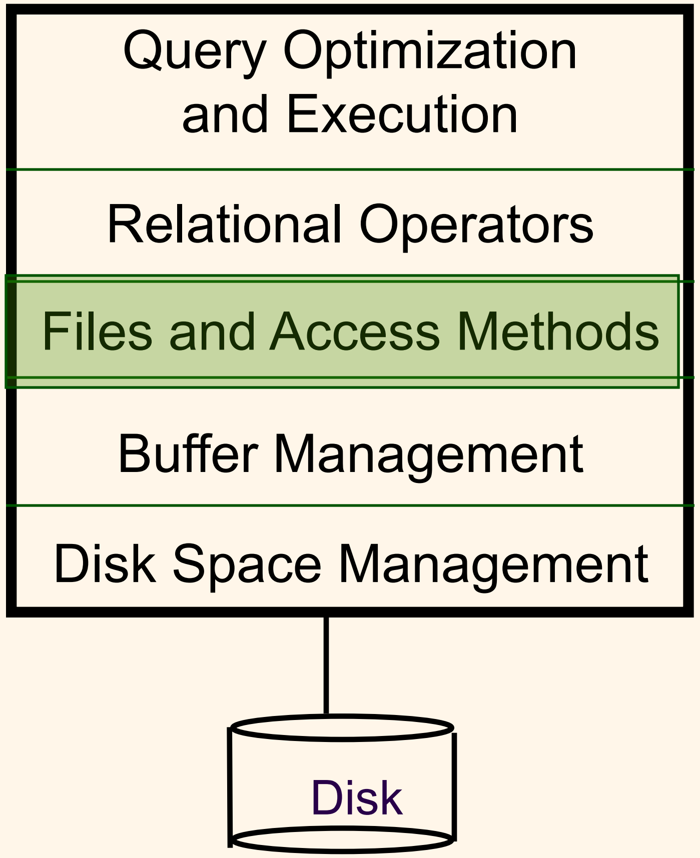
Overview of Storage and Indexing Storing Data: Disks and Files

Chapters 8-9

Overview of Storage and Indexing

- What would be a good way to store the records of a table of (id,name,age,salary)
- What about if we always want to retrieve records based on the age / salary..??
- Pages: The unit of information read from or written to disk. It is a DBMS parameter, typical values 4KB, 8KB

