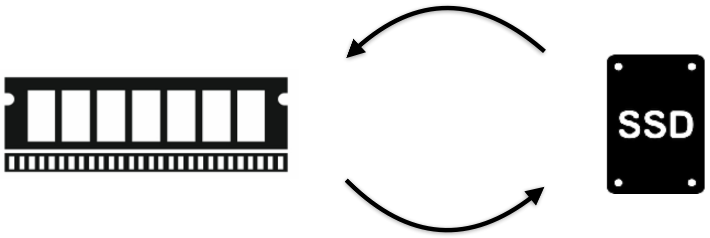
# Buffer Management



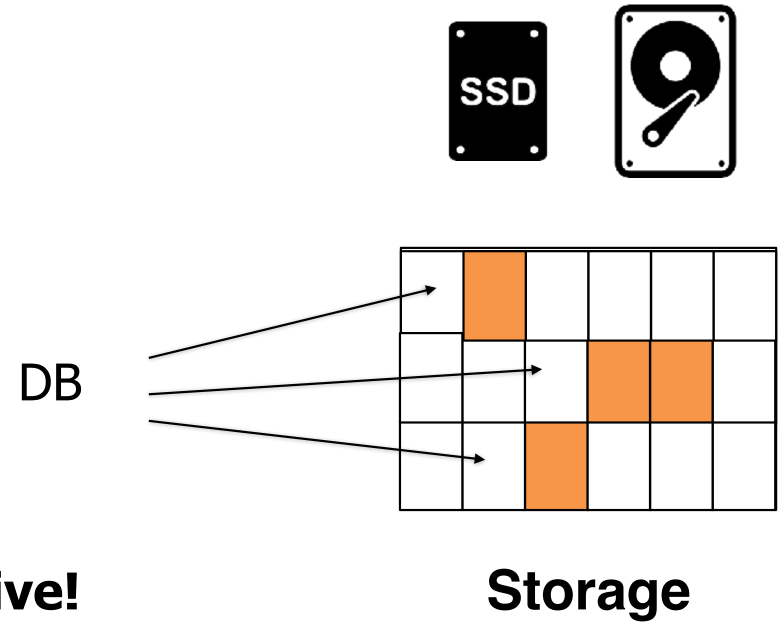

Database System Technology - Lecture 3, Chapter 9

Niv Dayan

# Context

A DB is reading and writing aligned 4KB storage pages

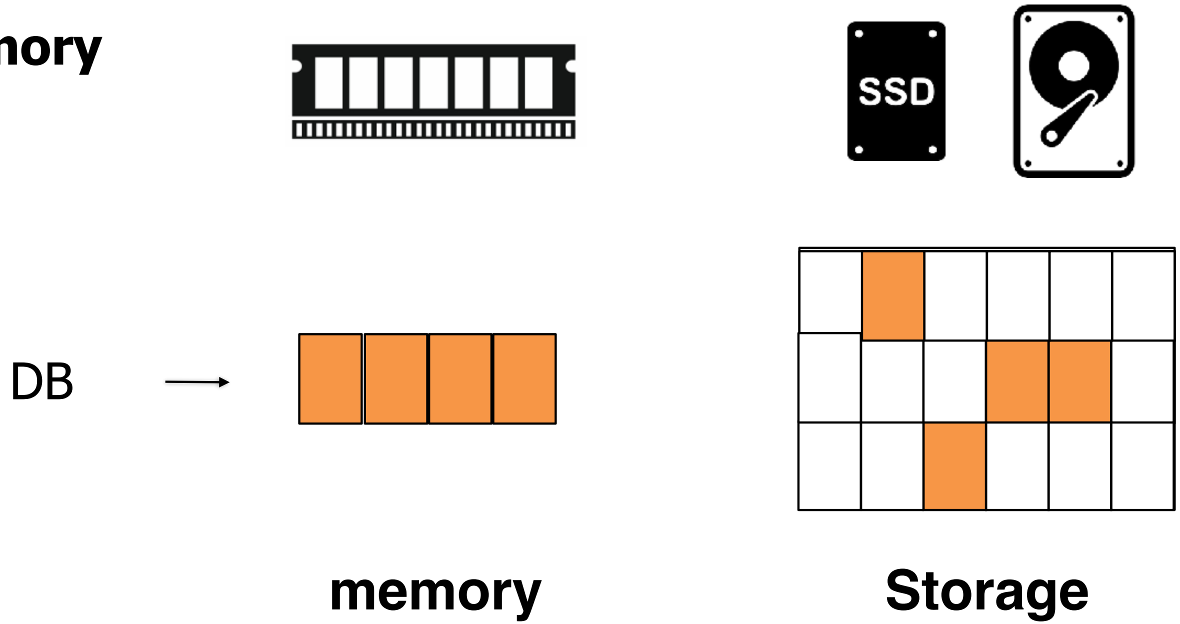
Suppose orange pages are frequently accessed (“hot”)




