

. /paging-policy.py -C 3 -a 1,2,3,4,1,2,5,1,2,3,
4,5

FIFO

$$\text{Miss} = M$$

$$\text{Hit} = H$$

$$C = 3, \text{ cache size}$$

M	1
M	2

M	3	[1, 2, 3]
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M	4	[4, 1, 3]
---	---	-----------

M	1	[4, 1, 3]
---	---	-----------

M	2	[4, 1, 2]
---	---	-----------

M	5	[5, 1, 2]
---	---	-----------

(H)	1	[5, 1, 2]
-----	---	-----------

(H)	2	
-----	---	--

M	3	[5, 3, 2]
---	---	-----------

M	4	[5, 3, 4]
---	---	-----------

(H)	5	[5, 3, 4]
-----	---	-----------

$$C = 4, \text{ cache size}$$

M	1
M	2

M	3	[1, 2, 3]
---	---	-----------

M	4	[1, 2, 3, 4]
---	---	--------------

(H)	1	[1, 2, 3, 4]
-----	---	--------------

(H)	2	
-----	---	--

M	5	[5, 2, 3, 4]
---	---	--------------

M	1	[5, 1, 3, 4]
---	---	--------------

M	2	[5, 1, 2, 4]
---	---	--------------

M	3	[5, 1, 2, 3]
---	---	--------------

M	4	[4, 1, 2, 3]
---	---	--------------

M	5	[4, 5, 2, 3]
---	---	--------------

① -S 0 -n 10

	FIFO	Default, cache-size = 3 LRU	OPT
8	M [8]	M [8]	M
7	M [8, 7]	M [8, 7]	M
4	M [8, 7, 4]	M [8, 7, 4]	M [8, 7, 4]
2	M [2, 7, 4]	M [2, 7, 4]	M [2, 7, 4]
5	M [2, 5, 4]	M [2, 5, 4]	M [5, 7, 4]
4	(H)	(H) [2, 5, 4]	(H) [5, 7, 4]
7	M [2, 5, 7]	M [7, 5, 4]	(H)
3	M [3, 5, 7]	M [7, 3, 4]	M [5, 3, 4]
4	M [3, 4, 7]	(H) [7, 3, 4]	(H)
5	M [3, 4, 5]	M [5, 3, 4]	(H)

-S 1 -n 10

	FIFO	. LRU	OPT
1	M [1]	M [1]	
8	M [1, 8]		
7	M [1, 8, 7]	M [1, 8, 7]	M [1, 8, 7]
2	M [2, 8, 7]	M [2, 8, 7]	M [2, 8, 7]
4	M [2, 4, 7]	M [2, 4, 7]	M [2, 4, 7]

t	(H)	(H)	(H)
6	M [2, 4, 6]	M [6, 2, 4]	M [6, 4, 7]
7	M [7, 4, 6]	M [6, 7, 4]	M [6, 4, 7]
0	M [7, 0, 6]	M [6, 7, 0]	M [6, 0, 7]
0	(H) [7, 8, 6]	(H) [7, 6, 3]	(H) [7, 6, 3]

-S 2 -n | 0

	FIFO	LRU	OPT
9	M [9]	M	M
9	(H)	(H)	(H)
0	M [9, 0]	M [9, 0]	M [9, 0]
0	(H) [9, 0]	(H) [9, 0]	(H) [9, 0]
8	M [9, 0, 8]	M [9, 0, 8]	M [9, 0, 8]
7	M [7, 0, 8]	M [7, 0, 8]	M [7, 0, 8]
6	M [8, 7, 6]	M [7, 6, 8]	M [7, 6, 8]
3	M [3, 7, 6]	M [7, 6, 3]	M [7, 6, 3]
6	(H) [3, 7, 6]	(H) [7, 6, 3]	(H) [7, 6, 3]
6	(H) [3, 7, 6]	(H) [7, 6, 3]	(H) [7, 6, 3]

⑦ cache size = 5

worst-case

FIFO $\Rightarrow -a = 0, 1, 2, 3, 4, 5, 0, 1, 2, 3$
0 hits

LRU $\Rightarrow -a = 0, 1, 2, 3, 4, 5, 0, 1, 2, 3$
0 hits

MRU $\Rightarrow -a = 0, 1, 2, 3, 4, 5, 4, 5, 4, 5$
0 hits

How ^{much} bigger cache size needed to improve
perform dramatically and approach OPT

OPT for FIFO worst-case = 4 hits

OPT for LRU worst-case = 4 hits (same address)