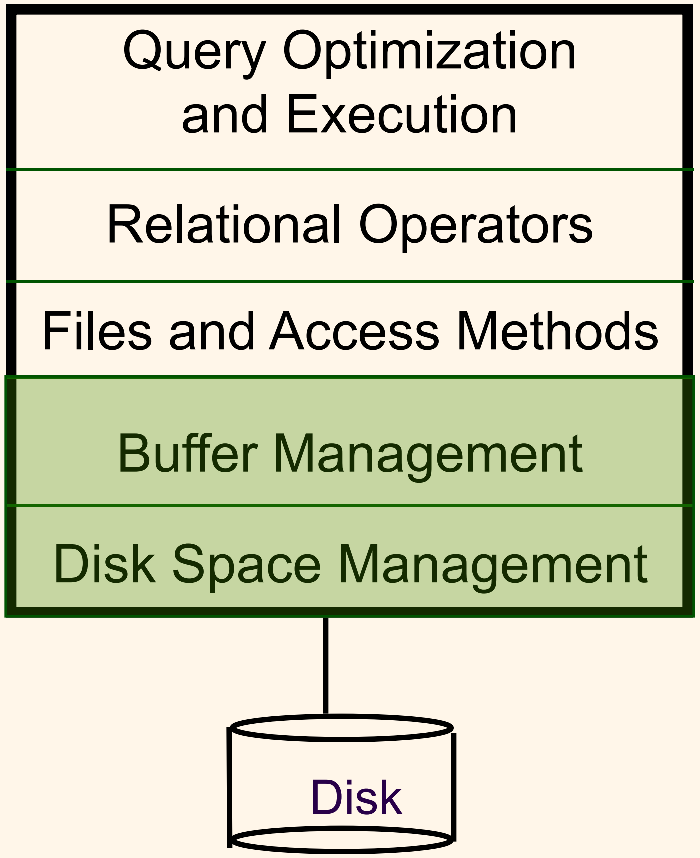


Data on External Storage

- Disks: Can retrieve random page at fixed cost
  - But reading several consecutive pages is much cheaper than reading them in random order
- Tapes: Can only read pages in sequence
  - Cheaper than disks; used for archival storage
- File organization: Method of arranging a file of records on external storage.
  - Record id (rid) is sufficient to physically locate record. An rid can identify the disk address of the page that contains the record.
  - Indexes are data structures that allow us to find the record ids of records with given values in index search key fields

Data on External Storage (Architecture)

- Buffer manager:
  - Reads data into memory for processing and write to disk for persistent storage
  - When the "file and access methods" layer needs to process a page, it passes the page's rid to the buffer manager that will fetch it in memory if it is not there



- Disk space manager
  - Allocates disk pages upon request from the file layer
  - If a page is freed by the file layer, the space manager tracks it and reuse it later if the file later requests a new page

