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CPSC 250 Computer Systems & Assembly

Homework 5

Memory Technologies

1. What are the differences among sequential access, direct access, and random access?

(6 pts)

Sequential Access: Memory is organized into records and data is accessed in a specific linear sequence

Direct Access: Data address based on a physical location and access is accomplished by direct access to reach a general vicinity plus sequential searching, waiting, or counting to reach a final location.

Random Access: Any location can be selected at random, and the addressable locations in memory have a unique, physically wired-in addressing mechanism

1. What is the distinction between spatial locality and temporal locality? (4 pts)

Spatial Locality: If a data location is referenced, data locations with nearby addresses will tend to be referenced soon

Temporal Locality: If a data location is referenced then it will tend to be referenced again soon

1. What is the difference between DRAM and SRAM in terms of characteristics such as speed, size, and cost? (6 pts)

DRAM: Slower, Larger, Cheap. Used for main memory

SRAM: Faster, Smaller, Expensive. Used for cache memory

1. What are the differences among EPROM, EEPROM, and flash memory? (6 pts)

EPROM: Read and written electrically. In order to write, all storage cells must be erased to the same initial state by exposure of the packaged chip to ultraviolet radiation. Erasure is performed by shining an intense ultraviolet light through a window that is designed into the memory chip.

EEPROM: Mostly a read memory that can be written to without erasing prior contents. Only bytes addressed are updated.

Flash Memory: Intermediate between EPROM and EEPROM. Uses electrical erasing (faster than EPROM). Also possible to erase blocks of memory compared to an entire chip. Does not provide byte-level erasure. Uses only one transistor per bit allowing for high density.

1. For an associative cache, a main memory address is viewed as consisting of two fields. List and define the two fields. (4 pts)

Tag: Uniquely identifies a block of main memory

Word: What is to be placed in the block of memory

1. A set-associative cache consists of 64 lines, or slots, divided into four-line sets. Main memory contains 4K blocks of 128 words each. Show the format of main memory addresses. (6 pts)

Cache is divided into 16 sets of 4 lines each -> Set = 4 bits

4K = 2^12 -> 12 = Set + Tag -> Tag = 8 bits

128 = 2^7 -> Word = 7 bits

Main Memory Address: Tag (8 bits) | Set (4 bits) | Word (7 bits)

1. Consider a machine with a byte addressable main memory of 216 bytes and block size of 8 bytes. Assume that a direct mapped cache consisting of 32 lines is used with this machine. (6 pts)
2. How is a 16-bit memory address divided into tag, line number, and byte number?

2^16 -> main memory = 16 bits

8 bytes = 2^3 bytes -> byte number = 3 bits

32 lines = 2^5 lines -> line number = 5 bits

Tag + line number + byte number = 16 -> tag = 8 bits

Tag = 8 bits

Line Number = 5 bits

Byte Number = 3 bits

1. How many total bytes of memory can be stored in the cache?

2^8 = 256 bytes

1. Why is the tag also stored in the cache?

Since it is possible to store two items with two different memory addresses in the same place in the cache, a tag is used to differentiate between them

1. Describe a simple technique for implementing an LRU replacement algorithm in a four-way set-associative cache. (5 pts)
2. Associate a 2-bit counter with each of the four blocks
3. Set the values of the four blocks to 0, 1, 2, and 3
4. On hit, counter of block set to 0, other counters lower than referenced counter incremented by 1, and remaining counters are unchanged
5. On miss, block in the set whose counter value is 3 is replaced and counter set to 0, other counters incremented by 1
6. Consider the following code: (4 pts)

***for*** *(i = 0; i < 20; i+ +)*

***for*** *(j = 0; j < 10; j+ +)*

*a[i] = a[i]\*j*

1. Give one example of the spatial locality in the code.

References to a[i] since the code is accessing contiguous memory locations

1. Give one example of the temporal locality in the code.

References to i and j since i is referenced every time a[i] is and j is referenced every execution of the loop (a[i] = a[i]\*j)

1. Define the terms track, cylinder, and sector as it relates to a magnetic disk. (8 pts)

Track: The portion of a disk which passes under a single stationary head during a disk rotation, a ring 1 bit wide

Cylinder: Comprised of the set of tracks described by all the heads at a single seek position

Sector: Track divided into segments of sectors. Basic unit of storage.

* 1. What is the typical disk sector size?

Size: 512 bytes