines of C** and **8000 lines of assembly code**.
- Linux is released under the GNU Public License (**GPL**), which, very basically means that anyone can copy and change it.

Linux 2.7

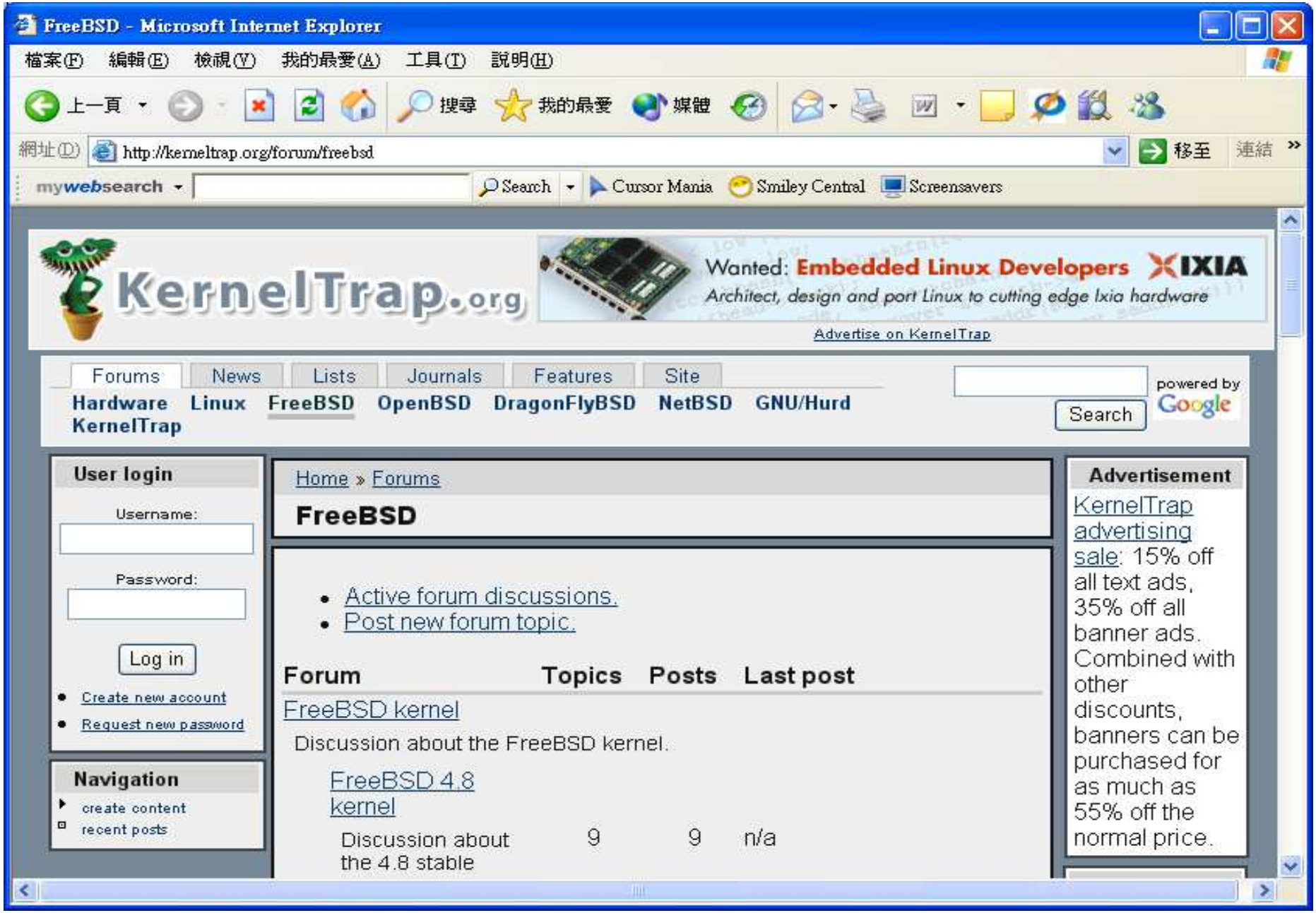
http://kerneltrap.org/forum/linux/kernel/

Linux Distributions

- Linux itself is free. It is aggregated with installation and management tools, and many other software packages, and made available for a small fee by various vendors on CD.
- These aggregates are known as distributions.
- Some common distributions are
  - Red Hat -- SuSE -- Mandrake
  - **Debian** -- **Slackware** -- **fedora (by RedHat)**
  - **Ubuntu** -- **XUbuntu**
  - **Knoppix (first Linux Live CD)**
- Differences
  - Locations of files (configuration, binaries, etc.)
  - GUI
  - Security, efficiency, etc.
- DRBL (Diskless Remote Boot in Linux)