**Retrieving these pages over and over is expensive!**

# Buffer Pool

**Keep copies of hot pages in memory**



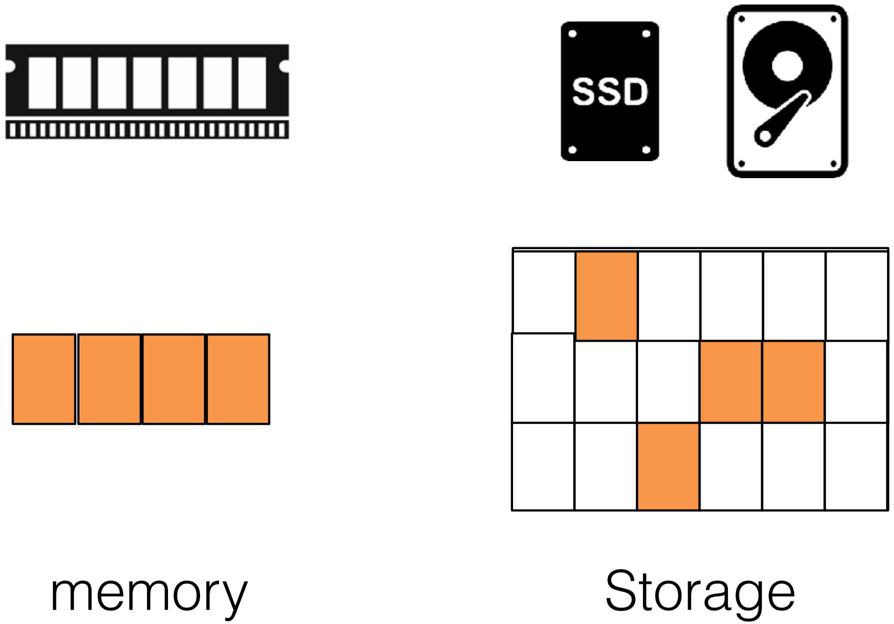
# Buffer Pool

Question 1:

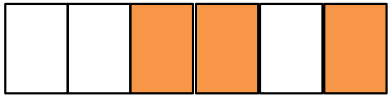
How to structure this buffer pool?

**hash table of your choice**

e.g., chaining, linear probing, etc.



# Buffer Pool



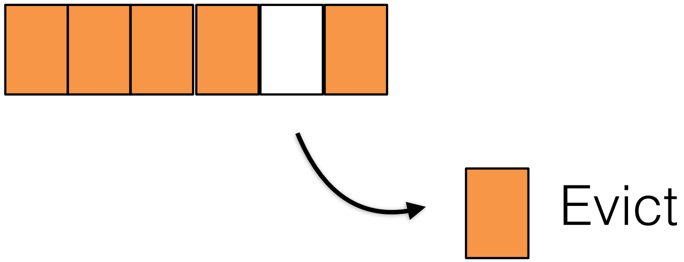
**Each frame must keep some metadata**

(1) **Pin count** - How many users are currently using this page

(2) **Dirty flag** - indicates whether the page has been updated

# Eviction Policy

Which page to evict when we run out of space?



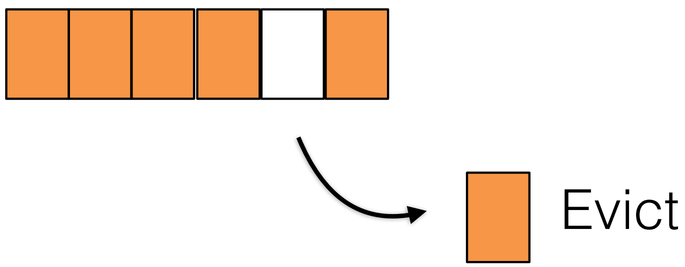

**Considerations:**

**(1) Avoid evicting a page that is likely to be used again**

**(2) Avoid excessive metadata or CPU overheads to make decision**

# Eviction Policy

Which page to evict when we run out of space?




