Principles of Database Systems
CSE 544

Lecture #4
Views and Constraints

Reading Material

- Views:
  - *Query answering using views*, by Halevy (due on Monday)
  - Book: 3.6
- Constraints:
  - Book 3.2, 3.3, 5.8

Views

- A view in SQL =
  - A table computed from other tables, s.t., whenever the base tables are updated, the view is updated too
- More generally:
  - A view is derived data that keeps track of changes in the original data
- Compare:
  - A function computes a value from other values, but does not keep track of changes to the inputs

Purchase(customer, product, store)
Product(pname, price)

StorePrice(store, price)

A Simple View

Create a view that returns for each store
the prices of products purchased at that store

```
CREATE VIEW  StorePrice AS
  SELECT DISTINCT x.store, y.price
  FROM  Purchase x, Product y
  WHERE x.product = y.pname
```

This is like a new table
StorePrice(store,price)

Purchase(customer, product, store)
Product(pname, price)

StorePrice(store, price)

We Use a View Like Any Table

- A "high end" store is a store that sell some products over 1000.
- For each customer, return all the high end stores that they visit.

```
SELECT DISTINCT u.customer, u.store
FROM Purchase u, StorePrice v
WHERE u.store = v.store
   AND v.price > 1000
```

Types of Views

- Virtual views
  - Used in databases
  - Computed only on-demand – slow at runtime
  - Always up to date

- Materialized views
  - Used in data warehouses
  - Pre-computed offline – fast at runtime
  - May have stale data (must recompute or update)
  - Indexes *are* materialized views

Purchase(customer, product, store)
Product(pname, price)

StorePrice(store, price)

Query Modification

For each customer, find all the high end stores that they visit.

```
CREATE VIEW  StorePrice AS
   SELECT DISTINCT x.store, y.price
   FROM  Purchase x, Product y
   WHERE x.product = y.pname
```

```
SELECT DISTINCT u.customer, u.store
FROM Purchase u, StorePrice v
WHERE u.store = v.store
    AND v.price > 1000
```

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Query Modification

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   SELECT DISTINCT x.store, y.price
   FROM  Purchase x, Product y
   WHERE x.product = y.pname
```

```
SELECT DISTINCT u.customer, u.store
FROM Purchase u, StorePrice v
WHERE u.store = v.store
    AND v.price > 1000
```

Modified query:

```
SELECT DISTINCT u.customer, u.store
FROM Purchase u,
  (SELECT DISTINCT x.store, y.price
   FROM  Purchase x, Product y
   WHERE x.product = y.pname) v
WHERE u.store = v.store
     AND v.price > 1000
```

Purchase(customer, product, store)
Product(<u>pname</u>, price)

StorePrice(store, price)

Query Modification

For each customer, find all the high end stores that they visit.

```
SELECT DISTINCT u.customer, u.store
FROM Purchase u, Purchase x, Product y
WHERE u.store = x.store
     AND y.price > 1000
     AND x.product = y.pname
```

Notice that Purchase occurs twice. Why?

Modified query:

```
SELECT DISTINCT u.customer, u.store
FROM Purchase u,
  (SELECT DISTINCT x.store, y.price
   FROM  Purchase x, Product y
   WHERE x.product = y.pname) v
WHERE u.store = v.store
     AND v.price > 1000
```

Modified and unnested query:

Purchase(customer, product, store)
Product(pname, price)

StorePrice(store, price)

Further Virtual View Optimization

Retrieve all stores whose name contains ACME

```
CREATE VIEW  StorePrice AS
  SELECT DISTINCT x.store, y.price
  FROM  Purchase x, Product y
  WHERE x.product = y.pname
```

```
SELECT DISTINCT v.store
FROM StorePrice v
WHERE v.store like '%ACME%'
```

Purchase(customer, product, store)
Product(pname, price)

StorePrice(store, price)

Further Virtual View Optimization

Retrieve all stores whose name contains ACME

```
CREATE VIEW StorePrice AS
  SELECT DISTINCT x.store, y.price
  FROM Purchase x, Product y
  WHERE x.product = y.pname
```

```
SELECT DISTINCT v.store
FROM StorePrice v
WHERE v.store like '%ACME%'
```

Modified query:

