Introduction to Data Management
CSE 344

Lecture 8: SQL Wrap-up

Announcements

- Homework 2: due on Monday (01/27)
- Webquiz 3: due on Tuesday (01/28)

Review: Indexes

```
V(M, N);
```

Suppose we have queries like these:

```
SELECT *
FROM V
WHERE M=?
```

```
SELECT *
FROM V
WHERE N=?
```

```
SELECT *
FROM V
WHERE M=? and N=?
```

Which of these indexes are helpful for each query?

1. Index on V(M)
2. Index on V(N)
3. Index on V(M,N)

Review: Indexes

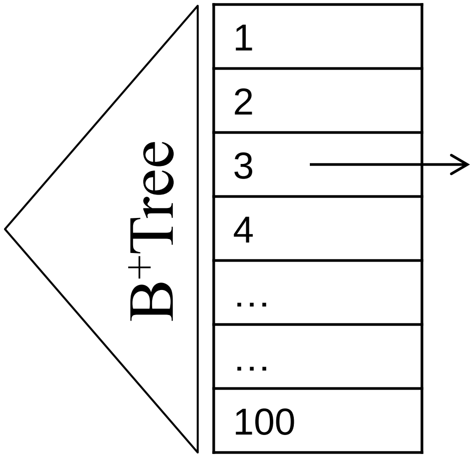
V(M, N);

Suppose V(M,N) contains 10,000 records:
(1,1), (1,2), (1,3), …, (1,100), (2,1),…, (100, 100)

```
SELECT *
FROM V
WHERE M=3
```

```
SELECT *
FROM V
WHERE N=5
```

```
SELECT *
FROM V
WHERE M=3 and N=5
```



List of pointers to records (3,1), (3,2), …, (3,100)

Index on V(M)

Review: Indexes

V(M, N);

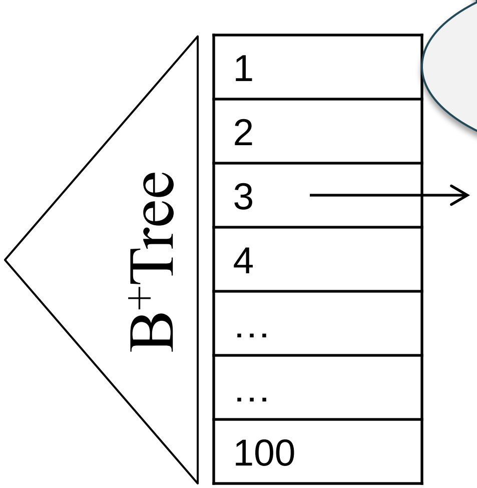
Suppose V(M,N) contains 10,000 records:
(1,1), (1,2), (1,3), …, (1,100), (2,1),…, (100, 100)

```
SELECT *
FROM V
WHERE M=3
```

```
SELECT *
FROM V
WHERE N=5
```

```
SELECT *
FROM V
WHERE M=3 and N=5
```

The index is useful here



B+Tree

1
2
3
4
…
…
100

List of pointers to records (3,1), (3,2), …, (3,100)

Index on V(M)

Review: Indexes

V(M, N);

Suppose V(M,N) contains 10,000 records:
(1,1), (1,2), (1,3), …, (1,100), (2,1),…, (100, 100)

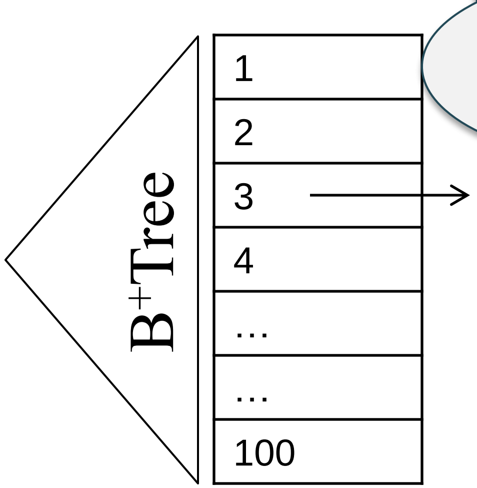
```
SELECT *
FROM V
WHERE M=3
```

```
SELECT *
FROM V
WHERE N=5
```

```
SELECT *
FROM V
WHERE M=3 and N=5
```

