Process Description and Control

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Introduction

- The fundamental task of any operating system is process management.
- OS must allocate resources to processes, enable sharing of information, protect resources, and enable synchronization among processes.
- In many modern OS the problems of process management is compounded by introduction of threads.
- We will process management in this lecture and threads in the next.

Topics for discussion

- Requirement of process
- Process states
- Creation, termination and suspension
- Five State Model
- Process Control Block (PCB)
- Process control
- Unix System V
- Summary

What is a process?

- A process is simply a program in execution: an instance of a program execution.
- Unit of work individually schedulable by an operating system.
- OS keeps track of all the active processes and allocates system resources to them according to policies devised to meet design performance objectives.
- To meet process requirements OS must maintain many data structures efficiently.
- The process abstraction is a fundamental OS means for management of concurrent program execution. Example: instances of process co-existing.

Major requirements

- OS must interleave the execution of a number of processes to maximize processor use while providing reasonable response time.
- OS must allocate resources to processes in conformance with a specific policy. Example: (i) higher priority, (ii) avoid deadlock.
- Support user creation of processes and IPC both of which may aid in the structuring of applications.

Process creation

- Four common events that lead to a process creation are:

1) When a new batch-job is presented for execution.

2) When an interactive user logs in.

3) When OS needs to perform an operation (usually IO) on behalf of a user process, concurrently with that process.

4) To exploit parallelism an user process can spawn a number of processes.

==> concept of parent and child processes.

Process Hierarchies

- Parent creates a child process, child processes can create its own process
- Forms a hierarchy
  - UNIX calls this a "process group"
- Windows has no concept of process hierarchy
  - all processes are created equal