**Big impact on number of I/Os and CPU efficiency**

**Depends on the access pattern**

# We’ll cover 5 eviction policies

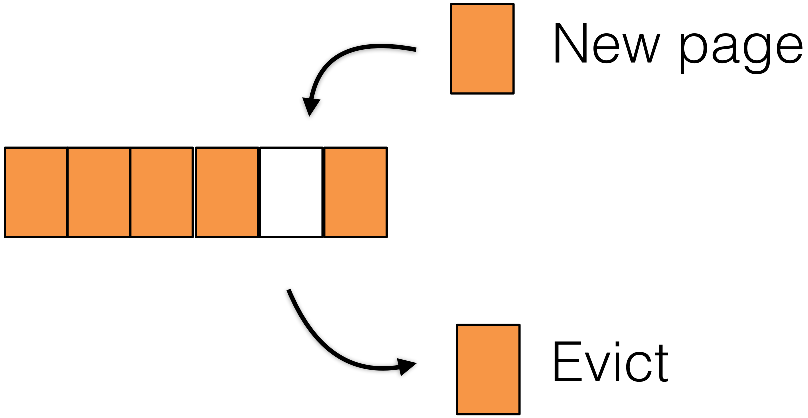
**Random** **FIFO** **LRU** **Clock** **MRU**

