香港中文大學
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CSCI2510 Computer Organization

Tutorial 10: Direct Mapping vs Associate Mapping

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Outline

- Direct Mapping vs Associate Mapping
- Hint for assignment3

Direct Mapping vs Associate Mapping

Number of Cache Hits (0~99 are randomly generated 1000 times)			
Cache Size	Direct	Associate (LRU)	Associate (FIFIO)
4	51	36	35
8	89	81	86
16	175	159	160
32	323	300	292

Increasing the cache size, the hit rate increases

Hints for Assignment 3

- A computer system uses 32-bit memory addresses and it has a main memory consisting of 1Gbytes. It has a 4K-byte cache organized in the block-set-associative manner, with 2 blocks per set and 32 bytes per block.
  - (a) Calculate the number of bits in each of the Tag, Set, and Word fields of the memory address.
  - (b) Assume that the cache is initially empty. Suppose that the processor fetches 1032 words of four bytes each from successive word locations starting at location 0. It then repeats this fetch sequence four more times. If the cache is 10 times faster than the memory, estimate the improvement factor resulting from the use of the cache.Assume that the LRU algorithm is used for block replacement.

Hints for Assignment 3

(a)

- A block has 32 bytes and it’s byte-addressable;hence the Word field is 5 bits long.
- With $2 \times 32 = 64$ bytes in a set, there are $4K/64 = 64$ sets, requiring a Set field of 6 bits.
- This leaves $32 - 5 - 6 = 21$ bits for the Tag field.

Hints for Assignment 3

(b)

LRU:Replace the least recently used cache block in its set

First round: 1032 words of four bytes consititude 129 blocks(32 bytes per block)

Fetch 0:

Set 0	Set 1	Set 2		Set 63
0	1	2	…	63
64	65	66		127

Fetch 128:

Set 0	Set 1	Set 2		Set 63
128	1	2	…	63
64	65	66		127

Let t be the access time of the cache.

$$1 \times 129 \times 11t$$

Hints for Assignment 3

(b)

LRU:Replace the least recently used cache block in its set

Second round:

Fetch 0:

Set 0	Set 1	Set 2	…	Set 63
128	1	2	…	63
0	65	66		127

Fetch 64:

Set 0	Set 1	Set 2	…	Set 63
64	1	2	…	63
0	65	66		127

Fetch 128

Set 0	Set 1	Set 2	…	Set 63
64	1	2	…	63
128	65	66		127

$$3 \times 11t + 126 * t$$

Hints for Assignment 3

(b) LRU:Replace the least recently used cache block in its set

Third round:

Fetch 0:

Set 0	Set 1	Set 2		Set 63
0	1	2	…	63
128	65	66		127

Fetch 64:

Set 0	Set 1	Set 2		Set 63
0	1	2	…	63
64	65	66		127

Fetch 128

Set 0	Set 1	Set 2		Set 63
128	1	2	…	63
64	65	66		127

$3 \times 11t + 126 * t$

Hints for Assignment 3

(b)

As execution proceeds, all memory blocks that occupy the first set of the 64 cache sets are always overwritten before they can be used on a succeeding round.

Memory blocks 0, 64, 128 continually displace each other as they compete for the 2 block positions in cache set 0.

First round:

Fetch 0: Set 0

0
64

Fetch 128:

Set 0

128
64

Second round:

Fetch 0: Set 0

128
0

Fetch 64: Set 0

64
0

Fetch 128 Set 0

64
128

Third round:

Fetch 0: Set 0

0
128

Fetch 64: Set 0

0
64

Fetch 128 Set 0

128
64

…

(b)

0, 64, 128 continually displace each other

Access memory

129 blocks

5 round

Blocks except 0 64 128

Let t be the access time of the cache.

Therefore, Improvement factor =

Time without cache / Time with cache =

$5 \times 129 \times 10t \,/\, (1 \times 129 \times 11t + 4(3 \times 11t + 126 * t))$

$= 3.14$

Access cache

2^{th} ~ 5^{th} round

The first round

Access memory+access cache

Summary

- Direct Mapping vs Associate Mapping
- Hint for assignment3