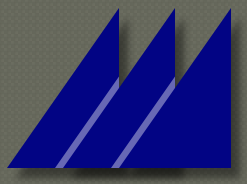


Department of Physics,
Computer Science & Engineering

CPSC 410 – Operating Systems I

Chapter 3: Process Description & Control

Keith Perkins

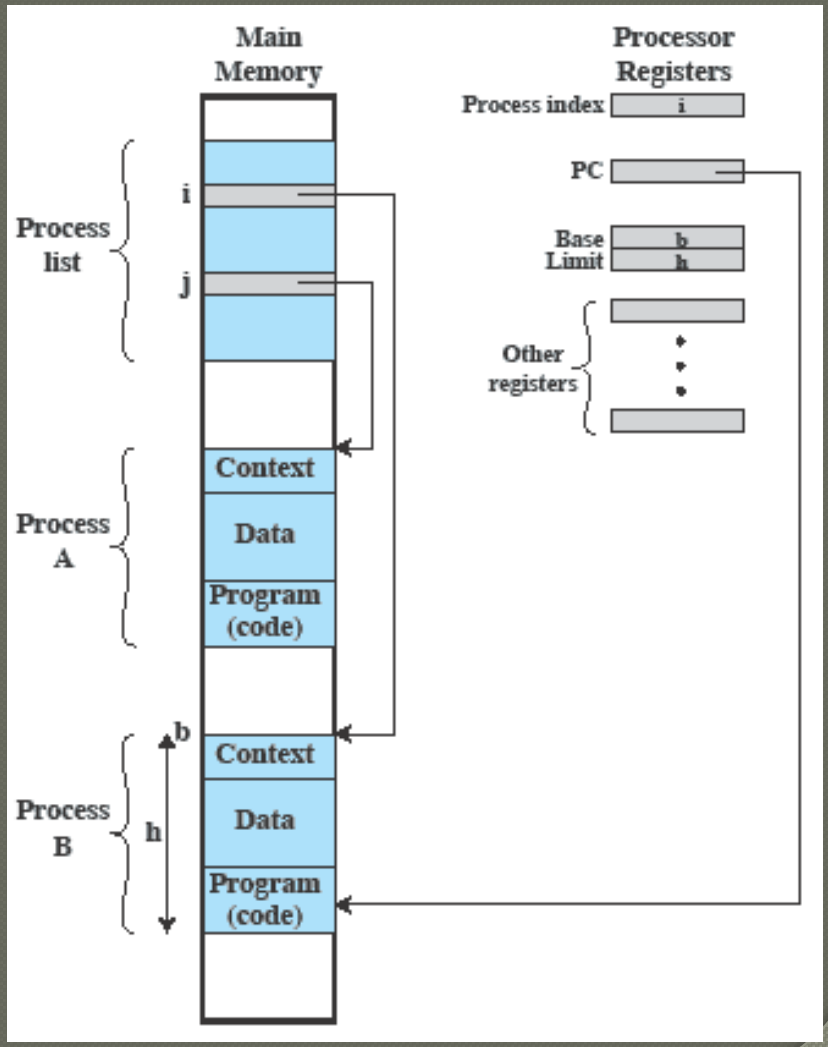
Adapted from original slides by Dr. Roberto A. Flores

Chapter 3 Topics

- Everything about Processes
  - Control blocks
  - States
  - Description
  - Control
- OS Execution
- Security Issues

Revisit - Process Management

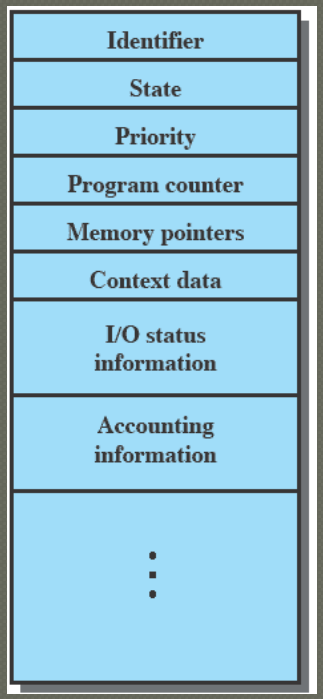
- Scheduler chooses a process to run (more later)
- Dispatcher runs it
- How? What's in the Process List?
- BTW this list is a simplification



Processes

Control Blocks

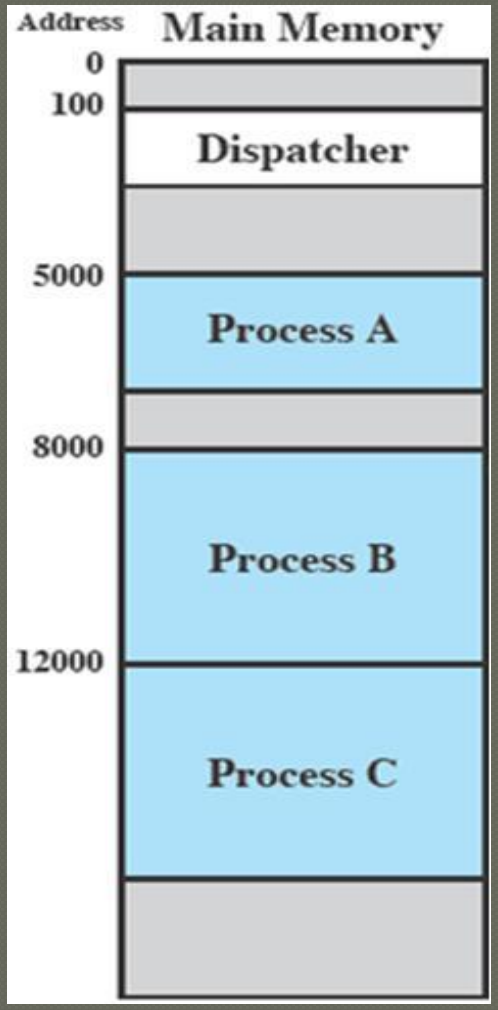
- data structure created & managed by OS
  - Identifier: unique ID
  - State: (e.g., running, blocked)
  - Priority: relative to other processes
  - Program counter: address of next instruction
  - Memory pointers: to code & data
  - I/O status: I/O in use/pending
  - Accounting: CPU time used, IDs, …
- data to hold/restore process state on interrupt/resume
  - key to support multiprocessing