http://en.wikipedia.org/wiki/Linux_distribution

Other Unix-like systems



The Operating System Kernel

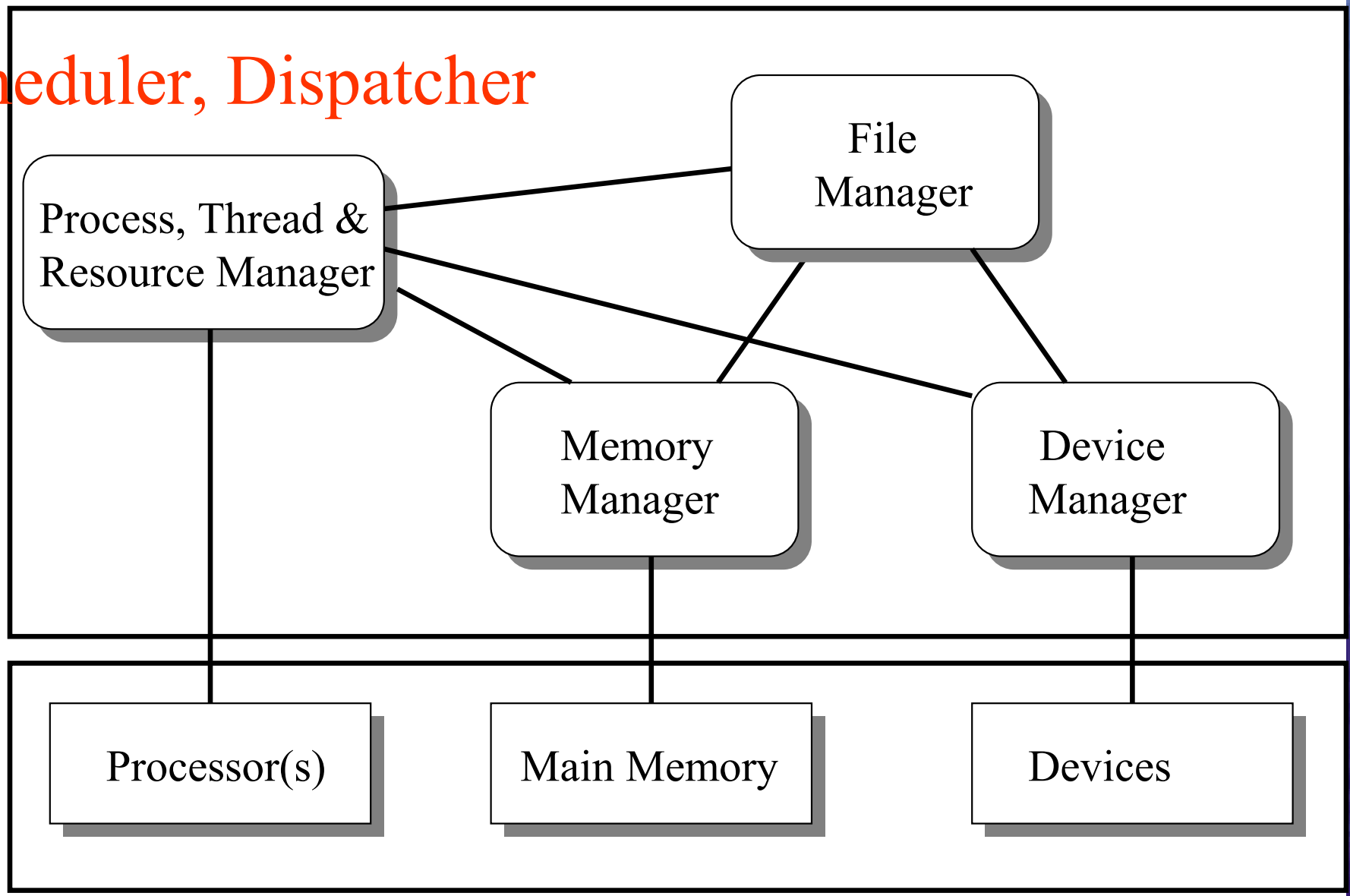
The internal part of the OS is often called the Kernel .

- Resident in memory, running in privileged mode
- System calls offer general purpose **services**
- Controls and mediates access to **hardware**
- Schedules / allocates system **resources**:
  - CPU, memory, disk, devices, etc.
- **Event driven**:
  - Responds to user requests for service (system calls)
  - Attends interrupts and exceptions
  - **Context switch** at quantum time expiration

OS Kernel Components (1/2)

- Kernel Components (OS 五大主要元件)
  - **File Manager** -- manages mass storage
  - **Memory Manager** -- manages main memory
  - **Device Drivers** -- communicate with peripherals
  - **Scheduler**-- manage processes 排班
  - **Dispatcher**-- manage processes 指揮
- The **`trap`** instruction is used to switch from user to **supervisor** mode, entering the OS

OS Kernel Components (2/2)



File Manager : OS Component 1/5

- Maintains information about the files that are available on the system
- Where files are located in mass storage, their size and type and their protections, what part of mass storage is available
- Files usually allowed to be grouped in ***directories*** or ***folders***. Allows hierarchical organization.

Memory Manager : OS Component 2/5

- This unit is responsible for coordinating the use of the machine's main memory.
- It decides what area of memory is to be allocated for a program and it's data
- It allocates and deallocates memory **for different programs** and always knows what areas are free.

Device Drivers : OS Component 3/5

- **Software to communicate with peripheral devices or controllers**
- Each driver is unique
- Translates general requests into specific steps for that device
- Some device Drivers are Loadable.
- Drive != Driver

不等於

車子 不等於 司機

Scheduler : OS Component 4/5

- Maintains a record of processes that are present, adds new processes, removes completed processes
  - memory area(s) assigned
  - priority
  - state of readiness to execute (ready/wait)

Scheduler == 排班者

Dispatcher : OS Component 5/5

- Ensures that **processes** that are ready to run are actually executed.
- Time is divided into small (e.g., 50 ms) segments called a ***time slice***.
- When the **time slice** is over, the dispatcher allows scheduler to update process state for each process, then selects the next process (from ready queue) to run.

