



# OPERATING SYSTEMS

## Memory Management -2

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### UNIT 3: Memory Management

Main Memory: Hardware and control structures, OS support, Address translation, Swapping, Memory Allocation (Partitioning, relocation), Fragmentation, Segmentation, Paging, TLBs context switches. Virtual Memory - Demand Paging, Copy-on-Write, Page replacement policy - LRU (in comparison with FIFO & Optimal), Thrashing, design alternatives - inverted page tables, bigger pages. Case Study: Linux/Windows Memory.

# OPERATING SYSTEMS

## Course Outline - Unit 3

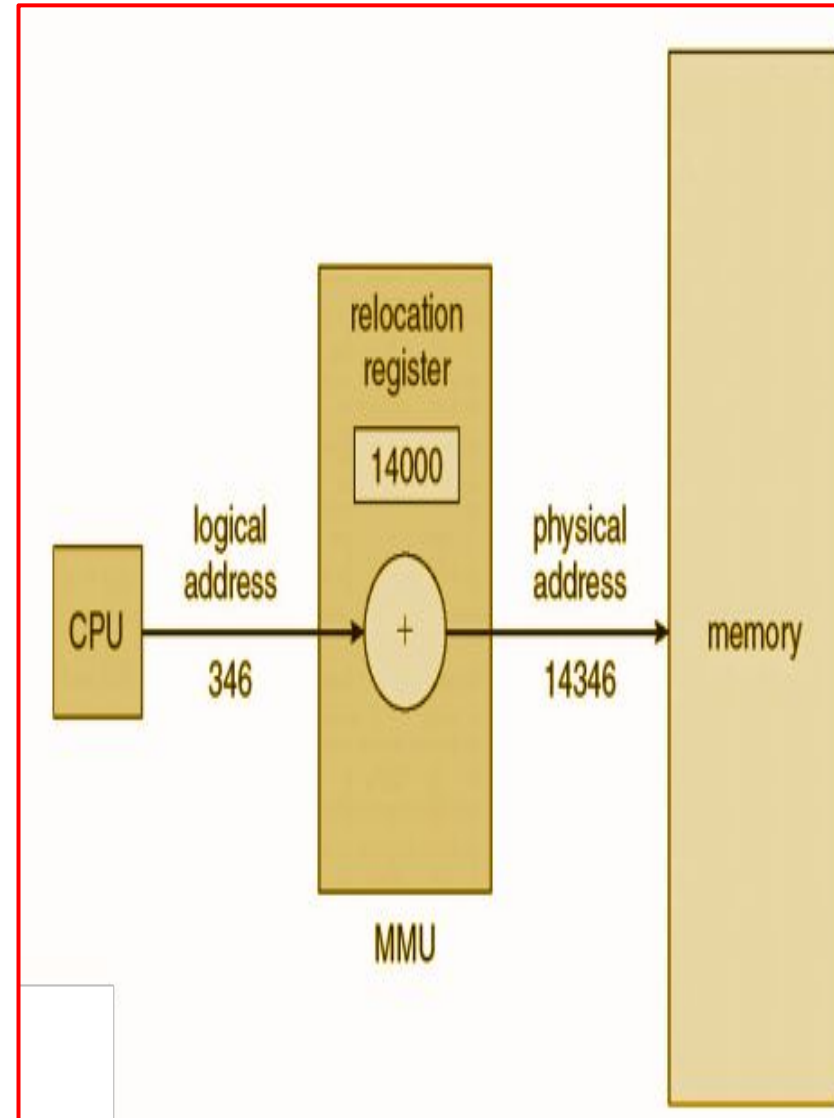


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- **Dynamic Allocation using Relocation Register**
- **Dynamic Linking**
- **Process Swapping**
- **Schematic view of Swapping**
- **Context Switching time including swapping**
- **Swapping on Mobile Systems**

# Dynamic Allocation using Relocation Register

- Routine is not loaded until it is called
- Better memory-space utilization; unused routine is never loaded
- All routines kept on disk in relocatable load format
- Useful when large amounts of code are needed to handle infrequently occurring cases
- No special support from the operating system is required
- Implemented through program design
- OS can help by providing libraries to implement dynamic loading



# Program Development in Unix - Additional Input



- When a process is running, what does its memory look like ? A collection of regions called sections. Basic memory layout for Linux and other Unix systems:
  - Code (or "text" in Unix terminology): starts at location 0
  - Data: starts immediately above code, grows upward
  - Stack: starts at highest address, grows downward
- System components that take part in managing a process's memory:
- **Compiler and assembler:**
  - Generate one object file for each source code file containing information for that source file.
  - Information is incomplete, since each source file generally references some things defined in other source files.