Control blocks
States
Description
Control

Processes

- Dispatcher
  - Program that switches processes in/out of the CPU



Processes

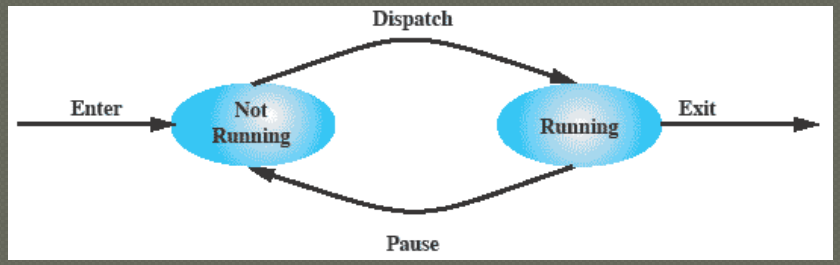
- States
  - Trace
    - Instructions executed by a process
    - In multiprogramming:
      - interleaving of instructions as processes alternate using the CPU
  - The pale blue lower right is dispatcher code
  - Process switches because of Interrupts (timer, I/O)

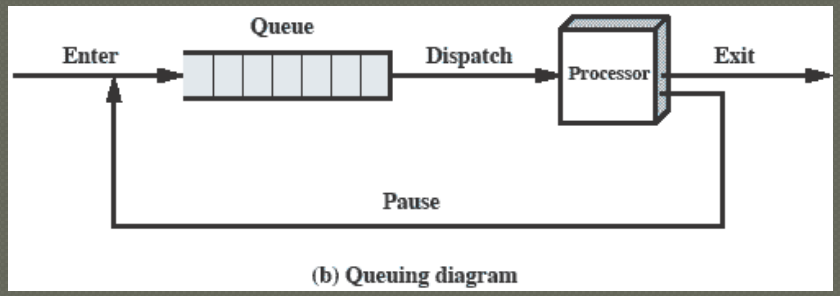
(a) Trace of Process A	(b) Trace of Process B	(c) Trace of Process C
5000	8000	12000
5001	8001	12001
5002	8002	12002
5003	8003	12003
5004		12004
5005		12005
5006		12006
5007		12007
5008		12008
5009		12009
5010		12010
5011		12011

1	5000	27	12004
2	5001	28	12005
3	5002	---------- Timeout	
4	5003	29	100
5	5004	30	101
6	5005	31	102
---------- Timeout		32	103
7	100	33	104
8	101	34	105
9	102	35	5006
10	103	36	5007
11	104	37	5008
12	105	38	5009
13	8000	39	5010
14	8001	40	5011
15	8002	---------- Timeout	
16	8003	41	100
---------- I/O Request		42	101
17	100	43	102
18	101	44	103
19	102	45	104
20	103	46	105
21	104	47	12006
22	105	48	12007
23	12000	49	12008
24	12001	50	12009
25	12002	51	12010
26	12003	52	12011
		---------- Timeout	

Processes

- States (2 states)
  - One CPU
  - Round-robin (timeout)
  - Running: CPU time!
  - Not running: or not





(b) Queuing diagram

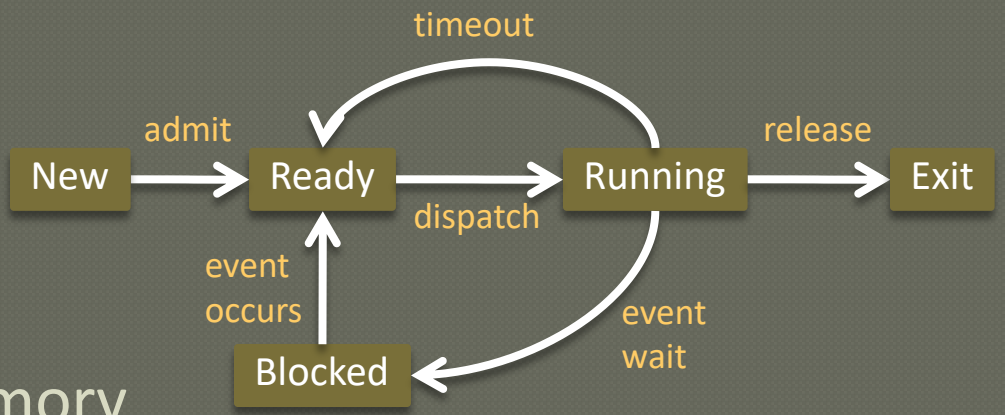
- Where do processes come from?
- When do they stop?

Processes

- Where do processes come from? (start)
  - New batch job: Next job in the incoming batch stream
  - Interactive logon: User in terminal logs in
  - OS service: OS-provided service (e.g., print spooler)
  - Spawned by process: uses parallelism (parent spawns child)
- When do they end? (termination)
  - Normal
    - Job finishes, user logs off, OS shutting down, etc.
  - Abnormal
    - Timeout: running too long
    - Resource error: out of memory, I/O device unresponsive, deadlock
    - Runtime error: arithmetic operation, uninitialized variable
    - Authorization error: memory out of bounds, resource/instruction privilege

