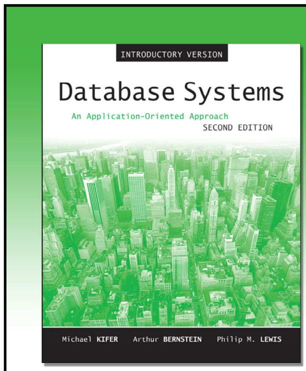

INTRODUCTORY VERSION
Database Systems
An Application-Oriented Approach
SECOND EDITION
Michael KIFER Arthur BERNSTEIN Philip M. LEWIS

Chapter 7

Triggers and Active Databases

Trigger Overview

- Element of the database schema
- General form:

  ON <*event*> IF <*condition*> THEN <*action*>

  – *Event*- request to execute database operation
  – *Condition* - predicate evaluated on databaase state
  – *Action* – execution of procedure that might involve database updates
- Example:

  ON updating maximum course enrollment
  IF number registered > new max enrollment limit
  THEN deregister students using LIFO policy

Trigger Details

- **Activation** - Occurrence of the *event*
- **Consideration** - The point, after activation, when *condition* is evaluated
  - Immediate or deferred (when the transaction requests to commit)
  - *Condition* might refer to both the state before and the state after *event* occurs

Trigger Details

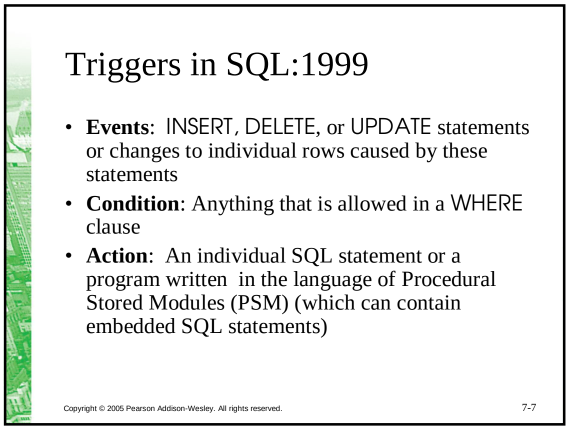
- **Execution** – point at which *action* occurs
  - With deferred consideration, execution is also deferred
  - With immediate consideration, execution can occur immediately after consideration or it can be deferred
    - If execution is immediate, execution can occur before, after, or instead of triggering event.
    - Before triggers adapt naturally to maintaining integrity constraints: violation results in rejection of event.

Trigger Details

- **Granularity**
  - *Row-level granularity*: change of a single row is an event (a single UPDATE statement might result in multiple events)
  - *Statement-level granularity*: events are statements (a single UPDATE statement that changes multiple rows is a single event).

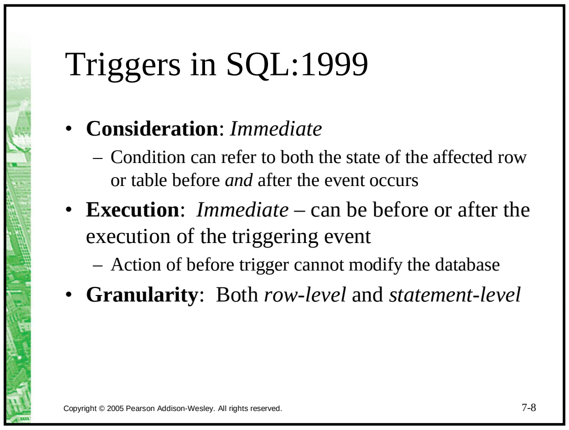
Trigger Details

- **Multiple Triggers**
  - How should multiple triggers activated by a single event be handled?
    - Evaluate one condition at a time and if true immediately execute action or
    - Evaluate all conditions, then execute actions
  - The execution of an action can affect the truth of a subsequently evaluated condition so the choice is significant.



