

## All frames needed soon?

- What if we examine all *check\_frames* frames and all are in lookahead list?
- Which one do we choose to remove?
- The one which is first needed at the latest time
  - An example should make it clear

## All frames needed example

w 1492 (page 2)  
w 50 (page 0)  
w 15400 (page 30)  
w 15300 (page 30)  
w 180 (page 0)  
r 2200 (page 4)  
w 1292 (page 2)

- Consider this lookahead list
- Suppose all checked frames are in this lookahead list
  - Which frame do we remove?

## All frames needed example

w 1492 (page 2)  
w 50 (page 0)  
w 15400 (page 30)  
w 15300 (page 30)  
w 180 (page 0)  
r 2200 (page 4)  
w 1292 (page 2)

## All frames needed example

w 1492 (page 2) First (page 2)  
w 50 (page 0)  
w 15400 (page 30)  
w 15300 (page 30)  
w 180 (page 0)  
r 2200 (page 4)  
w 1292 (page 2)

## All frames needed example

w 1492 (page 2) First (page 2)  
w 50 (page 0) First (page 0)  
w 15400 (page 30)  
w 15300 (page 30)  
w 180 (page 0)  
r 2200 (page 4)  
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## All frames needed example

w 1492 (page 2) First (page 2)  
w 50 (page 0) First (page 0)  
w 15400 (page 30) First (page 30)  
w 15300 (page 30)  
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r 2200 (page 4)  
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## All frames needed example

w 1492 (page 2) First (page 2)  
 w 50 (page 0) First (page 0)  
 w 15400 (page 30) First (page 30)  
 w 15300 (page 30)  
 w 180 (page 0)  
 r 2200 (page 4) First (page 4)  
 w 1292 (page 2)

## All frames needed example

w 1492 (page 2) First (page 2)  
 w 50 (page 0) First (page 0)  
 w 15400 (page 30) First (page 30)  
 w 15300 (page 30)  
 w 180 (page 0)  
 r 2200 (page 4) First (page 4)  
 w 1292 (page 2)

- Construct a list in order of when pages are first used, ie: 2, 0, 30, 4
  - Use the last item, ie. remove frame containing page 4

## PLRU example 2

- Same as before, except:
  - check\_frames = 2
- num\_frames = 6, page\_size = 512
- lookahead = 3, check\_frames = 2
- Current operation:
  - w 1492 (page 2)
- Lookahead list:
  - w 50 (page 0)
  - w 15400 (page 30)
  - r 2200 (page 4)

## PLRU example 2

Initially:

3	5	1	42	30	4
w	r	r	r	w	r

- Page 2 is not in cache
- Cache miss
- Must find a frame to remove

## PLRU example 2

Initially:

3	5	1	42	30	4
w	r	r	r	w	r

- Start at back of list
- Page 4 is in lookahead list
- Don't remove this frame

## PLRU example 2

Initially:

3	5	1	42	30	4
w	r	r	r	w	r

- Move to next frame
- Page 30 is in lookahead list
- Don't remove this frame

## PLRU example 2

Initially:

3	5	1	42	30	4
w	r	r	r	w	r

v v

^ ^

- Cannot move to next frame
  - Since *check\_frames* is only 2
- Must choose one of the last 2 frames

## PLRU example 2

- Examine lookahead list:
  - w 50 (page 0)
  - w 15400 (page 30)
  - r 2200 (page 4)
- Page 30 is needed before page 4
- So remove page 4

## PLRU example 2

Initially:

3	5	1	42	30	4
w	r	r	r	w	r

Finally:

2	3	5	1	42	30
w	w	r	r	r	w

- Same as normal LRU
- We were unlucky

## PLRU example 3

- What if the page 30 and page 4 operations were swapped?
  - w 50 (page 0)
  - r 2200 (page 4)
  - w 15400 (page 30)

Initially:

3	5	1	42	30	4
w	r	r	r	w	r

v v

^ ^

- Still must choose one of last 2 frames

## PLRU example 3

- This time page 4 is needed before page 30
- So remove page 30

Initially:

3	5	1	42	30	4
w	r	r	r	w	r

Finally:

2	3	5	1	42	4
w	w	r	r	r	r