Dispatcher == 指揮官; 調度官

Process Management

- **A *process* is a program in execution.** A process needs certain resources, including CPU time, memory, files, and I/O devices, to accomplish its task.
- The operating system is responsible, through Scheduler and Dispatcher, for the following activities in connection with process management.
  - Process creation and deletion.
  - process suspension and resumption.
  - Provision of mechanisms for:
    - process synchronization
    - process communication

Multiprogramming

- Goal: keep CPU busy
- **Fact: I/O times are large**
- When one program is waiting for I/O, run another program
- **=> Multiple programs resident in memory**
- Scheduling:
  - non-preemptive
  - Preemptive ➔ **TimeSharing**

Time sharing

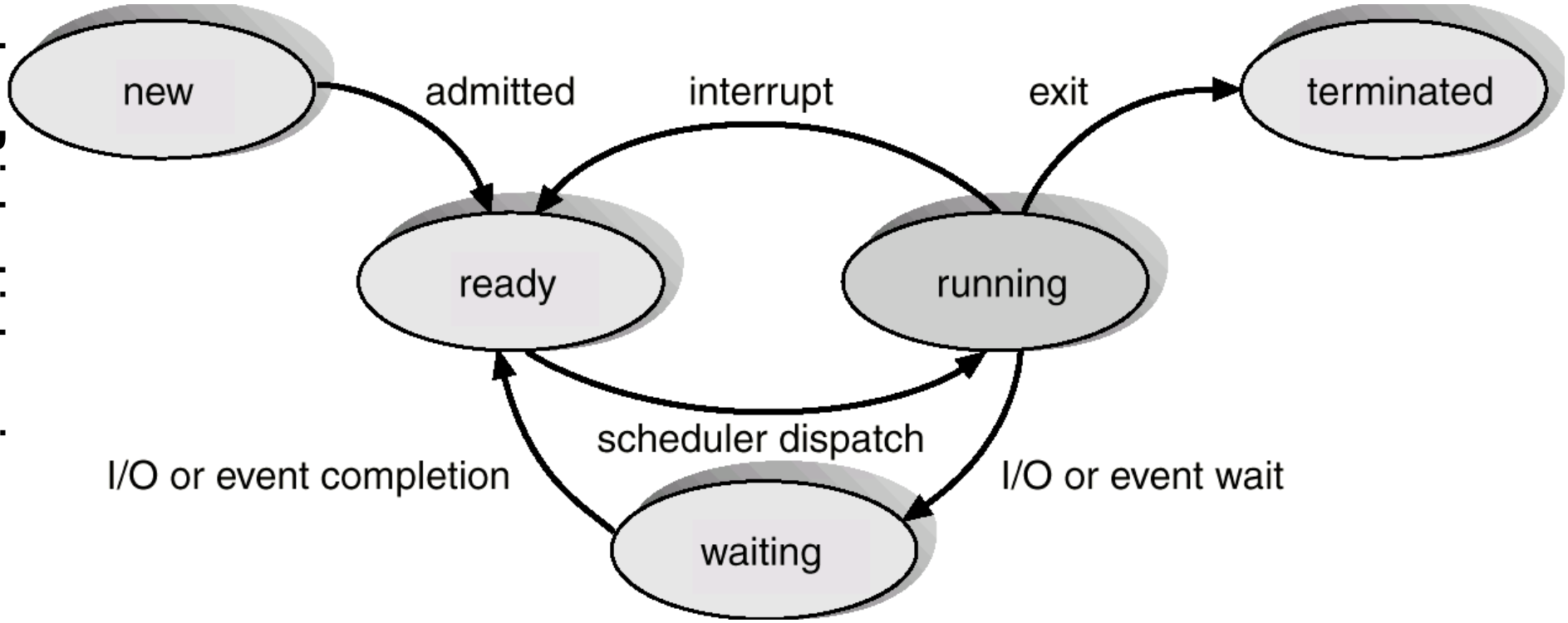
- Goal: allow access to multiple users at the same time
- **Fact: People's response time is large**
  - How to improve it?
- Schedule the programs fast
- Scheduling: preemptive

Time sharing = Multiprogramming + preemptive

Other Topics regarding OS

- Process state transition
- Trap instruction makes OS possible
- Processor **modes** give OS privilege
  - **User** mode vs. ***Supervisor*** mode
- OS Loading
  - How does the System start ? (**Bootstrapping**)
  - **Cold** start vs. **Warm** start

Diagram of process/thread State Transition



thread == Light weight process

Trap instruction

- Trap is like a function call
  - mode is set to *supervisor*
  - address of function is looked up from a table (interrupt vector)
  - the function body is executed
- Direct invocation of the function is not permitted.

若 CPU 沒提供 Trap instruction

則真正的 OS 寫不出來!