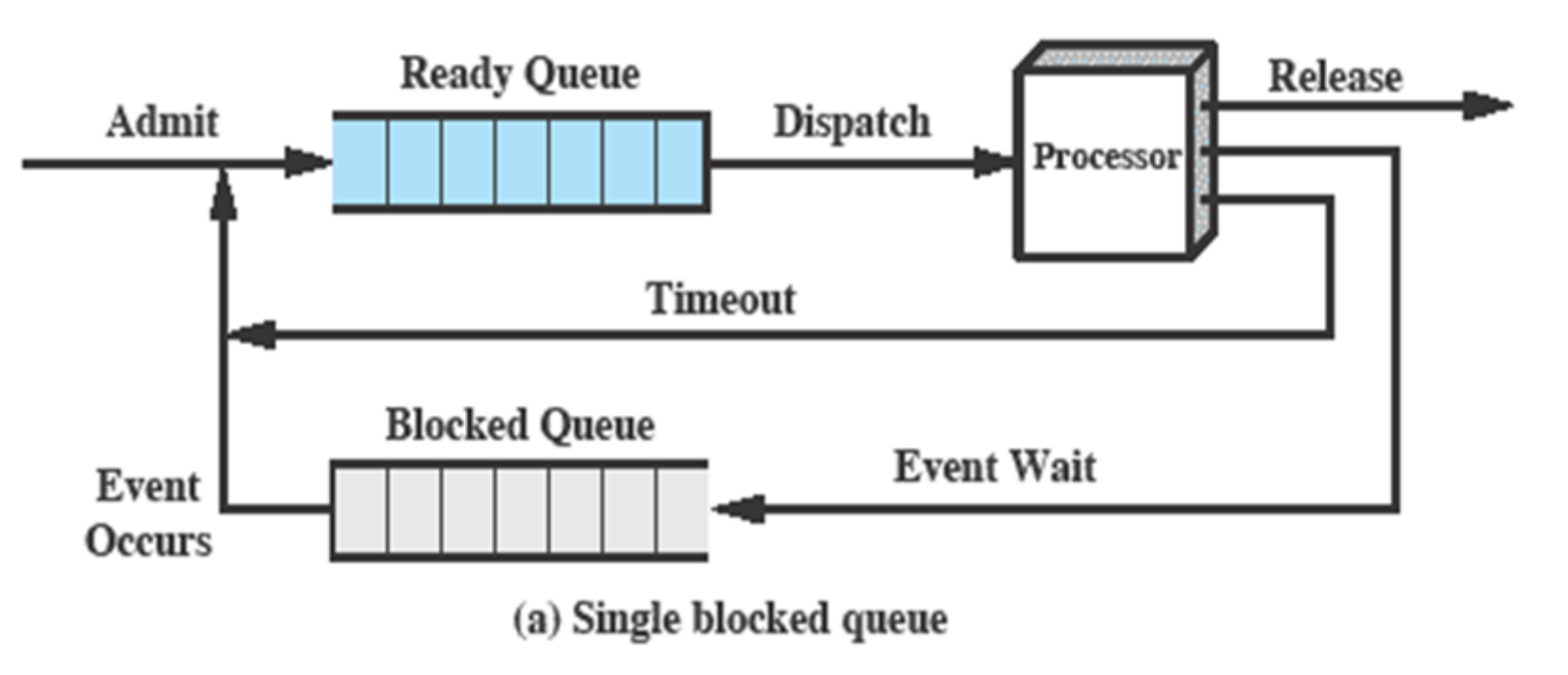
Processes

- States (5 states)



- New: not yet in memory
- Ready: awaiting its turn
- Running: CPU time!
- Blocked: waiting for I/O
- Exit: done & gone

