

Preview

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The Process

- A program becomes a process when an executable file is loaded into memory. A process is a program in execution. When a program starts to run, OS keep its status in a process table until its termination.
- The memory layout of a process is typically divided into four sections.
 - Text section—the executable code (fixed)
 - Data section—global variables (fixed)
 - Heap — used for dynamic memory allocation (change size during execution)
 - Stack section—temporary data storage for local variables when a function is called (function parameters, return addresses, and local variables) (change size during execution)

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The Process

stack

↓

↑

heap

data

text

- Text – program code
- Data – global variables
- Stack – local variables for function call
- Heap – dynamic memory allocation

the stack and heap sections grow toward one another, the operating system must ensure they do not overlap one another

Layout of a process in memory

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The Processes

- Just now we assume that there is only one CPU (with single core) in our system.
- Multiprogramming – several jobs are loaded in a memory, operating system simulate **Pseudo parallelism (virtual)**.
- OS schedule the CPU times for processes by switches from one process to another based on the scheduling algorithm and process state (by short-term scheduler).

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The Processes

CPU

ALU

Registers

Control Unit

↔

RAM

Job1

Job2

Job3

OS

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The Processes



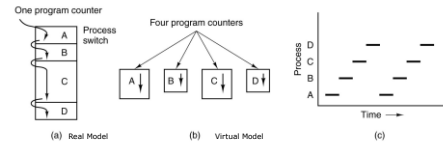
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The Process Model

We can consider processes as two different point of view.

- **Real Model** – Multiprogramming
- **Conceptual (virtual) Model** – each process has its own virtual CPU, PC, registers, stack pointer
- Check the following concept
 - Virtual machine–each OS run on its own machine
 - Virtual memory – each process has its own Memory
 - Virtual process model – each process run on it's own machine

The Process Model



The Process Model

- With the CPU switching back and forth among the processes, a process can hold CPU during its time term.
- The time term which assigned to each processes might not be uniform.
- The time term for a process might need be calculated based on the types of jobs – I/O bounded, CPU bounded or priority (usually CPU bounded job need more CPU time then I/O bounded job).

Process Creation

Process Creation

- **System initialization** – When an OS is booted, several processes are created and run concurrently.
- **A running process create a process by system call**– running process request a system call to create one or more new processes – web server example
- **A system user create by executing a program** – in interactive system, users can start a program by typing a command or click icon
- **Initiation of a batch job** – mainframe computer

Process Creation

- UNIX – system call **fork** create a new process
- In Window – system call **CreateProcess** create a new process
- Once a child process is created, both parent and child have their own distinct address – two process might need inter-process communication (for sharing resources)

Process Termination

A process terminate due to one of the following condition

- **Normal exit** – a process finish their job (**voluntary**)
- **Error exit** – the process discovers a fatal error – compiler try to compile a program, there is no such a file (**voluntary**).
- **Fatal error** – error caused by the process– a process try to modify the memory location where other process is located (**involuntary**)
- **Killed by another process** – a deadlock is occurred. OS terminate a process at a time to resolve the deadlock (**involuntary**)

Process States

- A process must be in one of state
 - Running State – a process is currently being executed by using CPU.
 - Block State (or Waiting State) - The process is waiting for some event to occur (such as an I/O completion or reception of a signal).
 - Ready State – a process is ready to use CPU but it is not currently available.

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Process State

1. Process blocks for input
2. Short-Term Scheduler picks a process
3. A process time out its time term
4. Input becomes available

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Process Table (Process Control Block)

- When a process is created, OS stores its run time information in a process table (Process Control Block).
- Process table contains information associated with a process.
 - Process State – ready, running or blocked
 - Program Counter – address of next instruction
 - CPU registers – Snapshot of CPU
 - CPU scheduling information –priority, pointer to scheduling queue,...
 - Memory management information –page table, segment table,... Depends on memory management method
 - Accounting information – the amount of CPU time used, CPU time limit, job number,...
 - I/O status information – list of I/O devices allocated, list of open files,...

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Process with Multiple-Threads

- Most modern operating systems have extended the process concept to allow a process to have multiple threads of execution and thus to perform more than one task at a time.
- This feature is especially beneficial on multicore systems, where multiple threads can run in parallel.
- A multithreaded word processor could, for example, assign one thread to manage user input while another thread runs the spell checker.
- On systems that support threads, the process table is expanded to include information for each thread.

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Process Scheduling (Scheduling Queues)

- The objective of multiprogramming to maximize CPU utilization.
- When a CPU become available, short term scheduler (CPU scheduler) select a process from the ready queue and let it use CPU.
- There are two queues which holds pointers to process tables for processes in block state and ready state.
 - Ready Queue – holds pointers to process tables for processes in ready state.
 - Wait Queues - holds pointers to process tables for processes waiting for some events(I/O devices, child termination, interrupt, semaphores).
- This queue is generally stored as a linked list; header contains pointers to the first process table in the list, and each process table includes a pointer field that points to the next PCB in the queue.

