File Organizations and Indexes

COST MODEL

D: average time to read or write a disk page.

C : average time to process a record.

H : the time required to apply a hash function to a record.

3 File Organizations:

Heap Files.

Sorted Files.

Hashed Files.

Operations to be investigated

Scan: fetch all records in a file.

Search with equality selection. (SWES) ("Find the students record with sid = 23")

Search with Range Selection. (SWRS)
("Find all students with name alphabetically after 'Smith'")

Insert: Insert a given record into the file.

Delete: Delete a record with given rid.

Below, we examine the costs of these operations with respect to the 3 different file organizations.

Heap Files

Scan:

$B(D + RC)$ where

- B is the number of pages, and
- R is the average number of records in a page (block).

SWES:

- $0.5B(D + RC)$ on average if the selection is specified on a key.
- Otherwise $B(D + RC)$.

Heap Files

SWRS: B(D + RC).

Insert: 2D + C . (Always insert to the end of the file)

Delete:

- Only one record is involved.
  - The average cost is 0.5B(D + RC) + D if rid is not given;
  - otherwise (D + C) + D.
- Several records are involved. Expensive.

Sorted Files

Sorted on a search key - a combination of one or more fields.

If the following query is made against the search key, then:

1. Scan: $B(D + RC)$.
2. SWES:
   - $O(D \log_2 B + C \log_2 R)$ if single record.
   - $O(D \log_2 B + C \log_2 R + \#matches)$.
3. SWRS: $O(D \log_2 B + C \log_2 R + \#matches)$.
4. Insert: expensive.
   - Search cost plus $2 * (0.5B(D + RC))$.
5. Delete: expensive.
   - Search cost plus $2 * (0.5B(D + RC))$.

Hashed Files

- The pages in a file are grouped into buckets.
- The buckets are defined by a hash function.
- Pages are kept at about 80% occupancy.

Assume the data manipulation is based on the hash key.

- Scan: 1.25B(D + RC).
- SWES: H + D + 0.5RC if each hash bucket contains only one page.
- SWRS: 1.25B(D + RC). (No help from the hash structure)
- Insert: Search cost plus C + D if one block involved.
- Delete: Search cost plus C + D if one block involved.

Summary

File Type	Scan	Equality Search	Range Search	Insert	Delete
Heap	BD	0.5 BD	BD	Search + D	Search + D
Sorted	B D	D log B	D log B + # matches	Search + BD	Search + BD
Hashed	1.25 BD	D	1.25 BD	2 D	Search + BD

A Comparison of I/O Costs

Indexes

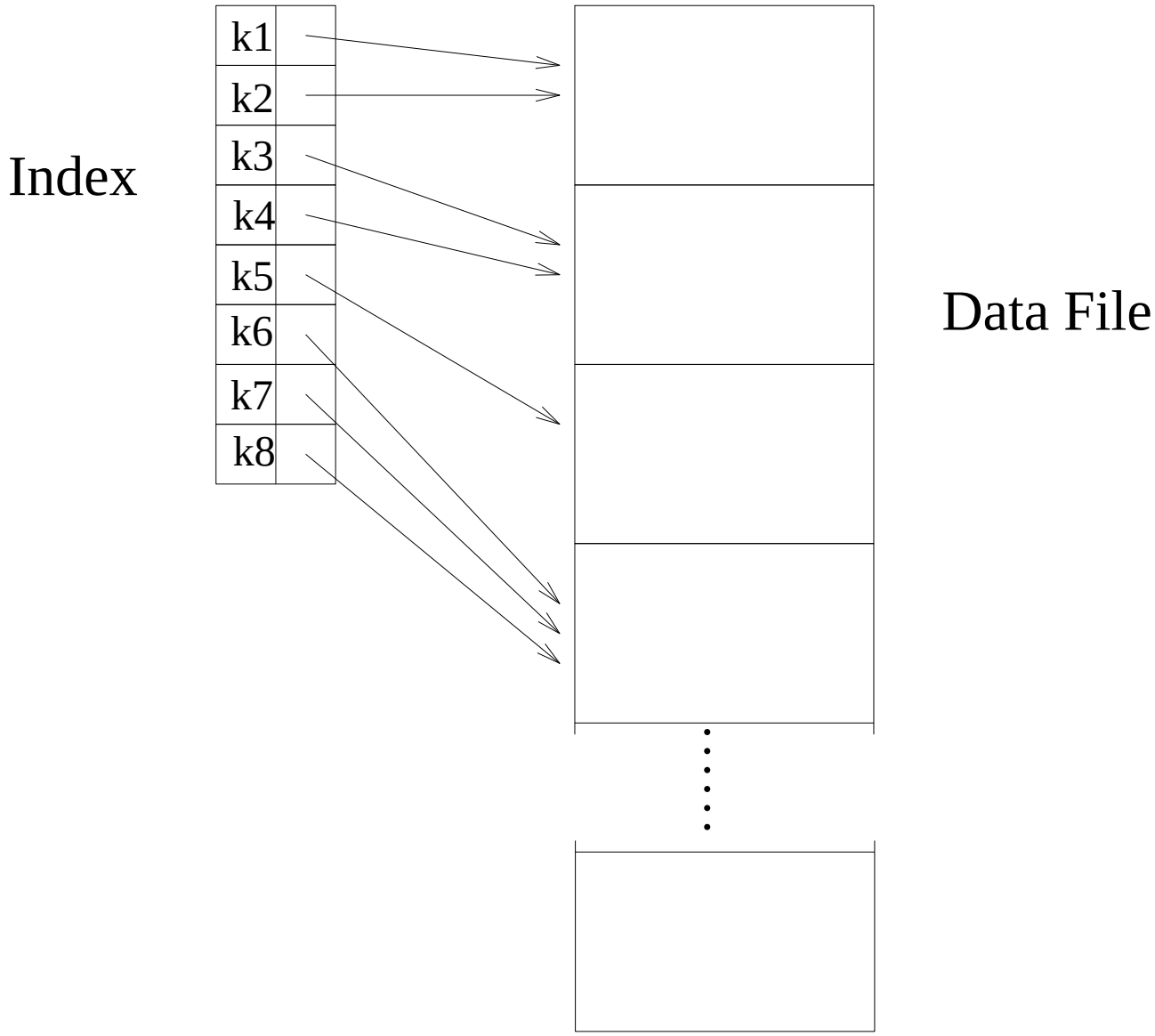
Basic idea behind index is as for books.