# Program Development in Unix - Additional Input

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- **Linker:**

- Combines all of the object files for one program into a single object file.
- Linker output is complete and self-sufficient.

- **Operating system:**

- Loads object files into memory.
- Allows several different processes to share memory at once.
- Provides facilities for processes to get more memory after they've started running.

- **Run-time library:**

- Works together with OS to provide dynamic allocation routines, such as malloc and free in C.

# Process Swapping

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- Does the swapped out process need to swap back in to same physical addresses ?
  - Depends on address binding method
  - Plus consider pending I/O to / from process memory space
- Modified versions of swapping are found on many systems (i.e., UNIX, Linux, and Windows)
  - Swapping normally disabled
  - Started if more than threshold amount of memory allocated
  - Disabled again once memory demand reduced below threshold



# Dynamic Linking

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- **Static linking** => system libraries and program code combined by the loader into the binary program image
- **Dynamic linking** => linking postponed until execution time
- Small piece of code, stub, used to locate the appropriate memory-resident library routine
- Stub replaces itself with the address of the routine, and executes the routine
- Operating system checks if routine is in process's memory address

# Dynamic Linking

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- Since late 1980's most systems have supported shared libraries and dynamic linking
- For common library packages, only keep a single copy in memory, shared by all processes.
- Don't know where library is loaded until runtime; must resolve references dynamically, when program runs.

# Process Swapping

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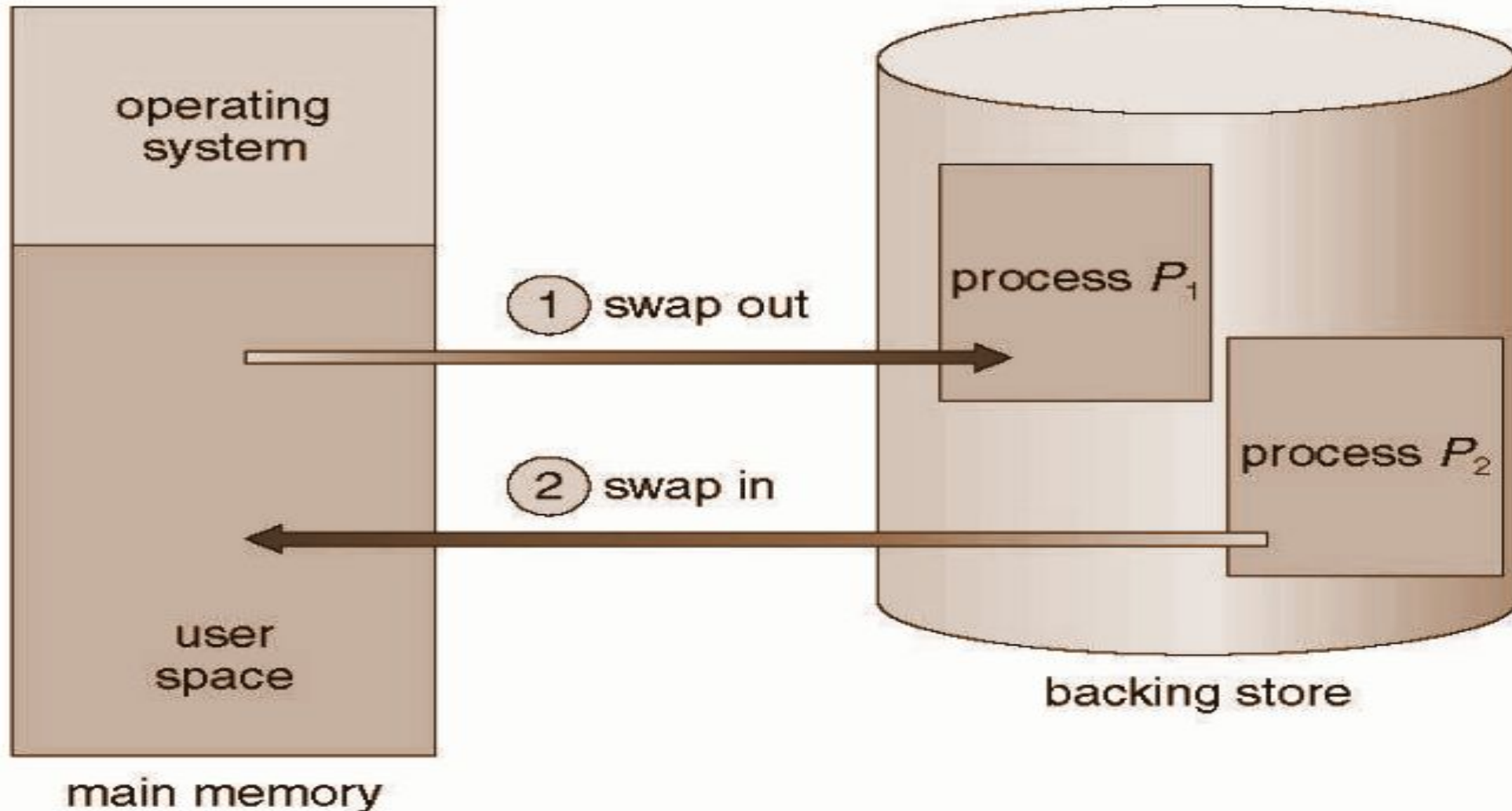
- A process can be swapped temporarily out of memory to a backing store, and then brought back into memory for continued execution
  - Total physical memory space of processes can exceed physical memory
- Backing store is fast disk large enough to accommodate copies of all memory images for all users; providing direct access to these memory images