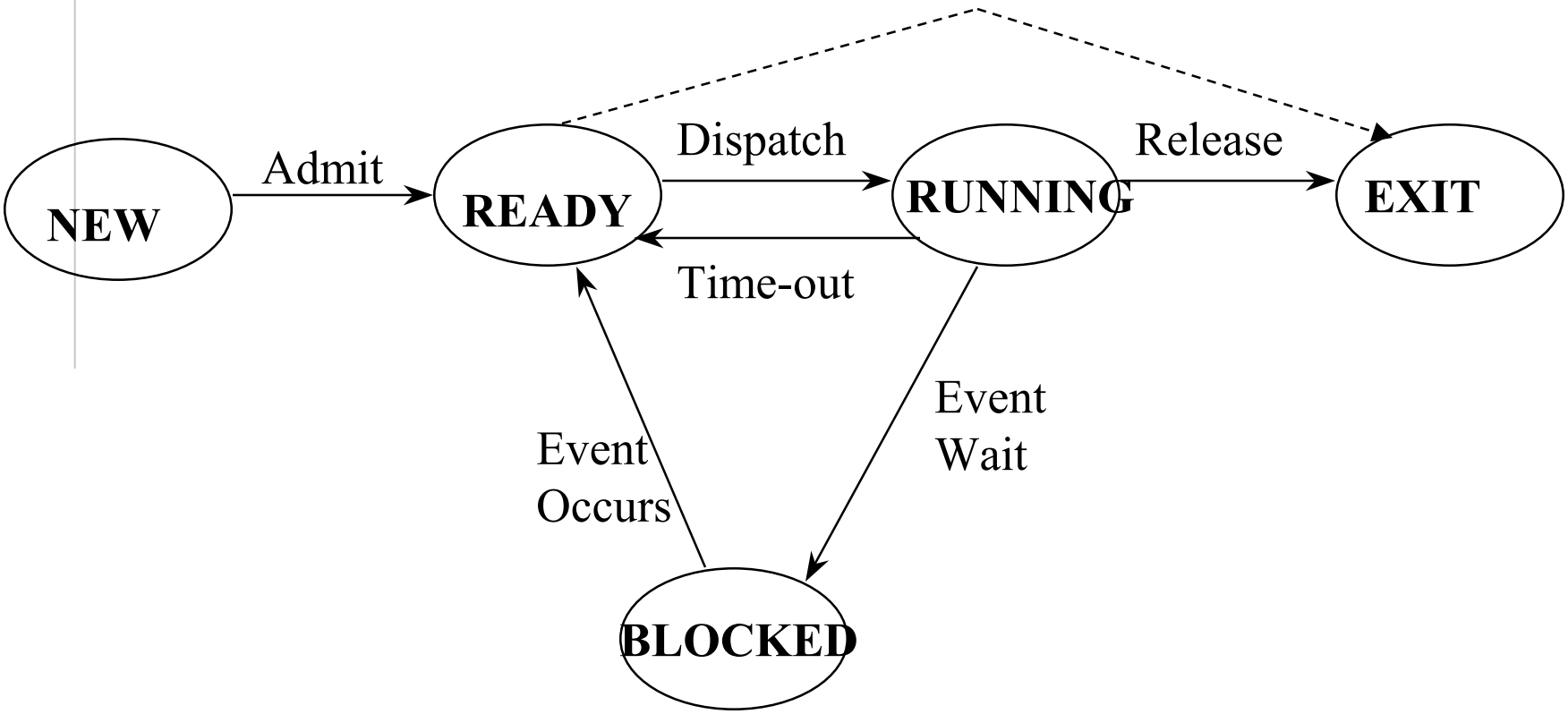
Termination of a process

- Normal completion, time limit exceeded, memory unavailable
- Bounds violation, protection error, arithmetic error, invalid instruction
- IO failure, Operator intervention, parent termination, parent request
- A number of other conditions are possible.
- **Segmentation fault** : usually happens when you try write/read into/from a non-existent array/structure/object component. Or access a pointer to a dynamic data before creating it. (new etc.)
- **Bus error:** Related to function call and return. You have messed up the stack where the return address or parameters are stored.

A five-state process model

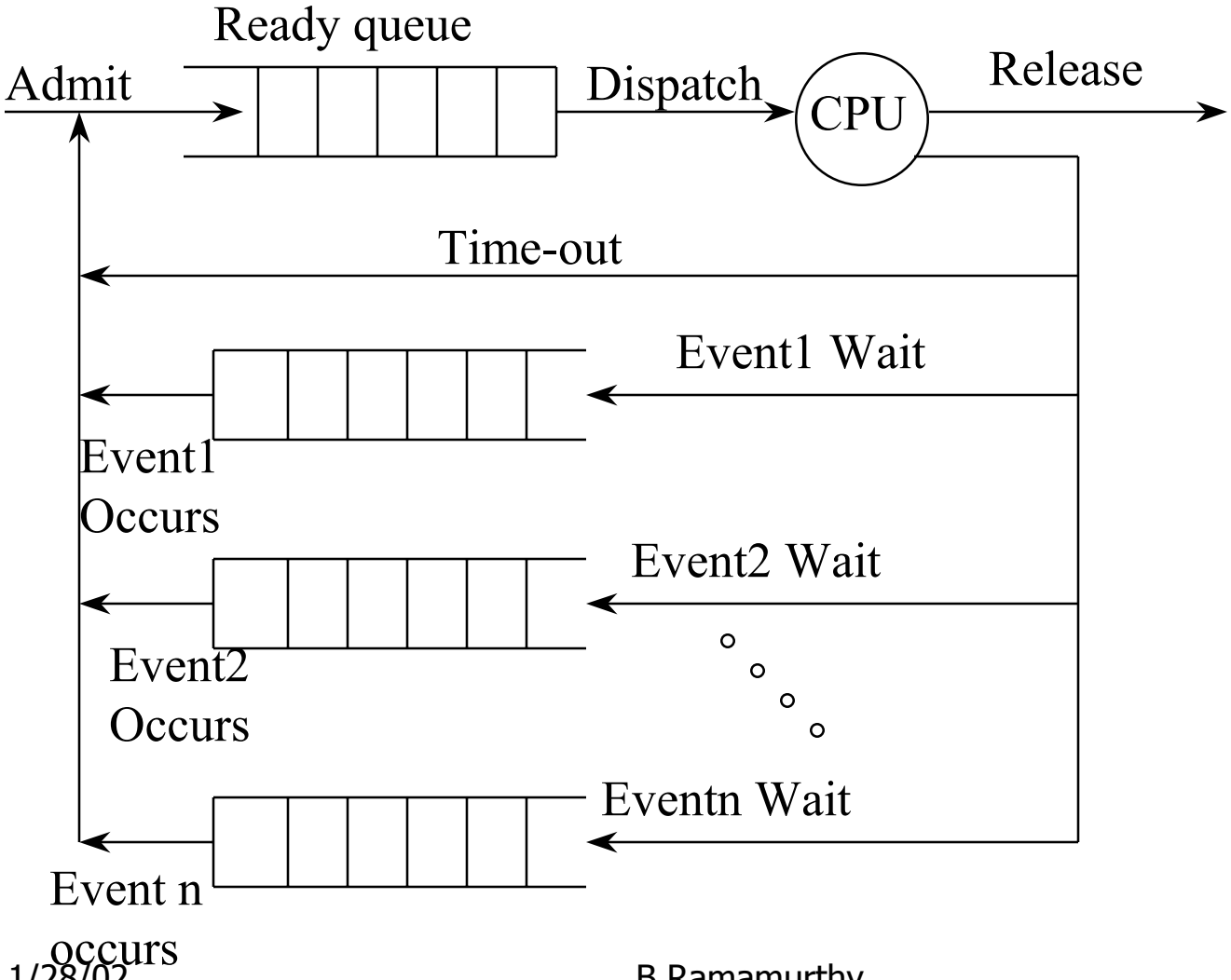
- Five states: New, Ready, Running, Blocked, Exit
- **New** : A process has been created but has not yet been admitted to the pool of executable processes.
- **Ready** : Processes that are prepared to run if given an opportunity. That is, they are not waiting on anything except the CPU availability.
- **Running**: The process that is currently being executed. (Assume single processor for simplicity.)
- **Blocked** : A process that cannot execute until a specified event such as an IO completion occurs.
- **Exit**: A process that has been released by OS either after normal termination or after abnormal termination (error).