The index is useful here

Useless here



1
2
3
4
…
…
100

List of pointers to records (3,1), (3,2), …, (3,100)

Index on V(M)

Review: Indexes

V(M, N);

Suppose V(M,N) contains 10,000 records:
(1,1), (1,2), (1,3), …, (1,100), (2,1),…, (100, 100)

```
SELECT *
FROM V
WHERE M=3
```

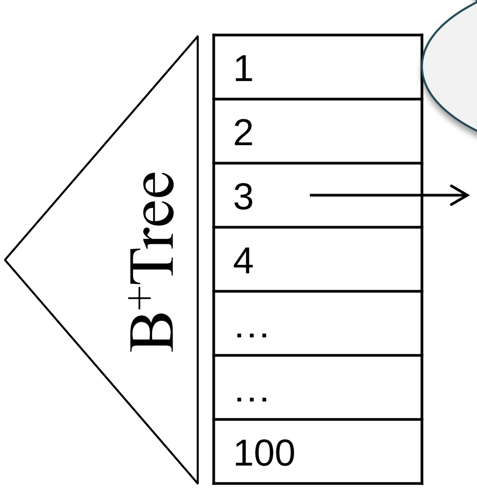
The index is useful here

```
SELECT *
FROM V
WHERE N=5
```

Useless here

```
SELECT *
FROM V
WHERE M=3 and N=5
```

Can we use it here?



List of pointers to records (3,1), (3,2), …, (3,100)

Index on V(M)

Review: Indexes

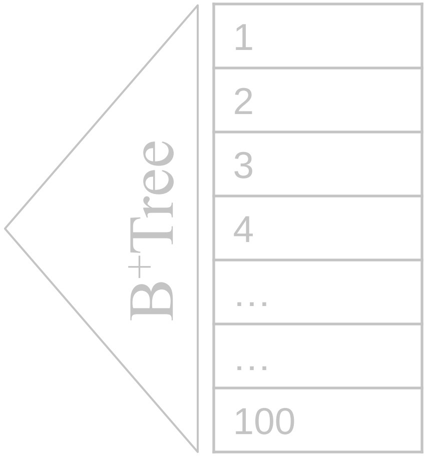
V(M, N);

Suppose V(M,N) contains 10,000 records:
(1,1), (1,2), (1,3), …, (1,100), (2,1),…, (100, 100)

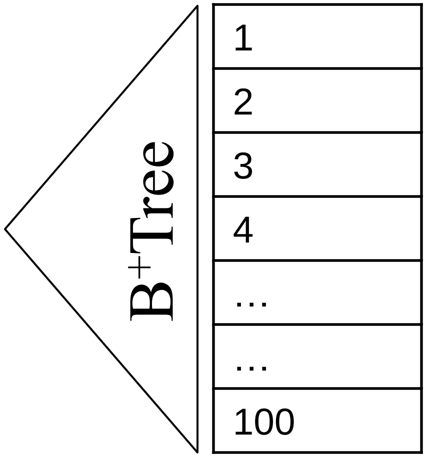
```
SELECT *
FROM V
WHERE M=3
```

```
SELECT *
FROM V
WHERE N=5
```

```
SELECT *
FROM V
WHERE M=3 and N=5
```



Index on V(M)



Index on V(N)

Where does this index help?

