Operating System Structure Overview

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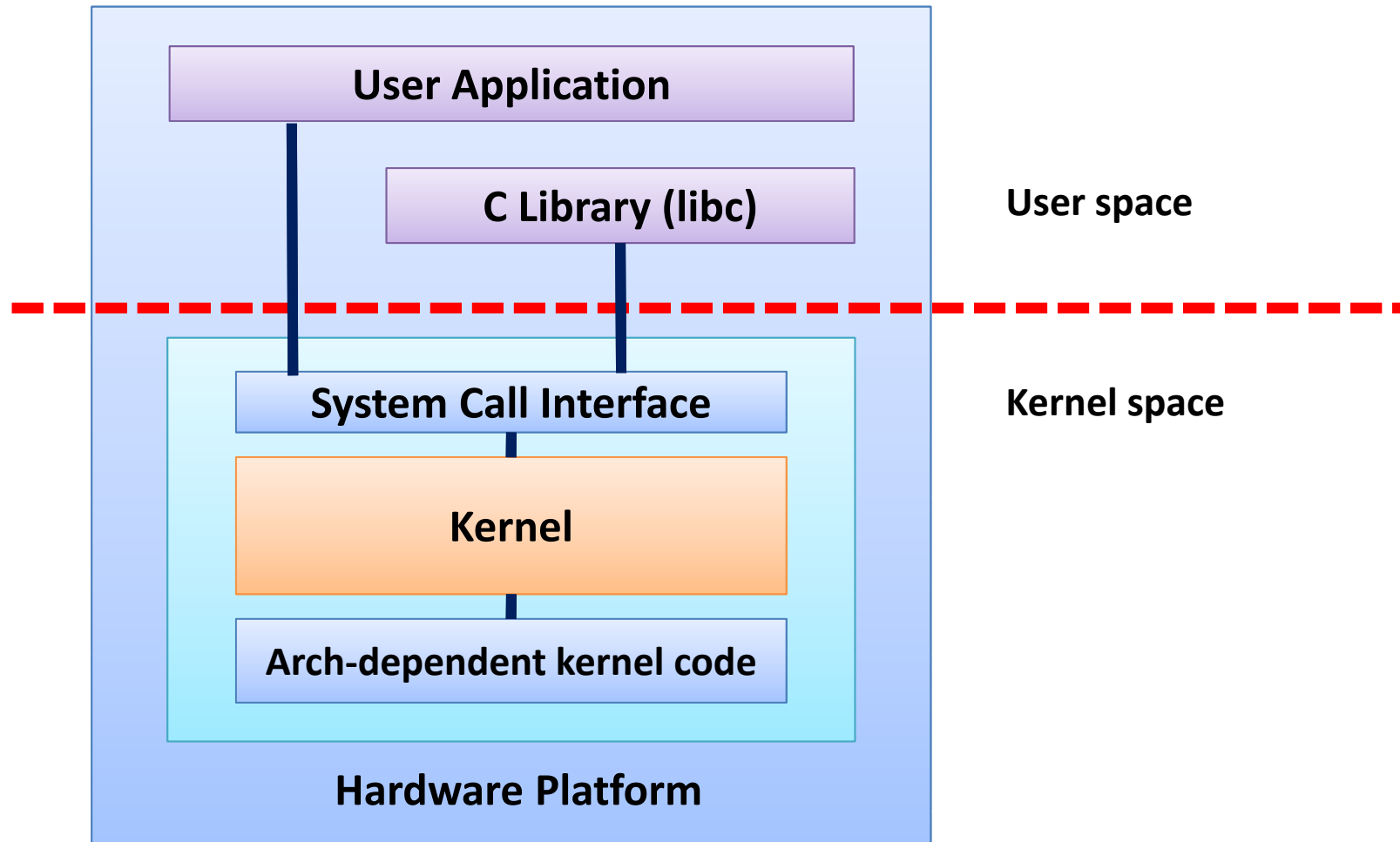http://csl.skku.edu