```
SELECT DISTINCT v.store
FROM
  (SELECT DISTINCT x.store, y.price
   FROM Purchase x, Product y
   WHERE x.product = y.pname) v
WHERE v.store like '%ACME%'
```

Purchase(customer, product, store)
Product(pname, price)

StorePrice(store, price)

Further Virtual View Optimization

Retrieve all stores whose name contains ACME

```
SELECT DISTINCT x.store
FROM Purchase x, Product y
WHERE x.product = y.pname
   AND  x.store like '%ACME%'
```

We can further optimize! How?

Modified query:

```
SELECT DISTINCT v.store
FROM
  (SELECT DISTINCT x.store, y.price
   FROM  Purchase x, Product y
   WHERE x.product = y.pname) v
WHERE v.store like '%ACME%'
```

Modified and unnested query:

Purchase(customer, product, store)
Product(pname, price)

StorePrice(store, price)

Further Virtual View Optimization

Retrieve all stores whose name contains ACME

SELECT DISTINCT x.store
FROM Purchase x, ~~Product y~~
WHERE ~~x.product = y.pname~~
~~AND~~ x.store like ‘%ACME%’

Assuming Product.pname is a key
and Purchase.product is a foreign key

Modified and unnested query:

Final Query

SELECT DISTINCT x.store
FROM Purchase x
WHERE x.store like ‘%ACME%’

Example: Finding Witnesses

Product (pname, price, category, manufacturer)
Company (cname, country)

For each country, find its most expensive product(s)

Example: Finding Witnesses

Product (pname, price, category, manufacturer)
Company (cname, country)

For each country, find its most expensive product(s)

Finding the maximum price is easy…

```
SELECT x.country, max(y.price)
FROM   Company x, Product y
WHERE  x.cname = y.manufacturer
GROUP BY  x.country
```

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

Product (pname, price, category, manufacturer)
Company (cname, country)

Example: Finding Witnesses

To find witnesses, create a view with the maximum price

```
CREATE TEMPORARY VIEW CountryMaxPrice AS
  SELECT x.country, max(y.price) as mprice
  FROM    Company x, Product y
  WHERE  x.cname = y.manufacturer
  GROUP BY  x.country
```

Is this virtual
or materialized?

Example: Finding Witnesses

To find witnesses, create a view with the maximum price

```
CREATE TEMPORARY VIEW CountryMaxPrice AS
  SELECT x.country, max(y.price) as mprice
  FROM   Company x, Product y
  WHERE  x.cname = y.manufacturer
  GROUP BY  x.country
```

Is this virtual or materialized?

Next, use it to find the product that matches that price

```
SELECT u.country, v.pname, v.price
FROM Company u, Product v, CountryMaxPrice AS p
WHERE  u.country = p.country and v.price = p.mprice
```

Product (pname, price, category, manufacturer)
Company (cname, country)

Example: Finding Witnesses

For one-time use, use temporary view, or:

```
SELECT u.country, v.pname, v.price
FROM Company u, Product v,
        (SELECT x.country, max(y.price) as mprice
         FROM   Company x, Product y
         WHERE  x.cname = y.manufacturer
         GROUP BY  x.country) AS p
WHERE  u.country = p.country and v.price = p.mprice
```

Or:

```
WITH CountryMaxPrice AS
        (SELECT x.country, max(y.price) as mprice
         FROM   Company x, Product y
         WHERE  x.cname = y.manufacturer
         GROUP BY  x.country)
SELECT u.country, v.pname, v.price
FROM Company u, Product v,  CountryMaxPrice p
WHERE  u.country = p.country and v.price = p.mprice
```

Example: Finding Witnesses

If the view is reused, *and* performance is an issue, then:

```
CREATE TABLE CountryMaxPrice AS
  SELECT x.country, max(y.price) as mprice
  FROM    Company x, Product y
  WHERE  x.cname = y.manufacturer
  GROUP BY  x.country
```

