Chapter 6

Implementing Processes, Threads and Resources

Introduction

- Scenario
  - One process running
  - One/more process performing I/O
  - One/more process waiting on resources
  - One process creating threads
- Most of the complexity stems from the need to manage multiple processes/threads

Introduction

- Process Manager
  - CPU sharing
  - Process synchronization
  - Deadlock prevention

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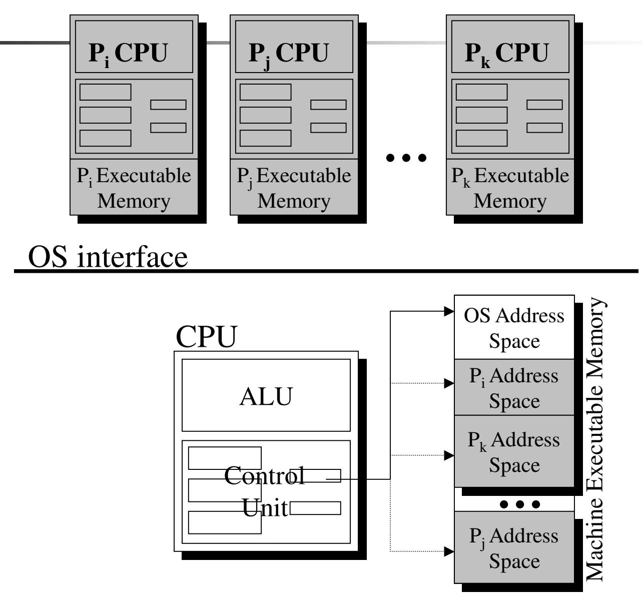
Implementing the Process Abstraction



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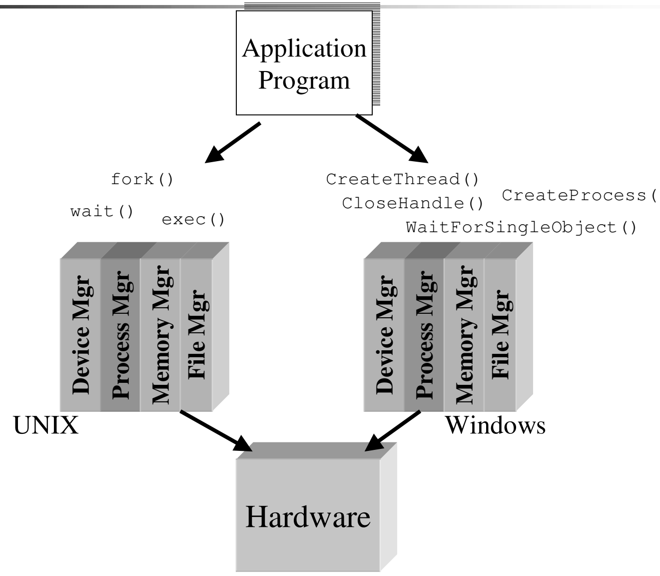
External View of the Process Manager



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Process Manager Responsibilities

- Define & implement the essential characteristics of a process and thread
  - Algorithms to define the behavior
  - Data structures to preserve the state of the execution
- Define what "things" threads in the process can reference – the *address space* (most of the "things" are memory locations)
- Manage the resources used by the processes/threads
- Tools to create/destroy/manipulate processes & threads

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Process Manager Responsibilities

- Tools to time-multiplex the CPU – Scheduling the (Chapter 7)
- Tools to allow threads to synchronization the operation with one another (Chapters 8-9)
- Mechanisms to handle deadlock (Chapter 10)
- Mechanisms to handle protection (Chapter 14)

