Discussion 4/5/19

Page Replacement Algorithms

- OPT
  - What the optimal page replacement would choose if it had perfect knowledge (Which you do!)
  - Swap out the page whose next use will occur farthest in the future.
- Clock
  - Otherwise known as second chance (more details on next slide).
- FIFO
  - Evict oldest page in memory
- Random Eviction
  - Randomly select page to evict
- **LRU**
  - **L**east **R**ecently **U**sed (LRU) algorithm is a Greedy algorithm where the page to be replaced is least recently used.

Physical and Virtual memory

Persistent Storage

0
1
2
3
4
5
6
7

Page Table

F#	D/C	Val
1	D	T
	C	F
0	C	T
	C	F
3	D	T
	C	F
2	D	T
	C	F

Physical Memory (RAM)

2
0
6
4

- Instructions:

  R 0100101
  W 0001111
  W 1101010
  R 0001111 // **Nothing!**
  R 1000000
  W 10010101

- What is the LRU order?

Physical and Virtual memory

Persistent Storage

0
1
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Page Table

F#	D/C	Val
1	D	T
	C	F
0	C	T
	C	F
3	D	T
	C	F
2	D	T
	C	F

Physical Memory (RAM)

2
0
6
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- Instructions:
  - R 0100101
  - W 0001111
  - W 1101010
  - R 0001111 // **Nothing!**
  - R 1000000
  - W 10010101
- What is the LRU order?
  - 010 -> 110 -> 000 -> 100
- Consider:
  - R 1110000

Physical and Virtual memory

Persistent Storage

0
1
2
3
4
5
6
7

Page Table

F#	D/C	Val
1	D	T
	C	F
	C	**F**
	C	F
3	D	T
	C	F
2	D	T
0	C	**T**

Physical Memory (RAM)

7
0
6
4

- Instructions:
  - R 0100101
  - W 0001111
  - W 1101010
  - R 0001111 // **Nothing!**
  - R 1000000
  - W 10010101
- What is the LRU order?
  - 010 -> 110 -> 000 -> 100
- Consider:
  - R 1110000
- Order is now 110 -> 000 -> 100 -> 111

Beladys Anomaly

- The phenomenon that some page replacement algorithms see an increase in performance with a decrease in frames.
- In other words, increasing amount of frames doesnt yield less page faults!
- Algorithms that are known to experience this:
  - First in first out (FIFO)
  - Second chance algorithm
  - Random page replacement algorithm

Beladys Anomaly

- Given the following page accesses:

1, 2, 3, 4, 1, 2, 5, 1, 2, 3, 4, 5

- Consider 4 frames:

1	1	1	1	1	1	2	3	4	5	1	2
	2	2	2	2	2	3	4	5	1	2	3
		3	3	3	3	4	5	1	2	3	4
			4	4	4	5	1	2	3	4	5
PF	PF	PF	PF	X	X	PF	PF	PF	PF	PF	PF

Beladys Anomaly

- Given the following page accesses:

1, 2, 3, 4, 1, 2, 5, 1, 2, 3, 4, 5

- Consider 3 frames:

1	1	1	2	3	4	1	1	1	2	5	5
	2	2	3	4	1	2	2	2	5	3	3
		3	4	1	2	5	5	5	3	4	4
PF	PF	PF	PF	PF	PF	PF	X	X	PF	PF	X

How to plot

- See example code in repo!