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CS 219-1002: Computer Organization

CS 219 – Assignment #10

Purpose: Become familiar with MIPS virtual memory implementation
Points: 90

Reading/References:

Chapter 5

Assignment:

Virtual memory systems use a page table to track the mapping of virtual addresses to physical addresses. The following table shows the results of a stream of virtual addresses generated on a given system. Assume 4 KB pages, a four-entry fully associative TLB and a true LRU replacement (top to bottom otherwise). If a page must be brought in from the disk, choose the lowest available page. [a, b, c → 30 pts each]

Initial Contents

TLB:

valid	tag	physical page number
1	11	12
1	7	1
1	3	6
0	4	9

Page Table:

valid	physical page or "on disk"
1	5
0	disk
0	disk
1	6
1	9
1	11
0	disk
1	1
0	disk
0	disk
1	2
1	12

1) Given the provided address stream and the initial TLB and page table entries provided, show the final state of the system (TLB and page table) for address stream ***1*** and address stream ***2***. For each reference show if it is a hit in the TLB, page table, or a page fault.
   Address Stream ***1***: 36863, 31272, 15789, 15000, 7193, 4096, 8912
   Address Stream ***2***: 5356, 30964, 12300, 19136, 46502, 38110, 16653, 48480

2) Repeat exercise a) with 8 KB pages (instead of the 4KB pages).

3) Repeat exercise a) with 16KB pages (instead of the 4KB pages).

Question #1

a) Address Stream *1* (4 KB): 36863, 31272, 15789, 15000, 7193, 4096, 8912

reference	reference (hex)	tag	hit?
36863	0x08fff	8	page fault, 0 assigned
31272	0x07a28	7	TLB
15789	0x03dad	3	TLB
15000	0x03a98	3	TLB
7193	0x01c19	1	page fault, 3 assigned
4096	0x01000	1	TLB
8912	0x022d0	2	page fault, 4 assigned

TLB:

valid	tag	physical page number
1	1	3
1	7	1
1	3	6
1	2	4

free:
0
3
4
7
8
10

Page Table:

	valid	physical page or "on disk"
0	1	5
1	1	3
2	1	4
3	1	6
4	1	9
5	1	11
6	0	disk
7	1	1
8	1	0
9	0	disk
10	1	2
11	1	12

Question #1

b) Address Stream *2* (4 KB): 5356, 30964, 12300, 19136, 46502, 38110, 16653, 48480

reference	reference (hex)	tag	hit?
5356	0x014EC	1	page fault, assigned 0
30964	0x078F4	7	TLB
12300	0x0300C	3	TLB
19136	0x04AC0	4	PT
46502	0x0B5A6	11	PT
38110	0x094DE	9	page fault, assigned 3
16653	0x0410D	4	TLB
48480	0x0BD60	11	TLB

TLB:

valid	tag	physical page number
1	4	9
1	9	3
1	3	6
1	11	12

Page Table:

	valid	physical page or "on disk"
0	1	5
1	1	0
2	0	disk
3	1	6
4	1	9
5	1	11
6	0	disk
7	1	1
8	0	disk
9	1	3
10	1	2
11	1	12

free:
0
3
4
7
8
10

Question #2

a) Address Stream *1* (8 KB): 36863, 31272, 15789, 15000, 7193, 4096, 8912

reference	reference (hex)	tag	hit?
36863	0x08fff	4	PT
31272	0x07a28	3	TLB
15789	0x03dad	1	page fault, assign 0
15000	0x03a98	1	TLB
7193	0x01c19	0	PT
4096	0x01000	0	TLB
8912	0x022d0	1	TLB

TLB:

valid	tag	physical page number
1	1	0
1	0	5
1	3	6
1	4	9

Page Table:

	valid	physical page or "on disk"
0	1	5
1	1	0
2	0	disk
3	1	6
4	1	9
5	1	11
6	0	disk
7	1	1
8	0	disk
9	0	disk
10	1	2
11	1	12

free:
0
3
4
7
8
10

Question #2

b) Address Stream *2* (8 KB): 5356, 30964, 12300, 19136, 46502, 38110, 16653, 48480

reference	reference (hex)	tag	hit?
5356	0x014EC	0	PT
30964	0x078F4	3	TLB
12300	0x0300C	1	page fault, assign 0
19136	0x04AC0	2	page fault, assign 3
46502	0x0B5A6	5	PT
38110	0x094DE	4	PT
16653	0x0410D	2	TLB
48480	0x0BD60	5	TLB

TLB:

valid	tag	physical page number
1	1	0
1	2	3
1	4	9
1	5	11

Page Table:

	valid	physical page or "on disk"
0	1	5
1	1	0
2	1	3
3	1	6
4	1	9
5	1	11
6	0	disk
7	1	1
8	0	disk
9	0	disk
10	1	2
11	1	12

free:
0
3
4
7
8
10

Question #3

a) Address Stream *1* (16 KB): 36863, 31272, 15789, 15000, 7193, 4096, 8912

reference	reference (hex)	tag	hit?
36863	0x08fff	3	TLB
31272	0x07a28	1	page fault, assign 0
15789	0x03dad	0	PT
15000	0x03a98	0	TLB
7193	0x01c19	0	TLB
4096	0x01000	0	TLB
8912	0x022d0	0	TLB

TLB:

valid	tag	physical page number
1	0	5
1	7	1
1	3	6
1	1	0

Page Table:

	valid	physical page or "on disk"
0	1	5
1	1	0
2	0	disk
3	1	6
4	1	9
5	1	11
6	0	disk
7	1	1
8	0	disk
9	0	disk
10	1	2
11	1	12

free:
0
3
4
7
8
10

Question #3

b) Address Stream *2* (16 KB): 5356, 30964, 12300, 19136, 46502, 38110, 16653, 48480

reference	reference (hex)	tag	hit?
5356	0x014EC	0	PT
30964	0x078F4	1	page fault, assign 0
12300	0x0300C	0	TLB
19136	0x04AC0	1	TLB
46502	0x0B5A6	2	page fault, assign 3
38110	0x094DE	2	TLB
16653	0x0410D	1	TLB
48480	0x0BD60	2	TLB

TLB:

valid	tag	physical page number
1	1	0
1	2	3
1	3	6
1	0	5

Page Table:

	valid	physical page or "on disk"
0	1	5
1	1	0
2	1	3
3	1	6
4	1	9
5	1	11
6	0	disk
7	1	1
8	0	disk
9	0	disk
10	1	2
11	1	12

free:
0
3
4
7
8
10