Lecture 03
Views, Constraints

Tuesday, April 14, 2009

Announcements

- Homework 1 was due a few minutes ago…
- Homework 2: due next week
- Homework 3: to be posted by tomorrow, due in two weeks

Outline

- Database modifications, Integrity constraints, triggers (Chapter 5)
- Views: (Chapters 3.6, 25.8, 25.9)
  - Some material discussed today is not in the book

Modifying the Database

Three kinds of modifications

- Insertions
- Deletions
- Updates

Sometimes they are all called "updates"

Inserting One Record

General form:

```
INSERT INTO R(A1,…., An) VALUES (v1,…., vn)
```

Example: Insert a new purchase to the database:

```
INSERT INTO Purchase(buyer, seller, product, store)
        VALUES ('Joe', 'Fred', 'wakeup-clock-espresso-machine',
                'The Sharper Image')
```

Missing attribute → NULL.

Bulk Insertions

Purchase(buyer, seller, product, store)
Product(name, price)

```
INSERT  INTO  Producct(name)

    SELECT  DISTINCT  Purchase.product
    FROM      Purchase
    WHERE   Purchase.store = 'Joe'
```

Deletions

Purchase(buyer, seller, product, store)
Product(name, price)

```
DELETE   FROM   Purchase
WHERE    seller = 'Joe'   AND
         product = 'Brooklyn Bridge'
```

<u>SQL Fact</u>: there is no way to delete only a single occurrence of a tuple that appears twice in a relation.

Updates

Purchase(buyer, seller, product, store)
Product(name, price)

```
UPDATE  Product
SET     price = 29.95
WHERE   name = 'gizmo'
```

```
UPDATE  Product
SET     price = price/2
WHERE   name  IN
              (SELECT product
               FROM   Purchase
               WHERE  store='Joe');
```

Data Definition in SQL

- Data Manipulation Language: DML
  - Query and modify the database
  - What we have seen so far
- Data Definition Language: DDL
  - Create, delete, modify tables
  - Constraints

Creating Tables

```
CREATE   TABLE Purchase(
   buyer VARCHAR(50),
   seller VARCHAR(50),
   product CHAR(20),
   store VARCHAR(30)
 );
```

```
CREATE   TABLE Product(
   name CHAR(20),
   price INT
 );
```

Purchase(buyer, seller, product, store)
Product(name, price)

INT, SHORTINT, BIT(1), BIT(5), DATETIME, etc, etc

Deleting or Modifying a Table

```
DROP Product;
```

Exercise with care !!

```
ALTER TABLE   Product
        ADD   category VARCHAR(30);

ALTER  TABLE   Purchase
        DROP  seller;
```

This changes the database *schema*. What happens to the data ?

Default Values

Specifying default values:

```
CREATE   TABLE Purchase(
   buyer VARCHAR(50),
   seller VARCHAR(50) DEFAULT  ‘Johnny’,
   product CHAR(20),
   store VARCHAR(30) DEFAULT  ‘Wal-Mart’
  );
```

The default of defaults: NULL

Indexes

REALLY important to speed up query processing time.

Person (name, age, city)

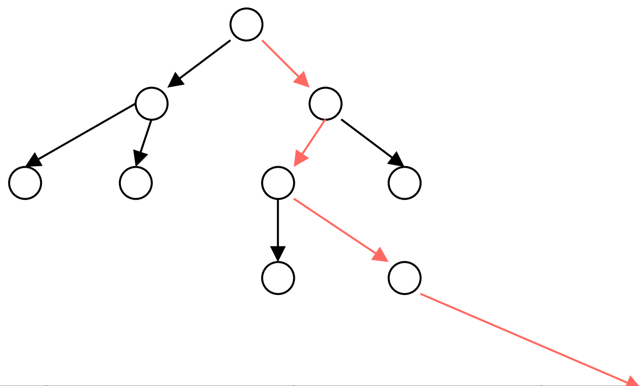
```
SELECT *
FROM    Person
WHERE   name = 'Smith'
```

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



Adam	Betty	Charles	….	Smith	….

We will discuss them in detail in a later lecture.