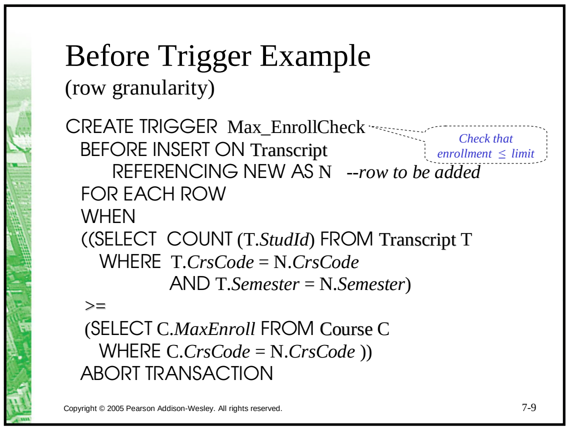
Triggers in SQL:1999

- **Events**: INSERT, DELETE, or UPDATE statements or changes to individual rows caused by these statements
- **Condition**: Anything that is allowed in a WHERE clause
- **Action**: An individual SQL statement or a program written in the language of Procedural Stored Modules (PSM) (which can contain embedded SQL statements)



Triggers in SQL:1999

- **Consideration**: *Immediate*
  - Condition can refer to both the state of the affected row or table before *and* after the event occurs
- **Execution**: *Immediate* – can be before or after the execution of the triggering event
  - Action of before trigger cannot modify the database
- **Granularity**: Both *row-level* and *statement-level*

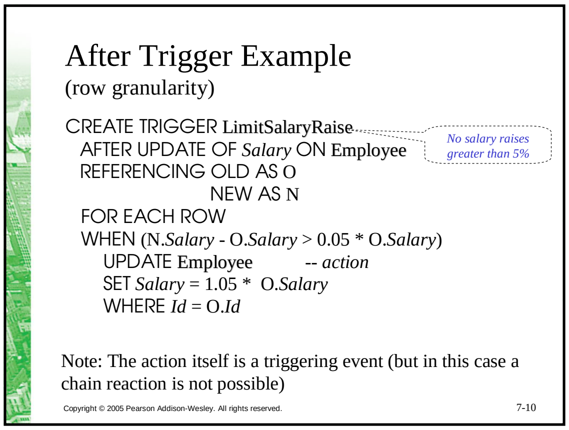


Before Trigger Example

(row granularity)

```
CREATE TRIGGER  Max_EnrollCheck
  BEFORE INSERT ON Transcript
       REFERENCING NEW AS N   --row to be added
  FOR EACH ROW
  WHEN
  ((SELECT  COUNT (T.StudId) FROM Transcript T
     WHERE  T.CrsCode = N.CrsCode
                AND T.Semester = N.Semester)
   >=
   (SELECT C.MaxEnroll FROM Course C
     WHERE C.CrsCode = N.CrsCode ))
  ABORT TRANSACTION
```

Check that enrollment ≤ limit



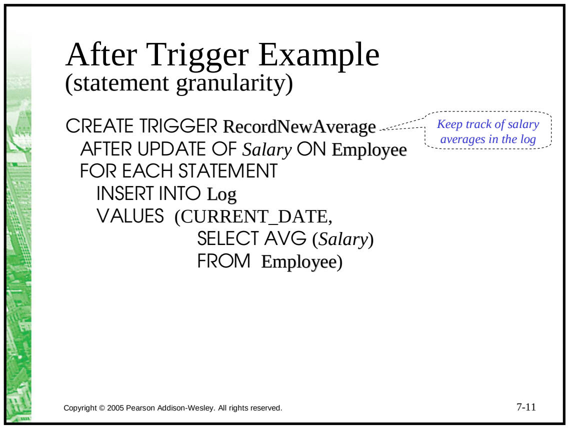
After Trigger Example

(row granularity)

```
CREATE TRIGGER LimitSalaryRaise
  AFTER UPDATE OF Salary ON Employee
  REFERENCING OLD AS O
                        NEW AS N
  FOR EACH ROW
  WHEN (N.Salary - O.Salary > 0.05 * O.Salary)
      UPDATE Employee          -- action
      SET Salary = 1.05 *  O.Salary
      WHERE Id = O.Id
```

No salary raises greater than 5%

Note: The action itself is a triggering event (but in this case a chain reaction is not possible)



After Trigger Example

(statement granularity)

```
CREATE TRIGGER RecordNewAverage
  AFTER UPDATE OF Salary ON Employee
  FOR EACH STATEMENT
     INSERT INTO Log
     VALUES  (CURRENT_DATE,
                       SELECT AVG (Salary)
                       FROM  Employee)
```

Keep track of salary averages in the log