操作系统 作业 8

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7. Consider the following C program:

```
int X[N];
int step = M; /* M is some predefined constant */
for (int i = 0; i < N; i += step)
        X[i] = X[i] + 1;
```

(a) If this program is run on a machine with a 4-KB page size and 64-entry TLB, what values of M and N will cause a TLB miss for every execution of the inner loop?

当 $M \geq 1024$ 时，才能保证每次访问都跨页，从而每次都会触发 TLB 缺失；N 的值与题目要求无关。

(b) Would your answer in part (a) be different if the loop were repeated many times? Explain.

M 依然需要满足 $M \geq 1024$；此时 `X` 占用的空间应大于 64×4 KB=256 KB，因此 N 应大于 64K=$2^1$6。

10. Suppose that a machine has 48-bit virtual addresses and 32-bit physical addresses.

(a) If pages are 4 KB, how many entries are in the page table if it has only a single level? Explain.

每页需要一个表项，共 $2^{48-12}/4$ K=$2^{36}/2^{12} = 2^{24}$ 项。

(b) Suppose this same system has a TLB (Translation Lookaside Buffer) with 32 entries. Furthermore, suppose that a program contains instructions that fit into one page and it sequentially reads long integer elements from an array that spans thousands of pages. How effective will the TLB be for this case?

指令地址均可命中；程序每完成对当前 4 KB 页面的访问就发生一次 TLB 缺失，需要重新访问主存，在此之前，数据访问也是一直命中的。假设长整型为 4 字节，则数据的 TLB miss rate 为 1/1024。

12. A computer with a 32-bit address uses a two-level page table. Virtual addresses are split into a 9-bit top-level page table field, an 11-bit second-level page table field, and an offset. How large are the pages and how many are there in the address space?

每个虚拟地址 20 位记录虚页号，剩下 12 位，故一个页面有 2^{12} B=4 KB，共 2^{20} 页。

14. A computer has 32-bit virtual addresses and 4-KB pages. The program and data together fit in the lowest page (0–4095) The stack fits in the highest page. How many entries are needed in the page table if traditional (one-level) paging is used? How many page table entries are needed for two-level paging, with 10 bits in each part?

若采用一级页表，则需要 2^20 个表项，其中两个有效表项；若采用两级页表，则需要一个顶级页表，其中 2 个有效表项；指令 + 数据和栈分别分配一个二级页表，其中各 1 个有效表项，因此共需要 3072 个表项，其中 4 个有效表项。

15. A computer whose processes have 1024 pages in their address spaces keeps its page tables in memory. The overhead required for reading a word from the page table is 5 nsec. To reduce this overhead, the computer has a TLB, which holds 32 (virtual page, physical page frame) pairs, and can do a lookup in 1 nsec. What hit rate is needed to reduce the mean overhead to 2 nsec?

$1x + (1 + 5)(1 - x) \leq 2 \Rightarrow x \geq 0.8$，故命中率至少要为 0.8。