In the Lecture Series Introduction to Database Systems

# Advanced SQL

*Presented by Stéphane Bressan*

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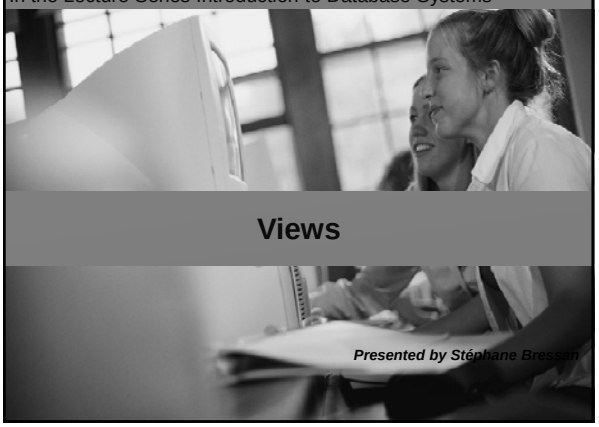


# Views

*Presented by Stéphane Bressan*

## Creating a View

Views are named queries.

This is now a table with

```
CREATE VIEW cs_student
AS (SELECT email, name, year, graduate
    FROM student
    WHERE department ='CS');
```



## Querying a View

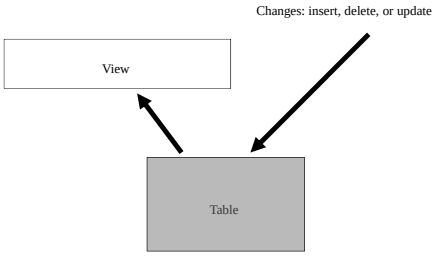
Views can be used as normal tables in queries.

```
SELECT *
FROM cs_student s, copy c
WHERE s.email = c.owner;
```



## Views

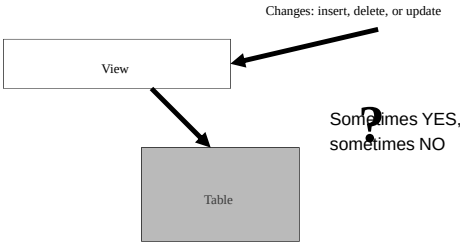
Changes in the base tables are propagated






## Views

Can we update the views?



## Updating a View

Under certain circumstances views can be updated.

```
INSERT INTO cs_student VALUES('GOH WEE SIONG',
   'gohws1989@gmail.com', '2008-01-01', NULL);
```

"cannot insert NULL into student"

But not our `cs_student` view because the faculty and department cannot be NULL (notice that the department at least should be understood)



## An Updatable View

```
CREATE VIEW student1
AS (SELECT email, name, year, faculty, department
    FROM student);

INSERT INTO student1 VALUES('GOH WEE SIONG',
   'gohws1989@gmail.com', '2008-01-01', 'School of
   Computing', 'CS');
```

`graduate` is NULL in the table `student`.



## A Surely not Updatable View

```
CREATE VIEW total_student (total)
AS (SELECT COUNT(*) FROM student);

INSERT INTO total_student VALUES(100);
```

"data manipulation operation not legal on this view"



## Updating Views with Triggers

Views can be updated by triggers using INSTEAD OF.



## Views

- Logical Data Independence is achieved by means of views
- Views can be pre-compiled
- However views may fool the optimizer

Ability to share code



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## Stored Procedures

- Similar to procedures in programming languages
- Stored inside the database
- Can access database tables
- May contain SQL statements
- Additionally they support:
  - LOOP
  - IF-THEN-ELSE statement



## Creating a Procedure

A procedure has a name and a body.

```
CREATE OR REPLACE PROCEDURE test IS
BEGIN
DBMS_OUTPUT.PUT_LINE('Hello World');
END test;
```



## Cursors

Cursors are used to iterate over query results.

```
CREATE OR REPLACE PROCEDURE test2 IS
    e student.email%TYPE;
    CURSOR c IS SELECT email FROM student;
BEGIN
OPEN c;
LOOP
FETCH c INTO e;
EXIT WHEN c%NOTFOUND;
DBMS_OUTPUT.PUT_LINE('Email: '|| e);
END LOOP;
CLOSE c;
END;
```



## Control Structures

Cursors are used to iterate over query results.

```
CREATE OR REPLACE PROCEDURE test3 IS
    e student.email%TYPE;
    d student.department%TYPE;
    CURSOR c IS SELECT email, department FROM student;
BEGIN
OPEN c;
LOOP
FETCH c INTO e, d;
EXIT WHEN c%NOTFOUND;
IF e='CS' THEN DBMS_OUTPUT.PUT_LINE('CS Email: '|| e);
ELSE DBMS_OUTPUT.PUT_LINE('Email: '|| e);
END IF;
END LOOP;
CLOSE c;
END;
```