# Random Eviction

Evict whichever page collides in the hash table with a new page

**Pro: No additional metadata needed**

**Con: May evict a frequently used page**

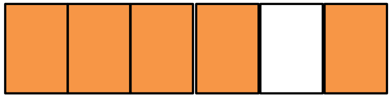


# First in First Out (FIFO)

Evict Page that was inserted the longest time ago

**Rationale?** Less likely to be used again

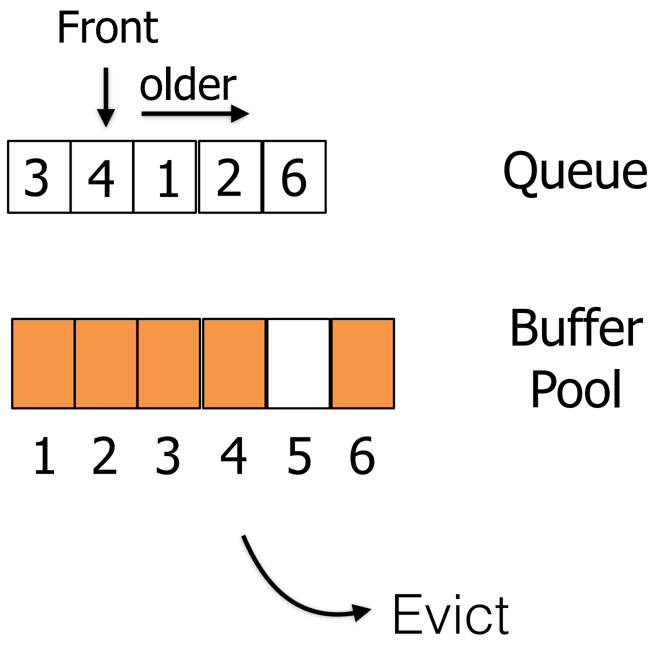
**Implementation?**



# First in First Out (FIFO)

Evict Page that was inserted the longest time ago

**Implementation?** Using a queue



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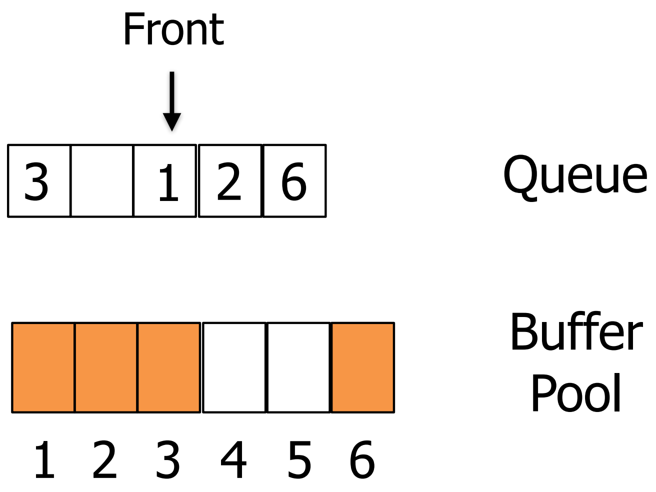
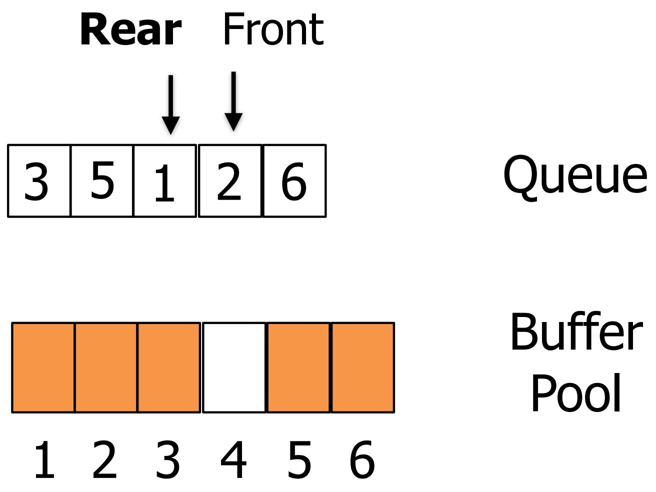


# First in First Out (FIFO)

Evict Page that was inserted the longest time ago




**Problems?**

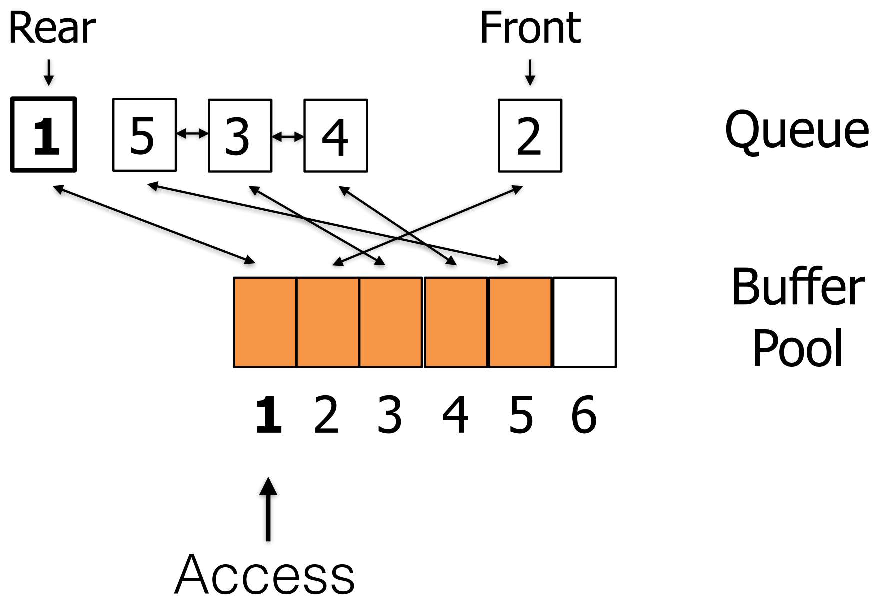
1. Pages we evict have different frames than pages we insert. Need to have more spare capacity to curb hash collisions. We'll accept this.