```
SELECT u.country, v.pname, v.price
FROM Company u, Product v, CountryMaxPrice p
WHERE  u.country = p.country and v.price = p.mprice
```

You can also create indexes on CountryMaxPrice

Indexes

REALLY important to speed up query processing time.

Person (pid, name, age, city)

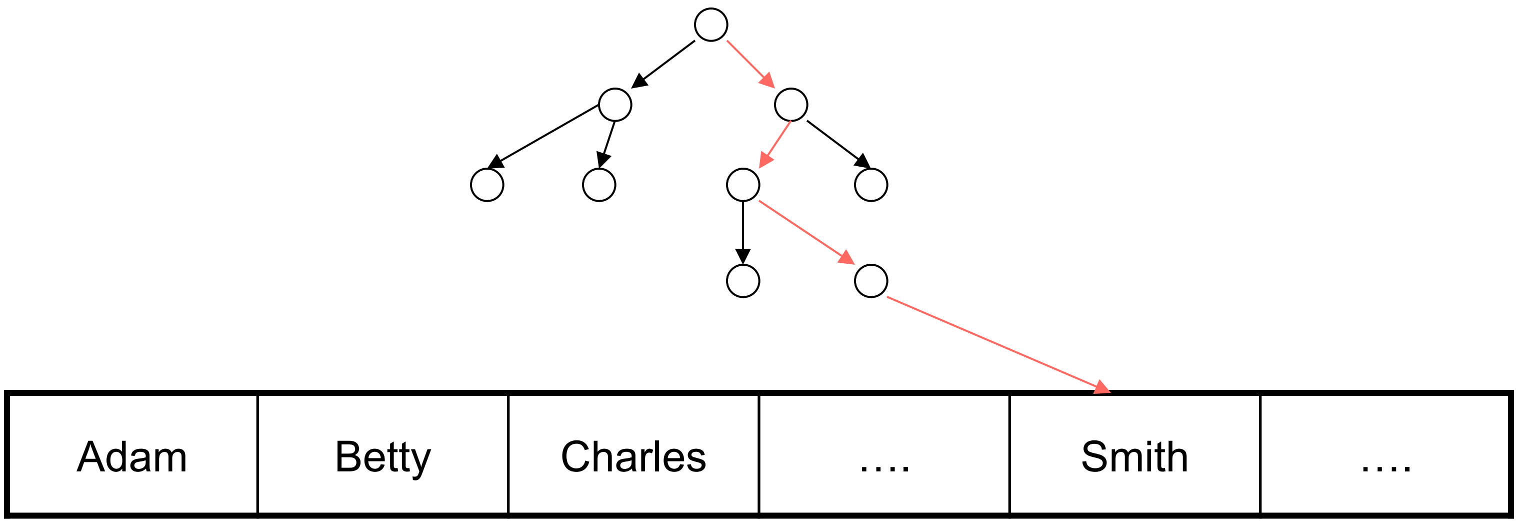
```
SELECT *
FROM    Person
WHERE   name = 'Smith'
```

May take too long to scan the entire Person table

```
CREATE INDEX  myindex05  ON Person(name)
```

Now, when we rerun the query it will be much faster

B+ Tree Index



We will discuss them in detail in a later lecture.

Creating Indexes

Indexes can be created on more than one attribute:

```
CREATE INDEX doubleindex ON  Person (age, city)
```

For which of the queries below is this index helpful?

```
SELECT *
FROM    Person
WHERE age = 55
```

```
SELECT *
FROM    Person
WHERE age = 55
    AND city = 'Seattle'
```

```
SELECT *
FROM    Person
WHERE city = 'Seattle'
```

Person(pid, name, age, city)

Creating Indexes

Indexes can be created on more than one attribute:

```
CREATE INDEX doubleindex ON  Person (age, city)
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For which of the queries below is this index helpful?

```
SELECT *
FROM    Person
WHERE age = 55
```

```
SELECT *
FROM    Person
WHERE age = 55
    AND city = 'Seattle'
```

```
SELECT *
FROM    Person
WHERE city = 'Seattle'
```

YES

YES

NO

Person(pid, name, age, city)

Indexes are Materialized Views

```
CREATE INDEX  W
    ON Person(age)
CREATE INDEX  P
    ON Person(city)
```

If W and P are "views", what is their schema?
Which query defines them?