Creating Indexes

Indexes can be created on more than one attribute:

Example:

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

Helps in:

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

and even in:

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

But not in:

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

Constraints in SQL

- A constraint = a property that we'd like our database to hold
- The system will enforce the constraint by taking some actions:
  - forbid an update
  - or perform compensating updates

Constraints in SQL

Constraints in SQL:

- Keys, foreign keys
- Attribute-level constraints
- Tuple-level constraints
- Global constraints: assertions

simplest

Most 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:

Product(<u>name</u>, price)

```
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~~

Product(<u>name, category</u>, price)

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),
   product CHAR(30) REFERENCES Product(name),
   store VARCHAR(30))
```

Foreign key

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

Product

<u>Name</u>	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),
    product CHAR(20),
    category VAVRCHAR(20),
    store VARCHAR(30),
    FOREIGN KEY (product, category)
        REFERENCES Product(name, category)
 );
```

Purchase(buyer, seller, product, category, store)
Product(name, category, 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

Product	Store
Gizmo	Wiz
Camera	Ritz
Camera	Wiz

What happens during updates ?

- SQL has three policies for maintaining referential integrity:
- Reject violating modifications (default)
- Cascade: after a delete/update do a delete/ update
- Set-null 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) . . .
```

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

Semantic Optimization using Constraints

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

```
SELECT Purchase.store
FROM   Product, Purchase
WHERE  Product.name=Purchase.product
```

⇓

Why ?

```
SELECT Purchase.store
FROM   Product
```

Triggers

Trigger = a procedure invoked by the DBMS in response to an update to the database

Trigger = Event + Condition + Action

Triggers in SQL

- Event = INSERT, DELETE, UPDATE
- Condition = any WHERE condition
  - Refers to the old and the new values
- Action = more inserts, deletes, updates
  - May result in cascading effects !

Example: Row Level Trigger

```
CREATE TRIGGER  InsertPromotions  AFTER UPDATE OF  price  ON Product

REFERENCING
    OLD  AS x
    NEW  AS  y

FOR EACH ROW
WHEN (x.price > y.price)
INSERT  INTO Promotions(name, discount)
VALUES  x.name,
            (x.price-y.price)*100/x.price
```

Event

Condition

Action

EVENTS

INSERT, DELETE, UPDATE

- Trigger can be:
  - AFTER event
  - INSTEAD of event

Scope

- FOR EACH ROW = trigger executed for every row affected by update
  - OLD ROW
  - NEW ROW

- FOR EACH STATEMENT = trigger executed once for the entire statement
  - OLD TABLE
  - NEW TABLE

Statement Level Trigger

```
CREATE TRIGGER  avg-price INSTEAD OF UPDATE OF price ON Product

REFERENCING
   OLD_TABLE  AS OldStuff
   NEW_TABLE AS NewStuff

FOR EACH STATEMENT
WHEN (1000 < (SELECT  AVG (price)
            FROM ((Product EXCEPT OldStuff) UNION NewStuff))
DELETE  FROM Product
            WHERE (name, price, company) IN OldStuff;
INSERT INTO Product
  (SELECT  * FROM NewStuff)
```

Trigers v.s. Integrity Constraints

Active database = a database with triggers

- Triggers can be used to enforce ICs
- Triggers are more general: alerts, log events
- But hard to understand: recursive triggers
- Syntax is vendor specific, and may vary significantly
  - Postgres has *rules* in addition to *triggers*

Views

- A view = a relation computed from other relations using a query

- May be stored (*materialized*), or computed on demand (*virtual*)

- Views have many kinds of applications

Example

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

```
CREATE VIEW  CustomerPrice  AS
       SELECT  x.customer, y.price
       FROM    Purchase x, Product y
       WHERE   x.product = y.pname
```

CustomerPrice(customer, price)   "virtual table"

Purchase(customer, product, store)

Product(pname, price)

CustomerPrice(customer, price)

We can later use the view:

```
SELECT  u.customer, v.store
FROM    CustomerPrice u, Purchase v
WHERE   u.customer = v.customer  AND
        u.price > 100
```

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
  - Indexes *are* materialized views (read book)

Querying Virtual Views

- Have views V1, V2, …, Vn
- Query Q refers to these views
- Need to inline view definitions in the query
- Then need to simplify the expression