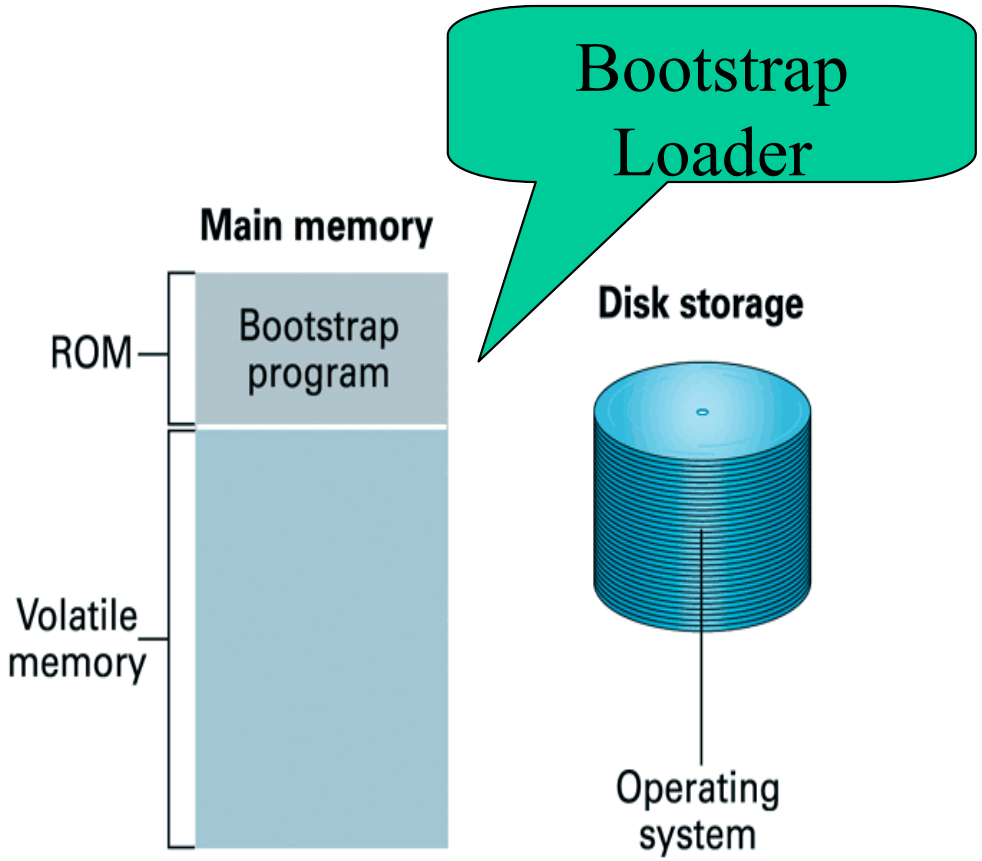
Processor Modes

- Mode bit: ***Supervisor*** or ***User*** mode
- **Supervisor** mode
  - Can execute all machine instructions
  - Can reference all memory locations
- **User** mode
  - Can only execute a subset of instructions
  - Can only reference a subset of memory locations

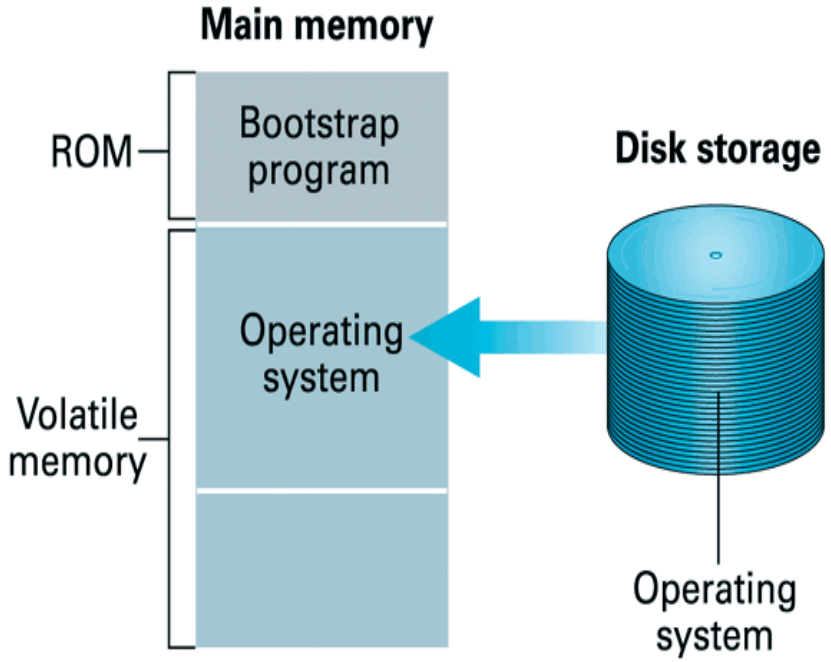
OS Loading

- **How does OS loads in the first place?**
- There's something called a *bootstrap* ***loader***, which is stored in ROM and brings the necessary pieces of OS (***bootstrap***) from the disks' **boot sector**, which know how to load the OS further, and transfers control to it.
- Then all the other parts of OS and device drivers are loaded.

Figure 3.5: The booting process



Step 1: Machine starts by executing the bootstrap program already in memory. Operating system is stored in mass storage.



Step 2: Bootstrap program directs the transfer of the operating system into main memory and then transfers control to it.