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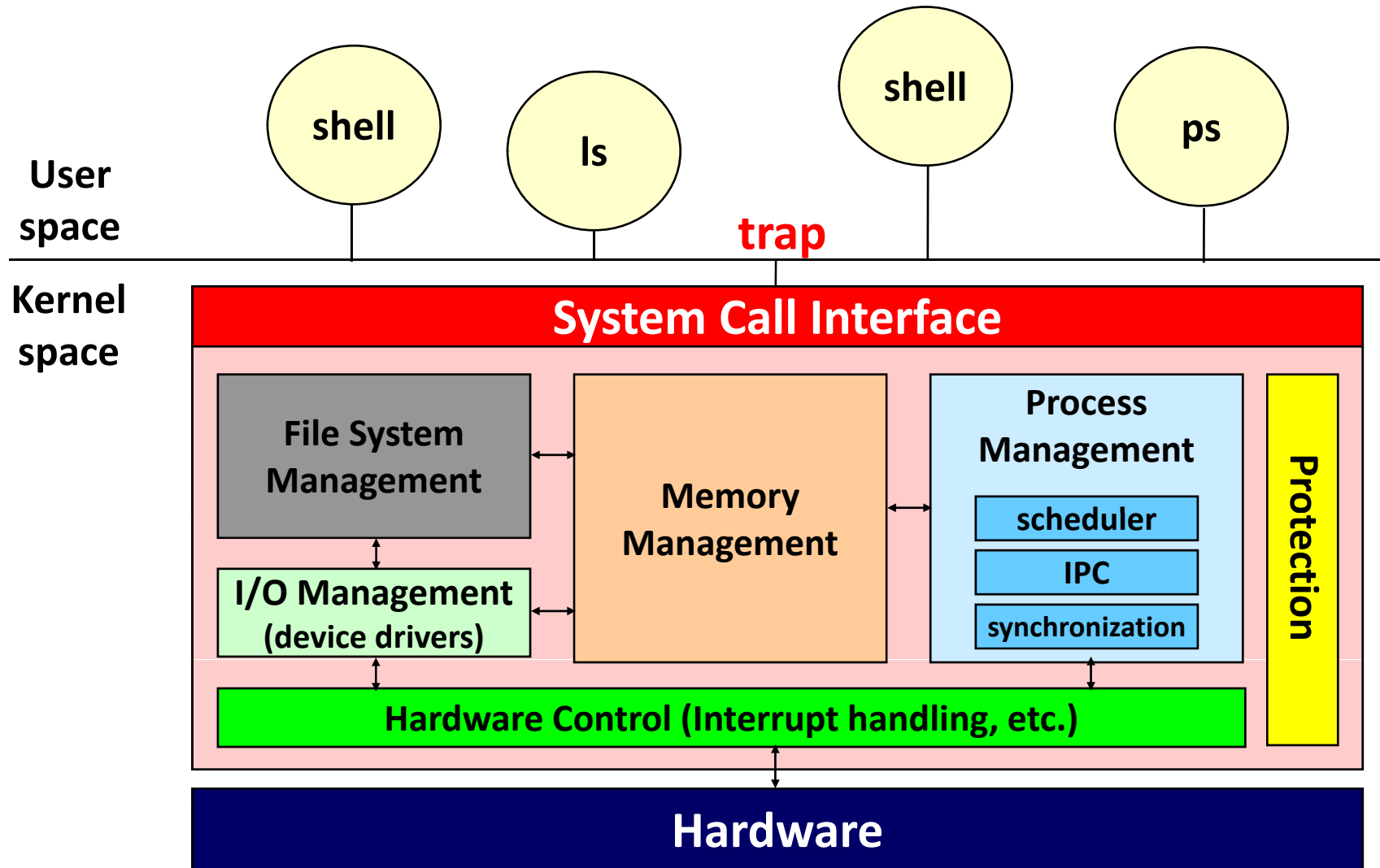
Today's Topics

- **Basic components of OS:**
  - Process management
  - Memory management
  - Storage management
  - I/O management
  - Protection and security

- **OS structure**

OS Internals (1)

User Application

C Library (libc)

System Call Interface

Kernel

Arch-dependent kernel code

Hardware Platform

User space

Kernel space

OS Internals (2)

OS Structure (1)

- **Layered**
  - A hierarchy of layers, each one constructed upon the one below it.
  - The layered approach is modular; simplifies the extension and maintenance of the code base.
  - THE (Dijkstra, 1968): 6 layers

| Layer	Function
5	The operator
4	User programs
3	Input/output management
2	Operator-process communication
1	Memory and drum management
0	Processor allocation and multiprogramming

OS Structure (2)

- **Layered (cont'd)**
  - Multics: 8 rings of protection
    - The inner ones are more privileged than the outer ones. (The supervisor runs in ring 0)
    - Calling a procedure in an inner ring requires a system call, where the parameters are carefully checked for validity.
    - The ring mechanism is present at run time and enforced by the hardware.
      - » The hardware made it possible to designate individual procedures (memory segments, actually) as protected against reading, writing, or executing.
    - The ring mechanism can easily be extended to structure user subsystems.