Queries Over Virtual Views

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

CustomerPrice(customer, price)

Query:

```
SELECT  u.customer, v.store
FROM    CustomerPrice u, Purchase v
WHERE   u.customer = v.customer  AND
        u.price > 100
```

Queries Over Virtual Views

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

CustomerPrice(customer, price)

Modified query:

```
SELECT  u.customer, v.store
FROM    (SELECT  x.customer, y.price
         FROM    Purchase x, Product y
         WHERE   x.product = y.pname) u, Purchase v
WHERE   u.customer = v.customer  AND
        u.price > 100
```

Queries Over Virtual Views

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

CustomerPrice(customer, price)

Modified and unnested query:

```
SELECT  x.customer, v.store
FROM    Purchase x, Product y, Purchase v,
WHERE   x.customer = v.customer  AND
        y.price > 100 AND
        x.product = y.pname
```

Another Example

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

CustomerPrice(customer, price)

```
SELECT DISTINCT u.customer, v.store
FROM    CustomerPrice u, Purchase v
WHERE   u.customer = v.customer  AND
        u.price > 100
```

↓

??

Answer

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

CustomerPrice(customer, price)

```
SELECT DISTINCT x.customer, v.store
FROM    Purchase x, Product y, Purchase v,
WHERE   x.customer = v.customer  AND
        y.price > 100 AND
        x.product = y.pname
```

Set v.s. Bag Semantics

```
SELECT   DISTINCT a,b,c
FROM     R, S, T
WHERE    . . .
```

Set semantics

```
SELECT   a,b,c
FROM     R, S, T
WHERE    . . .
```

Bag semantics

Inlining Queries: Sets/Sets

```
SELECT   DISTINCT a,b,c
FROM     (SELECT DISTINCT u,v
          FROM R,S
          WHERE …),  T
WHERE    . . .
```

⇒

```
SELECT   DISTINCT a,b,c
FROM     R, S, T
WHERE    . . .
```

Inlining Queries: Sets/Bags

```
SELECT   DISTINCT a,b,c
FROM     (SELECT u,v
          FROM R,S
          WHERE …),  T
WHERE    . . .
```

⇒

```
SELECT   DISTINCT a,b,c
FROM     R, S, T
WHERE    . . .
```

Inlining Queries: Bags/Bags

```
SELECT   a,b,c
FROM     (SELECT u,v
          FROM R,S
          WHERE …),  T
WHERE    . . .
```

⇒

```
SELECT   a,b,c
FROM     R, S, T
WHERE    . . .
```

Inlining Queries: Bags/Sets

```
SELECT   a,b,c
FROM     (SELECT DISTINCT u,v
          FROM R,S
          WHERE …),  T
WHERE    . . .
```

⇒

NO

Applications of Virtual Views

- Physical data independence
  - Vertical data partitioning
  - Horizontal data partitioning
- Security
  - The view reveals only what the users are allowed to know
- Materialized views for query speedup
  - Indexes, denormalization, semantic caching

Vertical Partitioning

Resumes

SSN	Name	Address	Resume	Picture
234234	Mary	Huston	Clob1…	Blob1…
345345	Sue	Seattle	Clob2…	Blob2…
345343	Joan	Seattle	Clob3…	Blob3…
234234	Ann	Portland	Clob4…	Blob4…

T1

SSN	Name	Address
234234	Mary	Huston
345345	Sue	Seattle
. . .		

T2

SSN	Resume
234234	Clob1…
345345	Clob2…

T3

SSN	Picture
234234	Blob1…
345345	Blob2…

Vertical Partitioning

```
CREATE VIEW  Resumes  AS
      SELECT  T1.ssn, T1.name, T1.address,
              T2.resume, T3.picture
      FROM    T1,T2,T3
      WHERE   T1.ssn=T2.ssn and T2.ssn=T3.ssn
```

When do we use vertical partitioning ?

Vertical Partitioning

```
SELECT address
FROM   Resumes
WHERE  name = 'Sue'
```

Which of the tables T1, T2, T3 will be queried by the system ?

