Constraints and Triggers

Topics discussed earlier

- basic constraints
  - entity integrity (not null)
  - referential integrity (foreign key)
  - key constraint (primary key)
  - candidate key constraint (uniqueness)
- Naming constraints
  - to add, modify, drop
  - deferrable constraints can be deferred

See Section 7.1 and 7.3 for details

Checks and Assertions

CHECK constraints
- attribute-level
- tuple-level

ASSERTIONS
- can include multiple tables

Attribute Level Checks

```
create table enrolled (
  StudentID     number(5),
  CourseID      number(4),
  Quarter       varchar(6)
       CHECK(quarter in ('Fall','Winter','Spring')),
  Year          number(4), ...

create table memberof (
  StudentID     number(5),
  GroupName     varchar(40),
  Joined        number(4)
       CHECK(Joined >= (SELECT Started
                        FROM student
                        WHERE studentID = SID)), ...
```

- has to be true or unknown (compare WHERE)
- checks get evaluated on a row when row is inserted/updated
  - so: checks may get violated
- subqueries not allowed in Oracle checks

Tuple Level Checks

```
create table course (
  CID   number(4),
  CourseName    varchar(40),
  Department    varchar(4),
  CourseNr       char(3),

  primary key (CID),

  check (department <> 'CSC' OR CourseNR > 100)
);
```

- same as attribute level check, just different placement

Examples

- enforce the following course ranges:
  CSC: 200-600, IT 100-500, GAM: 200-500
- a student must have either a first or last name
- we don't accept any undergraduate COMP-GPH and IT students after (and including) 2015
- only graduate students can be PhD students
- use to implement sub-classing

> EER-modeling problem: Employees can be hourly, in which case we want their ID, name, Address, the day they were hired, and the rate at which they were hired. For salaried employees we want to store their ID, name, address, the day they were hired, and their annual salary and stock options. Consultants also get an ID, and we store their name, address, hiring date, contract number, and billing rate.

Assertions

```
CREATE ASSERTION joined
CHECK (NOT EXISTS
       (SELECT *
        FROM student, memberof
        WHERE SID = StudentID and Joined < Started));
```

Example: ugrad/grad students can enroll in at most 2/4 courses a quarter

- not supported by anybody?
- can be mimicked using materialized views and/or triggers (procedural vs. declarative)

Triggers

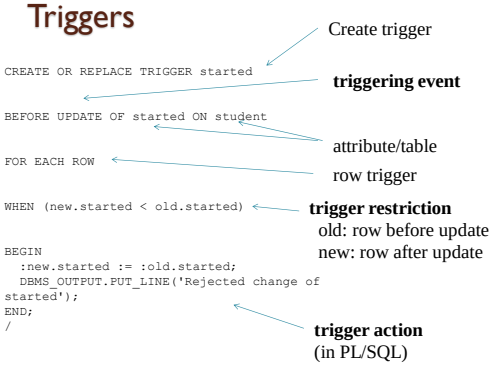
```
CREATE OR REPLACE TRIGGER started
BEFORE UPDATE OF started ON student
FOR EACH ROW
WHEN (new.started < old.started)
BEGIN
  :new.started := :old.started;
  DBMS_OUTPUT.PUT_LINE('Rejected change of started');
END;
/


SET SERVEROUTPUT ON;

UPDATE student
SET Started = 2001;

SELECT * FROM student;
```

Triggers



Create trigger

triggering event

attribute/table

row trigger

trigger restriction

old: row before update

new: row after update

trigger action
(in PL/SQL)

Triggering Events

When do we trigger:

- `before`
- `after`
- `instead of` (only for views)

```
CREATE OR REPLACE TRIGGER started
 BEFORE UPDATE OF started ON student
 FOR EACH ROW
 WHEN (new.started < old.started)
 BEGIN
   :new.started := :old.started;
   DBMS_OUTPUT.PUT_LINE('Rejected
change of started');
 END;
 /
```

What is doing the triggering:

- `insert, update, delete`
- system events

row/statement trigger

```
CREATE OR REPLACE TRIGGER started
BEFORE UPDATE OF started ON student
 FOR EACH ROW
 WHEN (new.started < old.started)
 BEGIN
   :new.started := :old.started;
   DBMS_OUTPUT.PUT_LINE('Rejected
change of started');
 END;
 /
```

WHEN only for row-level triggers

:new/:old only for row-level triggers

vs

```
CREATE OR REPLACE TRIGGER started
AFTER UPDATE ON student
BEGIN
   DBMS_OUTPUT.PUT_LINE(Student
Table updated');
END;
/
```

Restriction (WHEN)

- `old` (before change)
- `new` (after change)

```
CREATE OR REPLACE TRIGGER started
BEFORE UPDATE OF started ON student
 FOR EACH ROW
 WHEN (new.started < old.started)
 BEGIN
   :new.started := :old.started;
   DBMS_OUTPUT.PUT_LINE('Rejected
change of started');
 END;
 /
```