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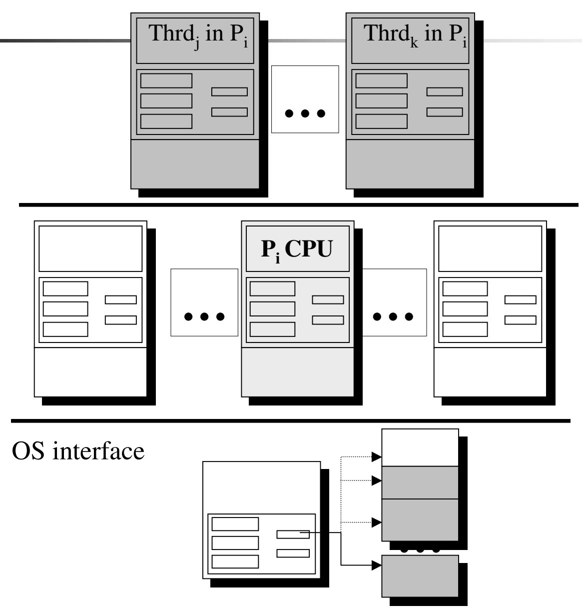
Modern Processes and Threads



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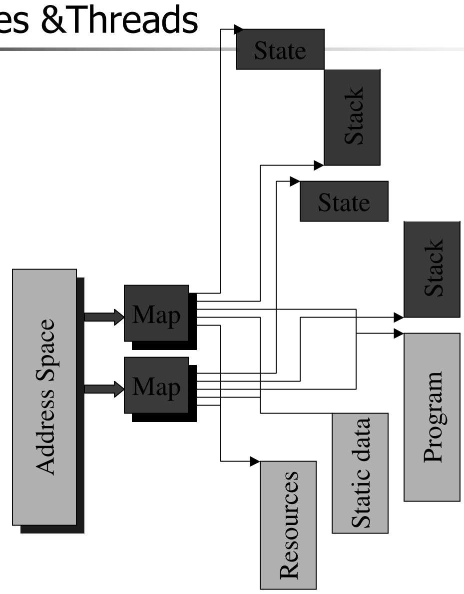
Processes &Threads



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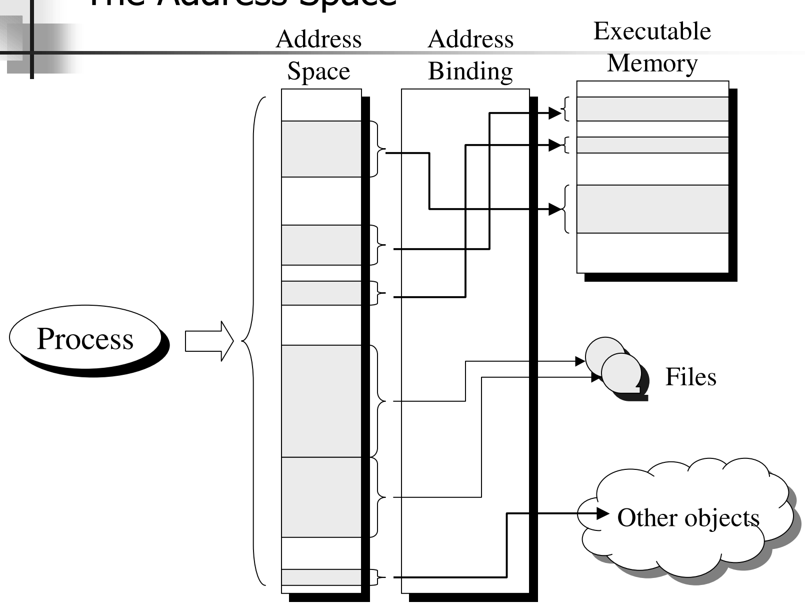
The Address Space



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Building the Address Space

- Some parts are built into the environment
  - Files
  - System services
- Some parts are imported at runtime
  - Mailboxes
  - Network connections
- Memory addresses are created at compile (and run) time

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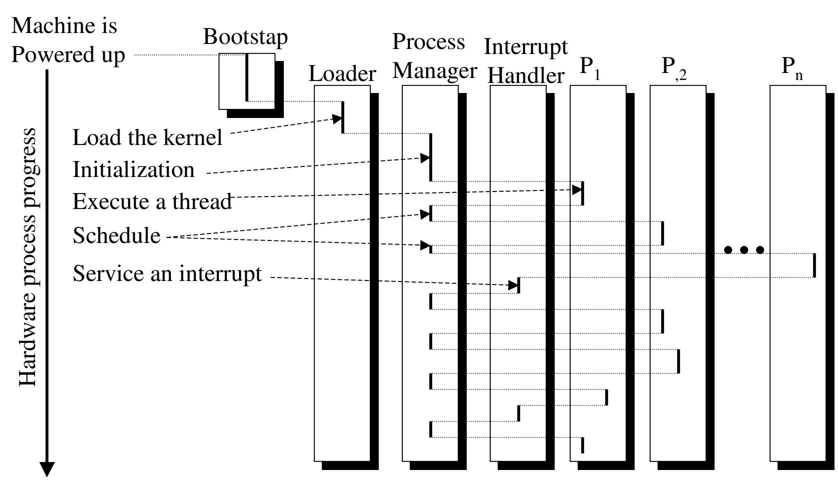
Tracing the Hardware Process