2. Oldest page may still be frequently used. We'll try to do better.

# Least Recently Used (LRU)

Evict page that was used last the longest time ago

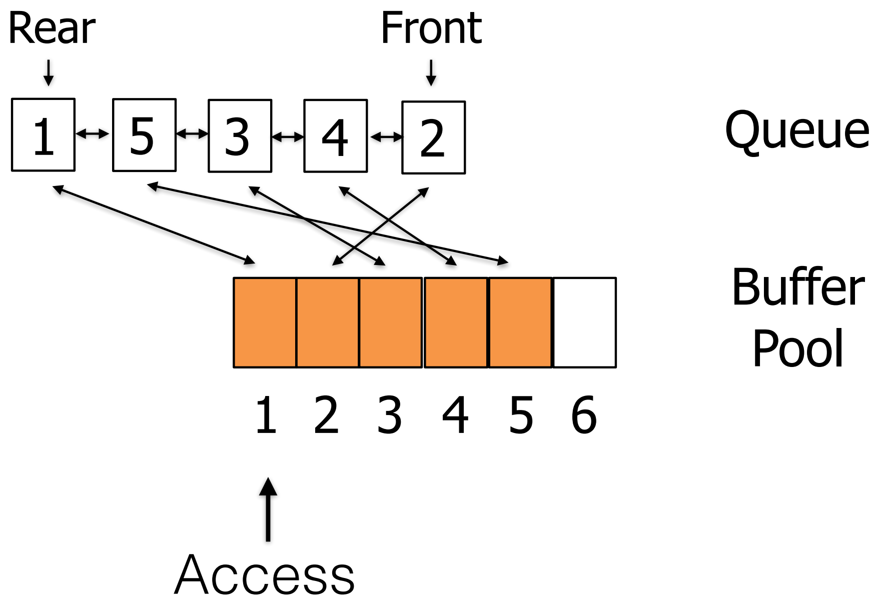
Implementation? Doubly-linked list



# Least Recently Used (LRU)

Evict page that was used last the longest time ago

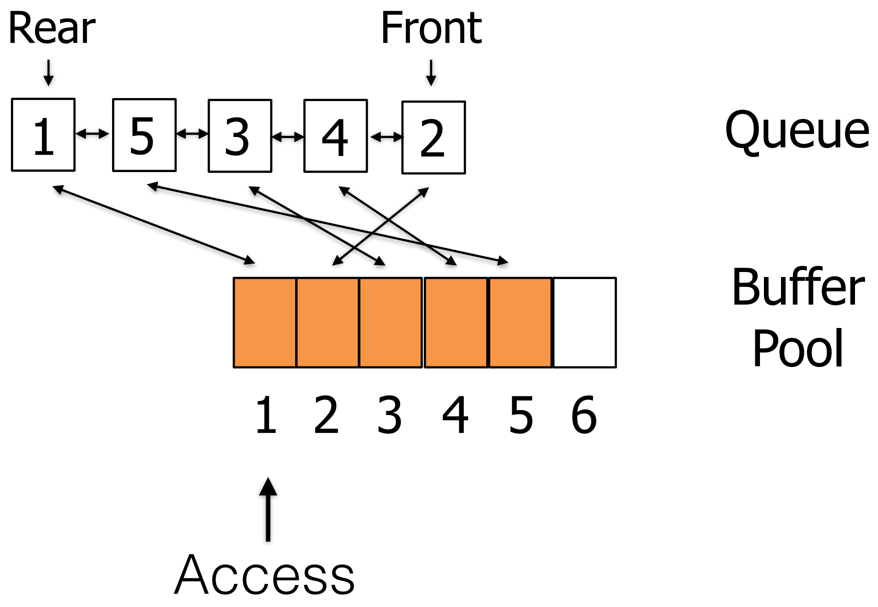
Implementation? Doubly-linked list



# Least Recently Used (LRU)

Evict page that was used last the longest time ago

**Problems?**



# Least Recently Used (LRU)

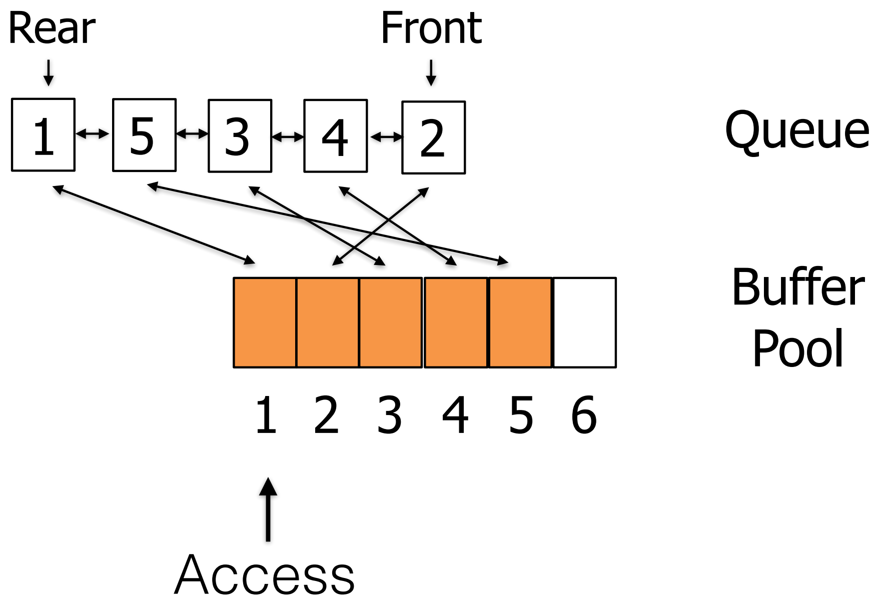
Evict page that was used last the longest time ago