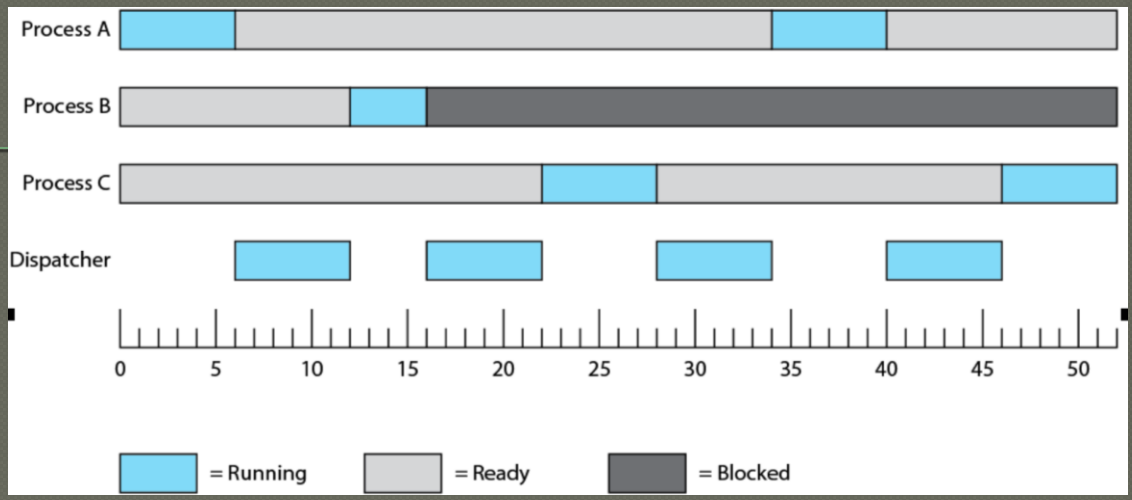
Using Two Queues



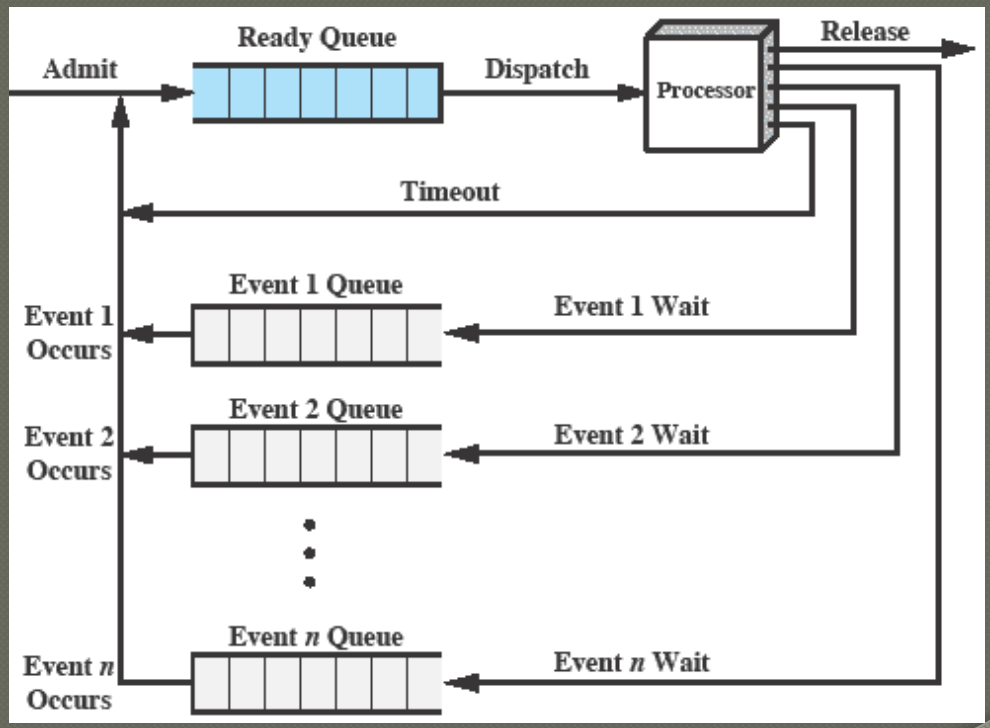
(a) Single blocked queue

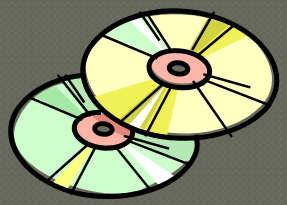
States (5 states)

- e.g., Processes A, B & C



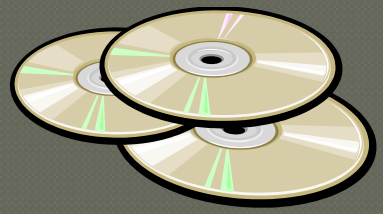
- Multiple block queues (1 per I/O device)





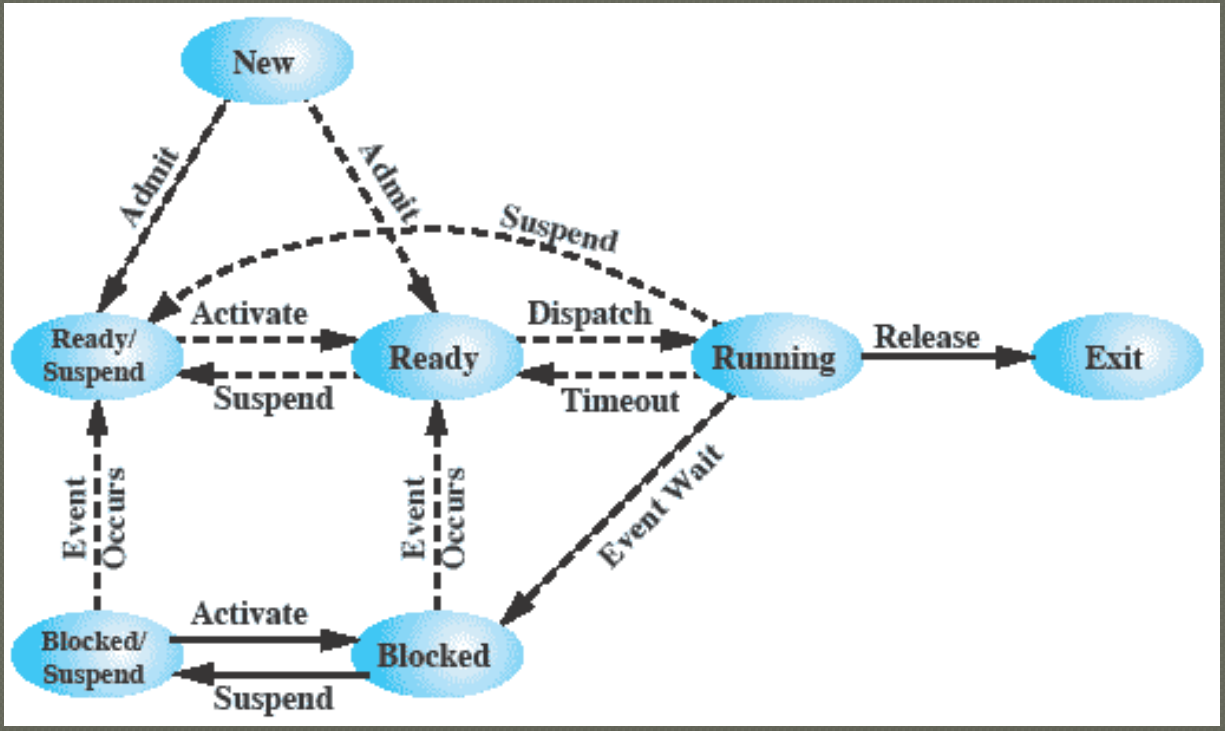
Suspended Processes

- Swapping
  - involves moving part of all of a process from main memory to disk
  - when none of the processes in main memory is in the Ready state, the OS swaps one of the blocked processes out on to disk into a suspend queue



Processes

- States (7 states)
  - What if not all processes fit in memory at once?
    - Suspended: when a process has been swapped to disk