Vertical Partitioning

When to do this:

- When some fields are large, and rarely accessed
  - E.g. Picture
- In distributed databases
  - Customer personal info at one site, customer profile at another
- In data integration
  - T1 comes from one source
  - T2 comes from a different source

Horizontal Partitioning

Customers

SSN	Name	City	Country
234234	Mary	Huston	USA
345345	Sue	Seattle	USA
345343	Joan	Seattle	USA
234234	Ann	Portland	USA
--	Frank	Calgary	Canada
--	Jean	Montreal	Canada

CustomersInHuston

SSN	Name	City	Country
234234	Mary	Huston	USA

CustomersInSeattle

SSN	Name	City	Country
345345	Sue	Seattle	USA
345343	Joan	Seattle	USA

CustomersInCanada

SSN	Name	City	Country
--	Frank	Calgary	Canada
--	Jean	Montreal	Canada

Horizontal Partitioning

```
CREATE VIEW  Customers  AS
    CustomersInHuston
        UNION ALL
    CustomersInSeattle
        UNION ALL
     . . .
```

Horizontal Partitioning

```
SELECT name
FROM   Cusotmers
WHERE  city = 'Seattle'
```

Which tables are inspected by the system ?

WHY ???

Horizontal Partitioning

Better:

```
CREATE VIEW  Customers  AS
    (SELECT * FROM CustomersInHuston
     WHERE city = 'Huston')
       UNION ALL
    (SELECT * FROM CustomersInSeattle
     WHERE city = 'Seattle')
       UNION ALL
     . . .
```

Horizontal Partitioning

```
SELECT name
FROM   Cusotmers
WHERE  city = 'Seattle'
```

↓

```
SELECT name
FROM   CusotmersInSeattle
```

Horizontal Partitioning

Applications:

- Optimizations:
  - E.g. archived applications and active applications
- Distributed databases
- Data integration

Views and Security

Customers:

Name	**Address**	**Balance**
Mary	Huston	450.99
Sue	Seattle	-240
Joan	Seattle	333.25
Ann	Portland	-520

Fred is not allowed to see this

```
CREATE VIEW PublicCustomers
      SELECT Name, Address
      FROM Customers
```

Fred is allowed to see this

Views and Security

Customers:

Name	Address	Balance
Mary	Huston	450.99
Sue	Seattle	-240
Joan	Seattle	333.25
Ann	Portland	-520

John is not allowed to see balances >0

```
CREATE VIEW BadCreditCustomers
        SELECT *
        FROM Customers
        WHERE Balance < 0
```

Materialized Views for Query Speedup

Examples:

- Indexes
  - Rule of thumb: an index is a view !
- Denormalization
  - E.g. Join indexes

Indexes are Materialized Views

Product(pid, name, weight, price, …) (big)

```sql
CREATE INDEX  W ON Product(weight)
CREATE INDEX  P  ON Product(price)
```

W(pid, weight)
P(pid, price) (smaller)

```sql
SELECT weight, price
FROM Product
WHERE weight > 10
      and price < 100
```

⇒

```sql
SELECT x.weight, y.price
FROM W x, P y
WHERE x.weight > 10
      and y.price < 100
      and x.pid = y.pid
```

Denormalization

Real example from Graduate Admissions

Application(id, name, school)
GRE(id, score, year)

Common query

```
SELECT  x.id, max(y.score)
FROM    Application x, GRE y
WHERE   x.id=y.id
GROUP BY x.id
```

VERY SLOW !

```
CREATE VIEW  AppWithGRE AS
      SELECT  x.id,x.name, x.school, y.score, y.year
      FROM    Application x, GRE y
      WHERE   x.id=y.id
```

Synchronize once per night

Semantic Caching

- Queries Q1, Q2, … have been executed, and their results are stored in main memory
- Now we need to compute a new query Q
- Sometimes we can use the prior results in answering Q
- This, too, is a form of query rewriting using views (why ?)