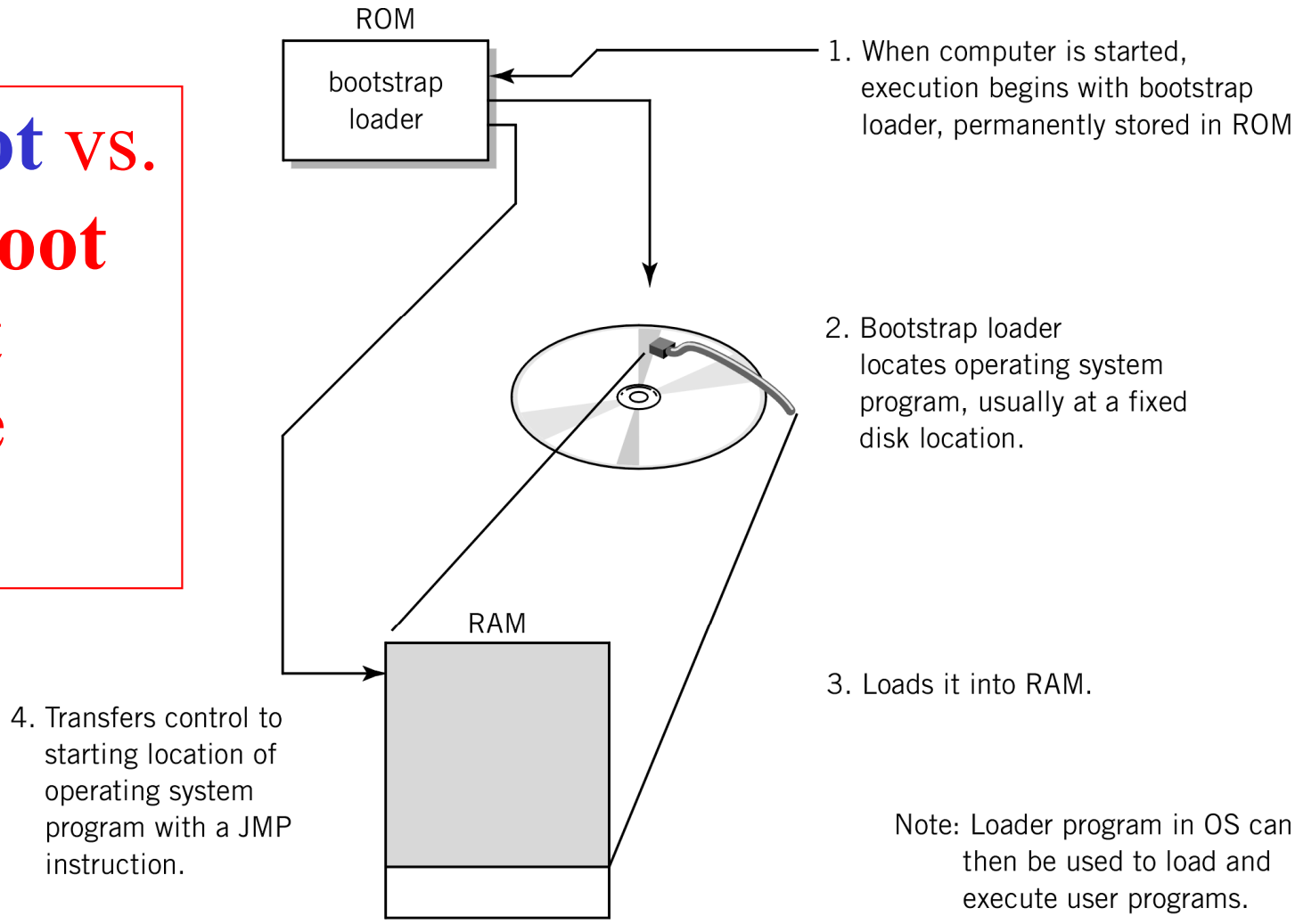
Getting it started (Start up the computer)

- When the computer is started, the control unit branches to a fixed memory location; e.g. initial PC value hardwired. (e.g., CS:IP = 0xffff:0000 in Intel_based computer.) (ffff:0 是 1M 倒數16byte)
- The fixed location is a ROM address that contains a small ***bootstrap loader.*** **(in BIOS ROM)**
- The **bootstrap loader** may be comprehensive enough to load the nucleus of the OS (**kernel**); **Otherwise**, it loads a **loader program** that does so. The **loader** program is usually called ***bootstrap***.
- Once bootstrap phase is done, any program can be run by loading it in memory and loading its initial address in the PC **(fetch-decode-exec** algorithm)

Intel CPU: CS:IP 0xffff:0x0000 ➔ 0xffff0

Bootstrapping

- **Cold boot** vs. **warm boot** (does not **re**test the system)