OS Structure (3)

- **Microkernel**
  - Move as much functionality as possible from the kernel into "user" space.
  - Communication takes place between user modules using message passing.
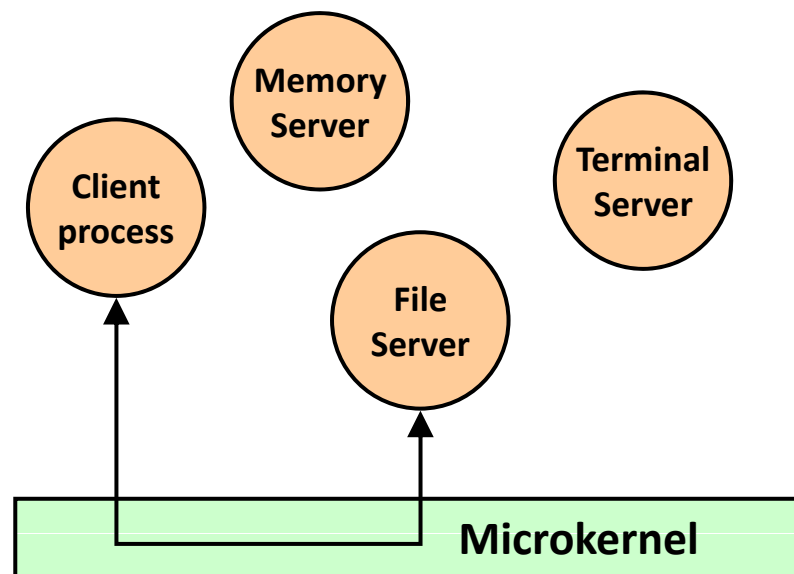
OS Structure (4)

- **Microkernel (cont'd)**
  - The Mach kernel only includes:
    - Thread scheduling
    - Message passing
    - Virtual memory
    - Device driver code
  - Microkernels
    - Mach (CMU) → OSF/1, NeXTSTEP, IBM OS/2, MkLinux, GNU Hurd, Microsoft Windows NT/XP, XNU (Mac OS X)
    - Chorus (INRIA, Chorus)
    - Amoeba (Andrew Tanenbaum @ Vrije Univ.)
    - QNX
   - L3/L4 (GMD, Jochen Liedtke @ Univ. Karlsruhe)

OS Structure (5)

- **Microkernel: Benefits**
  - Extensibility, Reliability, Simplicity, Maintainability, Flexibility
    - Modular structure (easy to add services)
    - Easing system design, implementation, and maintenance
    - Failure isolation, enhancing debuggability and validation (small microkernel can be rigorously tested.)
    - Coexistence of different APIs, file systems, and OS personalities.
  - Portability
    - Changes needed to port the system to a new processor is done in the microkernel – not in the other services.
  - Distributed system support
    - Messages are sent without knowing what the target is.
  - Object-oriented operating system
    - Components are objects with clearly defined interfaces that can be interconnected to form software.
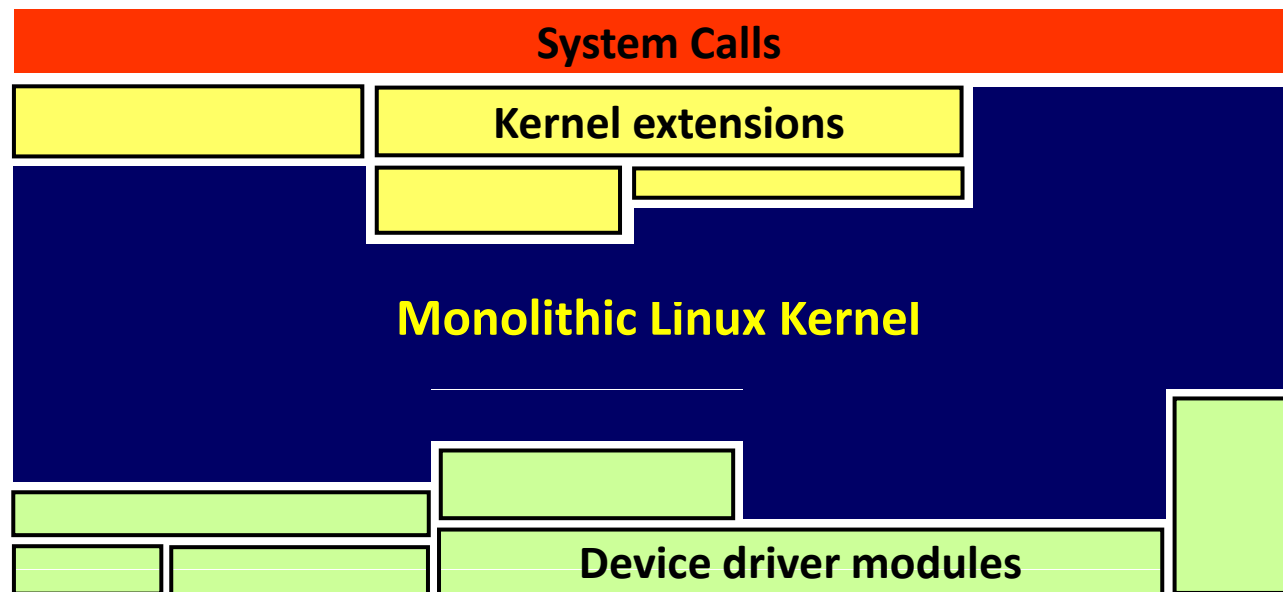
OS Structure (6)