OPT for MRU worst-case = 4 hits

cache-size = 6

FIFO, 4 hits

LRU, 4 hits

MRU, 4 hits

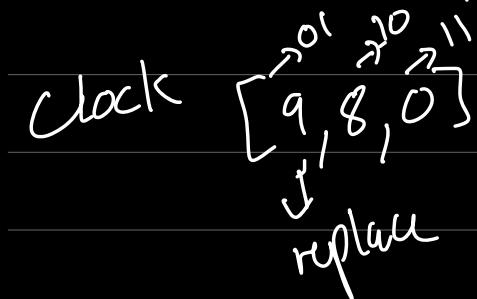
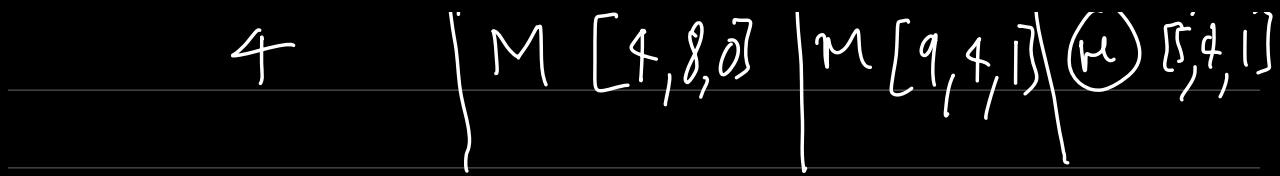
③

	FIFO	LRU	OPT
9	M H	M H	M H
9	M [9, 8]	M	M
8	M [9, 8, 0]	M	M
0	M [5, 8, 0]	M [9, 8, 0]	M [9, 8, 0]
5	M [5, 4, 0]	M [5, 8, 0]	M [5, 8, 0]
4	M [5, 4, 0] H [5, 4, 0]	M [5, 4, 0] H [5, 4, 0]	M [5, 4, 0] H [5, 4, 0]
5	M [5, 4, 0] H [5, 4, 0]	H [5, 4, 0] M [5, 4, 0]	H [5, 4, 0] M [5, 4, 0]
1	M [5, 4, 1] H [5, 4, 1]	M [5, 4, 1] H [5, 4, 1]	M [5, 4, 1] H [5, 4, 1]
1	M [5, 4, 1] H [5, 4, 1]	M [5, 4, 1] H [5, 4, 1]	M [5, 4, 1] H [5, 4, 1]
4	M [5, 4, 1] H [5, 4, 1]	M [5, 4, 1] H [5, 4, 1]	M [5, 4, 1] H [5, 4, 1]

4 hits

clockbits = 2

	DNOPT	RAND	CLOCK
9	M H	M H	M H
9	M	M	M [9, 8]
8	M [9, 8, 0]	M [9, 8, 0]	M [9, 8, 0]
0	M [5, 8, 0]	M [9, 8, 0]	M [9, 8, 0]
5	M [5, 8, 0]	M [9, 5, 0]	M [5, 8, 0]
4	M [4, 8, 0]	M [9, 5, 4]	M [5, 4, 8]
5	M [5, 8, 0]	H [9, 5, 4]	H [5, 4, 8]
1	M [1, 8, 0]	M [9, 5, 1]	M [5, 4, 1]
1	H [1, 8, 0]	H [9, 5, 1]	H [5, 4, 1]



④ Locality
 - spatial \Rightarrow nearby pages likely to be accessed like $P+1, P-1$
 - temporal \Rightarrow pages accessed recently are likely to be accessed again

$\Rightarrow -a \quad 8, 9, 7, 6, 7, 6, 5, 4, 5, 6$

LRU

```

Access: 8 MISS LRU -> [8] <- MRU Replaced:- [Hits:0 Misses:1]
Access: 9 MISS LRU -> [8, 9] <- MRU Replaced:- [Hits:0 Misses:2]
Access: 7 MISS LRU -> [8, 9, 7] <- MRU Replaced:- [Hits:0 Misses:3]
Access: 6 MISS LRU -> [9, 7, 6] <- MRU Replaced:8 [Hits:0 Misses:4]
Access: 7 HIT LRU -> [9, 6, 7] <- MRU Replaced:- [Hits:1 Misses:4]
Access: 6 HIT LRU -> [9, 7, 6] <- MRU Replaced:- [Hits:2 Misses:4]
Access: 5 MISS LRU -> [7, 6, 5] <- MRU Replaced:9 [Hits:2 Misses:5]
Access: 4 MISS LRU -> [6, 5, 4] <- MRU Replaced:7 [Hits:2 Misses:6]
Access: 5 HIT LRU -> [6, 4, 5] <- MRU Replaced:- [Hits:3 Misses:6]
Access: 6 HIT LRU -> [4, 5, 6] <- MRU Replaced:- [Hits:4 Misses:6]