Review: Indexes

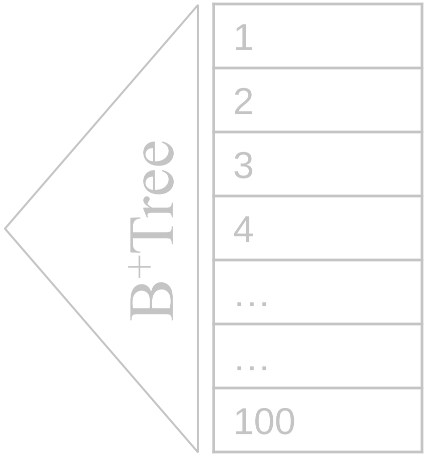
V(M, N);

Suppose V(M,N) contains 10,000 records:
(1,1), (1,2), (1,3), …, (1,100), (2,1),…, (100, 100)

```
SELECT *
FROM V
WHERE M=3
```

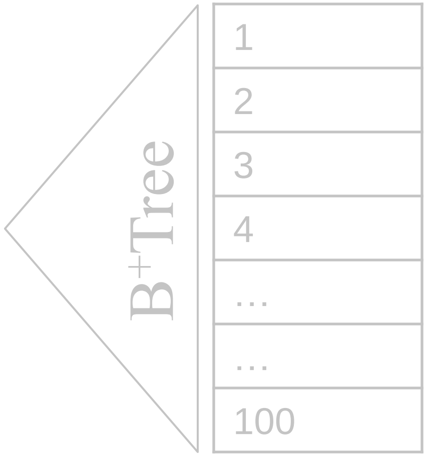
```
SELECT *
FROM V
WHERE N=5
```

```
SELECT *
FROM V
WHERE M=3 and N=5
```



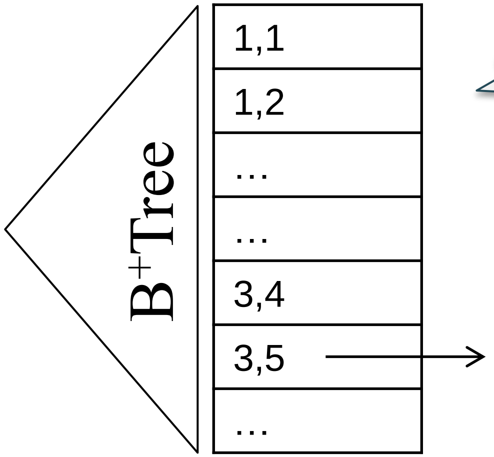
1
2
3
4
…
…
100

Index on V(M)



1
2
3
4
…
…
100

Index on V(N)



1,1
1,2
…
…
3,4
3,5
…

And this?

Single pointer to record (3,5)

Index on V(M,N)

Review: Indexes

Suppose M is the primary key in V(M, N):

How do the two indexes V(M) and V(M,N) compare?

Consider their utility for these predicates:

- M=5
- M=5 and N=7

Nested Queries

- Subqueries can occur in every clause:
  - SELECT
  - FROM
  - WHERE
- When we must use nested subqueries:
  - Non-monotone queries
  - Queries making complex use of aggregates
  - “Finding witnesses”

Practice these queries in SQL

Likes(drinker, beer)
Frequents(drinker, bar)
Serves(bar, beer)

Ullman's drinkers-bars-beers example

Find drinkers that frequent some bar that serves some beer they like.

x: $\exists y.\ \exists z.\ \text{Frequents}(x, y) \wedge \text{Serves}(y,z) \wedge \text{Likes}(x,z)$

Find drinkers that frequent only bars that serves some beer they like.

x: $\forall y.\ \text{Frequents}(x, y) \Rightarrow (\exists z.\ \text{Serves}(y,z) \wedge \text{Likes}(x,z))$

Find drinkers that frequent some bar that serves only beers they like.

x: $\exists y.\ \text{Frequents}(x, y) \wedge \forall z.(\text{Serves}(y,z) \Rightarrow \text{Likes}(x,z))$

Find drinkers that frequent only bars that serves only beer they like.

x: $\forall y.\ \text{Frequents}(x, y) \Rightarrow \forall z.(\text{Serves}(y,z) \Rightarrow \text{Likes}(x,z))$

Product (pname, price, cid)
Company(cid, cname, city)

Unnesting Aggregates

Find the number of companies in each city

```
SELECT DISTINCT X.city, (SELECT count(*)
                         FROM Company Y
                         WHERE X.city = Y.city)
FROM  Company X
```

```
SELECT city,  count(*)
FROM   Company
GROUP BY city
```

Equivalent queries

Note: no need for DISTINCT
(DISTINCT *is the same* as GROUP BY)

Product (pname, price, cid)
Company(cid, cname, city)

Unnesting Aggregates

Find the number of products made in each city

```
SELECT DISTINCT X.city, (SELECT count(*)
                         FROM Product Y, Company Z
                         WHERE Z.cid=Y.cid
                       AND Z.city = X.city)
FROM  Company X
```

```
SELECT X.city, count(*)
FROM Company X, Product Y
WHERE X.cid=Y.cid
GROUP BY X.city
```

NOT equivalent !
You should know why!