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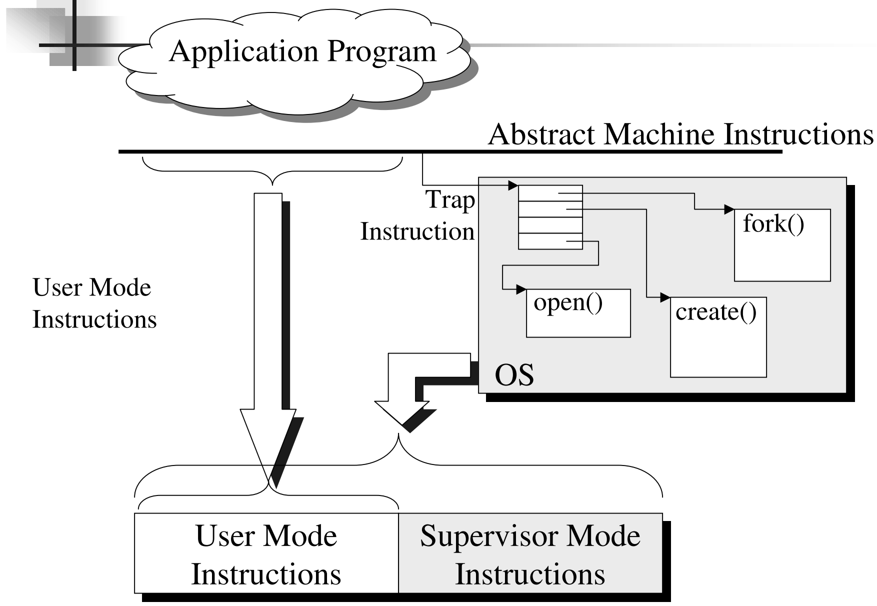
The Abstract Machine Interface



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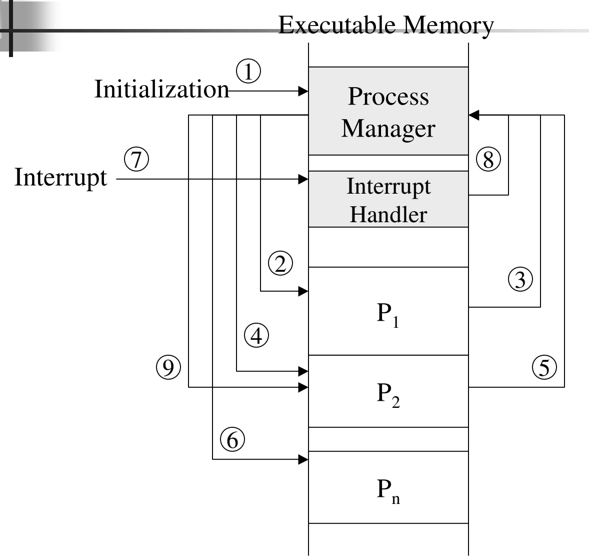
Context Switching



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Process components

- Program
  - defines behavior
- Data
- Resources
- Process Descriptor
  - keeps track of process during execution

Process Descriptors

- OS creates/manages process abstraction
- Descriptor is data structure for each process
  - Register values
  - Logical state
  - Type & location of resources it holds
  - List of resources it needs
  - Security keys
  - etc. (see Table 6.1 and the source code of your favorite OS)