Structure of Process Images in Virtual Memory

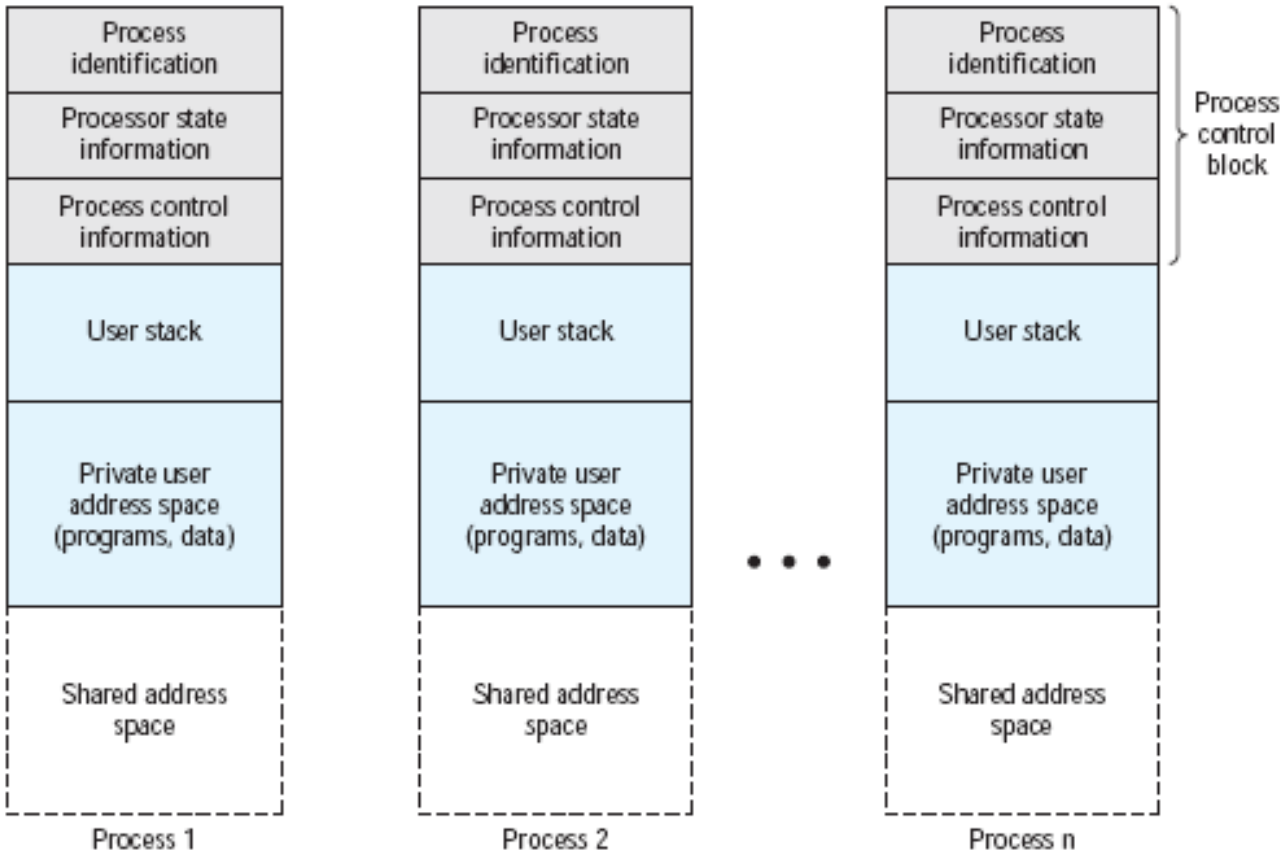


Figure 3.13 User Processes in Virtual Memory

Process List Structures

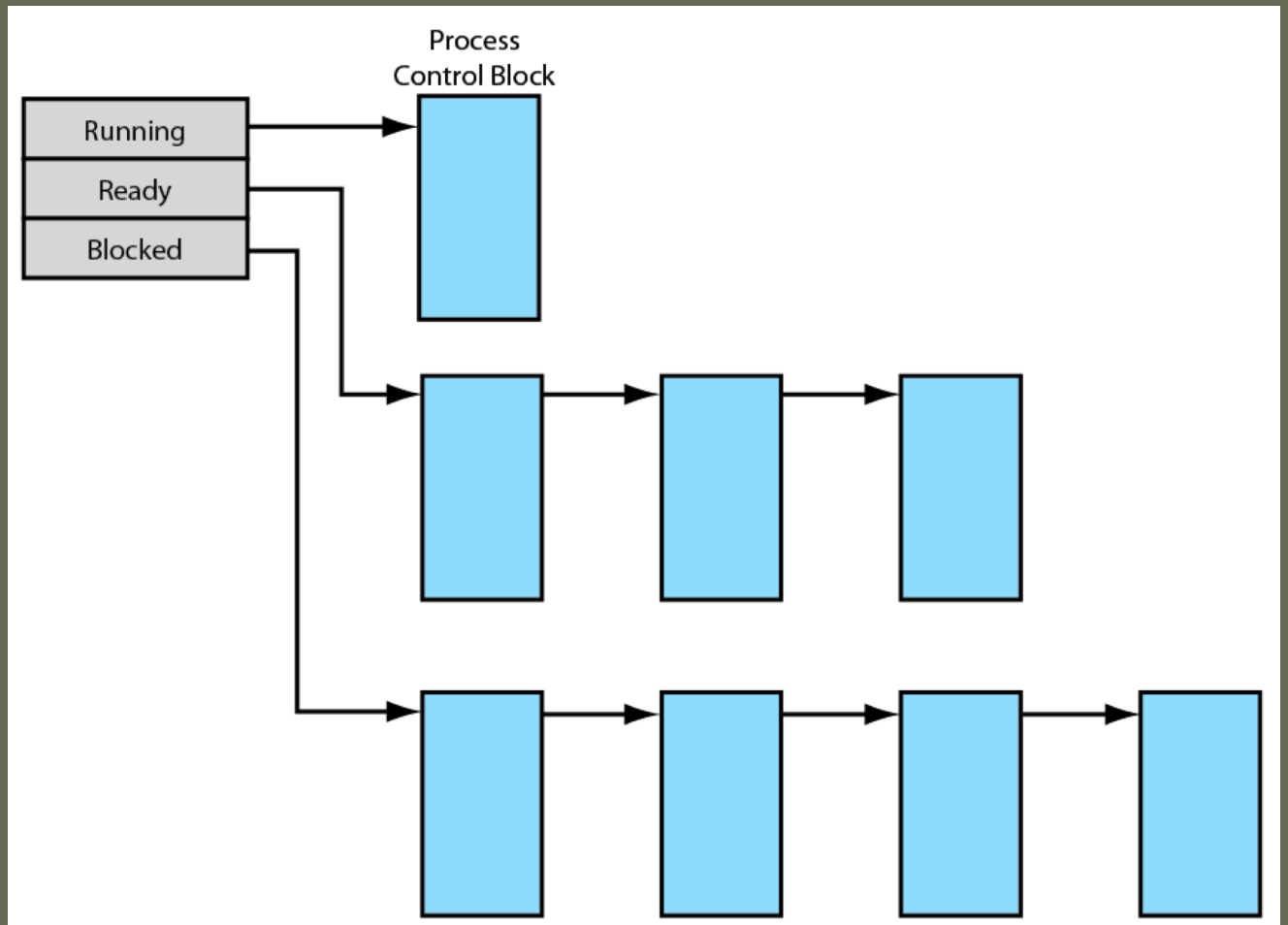


Figure 3.14 Process List Structures

Processes

- Process tables
  - keep data about each process (process image)
    - user data: modifiable part of program, e.g., variables
    - user program: program to execute
    - stack: stores method calls & parameters
    - process control block (PCB): data OS uses to control process
      - process identification: process/parent/user ID
      - processor state information: user/control registers, stack pointers
      - process control information: scheduling, inter-process comms, …
  - reference (directly/indirectly) memory, I/O & file tables

Processes

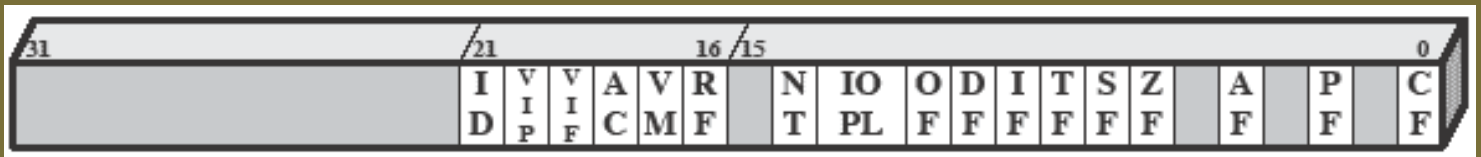
Process tables

Process identification
- Each process has a unique ID
- IDs are used for reference:
  - in other tables
  - in inter-process communication
  - when a parent spawns a child process

- process identification: process/parent/user ID
- processor state information: user/control registers, stack pointers
- process control information: scheduling, inter-process comms, …

- reference (directly/indirectly) memory, I/O & file tables

Process state information
- stack pointers