State Transition Diagram



Think of the conditions under which state transitions may take place.

Queuing model



Process Transitions

- Ready --> Running
  - When it is time, the dispatcher selects a new process to run
- Running --> Ready
  - the running process has expired his time slot
  - the running process gets interrupted because a higher priority process is in the ready state

Process Transitions

- Running --> Blocked
  - When a process requests something for which it must wait
    - a service that the OS is not ready to perform
    - an access to a resource not yet available
    - initiates I/O and must wait for the result
    - waiting for a process to provide input (IPC)
- Blocked --> Ready
  - When the event for which it was waiting occurs

Implementation of Processes

1. Hardware stacks program counter, etc.
2. Hardware loads new program counter from interrupt vector.
3. Assembly language procedure saves registers.
4. Assembly language procedure sets up new stack.
5. C interrupt service runs (typically reads and buffers input).
6. Scheduler decides which process is to run next.
7. C procedure returns to the assembly code.
8. Assembly language procedure starts up new current process.

Skeleton of what lowest level of OS does when an interrupt occurs

Operating System Control Structures

- An OS maintains the following tables for managing processes and resources:
  - Memory tables (see later)
  - I/O tables (see later)
  - File tables (see later)
  - Process tables (this chapter)

Process description

- OS constructs and maintains tables of information about each entity that it is managing : memory tables, IO tables, file tables, process tables.
- **Process control block:** Associated with each process are a number of attributes used by OS for process control. This collection is known as **PCB.**
- For more details on PCB see Figure 2-4.

Process Table Entry (PCB)

Process management	Memory management	File management
Registers	Pointer to text segment	Root directory
Program counter	Pointer to data segment	Working directory
Program status word	Pointer to stack segment	File descriptors
Stack pointer		User ID
Process state		Group ID
Priority		
Scheduling parameters		
Process ID		
Parent process		
Process group		
Signals		
Time when process started		
CPU time used		
Children's CPU time		
Time of next alarm		

Fields of a process table entry

Process control block

- Contains three categories of information:

1) Process identification
2) Process state information
3) Process control information

- **Process identification**:
  - numeric identifier for the process (pid)
  - identifier of the parent (ppid)
  - user identifier (uid) - id of the usr responsible for the process.
- **Process state information:**
  - User visible registers
  - Control and status registers : PC, IR, PSW, interrupt related bits, execution mode.
  - Stack pointers