Process Descriptor

FIELD	DESCRIPTION
Internal process name	An internal name of the process, such as an integer or table index, used in the operating system code.
State	The process's current state.
Owner	A process has an owner (identified by the owner's internal identification such as the login name). The descriptor contains a field for storing the owner identification.
Parent process descriptor	A pointer to the process descriptor of this process's parent.
List of child process descriptors	A pointer to a list of the child processes of this process.
List of reusable resources	A pointer to a list of reusable resource types held by the process. Each resource type will be a descriptor of the number of units of the resource.
List of consumable resources	Similar to the reusable resource list (see Section 6.3.2).
List of file descriptors	A special case of the reusable resource list.
Message queue	A special case of the consumable resource list.
Protection domain	A description of the access rights currently held by the process (see Chapter 14).
CPU status register content	A copy of each of the CPU status registers at the last time the process exited the running state.
CPU general register content	A copy of each of the CPU general registers at the last time the process exited the running state.

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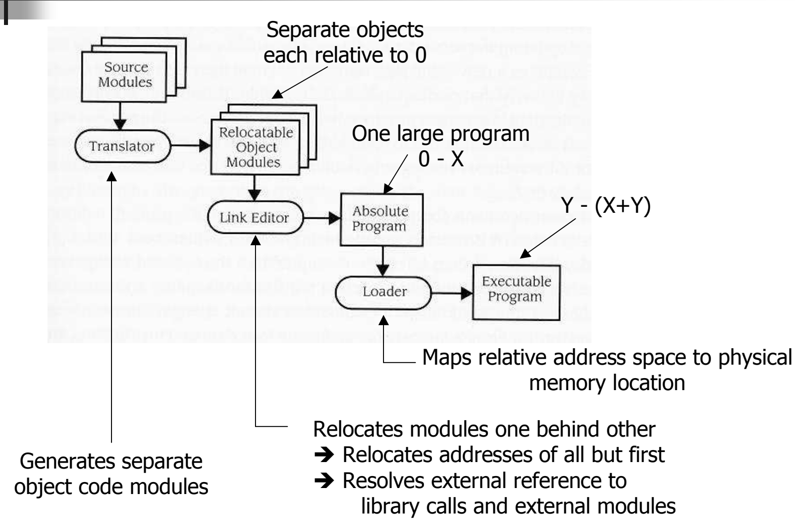
Creating an executable program



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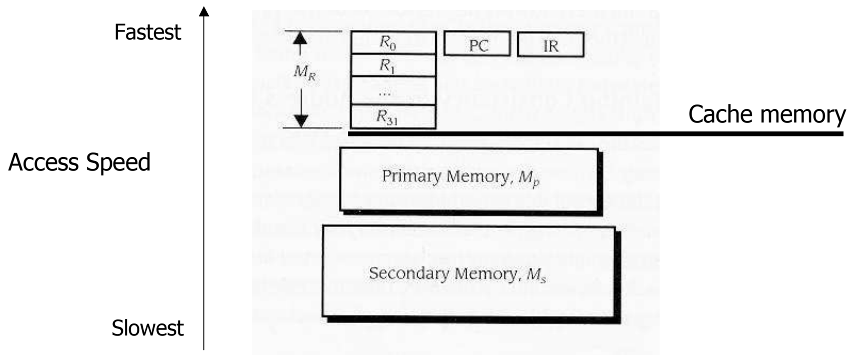
Basic Memory Hierarchy



Basic Memory Hierarchy…

- At any point in the same program, element can be in
  - Secondary memory M_S
  - Primary memory M_P
  - Registers M_R
- Consistency is a Problem
  - $M_S \neq M_P \neq M_R$ (code vs data)
  - When does one make them consistent?