INDEXES

aardvark 25,36	lion 18
bat 12	llama 17,21,22
cat 1,5,12	sloth 18
dog 3	tiger 18
elephant . . 17	wombat . . . 27
emu 28	zebra 19

- A table of key values, where each entry gives places where key is used.
- Aim: efficient access to records via key values.

Indexing Structure



Indexing Structure

Index is collection of data entries k∗.

Each data entry k∗ contains enough information to retrieve (one or more) records with search key value k.

Indexing:

- How are data entries organized in order to support efficient retrieval of data entries with a given search key value?
- Exactly what is stored as a data entry?

Alternatives for Data Entries in an Index

- A data entry k∗ is an actual data record (with search key value k).
- A data entry is (k, rid) pair (rid is the record id of a data record with search key value k).
- A data entry is a (k, rid – list) pair (rid – list is the list of record ids of data records with search key value k).

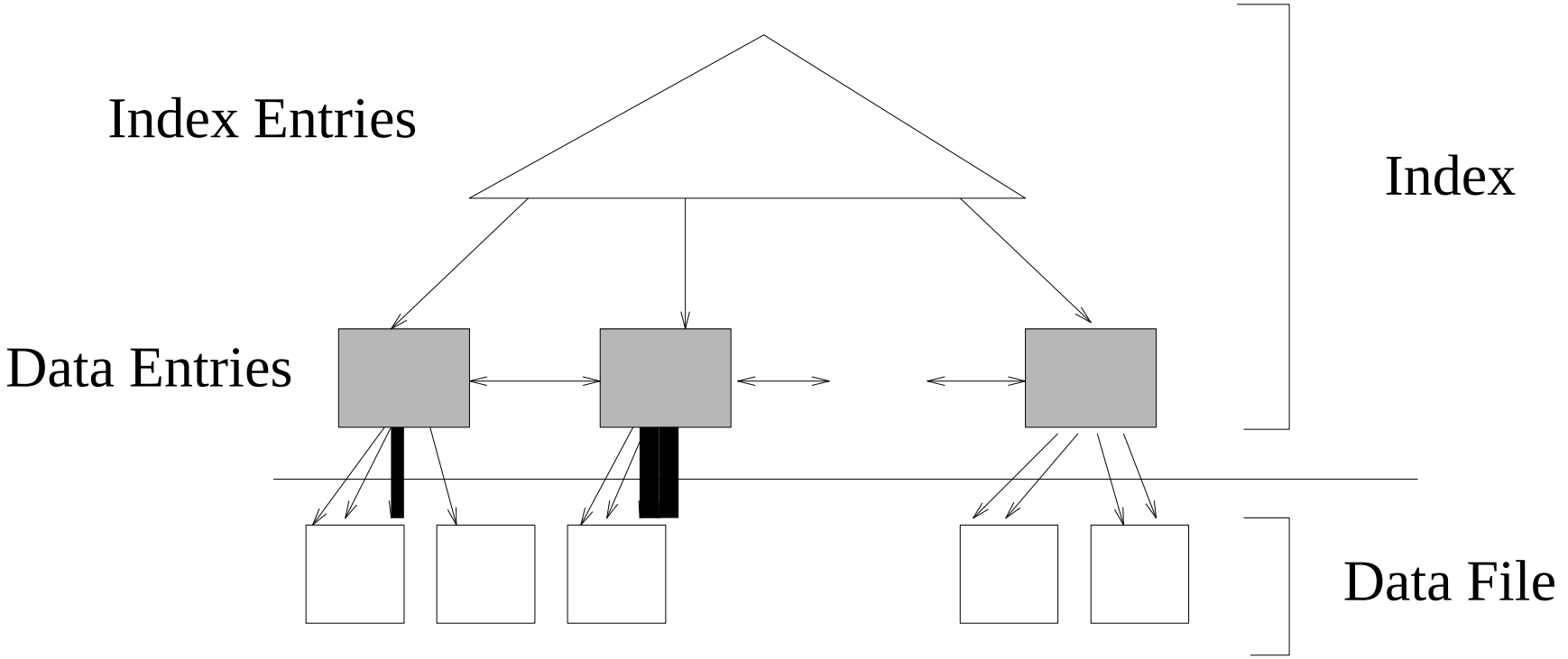
Example: (Xuemin Lin, page 12), (Xuemin Lin, page 100)

