Operating Systems : Overview

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CSE421

Topics for discussion

- What will you learn in this course? (goals)
- What is an Operating System (OS)?
- Evolution of OS
- Important OS Components
- Major achievements
- Operating system design hierarchy
- Sample systems

Goals for the course

- Study the working of an OS.
- Study the design and implementation of various components of an OS.
- Learn about the alternatives available to a designer at all levels of abstraction in an OS.
- Learn concurrent programming using processes, threads, and system calls.
- Understand the basics of distributed systems.
- Explore how you may contribute to solving many open problems in OS and distributed systems.

What is an Operating system?

- Interface manager
  - Human interaction made easy
  - interfacing, abstraction, control and sharing
- Resource manager
  - Efficient use of resources
- Enhances hardware features
  - "virtual" time, space and resource (processes, threads)
- System and data security and protection provider

User Interface

- Operating system provides these facilities for the user:
  - Program creation : editors, debuggers, other development tools.
  - Program execution : load, files, IO operations.
  - Access to IO devices: Read and writes.
  - Controlled access to files: protection mechanisms, abstraction of underlying device.
  - System access: Controls who can access the system.
  - Error detection and response: external, internal, software or hardware error.
  - Accounting: Collect stats., load sharing , for billing purposes.

Resource Manager

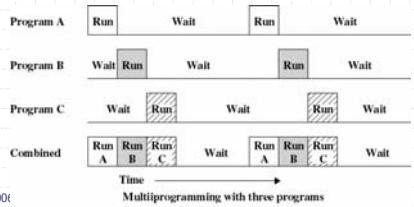
- Processors : Allocation of processes to processors, preemption, scheduling.
- Memory: Allocation of main memory.
- IO devices : when to access io devices, which ones etc.
- Files: Partitions, space allocation and maintenance.
- Applications, Data, objects.

Multiprogramming

- From uniprogramming to multiprogramming systems:
- Multiprogramming systems: batch programs, objective : maximize system (processor) utilization.
- Time sharing systems: Objective is minimize response time. Typical programs are interactive.

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)



Multiprogramming with three programs

Processes

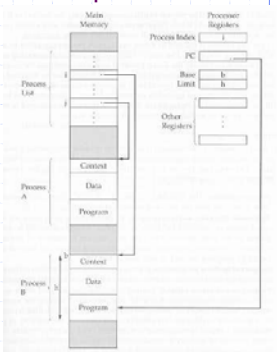
- A program in execution,
- An entity that can be assigned to and executed on a processes,
- It is a unit of work.
- Multiprogramming, time-sharing and real-time transaction systems lead to the refinement of the concept of process.
- A process can be defined by its attributes and behaviors : it can be viewed as an Abstract Data Type (ADT).
- When instances of this ADT co-exist we have concurrent processing.
- Issues in concurrent processing : synchronization, mutual exclusion, deadlock, communication.

Process

- Introduced to obtain a systematic way of monitoring and controlling program execution
- A process is an executable program with:
  - associated data (variables, buffers…)
  - execution context: ie. all the information that
    - the CPU needs to execute the process
      - content of the processor registers
    - the OS needs to manage the process:
      - priority of the process
      - the event (if any) after which the process is waiting
      - other data (that we will introduce later)

A simple implementation of processes

- The process index register contains the index into the process list of the currently executing process (B)
- A process switch from B to A consist of storing (in memory) B's context and loading (in CPU registers) A's context
- A data structure that provides flexibility (to add new features)



Memory management

- Requirements: Process isolation, automatic allocation and maintenance, protection and access control, long-term storage facilities.
- Virtual memory and file system facilities together satisfy all these requirements.
- Virtual memory allows programs to address the memory from a logical point of view without regard to the amount of main memory available.
- File : persistent storage for programs and data.
- Can view file also as an ADT? File concept makes makes access control and protection convenient for the OS.

Protection and Security

- When sharing resources, protection of the systems and user resources from intentional as well as inadvertent misuse.
- Protection generally deals with access control. Ex: Read only file
- Security deals usually with threats from outside the system that affects the integrity and availability of the system and information with the system.
- Example: username, password to access system. Data encryption to protect information.

Scheduling and resource management

- Scheduling and resource management is an Operations Research (OR) problem.
- Goals : Efficient use of resources, satisfy the service time requested by a process, say, in a real-time system and of course, fairness.
- Short-term and long-term scheduling.
- Queuing is one of the basic operations associated with scheduling. Interrupt is another important concept in the context of scheduling.

Scheduling and Resource Management

- Differential responsiveness
  - discriminate between different classes of jobs
- Fairness
  - give equal and fair access to all processes of the same class
- Efficiency
  - maximize throughput, minimize response time, and accommodate as many users as possible

File System

- Implements long-term store (often on disk)
- Information stored in named objects called files
  - a convenient unit of access and protection for OS
- Files (and portions) may be copied into virtual memory for manipulation by programs

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

Structure of OS

- Client-Server Model
  - **SERVERS**: Splitting the OS into parts, each of which handles one facet of the system, such as **file service, process service, terminal service, or memory service**
  - **CLIENTS:** User processes : A client process obtains services by sending messages to the servers.
  - Advantages:
    - Modularity : A bug in fileserver will crash only the fileserver and not the whole OS
    - **Adaptability to distributed system**: Services could be provided from a remote computer.