# Process Swapping

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- **Roll out, roll in** => swapping variant used for priority based scheduling algorithms; **lower-priority** process is **swapped out** so **higher-priority process** can be **loaded and executed**
- Major part of swap time is transfer time; total transfer time is directly proportional to the amount of memory swapped
- System maintains a ready queue of ready-to-run processes which have memory images on disk

# Schematic View of Process Swapping



# Context Switch Time including Process Swapping

- If next processes to be put on CPU is not in memory, need to swap out a process and swap in target process
- Context switch time can then be very high
- 100MB process swapping to hard disk with transfer rate of 50MB / sec  $\Rightarrow 50\text{MB} / 1000\text{ ms} \Rightarrow .05\text{ ms per Mb}$ 
  - Swap out time of 2000 ms
  - Plus swap in case of same sized process
  - Total context switch swapping component time of 4000 ms (4 seconds)

# Context Switch Time including Process Swapping

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- Can reduce  $\Rightarrow$  if reduce size of memory swapped  $\Rightarrow$  by knowing how much memory really being used ?
- System calls to inform OS of memory use via `request_memory()` and `release_memory()`

# Context Switch Time including Process Swapping

- Other constraints as well on swapping
  - Pending I/O – can't swap out as I/O would occur to wrong process
  - or always transfer I/O to kernel space, then to I/O device
    - Known as double buffering, adds overhead
- Standard swapping not used in modern operating systems
  - But modified version common.
    - Swap only when free memory extremely low



# Process Swapping on Mobile System

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- Not typically supported
  - Flash memory based
  - Small amount of space
  - Limited number of write cycles
  - Poor throughput between flash memory and CPU on mobile platform

# Process Swapping on Mobile System

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- Instead use other methods to free memory if low
  - iOS asks apps to voluntarily relinquish allocated memory
  - Read-only data thrown out and reloaded from flash if needed
  - Failure to free can result in termination
  - Android terminates apps if low free memory, but first writes application state

## Topic Uncovered in this session

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- **Dynamic Allocation using Relocation Register**
- **Dynamic Linking**
- **Process Swapping**
- **Schematic view of Swapping**
- **Context Switching time including swapping**
- **Swapping on Mobile Systems**



**THANK YOU**

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