## Control Structures

Print the top ten results.

```
CREATE OR REPLACE PROCEDURE test4 IS
    e student.email%TYPE;
    i NUMBER := 1;
CURSOR c IS SELECT email FROM student;
BEGIN
OPEN c;
LOOP
FETCH c INTO e;
i := i+1;
EXIT WHEN (i>10 OR c%NOTFOUND);
DBMS_OUTPUT.PUT_LINE('Email '||i|| ': ' || e);
END LOOP;
CLOSE c;
END;
```



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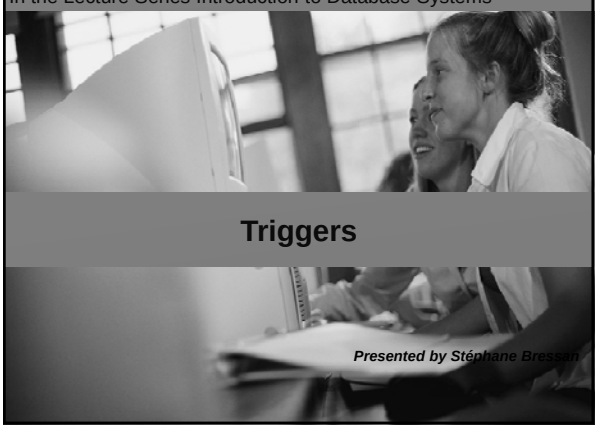

## Trigger

- Database Triggers refer to an active mechanism that allows the programming of reaction to database events.
  - Insertion, deletion, update
- A database trigger takes the general form:
  - ``When something happens and if some condition is met  do something''



## Trigger (Example with Oracle)

Type of changes

```
CREATE OR REPLACE TRIGGER say_something
BEFORE DELETE OR INSERT OR UPDATE ON student
FOR EACH ROW WHEN (new.department = 'CS' OR
  old.department= 'CS')
BEGIN
dbms_output.put_line('Something happened to
  us');
END;
```



## Trigger (Applications)

- Implement more application logic into the database (good idea!)
- Implement integrity constraint checking (bad idea but no sometimes choice)
- Implement integrity constraint checking and propagation (not the best of theoretically possible ways idea but no sometimes choice)



## Statement-level Trigger (Syntax)

```
CREATE [OR REPLACE] TRIGGER <name>
[BEFORE | AFTER]
[DELETE | INSERT | UPDATE [OF <column>[,
  column]*]
ON <table>
[WHEN (<condition>)]
<PL/SQL block>
```



## Statement-level Trigger (Semantics)

- A statement trigger is fired once for the triggering statement, regardless of the number of rows affected and even if no row is affected.
- For example, if a DELETE statement deletes several rows from a table, a statement-level DELETE trigger is fired only once.



## Statement-level Trigger (Example)

```
CREATE OR REPLACE TRIGGER say_something
BEFORE DELETE OR INSERT OR UPDATE ON student
BEGIN
dbms_output.put_line('Something happened to
  us');
END;
```

## Row-level Trigger (Syntax)

```
CREATE [OR REPLACE] TRIGGER <name>
[BEFORE | AFTER]
[DELETE | INSERT | UPDATE [OF <column>[,
  column]*]
ON <table>
FOR EACH ROW
[REFERENCING OLD|NEW AS <name>]
[WHEN (<condition>)]
<PL/SQL block>
```



## Row-level Trigger (Semantics)

- A row trigger is fired each time the table is for each row affected by the triggering statement.
- If the triggering statement affects no rows then nothing happens.
- For example, if a UPDATE statement updates several rows from a table, a row-level UPDATE trigger is fired for each affected row.



## Row-level Trigger (Example)

```
CREATE OR REPLACE TRIGGER say_something
BEFORE DELETE OR INSERT OR UPDATE ON student
FOR EACH ROW
WHEN (new.department = 'CS' OR
  old.department= 'CS')
BEGIN
dbms_output.put_line('Something happened to
  us');
END;
```



## Old/New in SQL Standard

- OLD and NEW reference the afftected rows only not the rows in the new and old table
  - OLD ROW AS <name>
  - NEW ROW AS <name>
  - OLD TABLE AS <name>
  - NEW TABLE AS <name>



## CASCADE DELETE

```
CREATE OR REPLACE TRIGGER
  cascade_delete_student_to_copy_and_loan
BEFORE DELETE
ON student
FOR EACH ROW
BEGIN
DELETE FROM loan WHERE
  loan.owner=:old.email;
DELETE FROM copy WHERE
  copy.owner=:old.email;
END
```

Why not so good?