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

- Only a few 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...

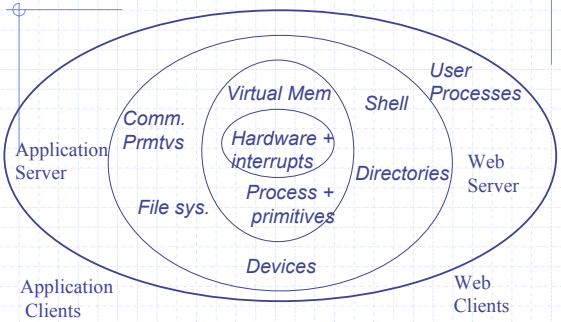
Multithreading

- A process is a collection of one or more threads that can run simultaneously
- Useful when the application consists of several tasks that do not need to be serialized
- Gives the programmer a greater control over the timing of application-related events
- All threads within the same process share the same data and resources and a part of the process's execution context
- It is easier to create or destroy a thread or switch among threads (of the same process) than to do these with processes

Symmetric Multiprocessing (SMP)

- A computer with multiple processors
- Each processor can perform the same functions and share same main memory and I/O facilities (symmetric)
- The OS schedule processes/threads across all the processors (real parallelism)
- Existence of multiple processors is transparent to the user.
- Incremental growth: just add another CPU!
- Robustness: a single CPU failure does not halt the system, only the performance is reduced.

Operating system Modular View



Metric Units

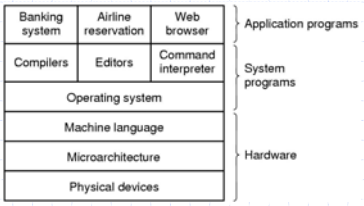
Exp.	Explicit	Prefix	Exp.	Explicit	Prefix
10^{-3}	0.001	milli	10^{3}	1,000	Kilo
10^{-6}	0.000001	micro	10^{6}	1,000,000	Mega
10^{-9}	0.000000001	nano	10^{9}	1,000,000,000	Giga
10^{-12}	0.000000000001	pico	10^{12}	1,000,000,000,000	Tera
10^{-15}	0.000000000000001	femto	10^{15}	1,000,000,000,000,000	Peta
10^{-18}	0.000000000000000001	atto	10^{18}	1,000,000,000,000,000,000	Exa
10^{-21}	0.000000000000000000001	zepto	10^{21}	1,000,000,000,000,000,000,000	Zetta
10^{-24}	0.000000000000000000000001	yocto	10^{24}	1,000,000,000,000,000,000,000,000	Yotta

The metric prefixes

Types of OS

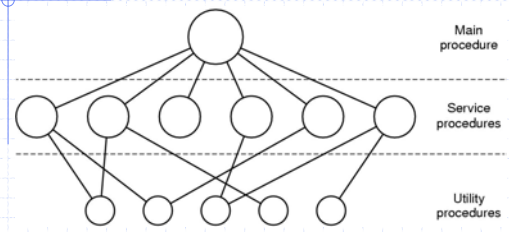
- Multiprocessing - multiple CPUs
- Multiprogramming - Time sharing, interactive
- Real-time : deadlines, time constraints, predictability
- Distributed systems : Sharing and fault tolerance, reliability, dependability.
- Network OS
- Network Transparent Systems : CORBA-like
- Network-centric Systems : Jini-like
- Component-based systems: Enterprise Java
- Read Chapter 1

Position of an Operating System



- A computer system consists of
  - hardware
  - system programs
  - application programs

Operating System Structure (1)



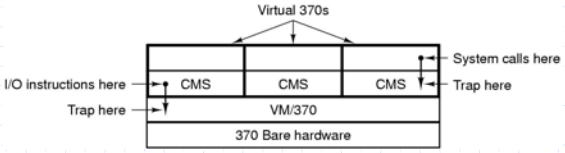
Simple structuring model for a monolithic system

Operating System Structure (2)

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

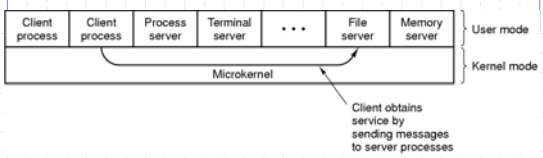
Structure of the THE operating system

Operating System Structure (3)



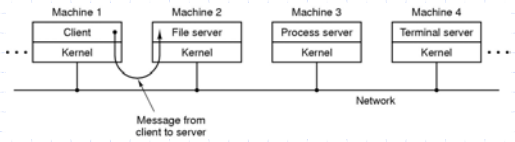
Structure of VM/370 with CMS

Operating System Structure (4)



The client-server model

Operating System Structure (5)



The client-server model in a distributed system

What's New?

- Virtual Machines: Virtualization
  - Technology goes around in cycles?
- VMWare: Linux virtualization
- Virtual appliances
- Device Virtualization
- JVM (Java Virtual Machine)
- Windows NT is an example
- Hypervisor architecture from Microsoft