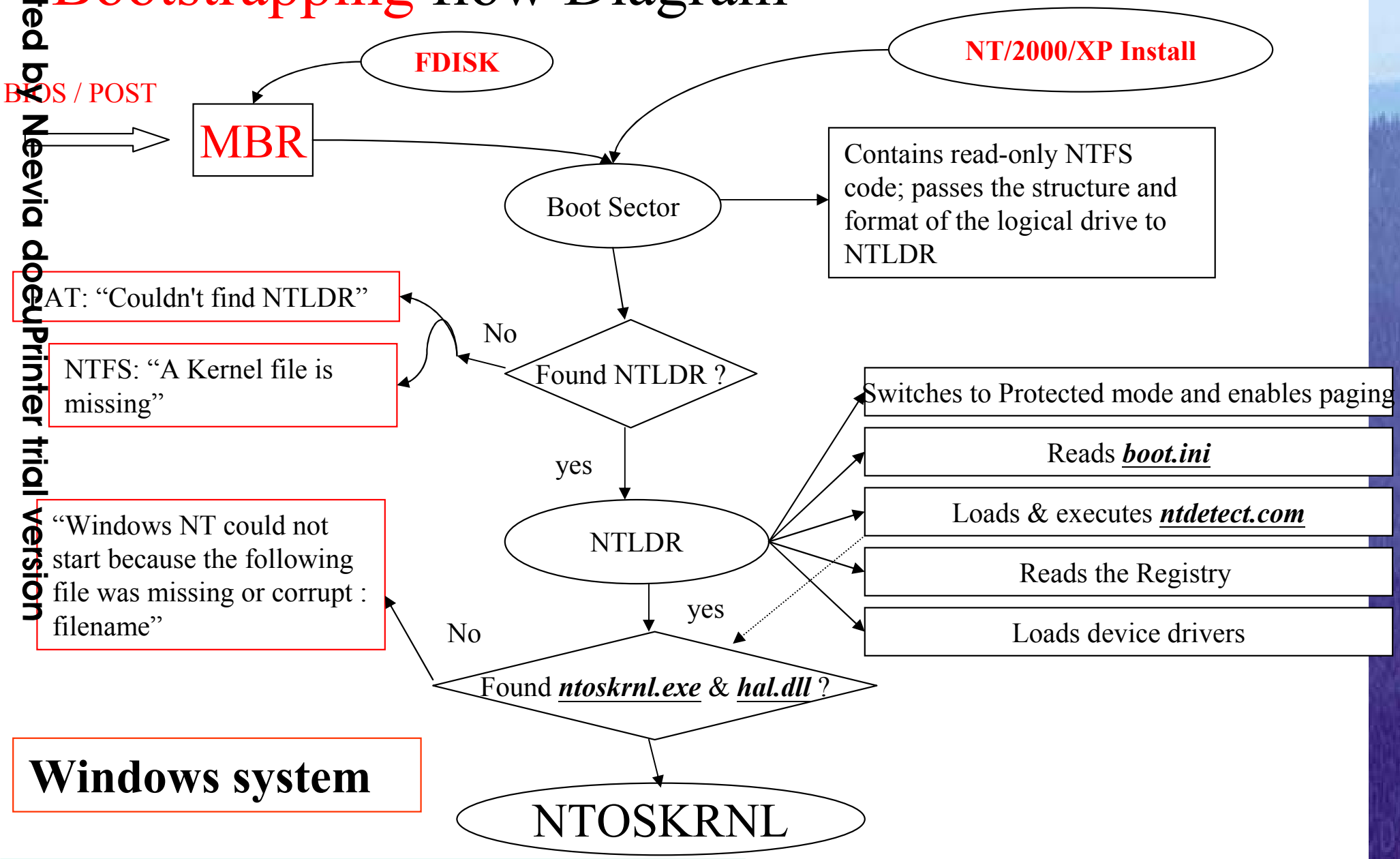


Bootstrapping Microsoft OS (DOS/Windows)

- Two step process when booting from Floppy:
  - a simple **bootstrap loader in ROM** fetches a more complex **boot program** from the **boot sector** in diskette, which in turn loads the **kernel**
- Three step process when booting from Hard Disk:
  - a simple **bootstrap loader in ROM (BIOS ROM)** fetches a pre-boot program in the MBR (Master Boot Record), and the Pre-boot program then find the bootable partition and load a the **boot program** from the **boot sector** in that partition (分割區), which in turn loads the **kernel**.

Bootstrapping flow Diagram

MBR = Master Boot Record



BIOS = Basic Input Output System

POST = Power On Self Test

Competition among Processes

- Semaphores
  - Test-and-set instruction (a primitive)
    - **if (mem[k] == 0) mem[k] = 1; //?**
  - Critical region (**Critical section**)
  - Race condition
  - Mutual exclusion

- **Deadlock** . . .
  - 兩隻狗從獨木橋兩端同時走到橋中間互不相讓?

Terminologies regarding OS

- Critical section: a section of code which reads or writes shared data
- Race condition: potential for interleaved execution of a critical section by multiple threads/processes
  - Results are non-deterministic
- Mutual exclusion: synchronization mechanism to avoid race conditions by ensuring exclusive execution of critical sections (Java 用 synchronized 達成)
- Deadlock: permanent blocking of threads/processes
- Starvation: execution but no progress (Livelock) (Dining Philosopher problem)

The Critical Section Problem

- n processes all **competing** to use some **shared** data
- Each process has a code segment, called critical section (CS), in which the shared data is accessed.
- Problem – ensure that when one process is executing in its critical section, no other process is allowed to execute in its critical section
  - Even with multiple CPUs
- Each process must request the permission to enter its CS
- The critical section problem is to design a protocol that the processes can use so that their action will not depend on the order in which their execution is interleaved (possibly on many processors)
  - Semaphore, Monitor : provided by OS
  - Test-and-Set instruction : Hardware

Semaphore

- Synchronization tool (provided by the OS) that does not require busy waiting
- Formally, a semaphore is comprised of:
  - An integer variable: value
  - Two **atomic** operations: P( ) and V( )
- P( ) --- also known as wait( )
  - While value = 0, sleep
  - Decrement value and return
- V( ) --- also known as signal( )
  - Increments value
  - If there are any threads sleeping waiting for value to become non-zero, wakeup at least 1 thread