- **Monolithic**
  - "The Big Mess" - a single large software system.
  - Local procedure calls are used to communicate among different components.
  - Advantages: performance
  - Disadvantages:
    - Difficult to maintain and upgrade because of the interdependencies in the code.
    - Operating system code runs at supervisor level in the same memory space so that any component of the system could corrupt data being used by other components.
  - Unixware, Solaris, AIX, HP-UX, Linux, etc.

API
Monolithic Kernel
Hardware
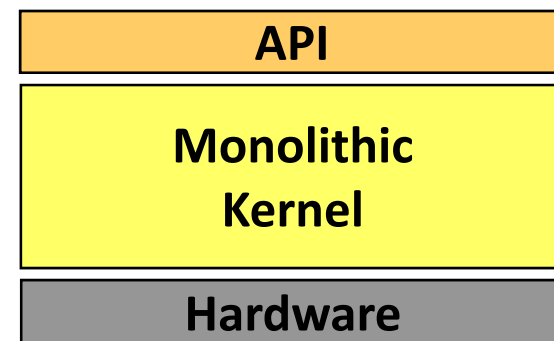
OS Examples (1)

- **Linux**
  - Monolithic kernel + (layered) kernel modules

System Calls

Kernel extensions

Monolithic Linux Kernel

Device driver modules

(cf.) Monolithic kernels vs. Microkernels:
    A debate between Linus Torvalds and Andrew Tanenbaum (1992)
    http://www.oreilly.com/catalog/opensources/book/appa.html
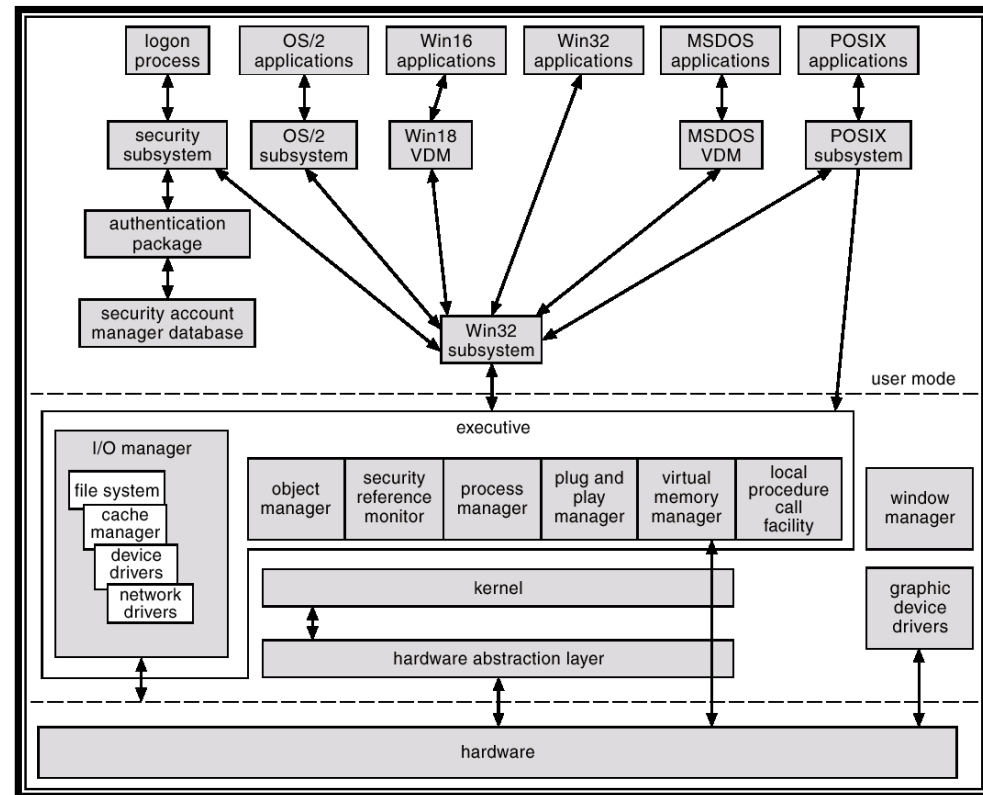
OS Examples (2)