**Problems?**

(1) CPU overhead to update queue for each access

(2) Metadata overhead for pointers

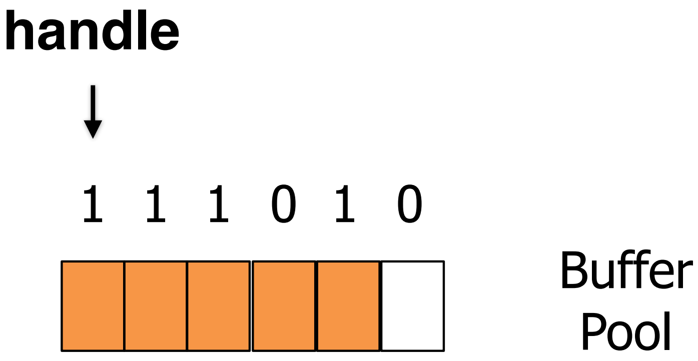
(3) Linked lists are less efficient than arrays due to pointer chasing



# Clock

Traverse hash table circularly as a clock.
Evict any entry not used since last traversal.

**Implementation? Bitmap**



# Clock

Traverse hash table circularly as a clock.
Evict any entry not used since last traversal.

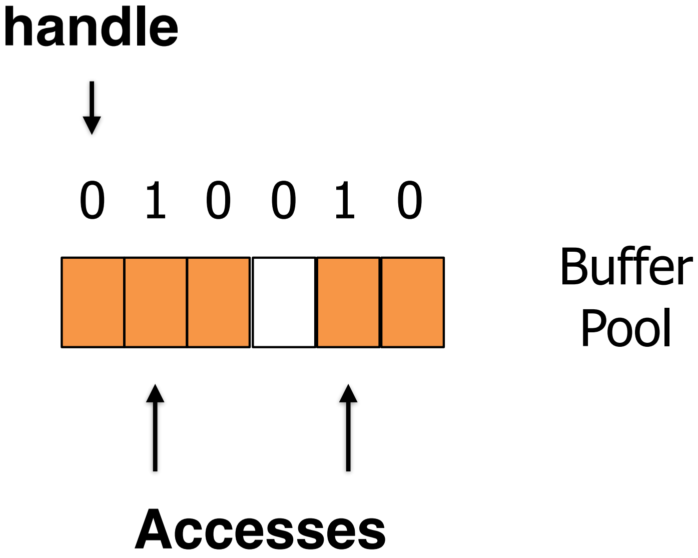
**Advantages**

(1) lower overheads as there is no queue

(2) bitmap takes little extra space

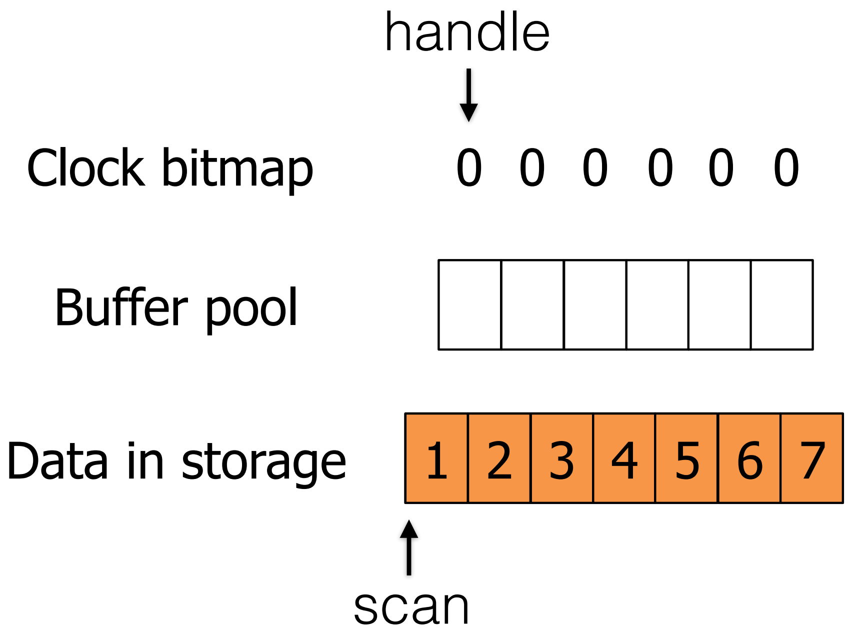
**Disadvantages**

(1) can evict "hotter" pages than LRU,
But still better than FIFO



# Sequential Flooding of Clock

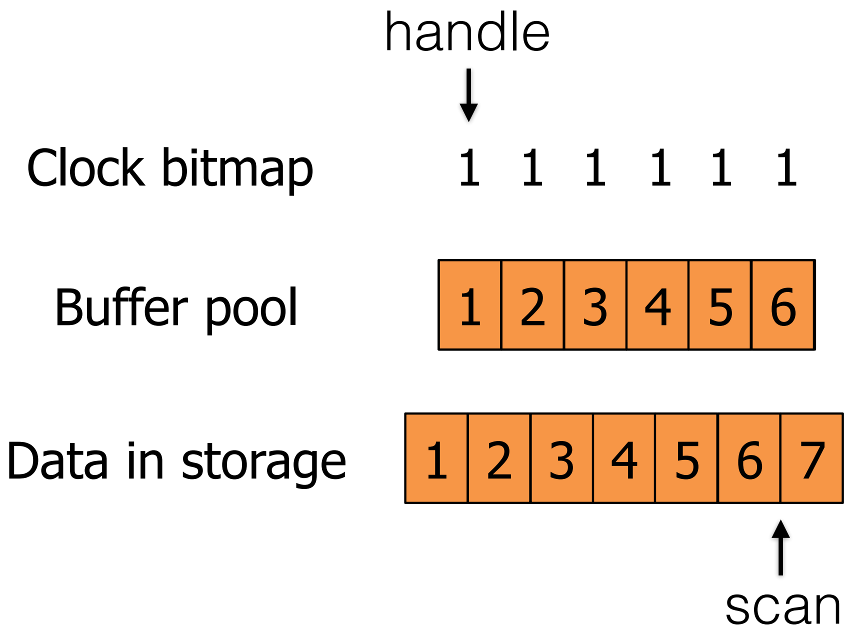
Suppose the DB is repeatedly scanning data larger than the buffer pool