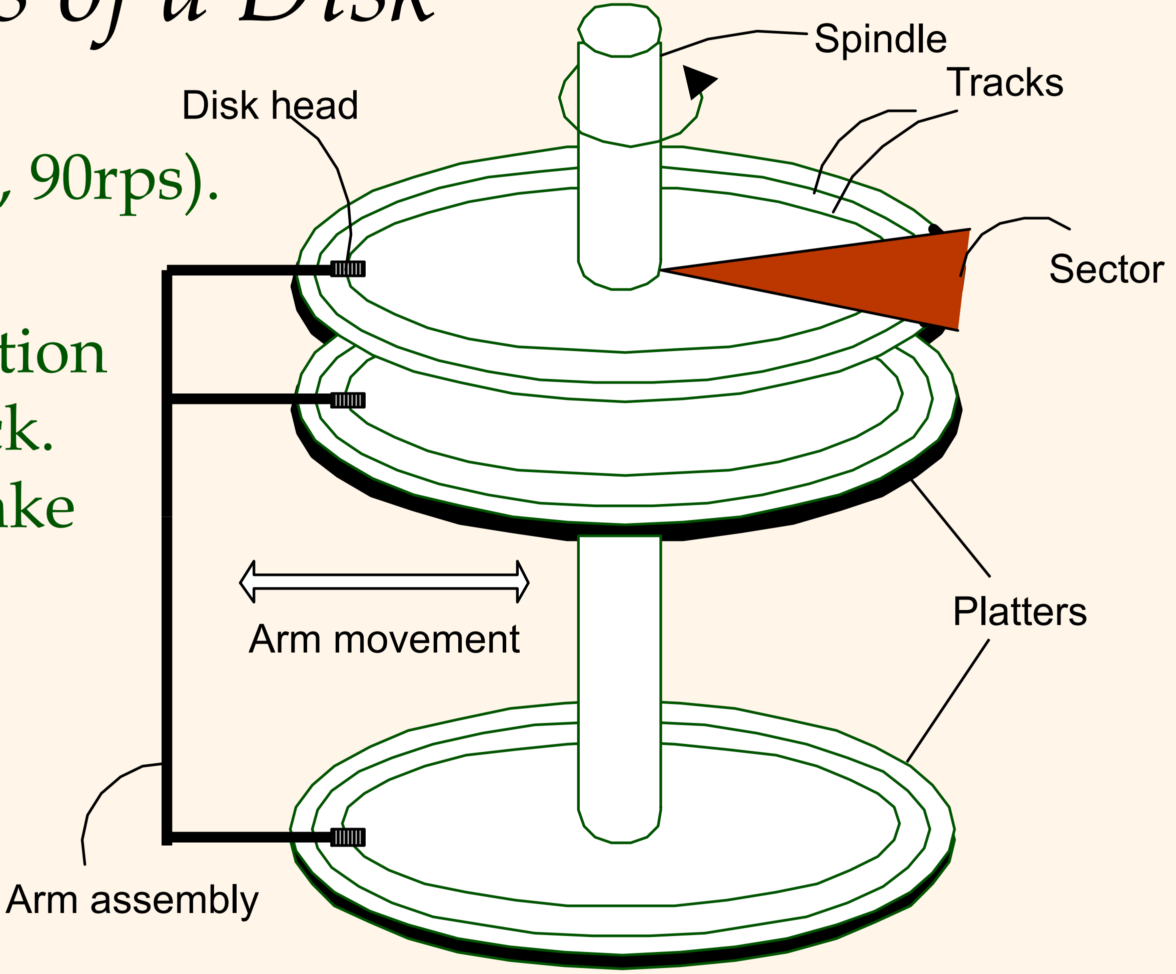
Disks and Files

- DBMS stores information on ("hard") disks.
- This has major implications for DBMS design!
  - READ: transfer data from disk to main memory (RAM).
  - WRITE: transfer data from RAM to disk.
  - Both are high-cost operations, relative to in-memory operations, so must be planned carefully!

- Why Not Store Everything in Main Memory?
  - *Costs too much*. Disks are much cheaper than memory.
  - *Main memory is volatile*. We want data to be saved between runs. (Obviously!)

Components of a Disk

- The platters spin (say, 90rps).
- The arm assembly is moved in or out to position a head on a desired track. Tracks under heads make a *cylinder* (imaginary!).
- Only one head reads/writes at any one time.



Accessing a Disk Page

- Time to access (read/write) a disk block:
  - *seek time* (moving arms to position disk head on track)
  - *rotational delay* (waiting for block to rotate under head)
  - *transfer time* (actually moving data to/from disk surface)

- Seek time and rotational delay dominate.

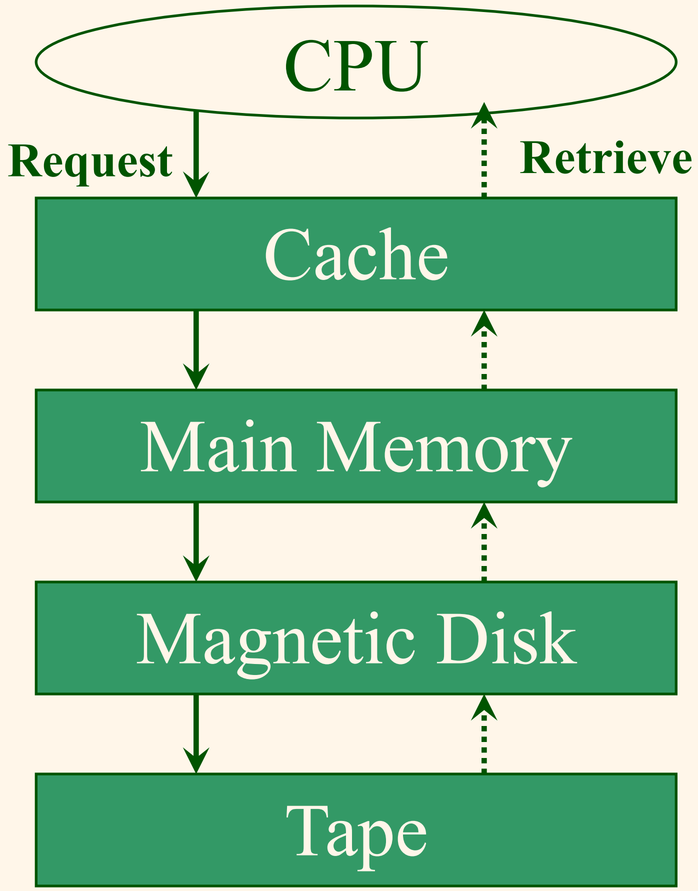
- Key to lower I/O cost: reduce seek/rotation delays! Hardware vs. software solutions?

Disks

- Secondary storage device of choice.
- Main advantage over tapes: *random access* vs. *sequential*.
- Data is stored and retrieved in units called *disk blocks* or *pages*.