- user-visible registers
- control & status registers
  - program status word (PSW), e.g., EFLAGS in x86 processors



ID = Identification flag
VIP = Virtual interrupt pending
VIF = Virtual interrupt flag
AC = Alignment check
VM = Virtual 8086 mode
RF = Resume flag
NT = Nested task flag
IOPL = I/O privilege level
OF = Overflow flag

DF = Direction flag
IF = Interrupt enable flag
TF = Trap flag
SF = Sign flag
ZF = Zero flag
AF = Auxiliary carry flag
PF = Parity flag
CF = Carry flag

- processor state information: user/control registers, stack pointers
- process control information: scheduling, inter-process comms, …
- reference (directly/indirectly) memory, I/O & file tables

Processes

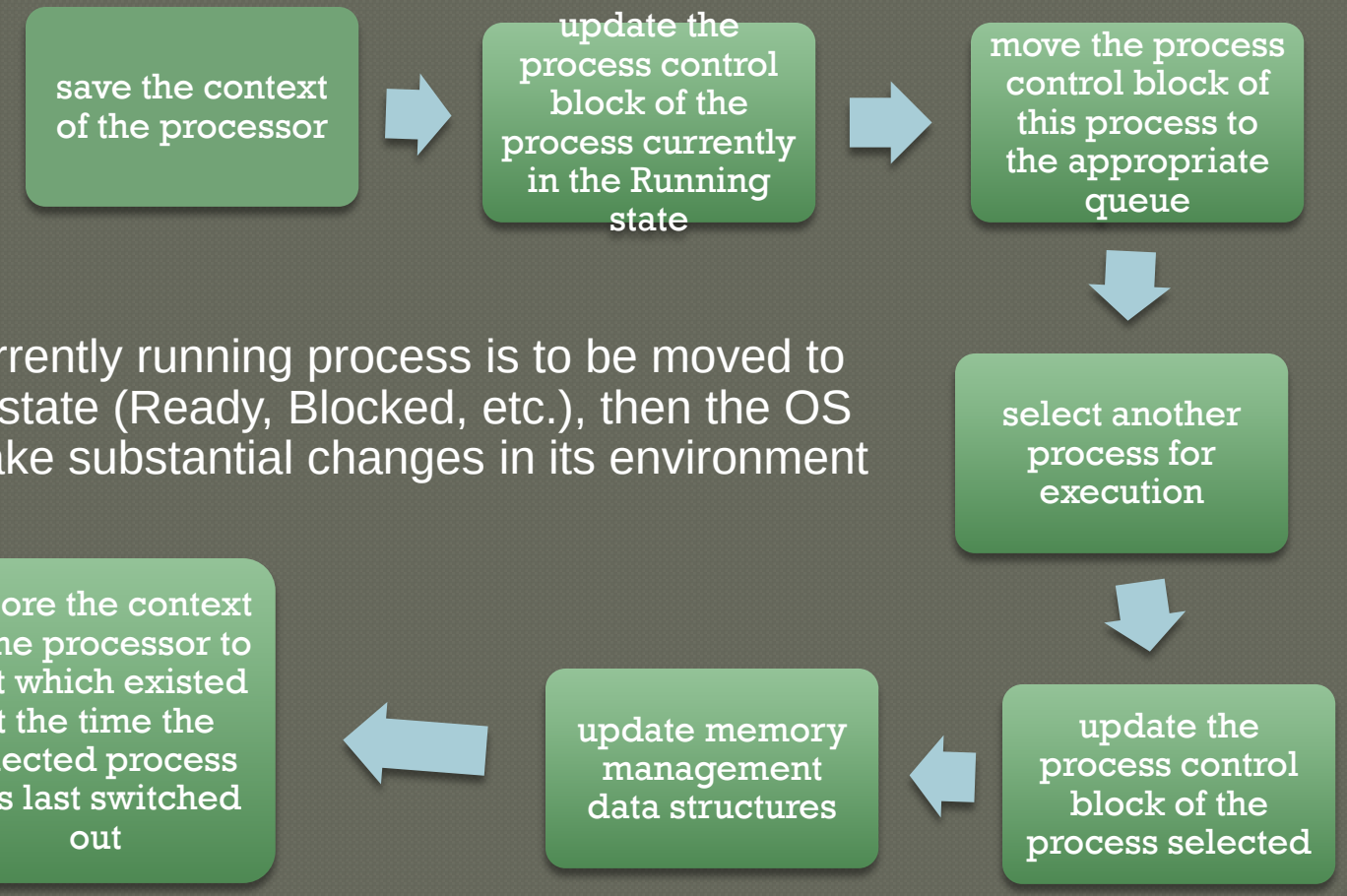
- Control
  - Modes of execution
    - User mode (-privileged) … Kernel mode (+privileged)
  - Process creation
    - What does OS do when a process is created?
      - assigns a new unique ID
      - allocates space for the process
      - initializes its process control block & sets it in place (e.g., ready list)
  - Process switching
    - Process is running…what events can give control back to OS?
      - interrupt: reaction to asynchronous external event (clock, I/O, …)
      - trap: reaction to an error or exception (recovery…?)
      - supervisor call: call to an OS instruction