Person(pid, name, age, city)

Indexes are Materialized Views

```
CREATE INDEX  W
    ON Person(age)
CREATE INDEX  P
    ON Person(city)
```

Each index is a relation:
(index value, record id)
Some DBMS make very advanced use…

Indexes as LAV:

```
CREATE VIEW  W  AS
       SELECT  age, pid
       FROM    Person y
CREATE VIEW  P  AS
       SELECT  city, pid
       FROM    Person y
```

Person(pid, name, age, city)

Indexes are Materialized Views

```
CREATE INDEX W
    ON Person(age)
CREATE INDEX P
    ON Person(city)
```

```
SELECT age, city
FROM Person
WHERE age > 22
    and city LIKE 'S%'
```

"Covering indexes": When the query uses *only* the indexes

Indexes as LAV:

```
CREATE VIEW W AS
    SELECT age, pid
    FROM   Person y
CREATE VIEW P AS
    SELECT city, pid
    FROM   Person y
```

```
SELECT x.age, y.city
FROM W x, P y
WHERE x.age > 22
    and y.city LIKE 'S%
    and x.pid = y.pid
```

Constraints

Constraints

- A constraint = a property that we'd like our database to hold
- Enforce it by taking some actions:
  – Forbid an update
  – Or perform compensating updates
- Two approaches:
  – Declarative integrity constraints
  – Triggers

Integrity Constraints in SQL

- Keys, foreign keys

simple

- Attribute-level constraints
- Tuple-level constraints
- Global constraints: assertions

complex

The more complex the constraint, the harder it is to check and to enforce

Keys

```
CREATE TABLE Product (
      name CHAR(30) PRIMARY KEY,
      price  INT)
```

OR:

```
CREATE TABLE Product (
      name CHAR(30),
      price INT,
PRIMARY KEY (name))
```

Keys with Multiple Attributes

```
CREATE TABLE Product (
    name CHAR(30),
    category VARCHAR(20),
    price INT,
   PRIMARY KEY (name, category))
```

name	category	price
Gizmo	Gadget	10
Camera	Photo	20
Gizmo	Photo	30
~~Gizmo~~	~~Gadget~~	~~40~~

Other Keys

```
CREATE TABLE Product (
    productID  CHAR(10),
    name CHAR(30),
    category VARCHAR(20),
    price INT,
    PRIMARY KEY (productID),
    UNIQUE (name, category))
```

There is at most one PRIMARY KEY;
there can be many UNIQUE

Foreign Key Constraints

```
CREATE TABLE Purchase (
   buyer CHAR(30),
   seller CHAR(30),
   prodName CHAR(30) REFERENCES Product,
   store VARCHAR(30))
```

Foreign key

Purchase(buyer, seller, product, store)
Product(<u>name</u>, price)

Product

name	category
Gizmo	gadget
Camera	Photo
OneClick	Photo

Purchase

prodName	store
Gizmo	Wiz
Camera	Ritz
Camera	Wiz

Foreign Key Constraints

```
CREATE   TABLE Purchase(
    buyer VARCHAR(50),
    seller VARCHAR(50),
    prodName CHAR(20),
    category VAVRCHAR(20),
    store VARCHAR(30),
    FOREIGN KEY (prodName, category)
        REFERENCES Product);
```

Purchase(buyer, seller, product, category, store)
Product(<u>name, category</u>, price)

What happens during updates ?

Types of updates:

- In Purchase: insert/update
- In Product: delete/update

Product

name	category
Gizmo	gadget
Camera	Photo
OneClick	Photo

Purchase

prodName	store
Gizmo	Wiz
Camera	Ritz
Camera	Wiz

What happens during updates ?

- SQL has three policies for maintaining referential integrity:
- <u>Reject</u> violating modifications (default)
- <u>Cascade</u>: after a delete/update do a delete/update
- <u>Set-null</u> set foreign-key field to NULL

Constraints on Attributes and Tuples

Attribute level constraints:

```
CREATE TABLE Purchase (   . . .
      store VARCHAR(30) NOT NULL,  . . . )
```

```
CREATE TABLE Product (   . . .
      price INT  CHECK (price >0 and price < 999))
```

Tuple level constraints:

```
. . . CHECK (price * quantity < 10000) . . .
```

What
is the difference from
Foreign-Key ?

```
CREATE TABLE Purchase (
    prodName CHAR(30)
        CHECK (prodName IN
                        SELECT Product.name
                        FROM Product),
    date DATETIME NOT NULL)
```

General Assertions

```
CREATE ASSERTION myAssert CHECK
  NOT EXISTS(
    SELECT Product.name
    FROM Product, Purchase
    WHERE Product.name = Purchase.prodName
    GROUP BY Product.name
    HAVING count(*) > 200)
```

Comments on Constraints

- Can give them names, and alter later
- We need to understand exactly *when* they are checked
- We need to understand exactly *what* actions are taken if they fail