OPERATING SYSTEMS

Memory Management

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Virtual Memory – Case Study

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Slides Credits for all the PPTs of this course

- The slides/diagrams in this course are an **adaptation**, **combination**, and **enhancement** of material from the following resources and persons:

1. Slides of Operating System Concepts, Abraham Silberschatz, Peter Baer Galvin, Greg Gagne - 9th edition 2013 and some slides from 10th edition 2018
2. Some conceptual text and diagram from Operating Systems - Internals and Design Principles, William Stallings, 9th edition 2018
3. Some presentation transcripts from A. Frank – P. Weisberg
4. Some conceptual text from Operating Systems: Three Easy Pieces, Remzi Arpaci-Dusseau, Andrea Arpaci Dusseau

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Virtual Memory Management in Windows

- Windows implements virtual memory using demand paging with clustering
- Clustering handles page faults by bringing in not only the faulting page but also several pages following the faulting page.
- When a process is first created, it is assigned a working-set minimum and maximum.
- The **working-set minimum** is the minimum number of pages the process is guaranteed to have in memory
- If sufficient memory is available, a process may be assigned as many pages as its **working-set maximum.**
- The virtual memory manager maintains a list of free page frames. Associated with this list is a threshold value that is used to indicate whether sufficient free memory is available.

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Virtual Memory Management in Windows

- If a page fault occurs for a process that is below its working-set maximum, the virtual memory manager allocates a page from this list of free pages.
- If a process that is at its working-set maximum incurs a page fault, it must select a page for replacement using a local LRU page-replacement policy
- When the amount of free memory falls below the threshold, the virtual memory manager uses a tactic known as **automatic working-set trimming** to restore the value above the threshold.
- Automatic working-set trimming works by evaluating the number of pages allocated to processes.
- If a process has been allocated more pages than its working-set minimum, the virtual memory manager removes pages until the process reaches its working-set minimum.
- A process that is at its working-set minimum may be allocated pages from the free-page-frame list once sufficient free memory is available. Windows performs working-set trimming on both user mode and system processes

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Virtual Memory Management in Linux Reference

- Linux uses demand paging to load executable images into a processes virtual memory.
- Whenever a command is executed, the file containing it is opened and its contents are mapped into the processes virtual memory. This is done by modifying the data structures describing this processes memory map and is known as *memory mapping*.
- However, only the first part of the image is actually brought into physical memory. The rest of the image is left on disk.
- As the image executes, it generates page faults and Linux uses the processes memory map in order to determine which parts of the image to bring into memory for execution.
- Linux on Alpha AXP systems uses 8 Kbyte pages and on Intel x86 systems it uses 4 Kbyte pages. Each of these pages is given a unique number; the **page frame number** (PFN).

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Virtual Memory Management in Linux

- In this paged model, a virtual address is composed of two parts; an offset and a virtual page frame number.
- If the page size is 4 Kbytes, bits 11:0 of the virtual address contain the offset and bits 12 and above are the virtual page frame number.
- Each time the processor encounters a virtual address it must extract the offset and the virtual page frame number.
- The processor must translate the virtual page frame number into a physical one and then access the location at the correct offset into that physical page. To do this the processor uses *page tables*.
- The page table is accessed using the virtual page frame number as an offset
- Linux uses a Least Recently Used (LRU) page aging technique to fairly choose pages which might be removed from the system.

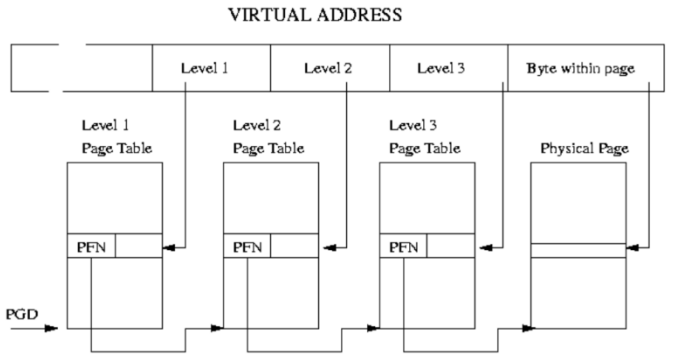

Figure 3.3: Three Level Page Tables

THANK YOU

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