- **Mac OS X structure**
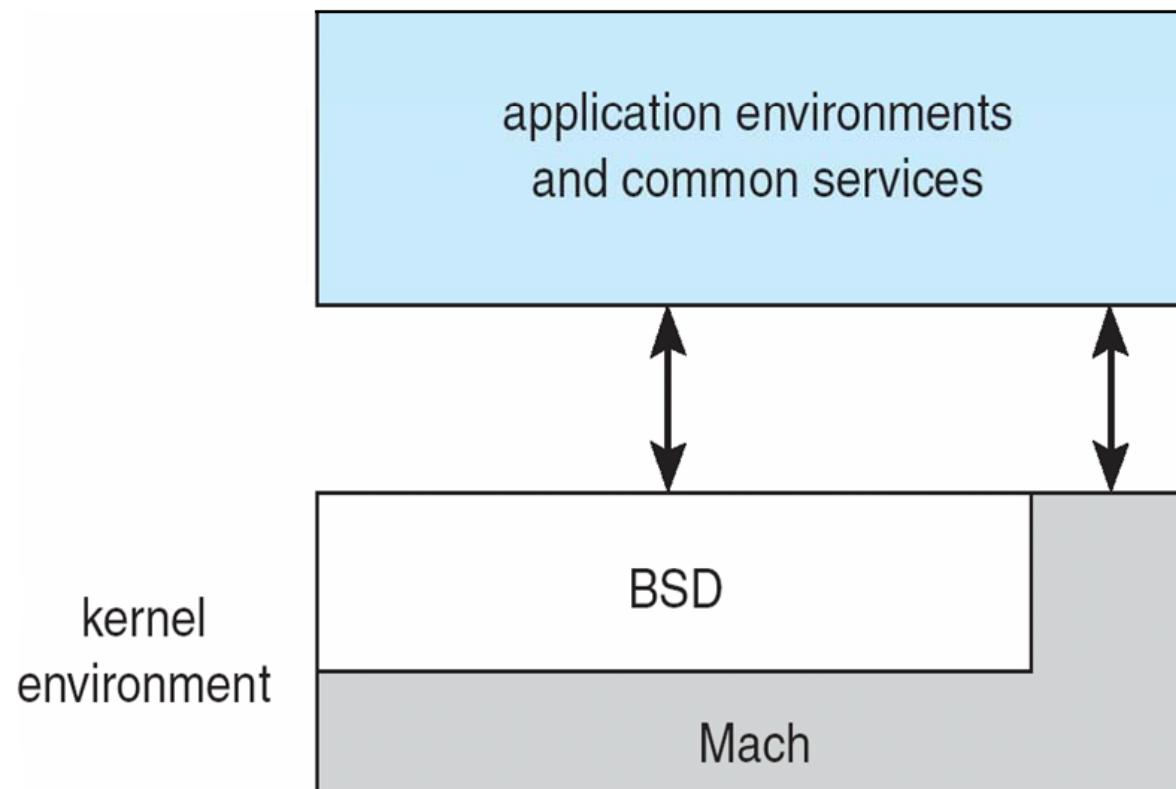
OS Examples (3)

- **Microsoft Windows NT/2000/XP**
  - "Microkernel-like"
    - OS personalities in subsystems (POSIX, OS/2, Win32)
    - Kernel focuses on memory, processes, threads, IPC, I/O

OS Classification (1)

	MS-DOS	Windows 98	Windows 2000/Vista	Linux
Multi-user	X	X	O	O
Multi-task Multi-process	X	O	O	O
Multi-processor	X	X	O	O
Multi-thread	X	O	O	O

OS Classification (2)

- **Mainframe OS**
- **Server OS**
- **Desktop OS**
- **Multiprocessor OS**
- **Cluster OS**
- **Distributed OS**
- **Embedded OS**
- **Real-time OS**
- **...**