VS

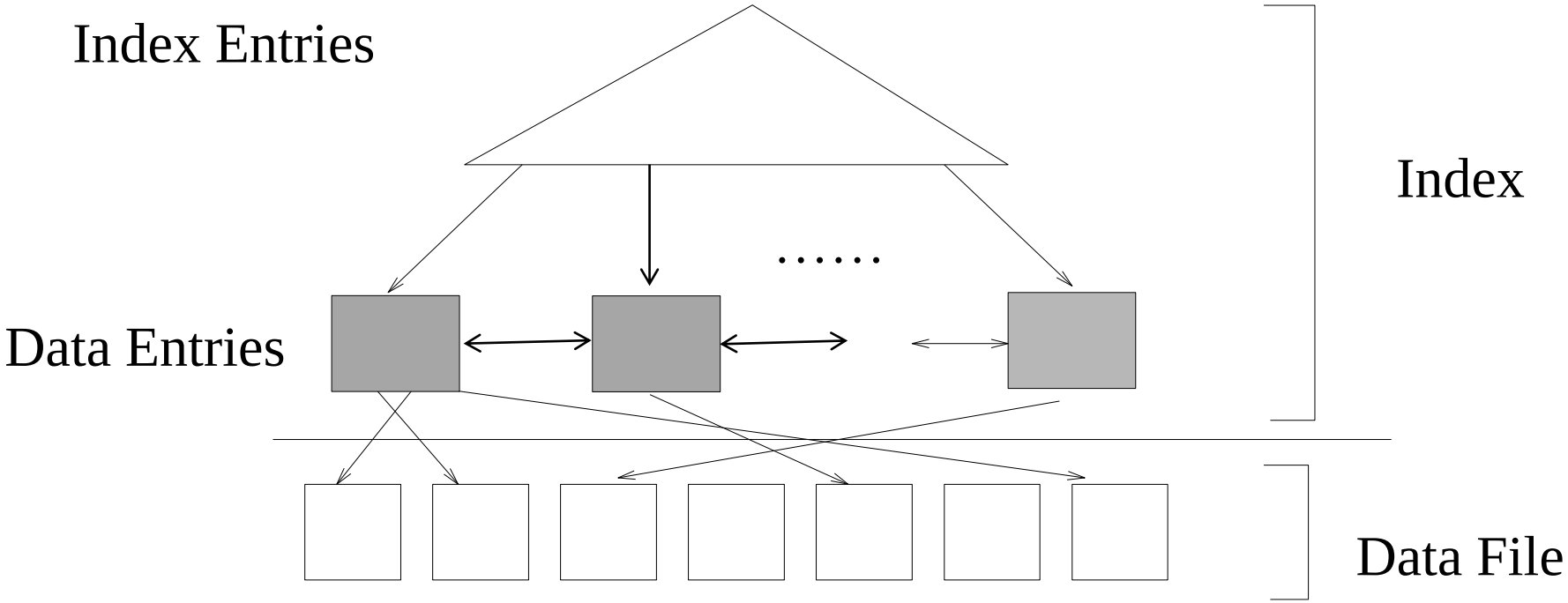
(Xuemin Lin, page 12, page 100)

Clustered Index

- Clustered: a file is organized of data records is the same as or close to the ordering of data entries in some index.
- Typically, the search key of file is the same as the search key of index.