Unlike RAM, time to retrieve a disk page varies depending upon location on disk. Therefore, relative placement of pages on disk has major impact on DBMS performance!

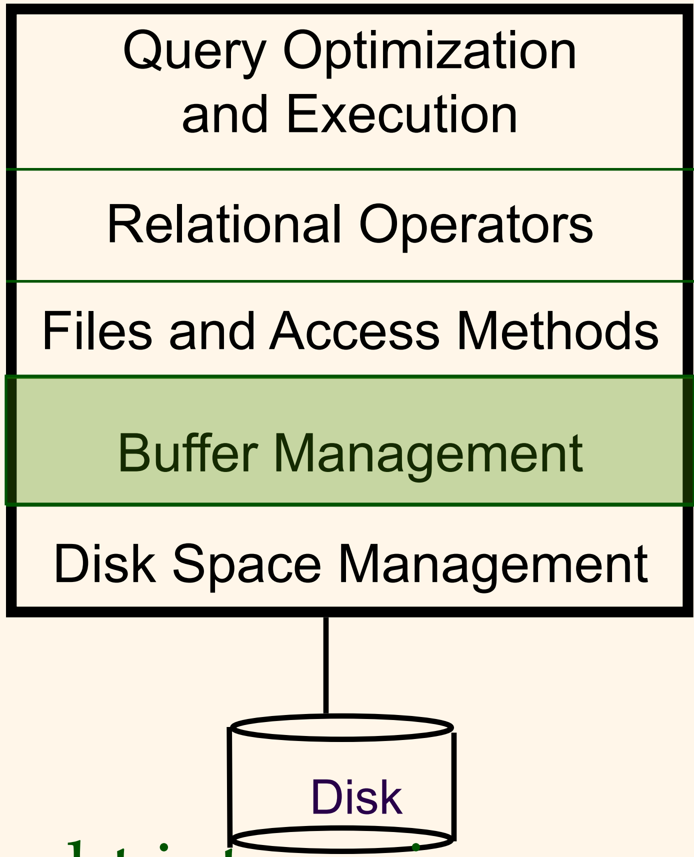
Storage Hierarchy



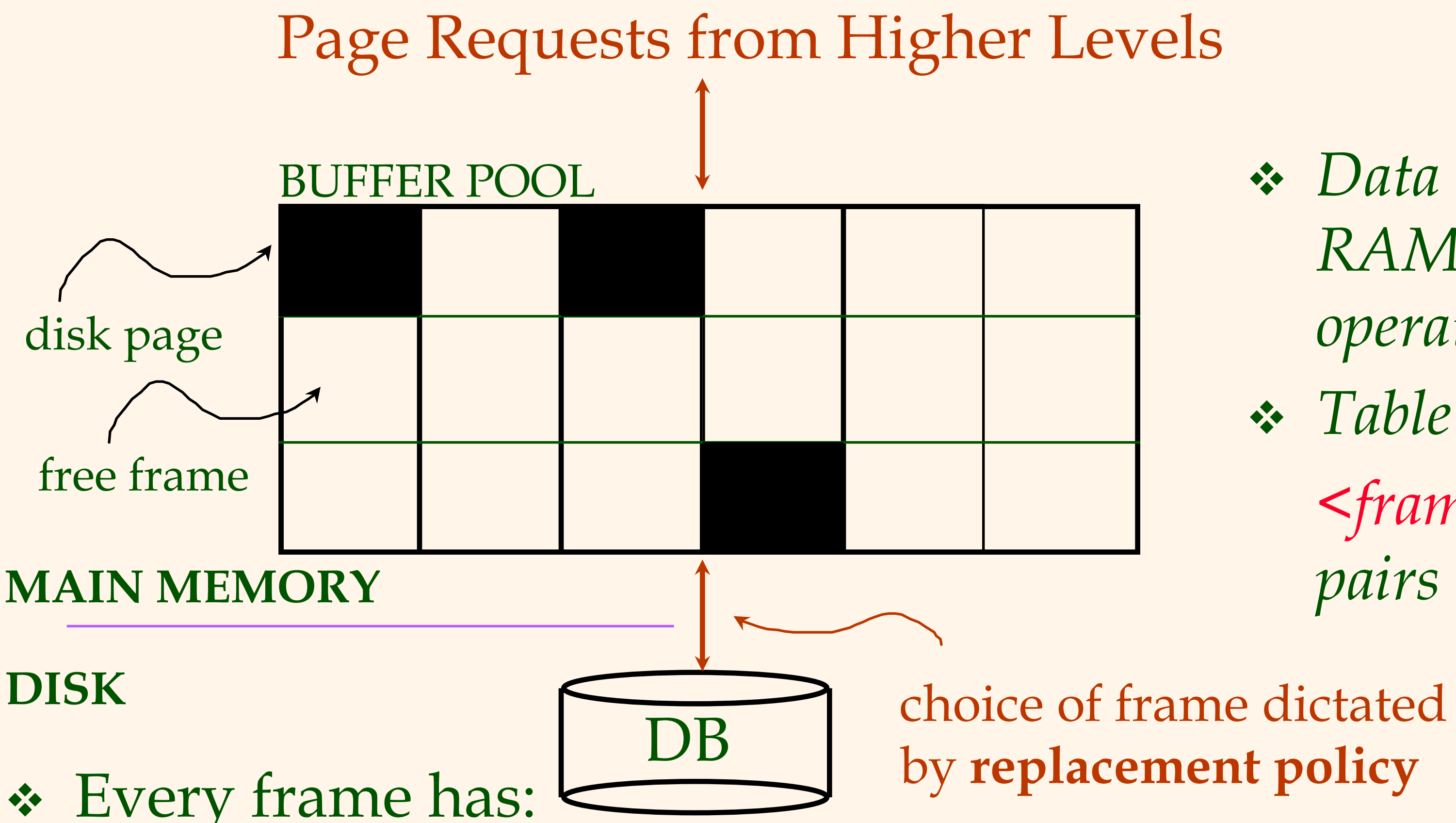
- Typical storage hierarchy:
  - Main memory (RAM) for currently used data.
  - Disk for the main database (secondary storage).
  - Tapes for archiving older versions of the data (tertiary storage).

Buffer Manager

- The buffer manager is a software layer responsible for bringing pages from disk to main memory as needed
- The buffer manager manages the available main memory (*buffer pool*) by partitioning it into a collection of pages (*frames*)
- Because all the data cannot be brought into main memory at one time, the buffer manager brings pages into memory only as they are needed, and decide what existing pages in main memory need to be replaced (*replacement policy*)



Buffer Pool


Page Requests from Higher Levels
BUFFER POOL
disk page
free frame
MAIN MEMORY
DISK
DB
choice of frame dictated by **replacement policy**

- *Data must be in RAM for DBMS to operate on it!*
- *Table of <frame#, pageid> pairs is maintained.*

- Every frame has:
  - *Pin_count:* The number of users who are using that frame
  - *Dirty bit:* Indication whether the page has been modified since brought to the buffer

When a Page is Requested ...

- *If requested page is not in pool:*
  - *If there are page frames in the pool with pin_count=0*
    - *Choose one of these frames for replacement*
    - *If the chosen frame is dirty, write it to disk*
    - *Read requested page into the chosen frame*
- *Pin the page (increment the pin count) and return its address.*

☛ *If requests can be predicted (e.g., sequential scans) pages can be pre-fetched several pages at a time!*

More on Buffer Management

- The requestor of a page is responsible on releasing it (*unpinning*), and indicate whether it has been modified:
  - *dirty* bit is used for this.
- A page in the pool may be requested many times,
  - A page is a candidate for replacement iff *pin count* = 0.
- If no frame has zero *pin_count* and a new page is requested, then the buffer manger must wait until some page is released or the transaction requesting the page is aborted
- Allowing multiple transactions to pin the same page may result in conflicting changes
  - Concurrency control would take care of this