## CASCADE DELETE

```
CREATE OR REPLACE TRIGGER
  cascade_delete_student_to_copy
BEFORE DELETE
ON student
FOR EACH ROW
BEGIN
DELETE FROM copy WHERE
  copy.owner=:old.email;
END
```

## CASCADE DELETE

```
CREATE OR REPLACE TRIGGER
  cascade_delete_copy_to_loan
BEFORE DELETE
ON copy
FOR EACH ROW
BEGIN
DELETE FROM loan WHERE copy.owner=:old.owner
AND copy.book=:old.book
AND copy.copy=:old.copy;
END
```



## CASCADE DELETE in SQL Standard

```
CREATE OR REPLACE TRIGGER
  cascade_delete_student_to_copy
BEFORE DELETE
ON student
REFERENCING OLD TABLE AS OT
BEGIN
DELETE FROM copy WHERE copy.owner in (SELECT
  email FROM OT);
END
```



## Other Triggers

- Oracle allows other types of triggers:
  - Schema triggers, monitoring modification to the schema (ALTER, CREATE, DROP, GRANT etc.)
  - Database triggers, monitoring system events (login, logoff, shutdown, etc.)
  - INSTEAD OF triggers for views (to define the update of a view)



## Schema Trigger (Example)

```
CREATE OR REPLACE TRIGGER drop_student
BEFORE DROP ON my.SCHEMA
BEGIN
RAISE_APPLICATION_ERROR (
   • num => -20000, msg => 'Cannot!');
END;
```



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## Indexes in Oracle

- An index is a data structure built and used for fast access.
- Oracle creates B-tree indexes.

## No Index

```
CREATE TABLE book (
title VARCHAR(255) NOT NULL,
format CHAR(9),
pages INT,
language VARCHAR(32),
authors VARCHAR(255),
publisher VARCHAR(64),
year DATE,
ISBN10 CHAR(10),
ISBN13 CHAR(14)
);
```



## Query Plan

```
SELECT *
FROM book
WHERE ISBN13 = '978-1449389673'
```

SELECT STATEMENT
    TABLE ACCESS BOOK FULL
        σ Filter Predicates
            ISBN13='978-1449389673'

The system performs a full table scan to find a row



## Primary Key

```
CREATE TABLE book (
title VARCHAR(255) NOT NULL,
format CHAR(9),
pages INT,
language VARCHAR(32),
authors VARCHAR(255),
publisher VARCHAR(64),
year DATE,
ISBN10 CHAR(10),
ISBN13 CHAR(14) PRIMARY KEY
);
```



## Primary Key

```
CREATE UNIQUE INDEX "STEPH"."SYS_C007097" ON
   "STEPH"."BOOK" ("ISBN13")
  PCTFREE 10 INITRANS 2 MAXTRANS 255
  STORAGE(INITIAL 65536 NEXT 1048576 MINEXTENTS 1
   MAXEXTENTS 2147483645
  PCTINCREASE 0 FREELISTS 1 FREELIST GROUPS 1 BUFFER_POOL
   DEFAULT FLASH_CACHE DEFAULT CELL_FLASH_CACHE DEFAULT)
  TABLESPACE "USERS" ;
```

The system has created an index and can use it to find a row given the ISBN13



## Query Plan

```
SELECT *
FROM book
WHERE ISBN13 = '978-1449389673'
```

SELECT STATEMENT
    TABLE ACCESS BOOK BY INDEX ROWID
        INDEX SYS_C007097 UNIQUE SCAN
            σ Access Predicates
                ISBN13='978-1449389673'



## UNIQUE

```
CREATE TABLE book (
title VARCHAR(255) NOT NULL,
format CHAR(9),
pages INT,
language VARCHAR(32),
authors VARCHAR(255),
publisher VARCHAR(64),
year DATE,
ISBN10 CHAR(10) UNIQUE NOT NULL,
ISBN13 CHAR(14) PRIMARY KEY
);
```

## Query Plan

```
SELECT *
FROM book
WHERE ISBN10 = '1449389678'
```

SELECT STATEMENT
    TABLE ACCESS BOOK BY INDEX ROWID
        INDEX SYS_C007098 UNIQUE SCAN
            σ Access Predicates
                ISBN13= '1449389678'

The system creates an index and uses it to find a row given the ISBN10



## Index on Attribute

We can create an index on frequently accessed attributes

```
CREATE INDEX student_name ON student(name);
```

The system has created an index and can use it to find a row given the name



## No Index on Attribute

```
SELECT
s.email
FROM student s
WHERE s.name LIKE 'G%';
```

SELECT STATEMENT
    TABLE ACCESS STUDENT FULL
        σ Filter Predicates S.NAME LIKE 'G%'
!