Consistency Problem

- Scheduler switching out processes – Context Switch
- Is Instruction a Problem ???
  - NO
  - Instructions are never modified
  - Separate Instruction and Data space
  - Therefore, $M_{R_j} = M_{P_j} = M_{S_j}$

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Consistency Problem…

- Is Data a Problem ???
  - YES
  - Variable temporarily stored in register has value added to it
  - Therefore, $M_{R_j} \neq M_{P_j}$
- On context switch, all registers are saved
  - Therefore, current state is saved

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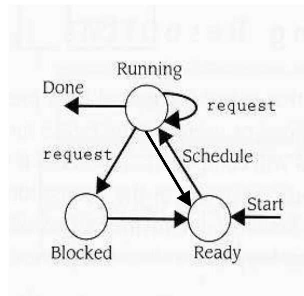
Process States

- Focus on Resource Management & Process Management

- Recall also that part of the process environment is its ***state***



State Transition Diagram

Process States…

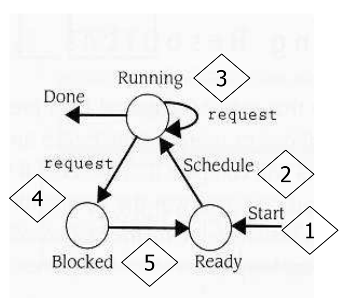
1. When process enters 'Ready' state, it must compete for CPU. Memory has already been allocated

2. Process has CPU

3. Process requests resource that is <u>immediately</u> available →NO blocking

4. Process requests resource that is <u>NOT</u> yet available

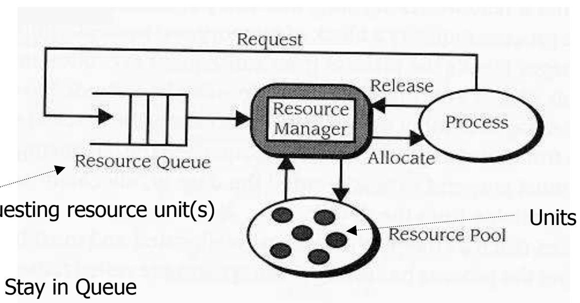
5. Resource allocated, memory re-allocated?



State Transition Diagram

Resources & Resource Manager

- 2 types of Resources
  - Reusable (Memory)
  - Consumable (Input/Time slice)



Process requesting resource unit(s)

→ Get it, or

→ Block => Stay in Queue

Units of Resource R

Resource Descriptor

- Each Resource R has a Resource Descriptor associated with it (similar to the process)
  => there is a "Status" for that Resource, and
  => a Resource Manager to manage it

Parts of a Resource Descriptor

FIELD	DESCRIPTION
Internal resource name	An internal name for the resource used by the operating system code. **/dev/...**
Total units	The number of units of this resource type configured into the system. **6**
* Available units	The number of units currently available. **3**
List of available units	The set of available units of this resource type that are available for use by processes. **A, B, C**
List of blocked processes	The list of processes that have a pending request for units of this resource type. **Only if * = 0**

Creating Processes

- Parent Process needs ability to
  - Block child
  - Activate child
  - Destroy child
  - Allocate resources to child

- True for User processes spawning child
- True for OS spawning `init`, `getty`, etc.
- Process hierarchy a natural,
  if `fork`/`exec` commands exist

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Factoring in additional Control Complexities

- Recall:
  - A parent process can suspend a child process

- Therefore, if a child is in run state and goes to ready (time slice up), and the parent runs and decides to suspend the child, then how do we reflect this in the process state diagram ???

- We need 2 more states
  - Ready suspended
  - Blocked suspended

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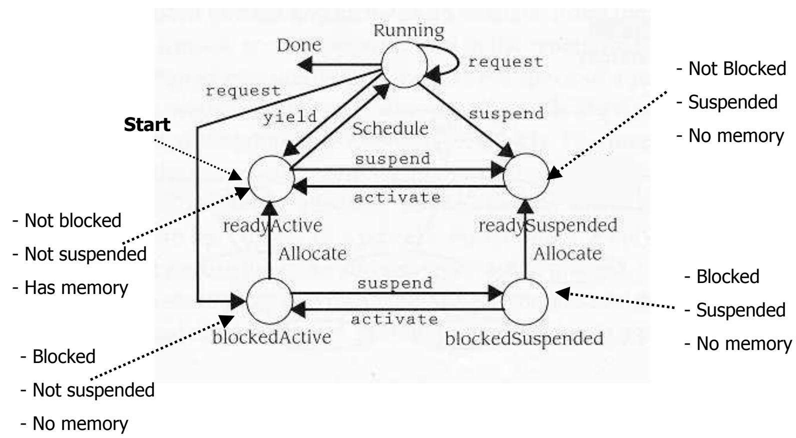
Process State diagram reflecting Control