Unclustered Index



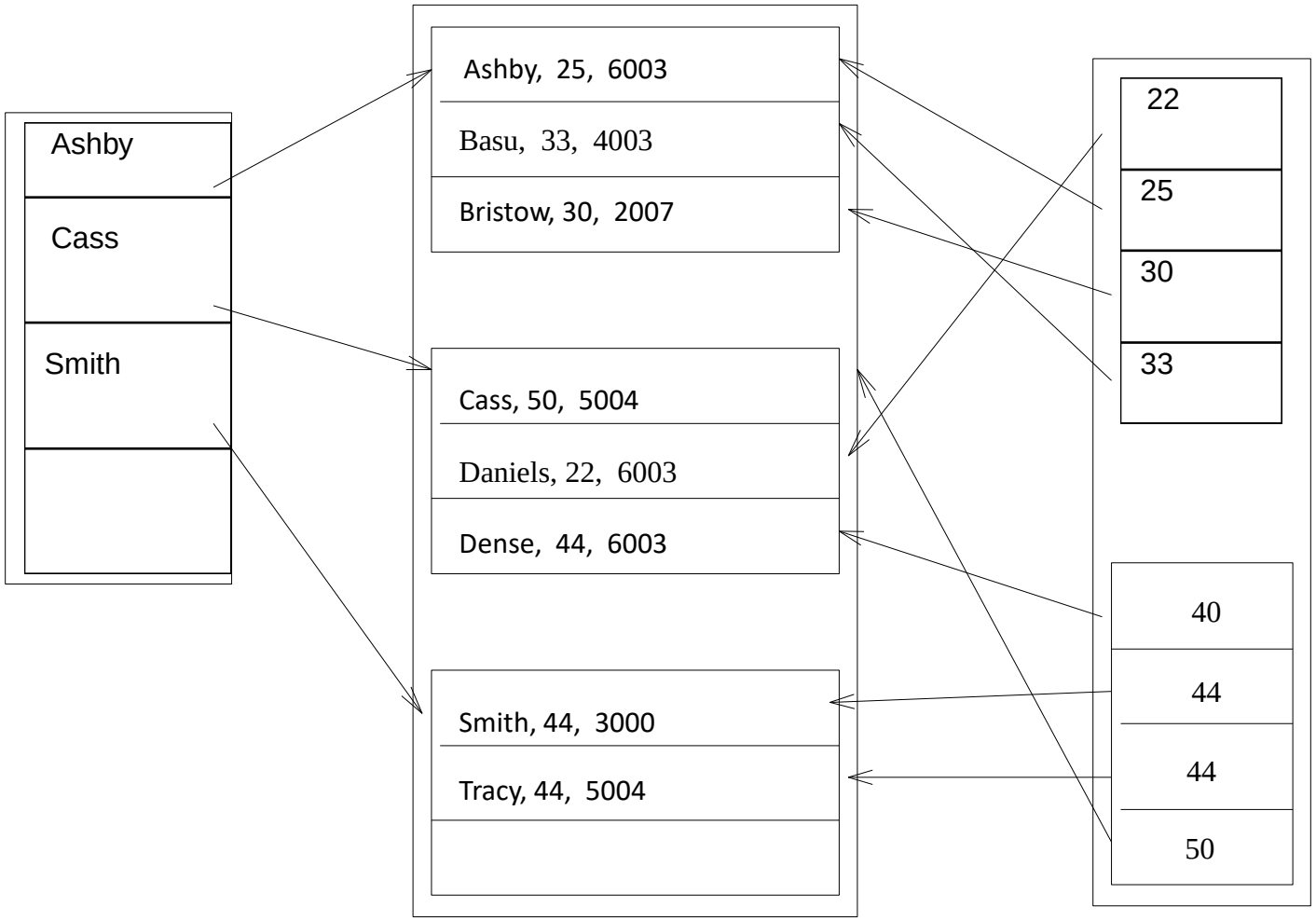
- Clustered indexes are relatively expensive to maintain.
- A data file can be clustered on at most one search key.

Dense VS Sparse Indexes

- Dense: it contains (at least) one data entry for every search key value.

- Sparse: otherwise.

Q: Can we build a sparse index that is not clustered?



Sparse Index VS Dense Index

Primary and Secondary Indexes

- Primary: Indexing fields include primary key.
- Secondary: otherwise.

There may be at most one primary index for a file.

Composite search keys: search key contains several fields.