Processes

- Control
  - Process is running…is an interrupt pending?
    - If not, fetch next instruction
    - If yes, point PC to interrupt handler, switch to kernel mode
  - Process is running…but it's changing state
    - (e.g., running->blocked) what does OS do?

Change of Process State

- The steps in a full process switch are:



If the currently running process is to be moved to another state (Ready, Blocked, etc.), then the OS must make substantial changes in its environment

Mode Switching

If no interrupts are pending the processor:

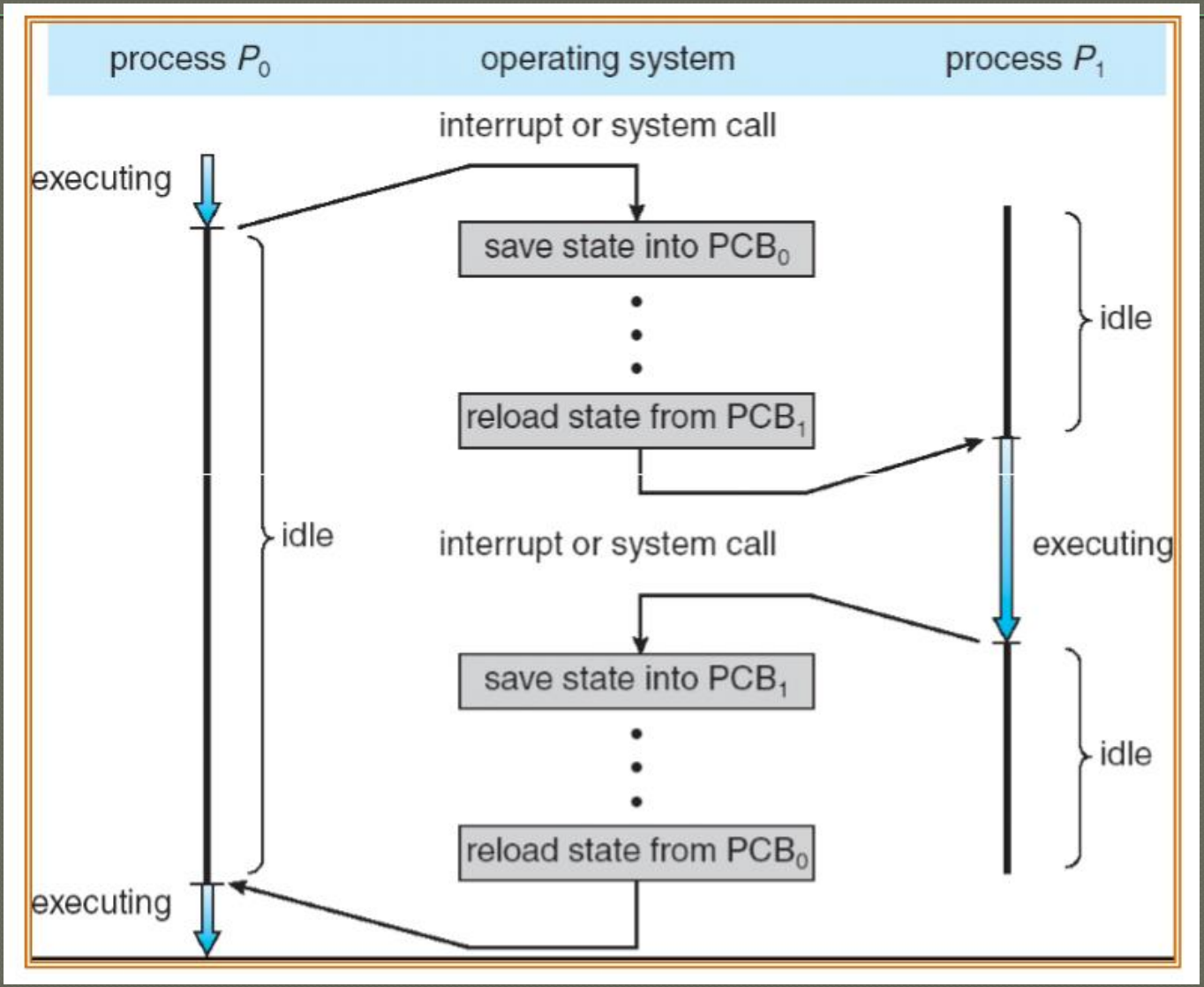
proceeds to the fetch stage and fetches the next instruction of the current program in the current process

If an interrupt is pending the processor:

sets the program counter to the starting address of an interrupt handler program

switches from user mode to kernel mode so that the interrupt processing code may include privileged instructions

Interrupts


process P_0
operating system
process P_1
interrupt or system call
executing
save state into PCB_0
idle
reload state from PCB_1
idle
interrupt or system call
executing
save state into PCB_1
idle
reload state from PCB_0
executing

