**Memory management**

Main memory (RAM) is an important resource that must be carefully managed. While the average home computer nowadays has 10,000 times more memory as the IBM 7094, the largest computer in the world in the early 1960s, programs are getting bigger faster than memories.

**NO MEMORY ABSTRACTION**

The simplest memory abstraction is no abstraction at all.

**Running Multiple Programs Without a Memory Abstraction**

However, even with no memory abstraction, it is possible to run multiple programs at the same time. What the operating system has to do is save the entire contents of memory to a disk file, then bring in and run the next program.

**A MEMORY ABSTRACTION: ADDRESS SPACES**

when there is no abstraction from physical memory, something had to be done**.**

**The Notion of an Address Space**

Two problems have to be solved to allow multiple applications to be in memory at the same time : protection and relocation.

**Virtual Memory**

can be used to create the abstraction of address spaces.

Pagging : programs reference a set of memory addresses.

Page Tables : In a simple implementation, the mapping of virtual addresses onto physical addresses can be summarized.

Translation Lookaside Buffers : small hardware device for mapping virtual addresses to physical addresses without going through the page table.

**Page Replacement Algorithm**

the operating system has to choose a page to evict (remove from memory) to make room for the incoming page

Optimal : At the moment that a page fault occurs, some set of pages is in memory. One of these pages will be referenced on the very next instruction

Not recent : In order to allow the operating system to collect useful page usage statistics, most computers with virtual memory have two status bits, R and M,

First-In First-Out : The operating system maintains a list of all pages currently in memory, with the most recent arrival at the tail and the least recent arrival at the head.

Second chance : A simple modification to FIFO that avoids the problem of throwing out a heavily used page is to inspect the R bit of the oldest page.

Clock replacement : to keep all the page frames on a circular list in the form of a clock

LRU : pages that have not been used for ages will probably remain unused for a long time.

WSClock page : based on the clock algorithm but also uses the working set information

In this chapter we have examined memory management. We saw that the simplest systems do not swap or page at all. Once a program is loaded into memory, it remains there in place until it finishes. Some operating systems allow only one process at a time in memory, while others support multiprogramming.

This model is still common in small, embedded real-time systems. The next step up is swapping. When swapping is used, the system can handle more processes than it has room for in memory. Processes for which there is no room are swapped out to the disk. Free space in memory and on disk can be kept track of with a bitmap or a hole list.

Modern computers often have some form of virtual memory. In the simplest form, each process’ address space is divided up into uniform-sized blocks called pages, which can be placed into any available page frame in memory. There are many page replacement algorithms; two of the better algorithms are aging and WSClock.

To make paging systems work well, choosing an algorithm is not enough; attention to such issues as determining the working set, memory allocation policy, and page size is required.

Segmentation helps in handling data structures that can change size during execution and simplifies linking and sharing. It also facilitates providing different protection for different segments. Sometimes segmentation and paging are combined to provide a two-dimensional virtual memory. The MULTICS system and the 32-bit Intel x86 support segmentation and paging. Still, it is clear that few operating system developers care deeply about segmentation (because they are married to a different memory model). Consequently, it seems to be going out of fashion fast. Today, even the 64-bit version of the x86 no longer supports real segmentation