Technical Challenges in Managing Views

- Updating views
- Simplifying queries over virtual views
- Synchronizing materialized views
- Query answering using views

Updating Views

Purchase(customer, product, store)

Product(<u>pname</u>, price)

```
CREATE VIEW  Expensive-Product AS
      SELECT  pname
      FROM    Product
      WHERE   price > 100
```

Updateable view

```
INSERT
INTO Expensive-Product
VALUES('Gizmo')
```

⇩

```
INSERT
INTO Product
VALUES('Gizmo', NULL)
```

Updating Views

Purchase(customer, product, store)

Product(<u>pname</u>, price)

```
CREATE VIEW AcmePurchase AS
    SELECT  customer, product
    FROM    Purchase
    WHERE   store = 'AcmeStore'
```

Updateable view

```
INSERT
INTO Toy-Product
VALUES('Joe', 'Gizmo')
```

⇓

```
INSERT
INTO Product
VALUES('Joe','Gizmo',NULL)
```

Note this

Updating Views

Purchase(customer, product, store)

Product(pname, price)

```
INSERT INTO CustomerPrice
VALUES('Joe', 200)
```

```
CREATE VIEW  CustomerPrice  AS
      SELECT  x.customer, y.price
      FROM    Purchase x, Product y
      WHERE   x.product = y.pname
```

? ? ? ? ?

Non-updateable view

Most views are non-updateable

Simplifying Queries over Virtual Views

- After the views are expanded in the query's body, the resulting expression is often redundant and inefficient
- Query minimization = the problem of rewriting a query into an equivalent query that is smaller (and, hence, more efficient)

Query Minimization

Order(<u>cid, pid</u>, date)
Product(<u>pid</u>, name, weight, price)

```
CREATE VIEW  CheapOrders AS
  SELECT  x.cid,x.pid,x.date,y.name,y.price
  FROM    Order x, Product y
  WHERE   x.pid = y.pid and y.price < 99

CREATE VIEW  LightOrders AS
  SELECT  a.cid,a.pid,a.date,b.name,b.price
  FROM    Order a, Product b
  WHERE   a.pid = b.pid and b.weight < 15
```

Customers who ordered a cheap, lightweight product

```
SELECT u.cid
FROM   CheapOrders u,
       LightOrders v
WHERE  u.pid = v.pid
   and u.cid = v.cid
```

Query Minimization

Order(<u>cid, pid</u>, date)
Product(<u>pid</u>, name, weight, price)

```
CREATE VIEW  CheapOrders AS
  SELECT  x.cid,x.pid,x.date,y.name,y.price
  FROM    Order x, Product y
  WHERE   x.pid = y.pid and y.price < 99

CREATE VIEW  LightOrders AS
  SELECT  a.cid,a.pid,a.date,b.name,b.price
  FROM    Order a, Product b
  WHERE   a.pid = b.pid and b.weight < 15
```

```
SELECT u.cid
FROM    CheapOrders u,
        LightOrders v
WHERE  u.pid = v.pid
       and u.cid = v.cid
```

⇓

```
SELECT a.cid
FROM    Order x, Product y
        Order a, Product b
WHERE  . . . .
```

Redundant Orders and Products

Query Minimization under Bag Semantics

Rule 1: If x, y are tuple variables over the same table and x.id = y.id, then combine x, y into a single variable

Rule 2: If x ranges over S, y ranges over T, the only condition on y is x.fk = y.key, and y is not used anywhere else, then remove T (and y) from the query

```
SELECT a.cid
FROM   Order x, Product y, Order a, Product b
WHERE  x.pid = y.pid and a.pid = b.pid
       and y.price < 99 and b.weight < 15
       and x.cid = a.cid and x.pid = a.pid
```

x = a

```
SELECT a.cid
FROM   Order x, Product y, Product b
WHERE  x.pid = y.pid and x.pid = b.pid
       and y.price < 99 and b.weight < 15
```

y = b

```
SELECT a.cid
FROM   Order x, Product y
WHERE x.pid = y.pid and
       y.price < 99 and x.weight < 15
```

Query Minimization under Set Semantics

```
SELECT DISTINCT x.pid
FROM   Product x, Product y, Product z
WHERE  x.category = y.category and y.price > 100
       and  x.category = z.category and z.price > 500
                                     and z.weight > 10
```

Same as:

```
SELECT DISTINCT x.pid
FROM   Product x, Product z
WHERE  x.category = z.category and z.price > 500
                                and z.weight > 10
```

Query Minimization under Set Semantics

Rule 3: Let Q' be the query obtained by removing the tuple variable x from Q. If there exists a homomorphism from Q to Q' and both Q, Q' have set semantics, then Q' is equivalent to Q. Hence one can safely remove x.