Chapter 3 Topics

- Everything about Processes
  - Elements
  - Control blocks
  - States
  - Description
  - Control
- OS Execution
- Security Issues

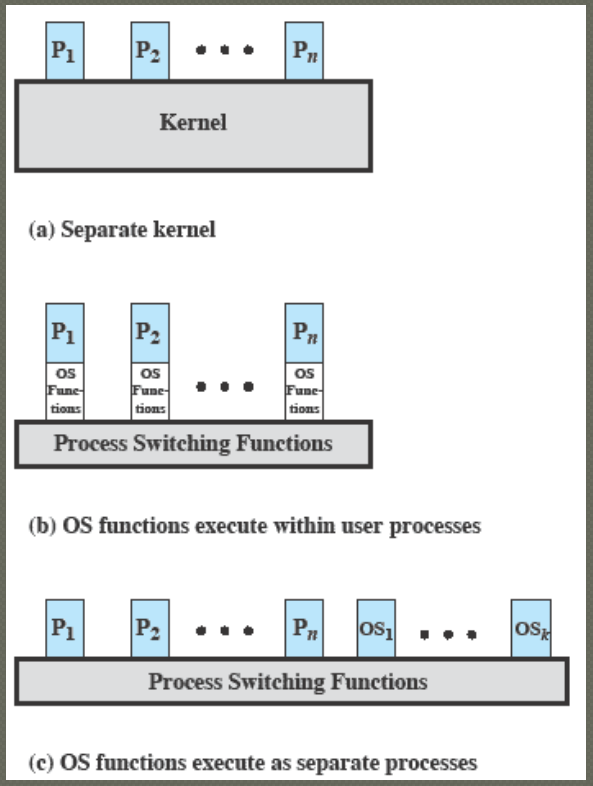
OS Execution

- OS is software, right?
  - How is it different from just another process?
  - How is it controlled?

a) Non-process Kernel
- Processes are processes. The kernel is the kernel.

b) Execution within user processes
- OS is a bare process switching mechanism
- OS routines are linked to user programs (OS data is shared)

c) Process-based OS
- OS routines run as independent processes
- Modular approach for parallelism (e.g., OS in one CPU, user processes in another)



Execution *Within* User Processes

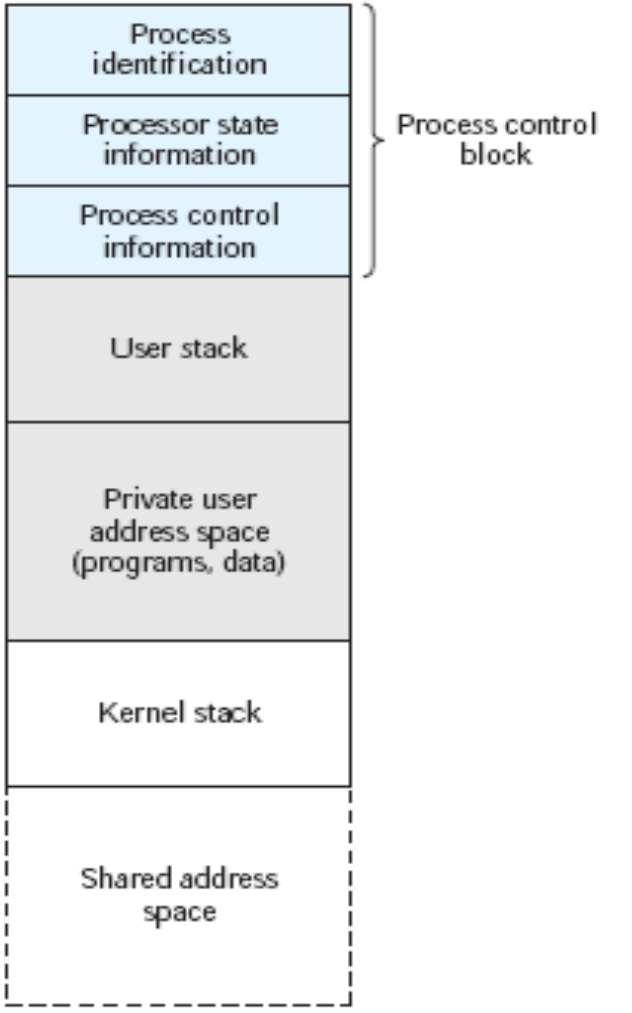


Figure 3.16 **Process Image: Operating System Executes within User Space**

Chapter 3 Topics

- Everything about Processes
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  - Control
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- Security Issues

Security

- Protecting computer resources
  - OS should prevent (or at least detect) users/malware attempts to gain unauthorized access
  - Privileges
    - Users have privilege levels (highest: administrator/root)
    - Processes have (at most) the same privilege as their user
- Threats
  - A potential violation of security, given a circumstance/capability/action/event breaching security and causing harm.
- Countermeasures
  - An action/technique that eliminates/prevents/minimizes/reports a threat.

[RFC 4949, 2007, http://tools.ietf.org/html/rfc4949]

Security

- Threats
  - Goal: gain access to / increase privileges in system
  - Intruders (hacker | cracker)
    - Misfeasor: user seeking more than allowed | misusing resources
    - Masquerader: non-user posing as legitimate user
    - Clandestine user: (non-) user seeking root privilege
  - Malicious software (malware)
    - Sophisticated (harmless -> crippling)
    - Parasitic (needs host program)
      - virus: self-replicating code embedded into another program
      - logic bomb: routine activated under certain conditions
      - backdoor: non-regular access to system (left by designers)
    - Independent: worm (virus-minus-host)

Security

- Countermeasures
  - Intrusion detection
    - Service monitoring system events, warning about attempts to access resources in an unauthorized manner.
    - 3 logical components
      - sensing >> analyzing >> reporting (UI)
  - Authentication
    - Process of verifying an identity claimed by a system entity.
      - Identification: representative token
      - Verification: examining token
  - Firewalls
    - Computer controlling network traffic (based on policies)

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