Trigger Action

- BEGIN
  pl/sql block
  END;
  /
- `:old, :new` variables
- `dbms_output`

```
CREATE OR REPLACE TRIGGER started
BEFORE UPDATE OF started ON student
FOR EACH ROW
WHEN (new.started < old.started)
BEGIN
  :new.started := :old.started;
  DBMS_OUTPUT.PUT_LINE('Rejected
change of started');
END;
/
```

Example: Logging

```
CREATE OR REPLACE TRIGGER studentlog
AFTER INSERT OR UPDATE OR DELETE ON student
BEGIN
  DBMS_OUTPUT.PUT_LINE('Insert/Delete/Update on
Student Table');
END;
/

CREATE OR REPLACE TRIGGER started
AFTER INSERT OR UPDATE OR DELETE ON student
BEGIN
  IF UPDATING THEN
    DBMS_OUTPUT.PUT_LINE('Update on Student');
  ELSIF INSERTING THEN
    DBMS_OUTPUT.PUT_LINE('Insert on Student');
  ELSIF DELETING THEN
    DBMS_OUTPUT.PUT_LINE('Delete on Student');
  END IF;
END;
/
```

Example: Unique IDs

ID fields often needed in tables

- Combinations of attributes can be unhandy
- No natural keys in the relation

Database support through **sequences**

- Each access gives new ID (by increasing the value)
- Microsoft Access: AutoNumber field (counter datatype)
- Oracle: sequence object

Sequences in Oracle

```
--- create a new sequence for student table
CREATE SEQUENCE SEQ_STUDENT_ID
INCREMENT BY 1
START WITH 1;

--- example application
INSERT INTO student(SID, LastName,FirstName)
VALUES(seq_student_id.nextval, 'Pendleton', 'Gabriela');

--- drop sequence
DROP seq_student_id;
```

Using sequence with trigger

```
--- create a new sequence for student table
CREATE SEQUENCE SEQ_STUDENT_ID
INCREMENT BY 1
START WITH 1;


--- create trigger to insert new ID automatically
CREATE OR REPLACE TRIGGER student_id_trigger
BEFORE INSERT ON student
FOR EACH ROW
BEGIN
    SELECT seq_student_id.nextval
    INTO :new.SID
    FROM dual;
END;
/
```

Example: Logging into table

```
CREATE OR REPLACE TRIGGER studentlog
AFTER INSERT ON student
FOR EACH ROW
BEGIN
  DBMS_OUTPUT.PUT_LINE('Insert on Student Table');
  insert into elog
  values(seq_student_id.nextval, :new.SID, 'I',
       systimestamp);
END;
/
```

```
CREATE TABLE elog(
  eid NUMBER,
  esid NUMBER(5),
  etype CHAR,
  etime DATE,

  PRIMARY KEY(eid)
);
```

Example 7.13

```
CREATE TRIGGER NetWorthTrigger
AFTER UPDATE OF netWorth ON MovieExec
REFERENCING
        OLD AS Oldtuple
        NEW AS Newtuple
FOR EACH ROW
WHEN (Oldtuple.networth > NewTuple.networth)
BEGIN
        UPDATE MovieExec
        SET netWorth = OldTuple.netWorth
        WHERE cert# = NewTuple.cert#
END;
/
```

Not Oracle Syntax

potentially problematic code, why?

Example 7.13

```
CREATE TRIGGER NetWorthTrigger
AFTER UPDATE OF netWorth ON MovieExec
REFERENCING
        OLD AS Oldtuple
        NEW AS Newtuple
FOR EACH ROW
WHEN (Oldtuple.networth > NewTuple.networth)
BEGIN
        UPDATE MovieExec
        SET netWorth = OldTuple.netWorth
        WHERE cert# = NewTuple.cert#
END;
/
```

Oracle compiles similar example, but rejects at runtime:

```
SQL Error: ORA-04091: table MSCHAEFER.STUDENT is mutating, trigger/function may
ORA-06512: at "MSCHAEFER.STARTED1", line 2
ORA-04088: error during execution of trigger 'MSCHAEFER.STARTED1'
04091. 00000 -  "table %s.%s is mutating, trigger/function may not see it"
*Cause:    A trigger (or a user defined plsql function that is referenced in
           this statement) attempted to look at (or modify) a table that was
           in the middle of being modified by the statement which fired it.
*Action:   Rewrite the trigger (or function) so it does not read that table.
```

Examples

- Extend the logging-into-table example, so it also logs updates and deletes
- write a trigger that cancels all deletions on the student table and writes a warning message that a deletion was attempted (need RAISE_APPLICATION_ERROR)
- if a student's program is PhD (update or insert), ensure the career is GRD (change if necessary)
- if a student is inserted without SSN, automatically assign a unique SSN starting with 900 (those SSNs are not currently in use)
- if a course is inserted with coursenr 666, allow the insert, but null the coursenr and issue a warning