Purchase(pid, product, quantity, price)

GROUP BY v.s. Nested Queries

```
SELECT      product, Sum(quantity) AS TotalSales
FROM        Purchase
WHERE       price > 1
GROUP BY    product
```

```
SELECT DISTINCT  x.product, (SELECT Sum(y.quantity)
                             FROM     Purchase y
                             WHERE x.product = y.product
                                   AND y.price > 1)
                            AS TotalSales
FROM        Purchase x
WHERE       x.price > 1
```

Why twice ?

Author(login,name)

Wrote(login,url)

More Unnesting

Find authors who wrote ≥ 10 documents:

Author(<u>login</u>,name)

Wrote(login,url)

More Unnesting

Find authors who wrote ≥ 10 documents:

Attempt 1: with nested queries

This is SQL by a novice

```
SELECT DISTINCT Author.name
FROM          Author
WHERE          (SELECT count(Wrote.url)
                FROM Wrote
                WHERE Author.login=Wrote.login)
                   >= 10
```

Author(login,name)

Wrote(login,url)

More Unnesting

Find authors who wrote ≥ 10 documents:

Attempt 1: with nested queries

Attempt 2: using GROUP BY and HAVING

```
SELECT      Author.name
FROM        Author, Wrote
WHERE       Author.login=Wrote.login
GROUP BY Author.name
HAVING      count(wrote.url) >= 10
```

This is SQL by an expert

Product (pname, price, cid)
Company(cid, cname, city)

Finding Witnesses

For each city, find the most expensive product made in that city

Product (pname, price, cid)
Company(cid, cname, city)

Finding Witnesses

For each city, find the most expensive product made in that city

Finding the maximum price is easy…

```
SELECT x.city, max(y.price)
FROM Company x, Product y
WHERE x.cid = y.cid
GROUP BY x.city;
```

But we need the *witnesses*, i.e. the products with max price

Product (pname, price, cid)
Company(cid, cname, city)

Finding Witnesses

To find the witnesses, compute the maximum price in a subquery

```
SELECT DISTINCT u.city, v.pname, v.price
FROM Company u, Product v,
    (SELECT x.city, max(y.price) as maxprice
     FROM Company x, Product y
     WHERE x.cid = y.cid
     GROUP BY x.city) w
WHERE u.cid = v.cid
      and u.city = w.city
      and v.price=w.maxprice;
```

Product (pname, price, cid)
Company(cid, cname, city)

Finding Witnesses

There is a more concise solution here:

```
SELECT u.city, v.pname, v.price
FROM Company u, Product v, Company x, Product y
WHERE u.cid = v.cid and u.city = x.city and x.cid = y.cid
GROUP BY u.city, v.pname, v.price
HAVING v.price = max(y.price);
```

Product (pname, price, cid)
Company(cid, cname, city)

Finding Witnesses

And another one:

```
SELECT u.city, v.pname, v.price
FROM Company u, Product v
WHERE u.cid = v.cid
  and v.price >= ALL (SELECT y.price
                                  FROM Company x, Product y
                                  WHERE u.city=x.city
                                        and x.cid=y.cid);
```

Where We Are

- Motivation for using a DBMS for managing data
- SQL, SQL, SQL
  - Declaring the schema for our data (CREATE TABLE)
  - Inserting data one row at a time or in bulk (INSERT/.import)
  - Modifying the schema and updating the data (ALTER/UPDATE)
  - Querying the data (SELECT)
  - Tuning queries (CREATE INDEX)

- Next step: More knowledge of how DBMSs work
  - Client-server architecture
  - Relational algebra and query execution