Definition of a Homomorphism

A *homomorphism* from Q to Q' is mapping h from the tuple variables of Q to the tuple variables of Q' such that:

For every predicate P in the WHERE clause of Q, the predicate h(P) is logically implied by the WHERE clause of Q'

Theorem If there exists a homomorphism from Q' to Q, then Q is contained in Q'.
If there exists homomorphisms both from Q' to Q and from Q to Q', then Q and Q' are logically equivalent.

Homomorphism

Q

```
SELECT DISTINCT x.pid
FROM   Product x, Product y, Product z
WHERE  x.category = y.category and y.price > 100
       and  x.category = z.category and z.price > 500
                                     and z.weight > 10
```

H(x) = x', H(y) = H(z) = z'

Q'

```
SELECT DISTINCT x'.pid
FROM   Product x', Product z'
WHERE  x'.category = z'.category and z'.price > 500
                                  and z'.weight > 10
```

Synchronizing Materialized Views

- Immediate synchronization = after each update
- Deferred synchronization
  - Lazy = at query time
  - Periodic
  - Forced = manual

Which one is best for: indexes, data warehouses, replication ?

Incremental View Update

Order(cid, pid, date)
Product(pid, name, price)

```
CREATE VIEW  FullOrder AS
  SELECT  x.cid,x.pid,x.date,y.name,y.price
  FROM    Order x, Product y
  WHERE   x.pid = y.pid
```

```
UPDATE Product
SET price = price / 2
WHERE pid = '12345'
```

→

```
UPDATE FullOrder
SET price = price / 2
WHERE pid = '12345'
```

No need to recompute the entire view !

Incremental View Update

Product(pid, name, category, price)

```
CREATE VIEW  Categories AS
   SELECT DISTINCT category
   FROM      Product
```

```
DELETE Product
WHERE pid = '12345'
```

→

```
DELETE Categories
WHERE category in
     (SELECT category
      FROM Product
       WHERE pid = '12345')
```

It doesn't work ! Why ? How can we fix it ?

Answering Queries Using Views

- We have several materialized views:
  - V1, V2, …, Vn
- Given a query Q
  - Answer it by using views instead of base tables
- Variation: *Query rewriting using views*
  - Answer it by rewriting it to another query first
- Example: if the views are indexes, then we rewrite the query to use indexes

Query Rewriting Using Views

Purchase(buyer, seller, product, store)
Person(<u>pname</u>, city)

Have this materialized view:

```
CREATE VIEW SeattleView AS
       SELECT  y.buyer, y.seller, y.product, y.store
       FROM    Person x, Purchase y
       WHERE   x.city = 'Seattle'   AND
               x.pname = y.buyer
```

Goal: rewrite this query in terms of the view

```
SELECT  y.buyer, y.seller
FROM    Person x, Purchase y
WHERE   x.city = 'Seattle'   AND
        x..pname = y.buyer AND
        y.product='gizmo'
```

Query Rewriting Using Views

```
SELECT  y.buyer, y.seller
FROM    Person x, Purchase y
WHERE   x.city = 'Seattle'   AND
        x..pname = y.buyer AND
        y.product='gizmo'
```

```
SELECT  buyer, seller
FROM    SeattleView
WHERE   product= 'gizmo'
```

Rewriting is not always possible

```
CREATE VIEW DifferentView AS
      SELECT  y.buyer, y.seller, y.product, y.store
      FROM    Person x, Purchase y, Product z
      WHERE   x.city = 'Seattle'   AND
              x.pname = y.buyer AND
              y.product = z.name AND
              z.price < 100
```

```
SELECT  y.buyer, y.seller
FROM    Person x, Purchase y
WHERE   x.city = 'Seattle'   AND
        x..pname = y.buyer AND
        y.product='gizmo'
```

"Maximally contained rewriting"

```
SELECT  buyer, seller
FROM    DifferentView
WHERE   product= 'gizmo'
```