練習

The memory architecture of a machine X is summarized in the Table.

Virtual Address	54 bits
Page Size	16 K bytes
PTE Size	4 bytes

(a) Assume that there are 8 bits reserved for the operating system functions (protection, replacement, valid, modified,...) other than required by the hardware translation algorithm. Derive the largest physical memory size (in bytes) allowed by this PTE format. Make sure you consider all the fields required by the translation algorithm.

(b) How large (in bytes) is the page table?

(c) Assuming 1 application exists in the system and the maximum physical memory is devoted to the process, how much physical space (in bytes) is there for the application's data and code.

Answer

(a) Physical page number = 32 – 8 = 24 bits.

The largest physical memory size = $2^{24} \times 16$ Kbytes = 256 GB

(b) The virtual page number has 54 – 14 = 40 bits. The number of page table entries are 2^{40}. Each PTE has 4 bytes. So the total size of the page table is 2^{42} bytes which is 4 terabytes.

(c) The application's page table has an entry for every physical page that exists on the system, which means the page table size is $2^{24} \times 4$ bytes. This leaves the remaining physical space to the process: $2^{24} \times 16K - 2^{26}$ bytes = $2^{38} - 2^{26}$ bytes.

練習

Consider a machine with 32-bit virtual addresses, 32-bit physical addresses, and a 4KB page size. Consider a two-level page table system where each table occupies one full page. Assume each page table entry is 32 bits long. To map the full virtual address space, how much memory will be used by the page tables?

Answer: The number of entries in the page table = 4KB/4B = 1024

Amount of memory used = 4 KB + 1024 × (4 KB) = 4.1 MB

練習

	Virtual address size	Page size	Page table entry size
a.	32 bits	4 KB	4 bytes
b.	64 bits	16 KB	8 bytes

Given the table above, calculate the total page table size for a system running 5 applications that utilize half of the memory available.

Answer

a.	4 KB page →12 offset bits, 20 page number bits 2^{20} = 1 M page table entries 1 M entries × 4 bytes/entry = 4 MB 4 MB × 5 = 20 MB
b.	16 KB (2^{14}) page size, 8 (2^3) bytes per page table entry 64 – 14 = 50 bits or 2^{50} page table entries with 8 bytes per entry, yields total of 2^{53} bytes for each page table Total for 5 applications = 5 × 2^{53} bytes