

## Section 5: Address Translation & Caches and TLBs

### Short Answer

1. If a computer has a 32 bit address space, and 1K (i.e.  $2^{10}$  bytes) sized pages, how many page table entries does it have? (fine to express answer base-2).
2. If you have a very large virtual address space, what are the benefits of using an inverted page table? What are the drawbacks?

### Long Answer

Caching: Assume a computer system employing a cache, where the access time to the main memory is 100 ns, and the access time to the cache is 20ns.

1. Assume the cache hit rate is 95%. What is the average access time?
2. Assume the system implements virtual memory using a two--level page table with no TLB, and assume the CPU loads a word X from main memory. Assume the cache hit rate for the page entries as well as for the data in memory is 95%. What is the average time it takes to load X?

### Longer Answer (From Fall 2012 Midterm)

Assume a system with a two level page table. The virtual memory address space is 32 bits and the physical memory address space is 16 bits.

1. Make sure that each translation table fits in a page.
  - a. What is the optimal page size?
  - b. Specify the length of each field in the virtual address.

(bit 31)

(bit 0)

Virtual P1 Index	Virtual P2 Index	Offset

2. Assume you add to your system a 4- way set--associative data cache with 16 total cache blocks. Each block in the cache holds 8 bytes of data. In order to address a specific byte of data, you will have to split the address into the cache tag, cache index and byte select. Assume there are no modifiers bits in the table.

tag	index	byte select

5. (From Fall 2013 Midterm) Paging:

Suppose you have a system with 32-bit pointers and 4 megabytes of physical memory that is partitioned into 8192-byte pages. The system uses an Inverted Page Table (IPT). Assume that there is no page sharing between processes.

a. Describe what page table entries should look like. Specifically, how many bits should be in each page table entry, and what are they for? Also, how many page table entries should there be in the page table?

b. Describe how an IPT is used to translate a virtual address into a physical address.