Java:
notify( )
notifyAll( )

http://en.wikipedia.org/wiki/Semaphore_(programming)

http://en.wikipedia.org/wiki/Producers-consumers_problem

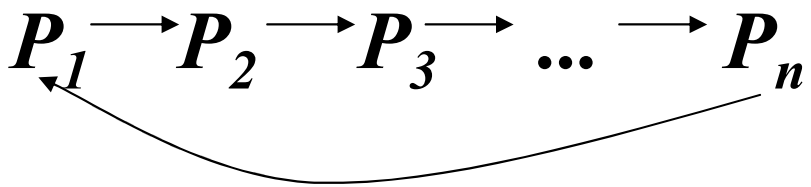
Deadlock

- Permanent **blocking** of a set of processes
- Normally due to the fact that they
  - wait for limited system resources for which they compete **or**
  - wait for messages
  - since messages can be seen as resources, in general it can be said that it is due to contention on resources.
- There is **no satisfactory solution** in the general case
  - to determine whether a program contains a potential deadlock is a computationally unsolvable problem

http://en.wikipedia.org/wiki/Deadlock

4 Necessary Conditions for Deadlock

- 1) Mutual exclusion:
  - One process hold a resource in a non-sharable mode. Other processes requesting resource must wait for resource to be released.
- 2) Hold-and-wait:
  - a process must hold at least one allocated resource while awaiting other resources (one or more) held by other processes.
- 3) No preemption:
  - no resource can be forcibly removed from a process holding it. That is, resources are voluntarily released by the process holding it.
- 4) Circular wait (循環等待)
  - a closed chain of processes exists, such that each process holds at least one resource needed by the next process in the chain.



Dining Philosopher Problem

In 1965, ***Edsger Dijkstra*** set an examination question on a synchronization problem where five computers competed for access to five shared **tape drive** peripherals.

Soon afterwards the problem was retold by ***Tony Hoare*** as the dining philosophers problem.

- Five philosophers sitting at a round table doing one of two things: **eating** or **thinking**.
- A fork is placed in between each pair of adjacent philosophers, and as such, each philosopher has one fork to his left and one fork to his right.
- It is assumed that a philosopher must eat with two forks. Assuming each philosopher takes a different fork as a first priority and then looks for another fork whenever he/she wants to eat.

http://en.wikipedia.org/wiki/Dining_philosophers_problem

Starvation : LiveLock

Processes vs. threads

- Different meanings when operating system terminology
- Regular processes
  - Heavyweight process
  - Own virtual address space (stack, data, code)
  - System resources (e.g., open files)
- Threads
  - Lightweight process
  - Subprocess within process
  - Only program counter, stack, and registers
  - **Shares address space, system resources with other threads**
    - Allows quicker communication between threads
  - Small compared to heavyweight processes
    - Can be created quickly
    - Low cost switching between threads

Critical Section in Java program

```
public String aLock = "just a Lock ha ha ha";
///… critical section 可能只有一個片斷程式
synchronized( a Lock ) {
    /// critical code accessing shared data
}
/// critical section 也可能由好幾個片斷程式合起來組成
synchronized( aLock ) {
    /// Other critical code accessing shared data
}
```