## Index on Attribute

```
SELECT
s.email
FROM student s
WHERE s.name LIKE 'G%';
```

SELECT STATEMENT
    TABLE ACCESS STUDENT BY INDEX ROWID
        INDEX SUDENT_NAME RANGE SCAN
        σ Access Predicates S.NAME LIKE 'G%'
        σ Filter Predicates S.NAME LIKE 'G%'

!



## Index on Foreign Key

We can create an index on a foreign key

```
CREATE INDEX copy_owner ON copy(owner);
```

The system has created an index and can use it to find a row given the owner



## No Index on Foreign Key

```
SELECT s.email, COUNT(*)
FROM student s, copy c
WHERE
s.email=c.owner
GROUP BY s.email;
```

SELECT STATEMENT
    HASH GROUP BY
        TABLE ACCESS COPY FULL

There is no need to access student!

## Index on Foreign Key

```
SELECT s.email, COUNT(*)
FROM student s, copy c
WHERE
s.email=c.owner
GROUP BY s.email;
```

SELECT STATEMENT
- HASH GROUP BY
  - INDEX COPY_OWNER FAST FULL SCAN



## No Index on Foreign Key

```
SELECT s.email, COUNT(*)
FROM student s RIGHT OUTER JOIN  copy c ON s.email=c.owner
GROUP BY s.email;
```

SELECT STATEMENT
- HASH GROUP BY
  - ▷◁ NESTED LOOPS
    - TABLE ACCESS COPY FULL
    - INDEX SYS_C007126 UNIQUE SCAN
      - σ Access Predicates S.EMAIL(+)=C.OWNER



## Index on Foreign Key

```
SELECT s.email, COUNT(*)
FROM student s RIGHT OUTER JOIN copy c ON s.email=c.owner
GROUP BY s.email;
```

SELECT STATEMENT
- HASH GROUP BY
  - ▷◁ NESTED LOOPS
    - INDEX COPY_OWNER FAST FULL SCAN
    - INDEX SYS_C007126 UNIQUE SCAN
      - σ Access Predicates S.EMAIL(+)=C.OWNER



## No Index on Foreign Key

```
SELECT s.email, s.name, COUNT(*)
FROM student s, copy c
WHERE
s.email=c.owner
GROUP BY s.email, s.name;
```

SELECT STATEMENT
- HASH GROUP BY
  - ▷◁ HASH JOIN
    - σ Access Predicates S.EMAIL=C.OWNER
    - TABLE ACCESS STUDENT FULL
    - TABLE ACCESS COPY FULL



## Index on Foreign Key

```
SELECT s.email, s.name COUNT(*)
FROM student s, copy c
WHERE
s.email=c.owner
GROUP BY s.email, s.name;
```

SELECT STATEMENT
- HASH GROUP BY
  - ▷◁ HASH JOIN
    - σ Access Predicates S.EMAIL=C.OWNER
    - TABLE ACCESS STUDENT FULL
    - INDEX COPY_OWNER FAST FULL SCAN



## Composite Index

```
CREATE INDEX loan_owner_ISBN13_copy ON loan(owner, ISBN13,
  copy);
```

The system has created a B-tree index and can use it to find a row given the owner, ISBN13 and copy (the book)

Queries that access all three columns, only the owner column or only the owner and ISBN13 columns can use this index.

## No Index on Foreign Key

```
SELECT s.email, COUNT(*)
FROM student s, loan l
WHERE s.email=l.owner
GROUP BY s.email;
```

SELECT STATEMENT
- HASH GROUP BY
  - ▷◁ NESTED LOOPS
    - TABLE ACCESS LOAN FULL
    - INDEX SYS_C007126 UNIQUE SCAN
      - σ Access Predicates S.EMAIL=L.OWNER



## Index on Foreign Key

```
SELECT s.email, COUNT(*)
FROM student s, loan l
WHERE s.email=l.owner
GROUP BY s.email;
```

SELECT STATEMENT
- HASH GROUP BY
  - ▷◁ NESTED LOOPS
    - INDEX LOAN_OWNER_BOOK_COPY FAST FULL SCAN
    - INDEX SYS_C007126 UNIQUE SCAN
      - σ Access Predicates S.EMAIL=L.OWNER



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