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CMSC 421: Homework 2

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1. Describe the functions of the Memory Management Unit in a modern computer system.

A Memory Management Unit (MMU) is a hardware unit used for all memory references including translating virtual addresses to physical addresses. The mapping of the virtual addresses can be achieved by many different methods. One such scheme is utilizing relocation registers. The MMU maps the logical address dynamically by adding the value in the relocation register and sent to memory.

2. What is a virtual address space? Why do we use virtual address spaces in modern operating systems?

Virtual address space is the address range which a process typically works in. The range spans from low (0x0) to as high as the instruction set architecture and the maximum pointer size allows. It is used because of data security via process isolation. Each process is given a separate virtual address space so that they do not access or interfere each other.

3. Compare and contrast the use of paging and segmentation for memory management in an OS.

Paging is a form of memory management that eliminates the need for contiguous allocation of physical memory. It retrieves data from the secondary storage for use in the main memory. Segmentation stores all the data in segments along with their memory locations. Every segments are loaded into a contiguous block of available memory. Paging requires more memory overhead to maintain the translation structures. Segmentation requires two registers per segment, while paging requires only one entry per page.

4. Consider a logical address space of 64 pages of 1024 words each, mapped onto a physical memory of 32 frames of 1024 words each. How many bits are required to represent a logical address (assuming word-based addressing).

Since logical address space = (number of pages in logical address space) $\times$ (page size), with the number of bits required being $\log_2$ of the size

Then,

$$\begin{aligned}\text{logical address space} &= 64 \times 1024 \\ &= 2^6 \times 2^{10} \\ &= 2^{16} \\ &= \log_2(2^{16}) = 16 \text{ bits}\end{aligned}$$

5. With the same address space layout as the previous question, how many bits are required to represent a physical address (once again, assuming word-based addressing).

Since physical address space = (number of frames in physical address space) $\times$ (frame size), with the number of bits required being $\log_2$ of the size

Then,

$$\begin{aligned}\text{physical address space} &= 32 \times 1024 \\ &= 2^5 \times 2^{10} \\ &= 2^{15} \\ &= \log_2(2^{15}) = 15 \text{ bits}\end{aligned}$$