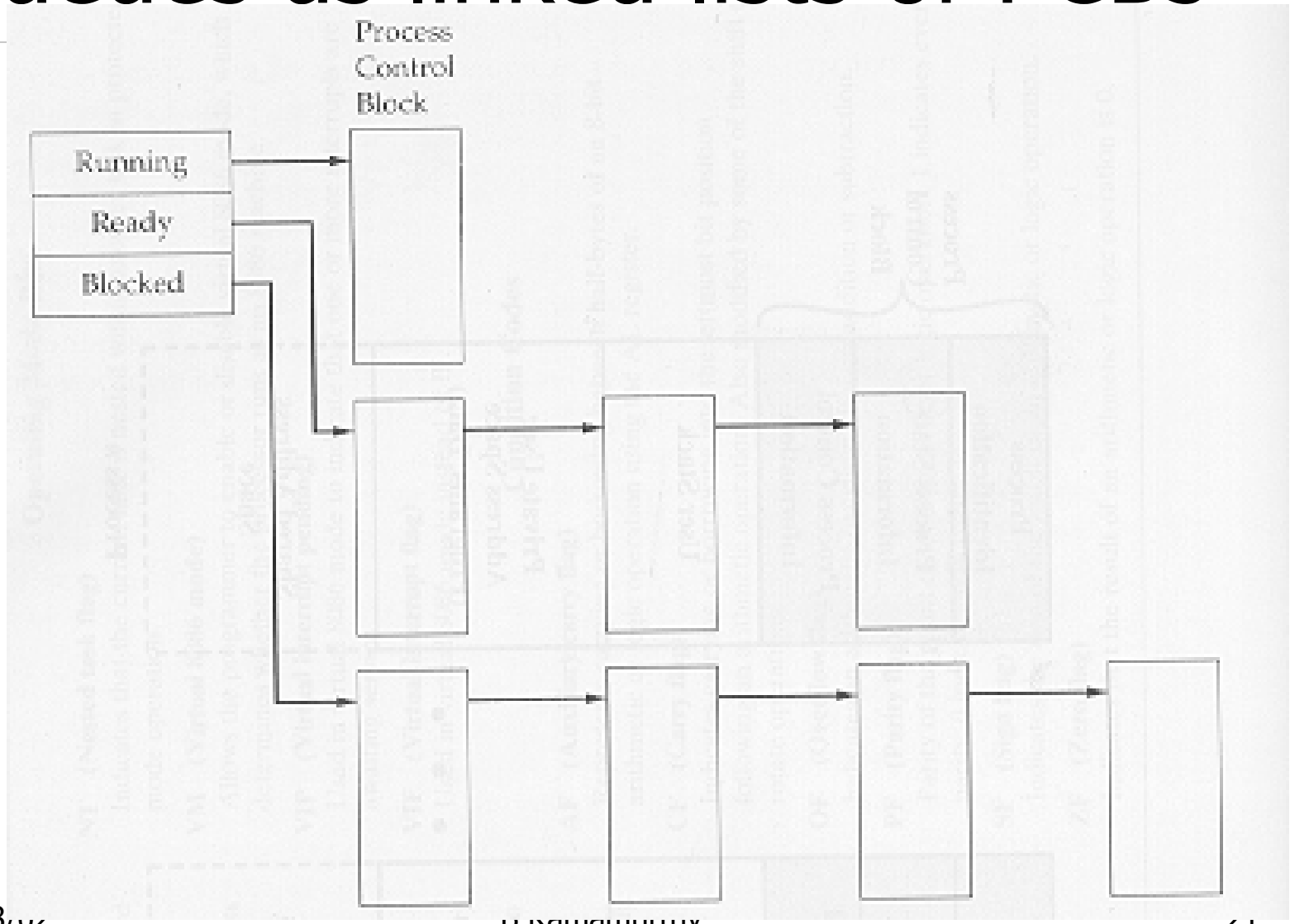
Process control block (contd.)

- **Process control information:**
  - Scheduling and state information : Process state, priority, scheduling-related info., event awaited.
  - Data structuring : pointers to other processes (PCBs): belong to the same queue, parent of process, child of process or some other relationship.
  - Interprocess comm: Various flags, signals, messages may be maintained in PCBs.

Process control block (contd.)

- Process control information (contd.)
  - Process privileges: access privileges to certain memory area, critical structures etc.
  - Memory management: pointer to the various memory management data structures.
  - Resource ownership : Pointer to resources such as opened files. Info may be used by scheduler.
- PCBs need to be protected from inadvertent destruction by any routine. So protection of PCBs is a critical issue in the design of an OS.

Queues as linked lists of PCBs



OS Functions related to Processes

- Process management: Process creation, termination, scheduling, dispatching, switching, synchronization, IPC support, management of PCBs
- Memory management: Allocation of address space to processes, swapping, page and segment management.
- IO management: Buffer management, allocation of IO channels and devices to processes.
- Support functions: Interrupt handling, accounting, monitoring.

Modes of execution

- Two modes : **user mode** and a privileged mode called the **kernel mode**.
- Why? It is necessary to protect the OS and key OS tables such as PCBs from interference by user programs.
- In the kernel mode, the software has complete control of the processor and all its hardware.
- When a user makes a system call or when an interrupt transfers control to a system routine, an instruction to change mode is executed. This mode change will result in an error unless permitted by OS.

Summary

- A process is a unit of work for the Operating System.
- Implementation of the process model deals with process description structures and process control methods.
- Process management is the of the operating system requiring a range of functionality from interrupt handling to IO management.
- Read Chapter 2: Material on Processes.