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Process Scheduling (Scheduling Queues)

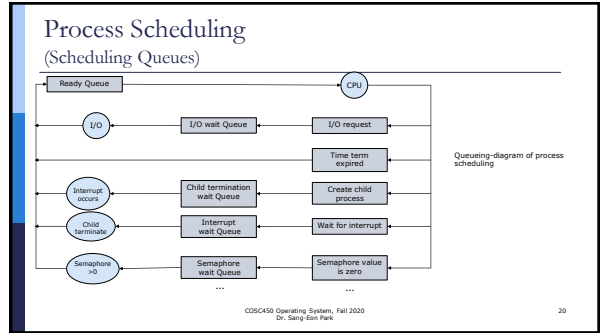
The ready queue or wait queues

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Process Scheduling (Scheduling Queues)

- Once the process is allocated a CPU and is executing, one of several events could occur:
 - The process could issue an I/O request and then be placed in an I/O wait queue.
 - The process could create a new child process and then be placed in a wait queue while it awaits the child's termination.
 - The process could be removed forcibly from the core, as a result of an interrupt or having its time slice expire, and be put back in the ready queue.
 - The process tries down semaphore but semaphore value is 0, and be placed in a wait queue for the semaphore.
 - ...

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Process Scheduling (CPU Scheduling)

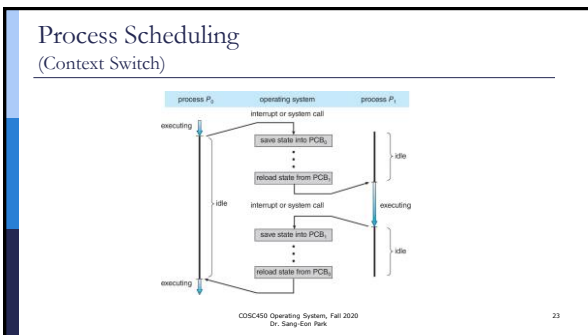
- A process migrates to the ready queue from various wait queues throughout its lifetime.
- The role of the short-term scheduler (the CPU scheduler) is to select from among the processes that are in the ready queue and allocate an available CPU.
- The short-term scheduler select a process from ready queue base on rules.
 - Shortest Job First
 - Shortest Remaining Time
 - Round Robin
 - Priority Queue
 - Guaranteed Scheduling
 - Lottery Scheduling

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Process Scheduling (Context Switch)

- Interrupts cause the operating system to change a CPU from its current task and to run a kernel routine by context switch.
- Context switch - performing a state save of the current process to its process table and a state load of a process from its process table.
- Context switch time is pure overhead, since the system does not useful work while switching.

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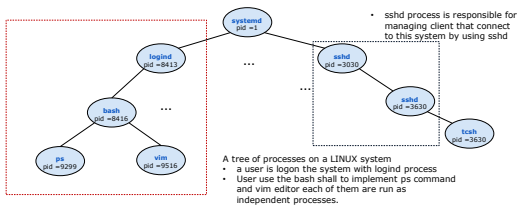


Process Creation

- A process may create several new processes. Each of these new processes may create other processes, forming a tree of processes.
- Most operating systems (including UNIX, Linux, and Windows) identify processes according to a unique process id (or pid), which is typically an integer number.
- In Linux, once the system has booted, the systemd (init in UNIX) process is created with pid = 1 and it becomes root parent process of all processes.
- The systemd process creates processes which provide additional services such as a web or print server, an ssh server, and so on

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Process Creation



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Process Creation

- Linux systems provide the `ps` command, which displays a tree of all processes in the system. Command `ps` with `-p` flag show process tree with `pid`

```
ps -p
```
- When a process creates a child process, that child process need certain resources (CPU time, memory, files, I/O devices) to accomplish its task.
- A child process may be able to obtain its resources directly from the operating system, or it may be constrained to a subset of the resources of the parent process.
- The parent may have to partition its resources among its children, or it may be able to share some resources (such as memory or files) among several of its children.

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Process Creation

- When a process creates a new process, two possibilities for execution exist.
 1. The parent continues to execute concurrently with its children by `waitpid()` system call with option.
 2. The parent waits until some or all of its children have terminated by `wait()` system call.
- There are also two address-space possibilities for the new process:
 1. The child process is a duplicate of the parent process (it has the same program and data as the parent).
 2. The child process has a new program loaded (with `exec`) into it and run.

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Process termination

- A process terminates by calling the `exit()` system call. At that point, the process may return a status value (typically an integer) to its waiting parent process (via the `wait()` system call).
- All the resources of the process are deallocated and reclaimed by the operating system.
- A parent process may possibly terminate one of its children by using signal with signal handler for several reason.
 - The child has exceeded its usage of some of the resources that it has been allocated (when parent and child run currently, parent send signal to a child process to terminate it)
 - In some system, the parent is exiting and the OS does not allow a child to continue if its parent terminates.

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Process Termination

- **Zombie process**
 - When a process terminates by calling `exit()` system call, its resources are deallocated by the OS. However, its entry in the process table may remain there until the parent calls `wait()`, because the process table contains the process's exit status.
 - A process that has terminated, but whose parent has not yet called `wait()`, then a process is remained as a zombie process since child status will use for parent's termination.
- **Orphans process**
 - Every process must have parent. If a parent process terminate before child process, the child process become orphan process.
 - The root process `systemd()` (init in UNIX) will be its parent.

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Process Termination

(Android Process Hierarchy)

- Because of resource constraints (limited memory), mobile operating systems may have to terminate existing processes based on a process's importance.
- The hierarchy of process classifications from most to least important is as follows:
 - **Foreground process**—The current process visible on the screen.
 - **Visible process**—A process that is not directly visible on the foreground but that is performing an activity
 - **Service process**—A process that is similar to a background process but is performing an activity that is apparent to the user (such as streaming music)
 - **Background process**—A process that may be performing an activity but is not apparent to the user.
 - **Empty process**—A process that holds no active components associated with any application

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Process Termination

(Android Process Hierarchy)

- If system resources must be reclaimed, Android will first terminate empty processes, followed by background processes, and so forth.
- Processes are assigned an importance ranking, and Android attempts to assign a process as high a ranking as possible.