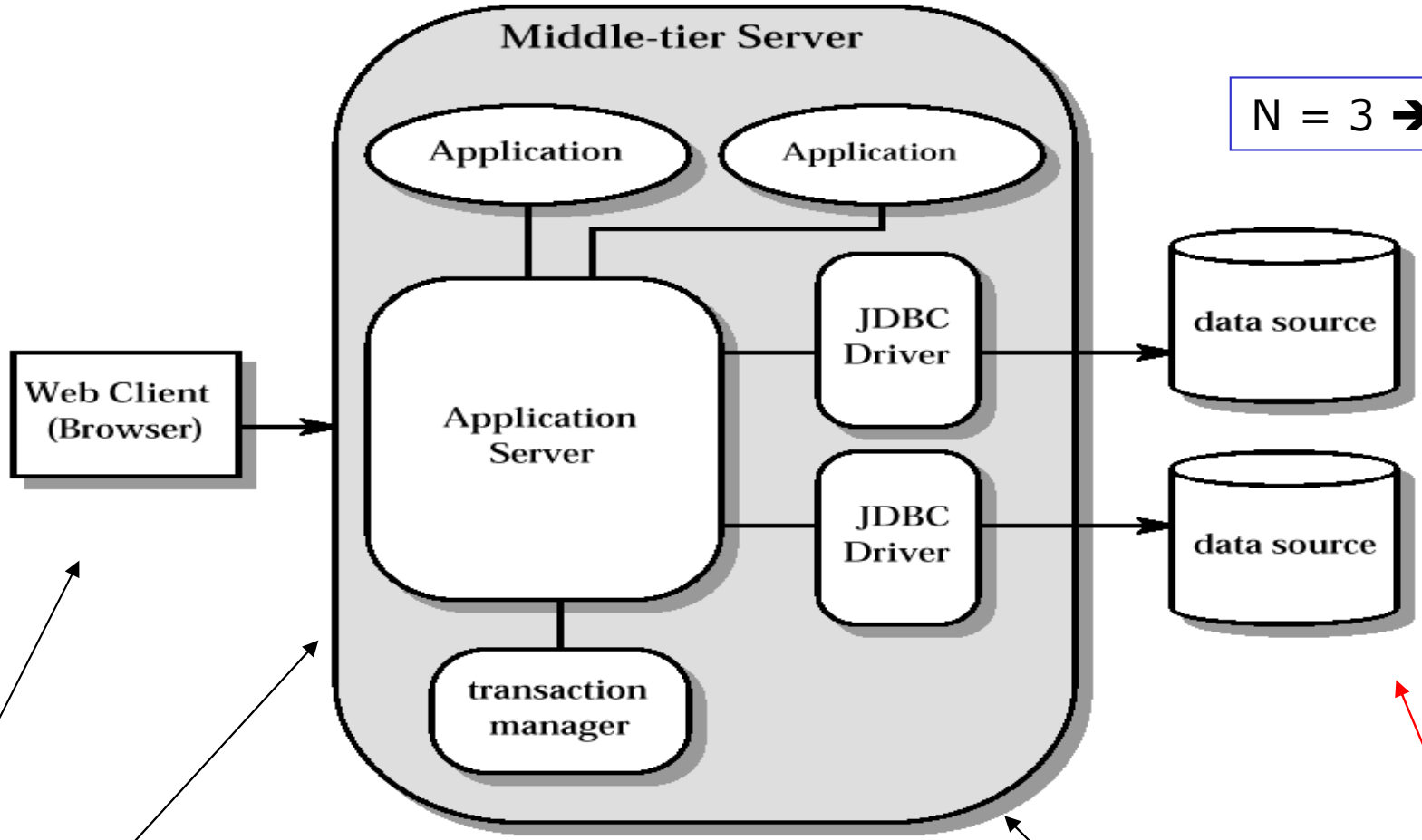
考慮有很多份(thread)上述程式“同時”在執行

考慮黑板上寫著教室內現有人數, 由兩人負責更新?

Programming Model

- Client / Server
  - BBS
  - News
  - FTP
- Traditional (non-component) N-Tier Systems
  - 3-Tier Programming (N == 3)
    - Browser + HTTP Server + DBMS
- N-Tier Programming, JavaEE

Traditional (non-component) N-Tier Systems

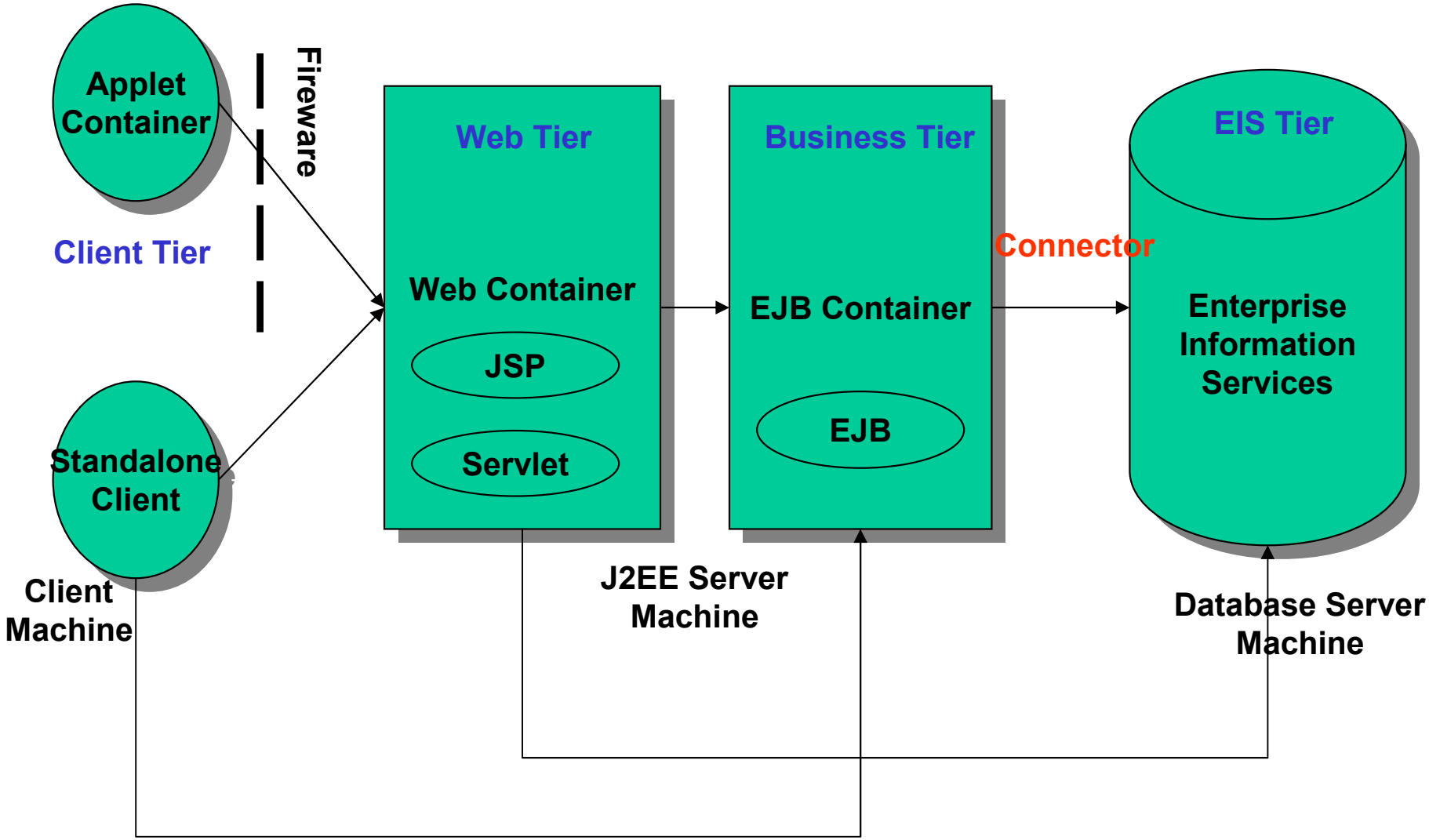


- Client Tier – Presentation Logic
- Application Tier – Business Logic
- Data Tier – Database Management Services

Source: **Sun Microsystems**, Inc., *JDBC 3.0 Specification*

Component N-Tier Systems

J2EE Architecture (Java EE)



Thank You!

CHAPTER 3

Operating Systems

謝謝捧場

tsaiwn@csie.nctu.edu.tw

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