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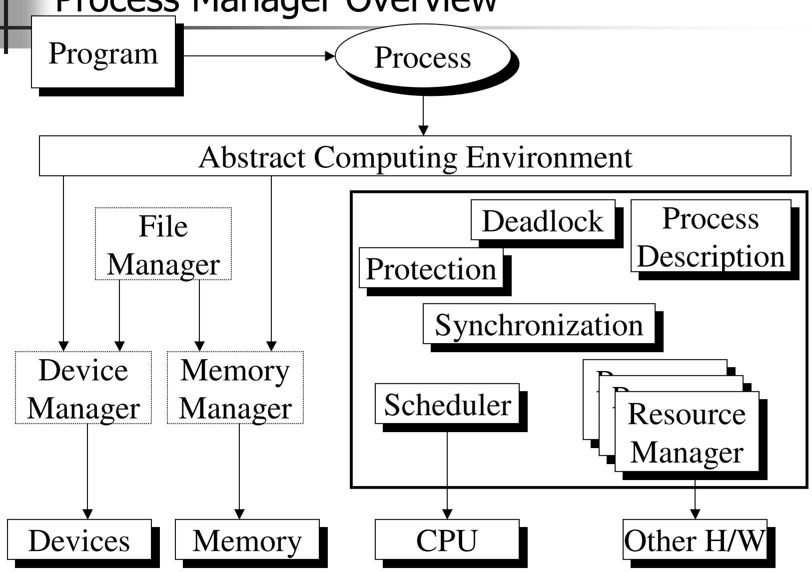
Process Manager Overview



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Process Management under Linux

Mir Farooq Ali

Processes in Linux

- Also called *tasks*
- Task table or process table defined in src/linux/include/sched.h

```
extern struct task_struct
  *pidhash[PIDHASH_SZ];
```

- Can also be accessed as a doubly-linked list `p->next_task` and `p->prev_task`

Process or task descriptor

- Called task_struct
- Present in src/include/linux/sched.h
- Contains various fields to indicate
  - state
  - priority
  - pointers to parent, children, other tasks in pid list
  - tty
  - memory location
  - file descriptors
  - …

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Process States

- Linux identifies six different states including

1. TASK_RUNNING
2. TASK_INTERRUPTIBLE
3. TASK_UNINTERRUPTIBLE
4. TASK_ZOMBIE
5. TASK_STOPPED
6. TASK_EXCLUSIVE

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Process Creation

- Remember in traditional UNIX, we use fork() and then typically exec()
- fork() duplicates resources owned by parent for child process and copies them to new address space
- This method is slow and inefficient, since exec() wipes out address space anyway

Process creation in Linux

- Copy-On-Write technique
- Lightweight processes
- vfork()

Copy-on-write

- Child pages are pointers to parent pages
- If child makes a change to a page, a new copy is made for the child
- This way, you avoid making separate copies of pages unnecessarily

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Lightweight processes

- Allow parent and child processes to share many kernel data structures
- created in Linux by function called __clone()
- uses non-standard clone() system call

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vfork()

- Creates a process that shares memory address of parent
- Parent is blocked until child exits or executes a new program by doing exec()

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User view of processes

- Can use ps command with various options, for example,
  - ps –aux
  - ps –ef

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/proc file system

- process information pseudo file system
- Do `man proc` to get more info
- /proc directory contains
  - Numerical subdirectory for each running process
  - A number of other files containing kernel table information

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/proc… continued

- Files include
  - cpuinfo – contains CPU specs
  - uptime – time in secs since machine was last rebooted and idle time since then
  - version – kernel version
  - loadavg – Load average of machine over the past 1, 5 and 15 minutes
  - …

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Process directories

- One subdirectory for each running process
- Files include
  - cmdline
  - cwd
  - environ
  - exe
  - fdm
  - map
  - mem
  - root

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References

- Linux Kernel 2.4 internals, Tigran Aivazian http://www.tldp.org/LDP/lki/
- Modern Operating Systems, 2nd Ed., A. Tanenbaum
- Understanding the Linux Kernel, D. Bovet, and M. Cesati

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