

## Least recently used replacement

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1, 3, 2, 1, 2, 4, 4, 3, 2    which block is the least recently used??

1, 2, 2, 2, 1, 2, 1    which block is the least recently used??

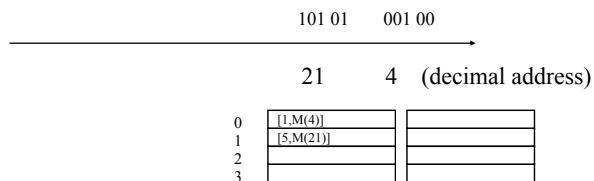
1, 2, 3, 1, 2, 3, 1, 2, 3, ...    assuming a set size of 2, which of LRU or random replacement results in a better hit rate?

1

## Example (2-way set associative, Block size = 1)

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	v	tag	data	v	tag	data
00	1	001	A B C D	0		
01	1	101	X Y Z W	0		
10	0			0		
11	0			0		



000 00	
000 01	
000 10	
000 11	
001 00	A B C D
001 01	
001 10	
001 11	
010 00	
010 01	
010 10	
010 11	
011 00	
011 01	K L M N
011 10	
011 11	
100 00	
100 01	
100 10	
100 11	
101 00	
101 01	X Y Z W
101 10	
101 11	
110 00	
110 01	E F G H
110 10	
110 11	
111 00	
111 01	
111 10	
111 11	

2

### Example (2-way set associative, Block size = 1)

	v	tag	data	v	tag	data
00	1	001	A B C D	0		
01	1	101	X Y Z W	1	110	E F G H
10	0			0		
11	0			0		

110 01 101 01 001 00  
 →  
 25 21 4 (decimal address)

0	[1,M(4)]	
1	[5,M(21)]	[6,M(25)]
2		
3		

000 00	
000 01	
000 10	
000 11	
001 00	A B C D
001 01	
001 10	
001 11	
010 00	
010 01	
010 10	
010 11	
011 00	
011 01	K L M N
011 10	
011 11	
100 00	
100 01	
100 10	
100 11	
101 00	
101 01	X Y Z W
101 10	
101 11	
110 00	
110 01	E F G H
110 10	
110 11	
111 00	
111 01	
111 10	
111 11	

3

### Example (2-way set associative, Block size = 1)

	v	tag	data	v	tag	data
00	1	001	A B C D	0		
01	1	011	K L M N	1	110	E F G H
10	0			0		
11	0			0		

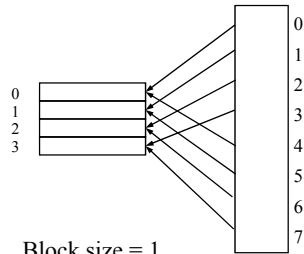
011 01 110 01 101 01 001 00  
 →  
 13 25 21 4 (decimal address)

0	[1,M(4)]	
1	[5,M(21)] [3,M(13)]	[6,M(25)]
2		
3		

000 00	
000 01	
000 10	
000 11	
001 00	A B C D
001 01	
001 10	
001 11	
010 00	
010 01	
010 10	
010 11	
011 00	
011 01	K L M N
011 10	
011 11	
100 00	
100 01	
100 10	
100 11	
101 00	
101 01	X Y Z W
101 10	
101 11	
110 00	
110 01	E F G H
110 10	
110 11	
111 00	
111 01	
111 10	
111 11	

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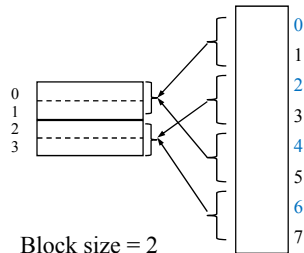
## Are larger blocks always better than smaller blocks?



Block size = 1

Example 1:

Decimal addresses: 0, 1, 2, 3, 4, 5, 6, 7  
(larger block size is better)



Block size = 2

Example 2:

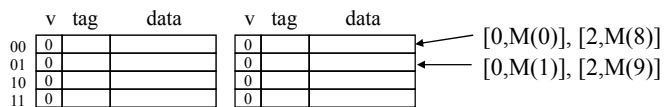
Decimal addresses: 0, 5, 0, 5, 0, 5, 0, 5  
(smaller block size is better)

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## Is larger associativity better than larger block size?

Example 1:

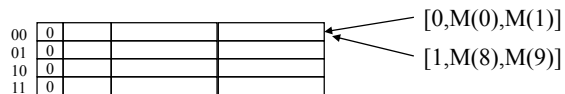
Decimal addresses: 0, 1, 8, 9, 0, 1, 8, 9



[0,M(0)], [2,M(8)]

[0,M(1)], [2,M(9)]

2-way associative



[0,M(0),M(1)]

[1,M(8),M(9)]

Block size = 2

Larger associativity is better

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## Is larger associativity better than larger block size?

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	v	tag	data	v	tag	data
00	0			0		
01	0			0		
10	0			0		
11	0			0		

2-way associative

Example 2:

Decimal addresses: 0, 1, 2, 3, 4, 5, 6, 7

00	0			
01	0			
10	0			
11	0			

Block size = 2

Larger block size is better