```

FINALSTATS hits 4 misses 6 hitrate 40.00

RAND

```
Access: 8 MISS Left -> [8] <- Right Replaced:- [Hits:0 Misses:1]
Access: 9 MISS Left -> [8, 9] <- Right Replaced:- [Hits:0 Misses:2]
Access: 7 MISS Left -> [8, 9, 7] <- Right Replaced:- [Hits:0 Misses:3]
Access: 6 MISS Left -> [8, 9, 6] <- Right Replaced:7 [Hits:0 Misses:4]
Access: 7 MISS Left -> [8, 9, 7] <- Right Replaced:6 [Hits:0 Misses:5]
Access: 6 MISS Left -> [8, 7, 6] <- Right Replaced:9 [Hits:0 Misses:6]
Access: 5 MISS Left -> [7, 6, 5] <- Right Replaced:8 [Hits:0 Misses:7]
Access: 4 MISS Left -> [7, 5, 4] <- Right Replaced:6 [Hits:0 Misses:8]
Access: 5 HIT Left -> [7, 5, 4] <- Right Replaced:- [Hits:1 Misses:8]
Access: 6 MISS Left -> [7, 4, 6] <- Right Replaced:5 [Hits:1 Misses:9]

FINALSTATS hits 1 misses 9 hitrate 10.00
```

CLOCK

```
Access: 8 MISS Left -> [8] <- Right Replaced:- [Hits:0 Misses:1]
Access: 9 MISS Left -> [8, 9] <- Right Replaced:- [Hits:0 Misses:2]
Access: 7 MISS Left -> [8, 9, 7] <- Right Replaced:- [Hits:0 Misses:3]
Access: 6 MISS Left -> [8, 9, 6] <- Right Replaced:7 [Hits:0 Misses:4]
Access: 7 MISS Left -> [8, 6, 7] <- Right Replaced:9 [Hits:0 Misses:5]
Access: 6 HIT Left -> [8, 6, 7] <- Right Replaced:- [Hits:1 Misses:5]
Access: 5 MISS Left -> [6, 7, 5] <- Right Replaced:8 [Hits:1 Misses:6]
Access: 4 MISS Left -> [6, 5, 4] <- Right Replaced:7 [Hits:1 Misses:7]
Access: 5 HIT Left -> [6, 5, 4] <- Right Replaced:- [Hits:2 Misses:7]
Access: 6 HIT Left -> [6, 5, 4] <- Right Replaced:- [Hits:3 Misses:7]

FINALSTATS hits 3 misses 7 hitrate 30.00
```

CLOCK

```
ARG addresses 1,2,3,1,4,2,5,1,6,3,4,5,6,2,1,3,4,5,6,2
ARG addressfile
ARG numaddrs 10
ARG policy CLOCK
ARG clockbits 2
ARG cachesize 3
ARG maxpage 10
ARG seed 0
ARG notrace False

Solving...

Access: 1 MISS Left -> [1] <- Right Replaced:- [Hits:0 Misses:1]
Access: 2 MISS Left -> [1, 2] <- Right Replaced:- [Hits:0 Misses:2]
Access: 3 MISS Left -> [1, 2, 3] <- Right Replaced:- [Hits:0 Misses:3]
Access: 1 HIT Left -> [1, 2, 3] <- Right Replaced:- [Hits:1 Misses:3]
Access: 4 MISS Left -> [1, 2, 4] <- Right Replaced:3 [Hits:1 Misses:4]
Access: 2 HIT Left -> [1, 2, 4] <- Right Replaced:- [Hits:2 Misses:4]
Access: 5 MISS Left -> [1, 4, 5] <- Right Replaced:2 [Hits:2 Misses:5]
Access: 1 HIT Left -> [1, 4, 5] <- Right Replaced:- [Hits:3 Misses:5]
Access: 6 MISS Left -> [1, 5, 6] <- Right Replaced:4 [Hits:3 Misses:6]
Access: 3 MISS Left -> [1, 6, 3] <- Right Replaced:5 [Hits:3 Misses:7]
Access: 4 MISS Left -> [1, 3, 4] <- Right Replaced:6 [Hits:3 Misses:8]
Access: 5 MISS Left -> [3, 4, 5] <- Right Replaced:1 [Hits:3 Misses:9]
Access: 6 MISS Left -> [3, 4, 6] <- Right Replaced:5 [Hits:3 Misses:10]
Access: 2 MISS Left -> [3, 4, 2] <- Right Replaced:6 [Hits:3 Misses:11]
Access: 1 MISS Left -> [4, 2, 1] <- Right Replaced:3 [Hits:3 Misses:12]
Access: 3 MISS Left -> [4, 2, 3] <- Right Replaced:1 [Hits:3 Misses:13]
Access: 4 HIT Left -> [4, 2, 3] <- Right Replaced:- [Hits:4 Misses:13]
Access: 5 MISS Left -> [4, 3, 5] <- Right Replaced:2 [Hits:4 Misses:14]
Access: 6 MISS Left -> [4, 5, 6] <- Right Replaced:3 [Hits:4 Misses:15]
Access: 2 MISS Left -> [4, 5, 2] <- Right Replaced:6 [Hits:4 Misses:16]

FINALSTATS hits 4 misses 16 hitrate 20.00
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(5)

TODD