OPERATING SYSTEMS

Memory Management -2

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Course Syllabus - Unit 3

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.

Course Outline - Unit 3

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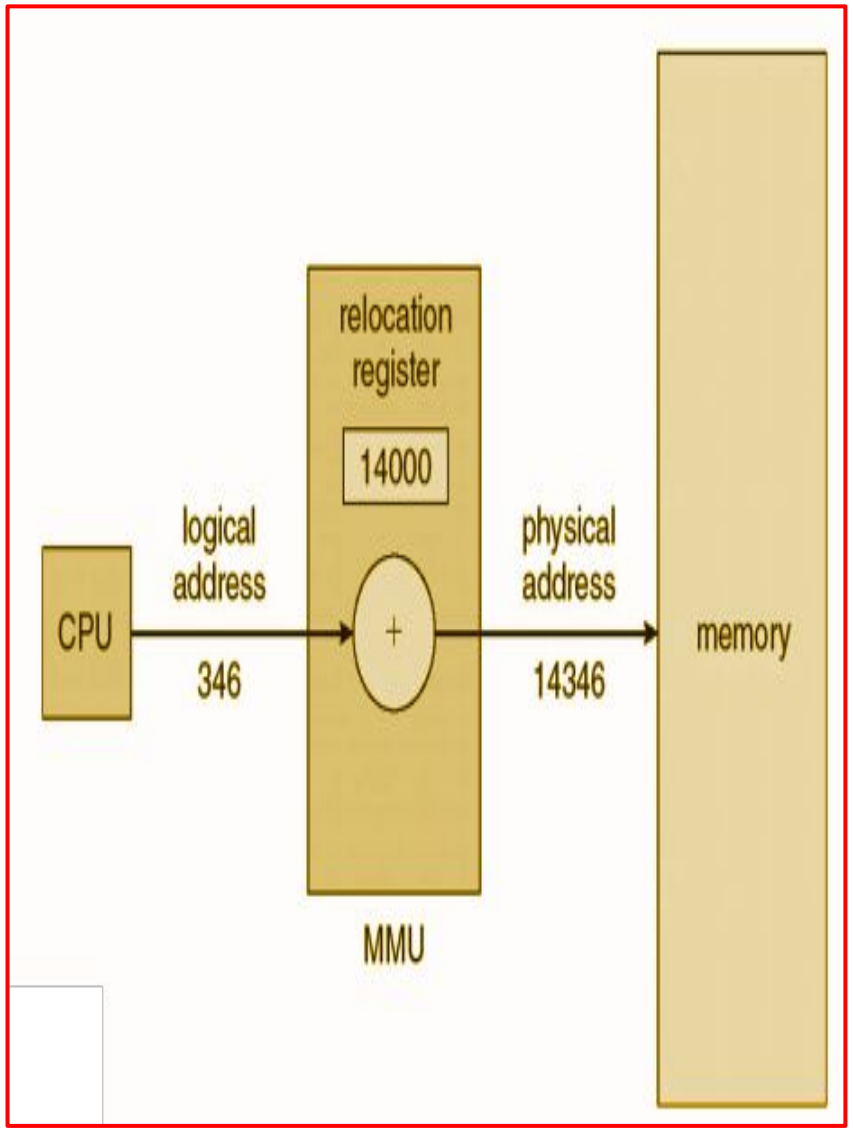
Topic Outline

- 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

- **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

- 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

- **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

- 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

- 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

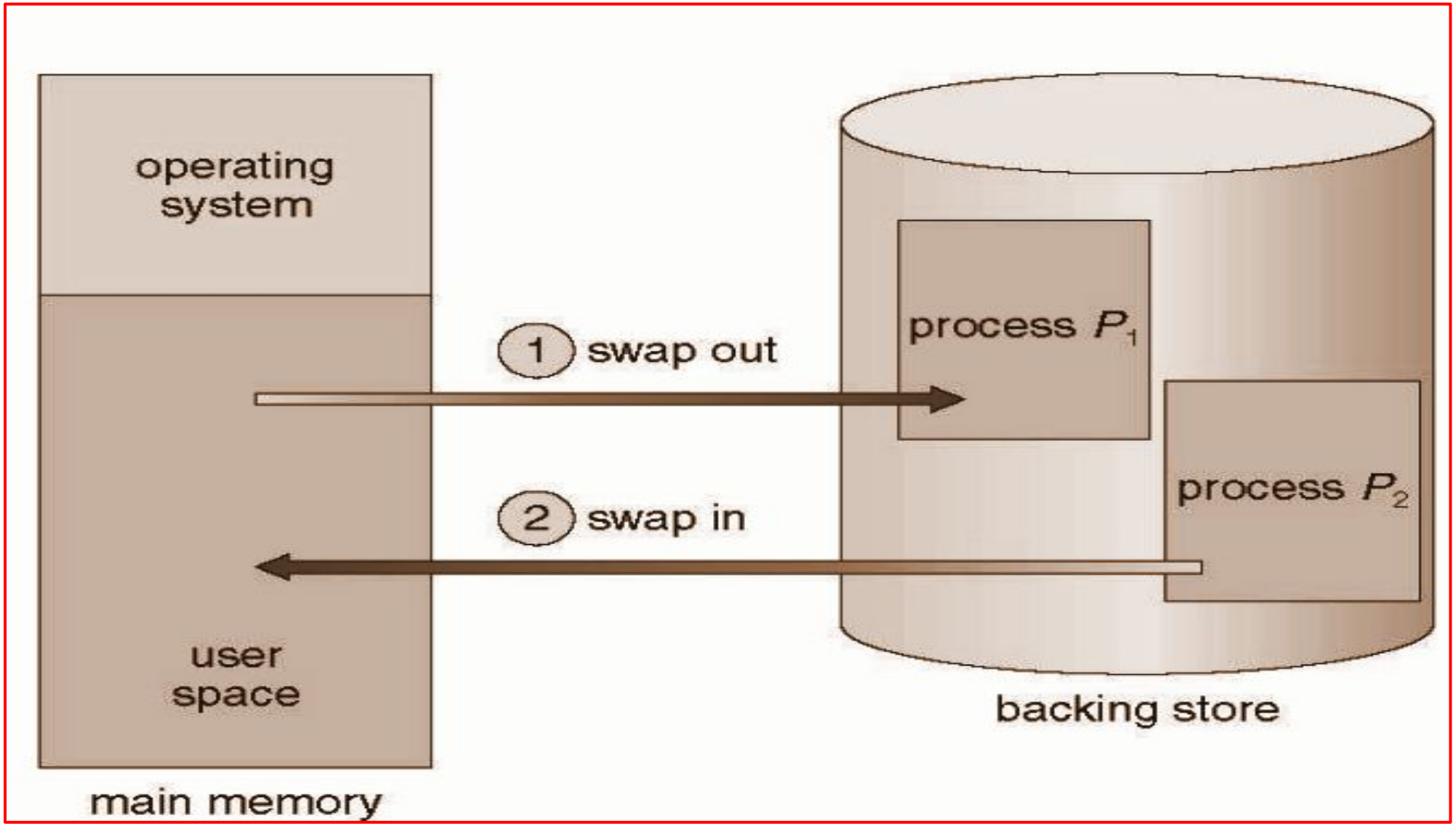
Process Swapping

- **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 => 50MB / 1000 ms => .05 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

- Can reduce => if reduce size of memory swapped => 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

- 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

- 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

- 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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