# Sequential Flooding of Clock

Suppose the DB is repeatedly scanning data larger than the buffer pool

**Note the Simplification. Elements would really be randomly mapped in the buffer pool due to hashing.**



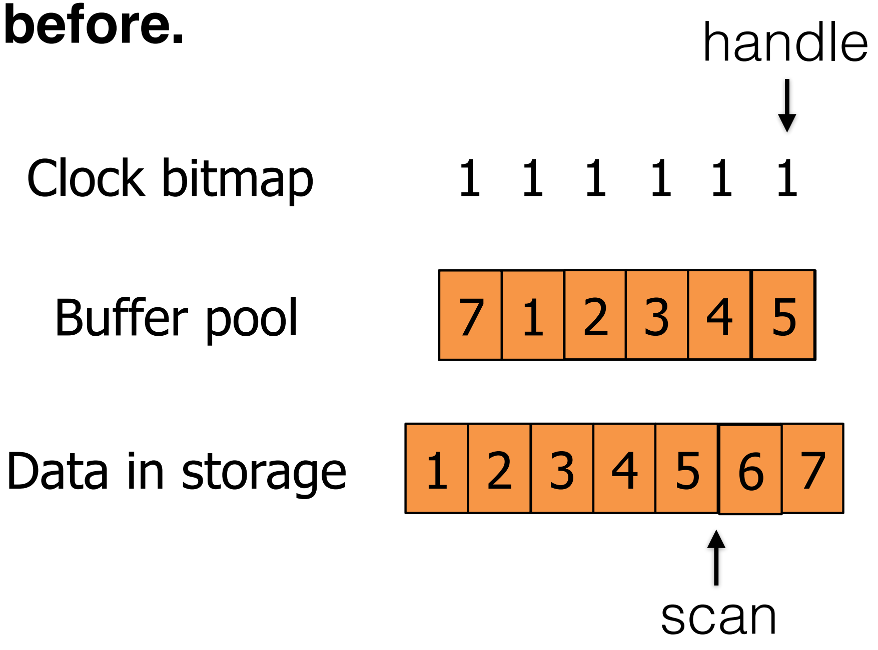
# Sequential Flooding of Clock

Suppose the DB is repeatedly scanning data larger than the buffer pool

Clock constantly evicts the page we need to read next!

**Also a problem for LRU from before.**

**Solution?**

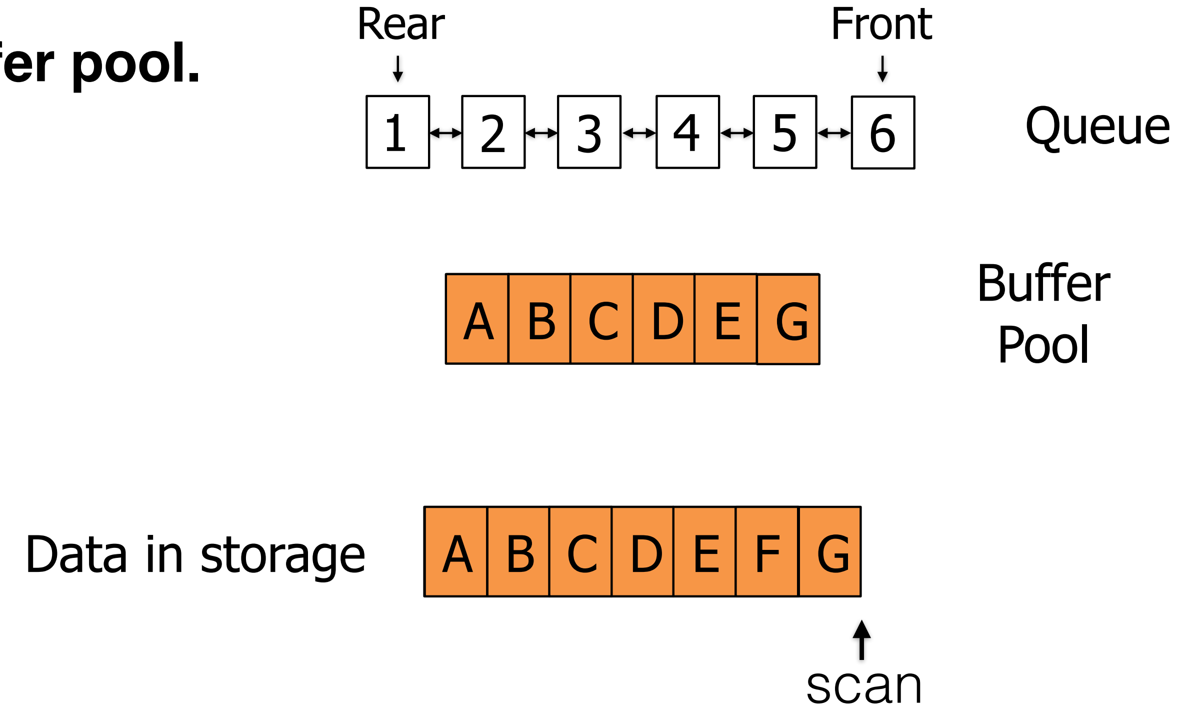


# Sequential Flooding of Clock

Let's instead evict "most recently used" (MRU) entries?

**How? Opposite of LRU.**

**Most data stays in the buffer pool.**



# Sequential Flooding of Clock

In reality, DBs typically use LRU or clock

To prevent sequential flooding, they avoid putting scanned data in the buffer pool

Core message: no eviction policy is perfect.

# Summary

| | Eviction Effectiveness | CPU |
|---|---|---|
| **Random** | Worst | Best |
| **FIFO** | Moderate | Moderate |
| **LRU** | Best | Worst |
| **Clock** | Good | Good |

# Two trade-offs