Overview of Storage and Indexing Storing Data: Disks and Files

Chapters 8-9

Examples of Clustered Indexes

- B+ tree index on E.age can be used to get qualifying tuples.
  - How selective is the condition?
  - Is the index clustered?
- Consider the GROUP BY query.
  - If many tuples have *E.age* > 10, using *E.age* index and sorting the retrieved tuples may be costly.
  - Clustered *E.dno* index may be better!
- Equality queries and duplicates:
  - Clustering on *E.hobby* helps!

```
SELECT  E.dno
FROM  Emp E
WHERE  E.age>40
```

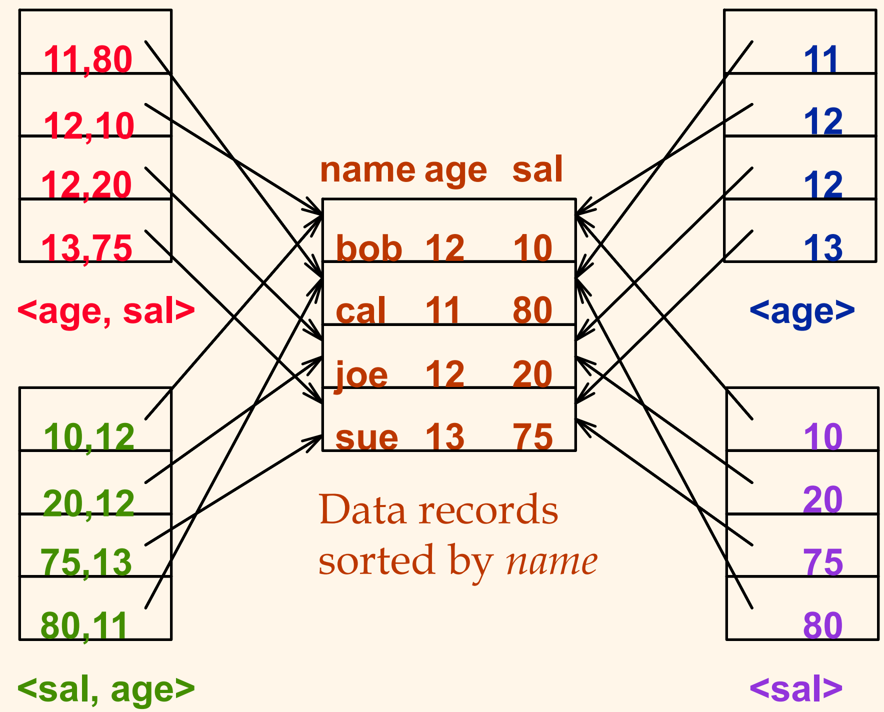
```
SELECT  E.dno,  COUNT (*)
FROM  Emp E
WHERE  E.age>10
GROUP BY E.dno
```

```
SELECT  E.dno
FROM  Emp E
WHERE  E.hobby=Stamps
```

Indexes with Composite Search Keys

- *Composite Search Keys*: Search on a combination of fields.
  - Equality query: Every field value is equal to a constant value. E.g. wrt <sal,age> index:
    - age=20 and sal =75
  - Range query: Some field value is not a constant. E.g.:
    - age =20; or age=20 and sal > 10
- Data entries in index sorted by search key to support range queries.

Examples of composite key indexes using lexicographic order.



Data entries in index sorted by <*sal,age*>

Data entries sorted by <*sal*>

Composite Search Keys

- To retrieve Emp records with *age*=30 AND *sal*=4000, an index on <*age,sal*> would be better than an index on *age* or an index on *sal*.
  - Choice of index key orthogonal to clustering etc.
- If condition is: 20<*age*<30 AND 3000<*sal*<5000:
  - Clustered tree index on <*age,sal*> or <*sal,age*> is best.
- If condition is: *age*=30 AND 3000<*sal*<5000:
  - Clustered <*age,sal*> tree index much better than <*sal,age*> index!
- Composite indexes are larger, updated more often.

Index-Only Plans

- A number of queries can be answered without retrieving any tuples from one or more of the relations involved if a suitable index is available.

<E.dno>

```
SELECT E.dno, COUNT(*)
FROM Emp E
GROUP BY E.dno
```

<E.dno,E.sal>

Tree index!

```
SELECT E.dno, MIN(E.sal)
FROM Emp E
GROUP BY E.dno
```

<E. age,E.sal>
or
<E.sal, E.age>

Tree index!

```
SELECT AVG(E.sal)
FROM Emp E
WHERE E.age=25 AND
 E.sal BETWEEN 3000 AND 5000
```

Example

- Available Index:
  - Unclustered B+-tree on Grade
- Assumptions:
  - Number of pages: 4,000
  - Number of Students: 80,000
  - Grade is between 1 and 100
  - Grades are uniformly distributed
  - Non-leaf pages are in memory

```
SELECT  S.id, S.grade
FROM  Student S
Where S.grade > 70
```

Example

- Available Index:
  - Unclustered B+-tree on Grade
- Assumptions:
  - Number of pages: 4,000
  - Number of Students: 80,000
  - Grade is between 1 and 100
  - Grades are uniformly distributed
  - Non-leaf pages are in memory

```
SELECT  S.id, S.grade
FROM  Student S
Where S.grade > 98
```

Example

- Available Index:
  - Unclustered B+-tree on Grade
- Assumptions:
  - Number of pages: 4,000
  - Number of Students: 80,000
  - Grade is between 1 and 100
  - Grades are uniformly distributed
  - Non-leaf pages are in memory

```
SELECT  S.id, S.grade
FROM  Student S
Where S.grade > X
```