Database Applications (15-415)

SQL-Part III
Lecture 9, February 7, 2016

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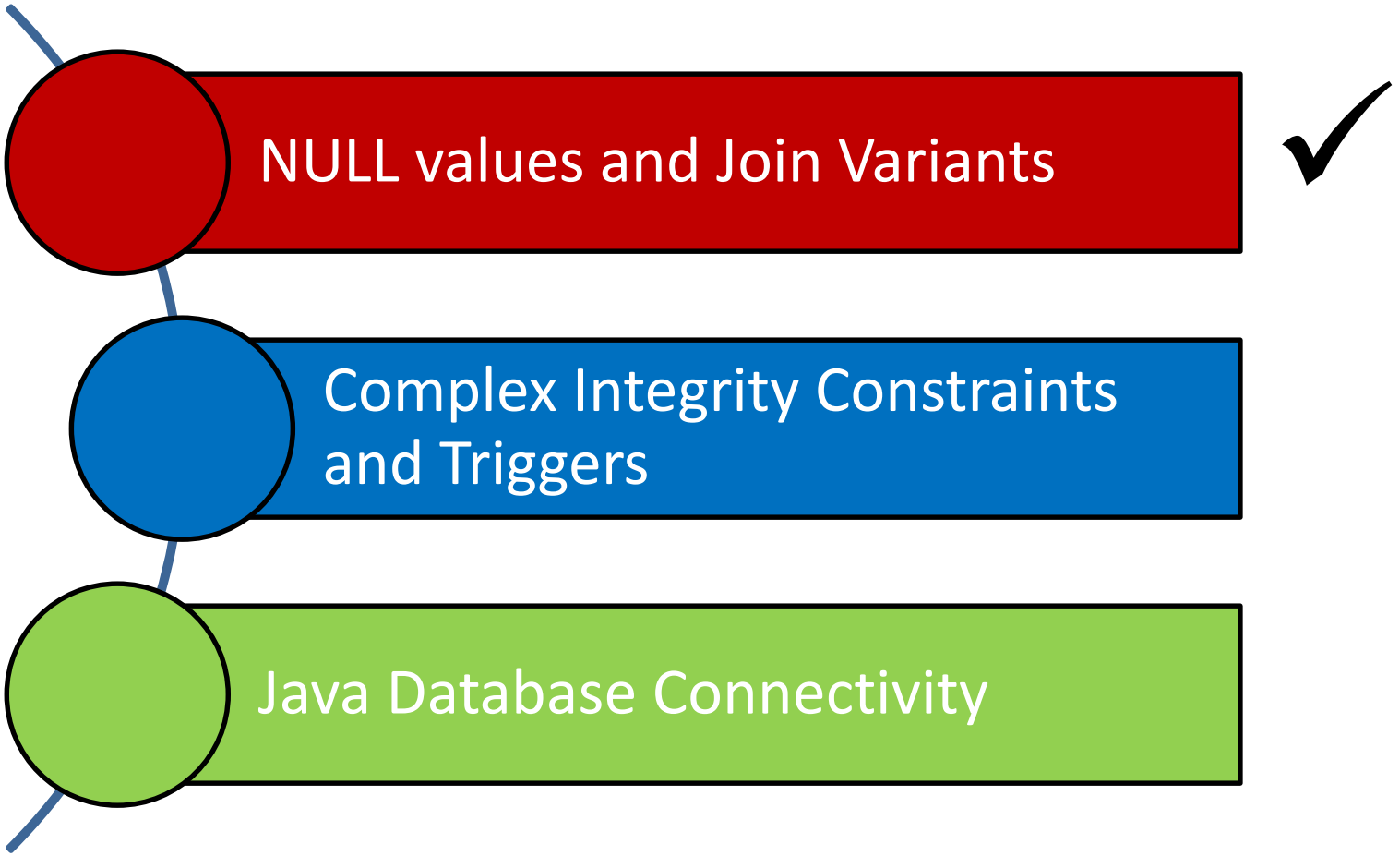
Today…

- Last Session:
  - Standard Query Language (SQL)- Part II
- Today's Session:
  - Standard Query Language (SQL)- Part III
- Announcements:
  - PS2 is due today by midnight
  - Quiz I is on Thursday Feb 11, 2015 (all topics covered so far are included)
  - No class on Tuesday Feb 09 due to the Qatar National Sports Day
  - Project I is due on Tuesday Feb 16 by midnight

Outline


NULL values and Join Variants
Complex Integrity Constraints and Triggers
Java Database Connectivity

NULL Values

- Column values can be *unknown* (e.g., a sailor may not yet have a rating assigned)
- Column values may be *inapplicable* (e.g., a maiden-name column for men!)
- **NULL** values can be used in such situations
- However, NULL values complicate many issues!
  - Comparing NULL to a valid value returns unknown
  - Comparing NULL to a NULL returns unknown

NULL Values

- Considering a row with rating = NULL and age = 20; How does it compare with the following Boolean expressions?
  - Rating = 8 OR age < 40 ➔ TRUE
  - Rating = 8 AND age < 40 ➔ unknown

- In general, what about?
  - NOT unknown ➔ unknown
  - True OR unknown ➔ True
  - False OR unknown ➔ unknown
  - False AND unknown ➔ False
  - True AND unknown ➔ unknown

NULL Values

- Considering a row with rating = NULL and age = 20; How does it compare with the following Boolean expressions?
  - Rating = 8 OR age < 40 ➔ TRUE
  - Rating = 8 AND age < 40 ➔ unknown
- In general, what about?
  - NOT unknown ➔ unknown
  - True OR unknown ➔ True
  - False OR unknown ➔ unknown
  - False AND unknown ➔ False
  - True AND unknown ➔ unknown

Three-Valued Logic!

Inner Joins

- Tuples of a relation that do not match some row in another relation (according to a join condition ***c***) do not appear in the result
  - Such a join is referred to as "Inner Join" (*so far, all inner joins*)

```
select ssn, c-name
from takes, class
where takes.c-id = class.c-id
```

Equivalently:

```
select ssn, c-name
from takes join class on takes.c-id = class.c-id
```

An Example of Inner Joins

- Find all SSN(s) taking course s.e.

TAKES		
SSN	**c-id**	**grade**
123	15-413	A
234	15-413	B

CLASS		
c-id	**c-name**	**units**
15-413	s.e.	2
15-412	o.s.	2

SSN	c-name
123	s.e
234	s.e

o.s.: gone!

Outer Joins

- Tuples of a relation that do not match some row in another relation (according to a join condition ***c***) can still appear exactly once in the result
  - Such a join is referred to as "Outer Join"
  - Result columns will be assigned NULL values

select ssn, c-name
from takes **outer join** class
on takes.c-id=class.c-id

An Example of Outer Joins

- Find all SSN(s) taking course s.e.

TAKES		
SSN	**c-id**	**grade**
123	15-413	A
234	15-413	B

CLASS		
c-id	**c-name**	**units**
15-413	s.e.	2
15-412	o.s.	2

SSN	c-name
123	s.e
234	s.e.
null	o.s.

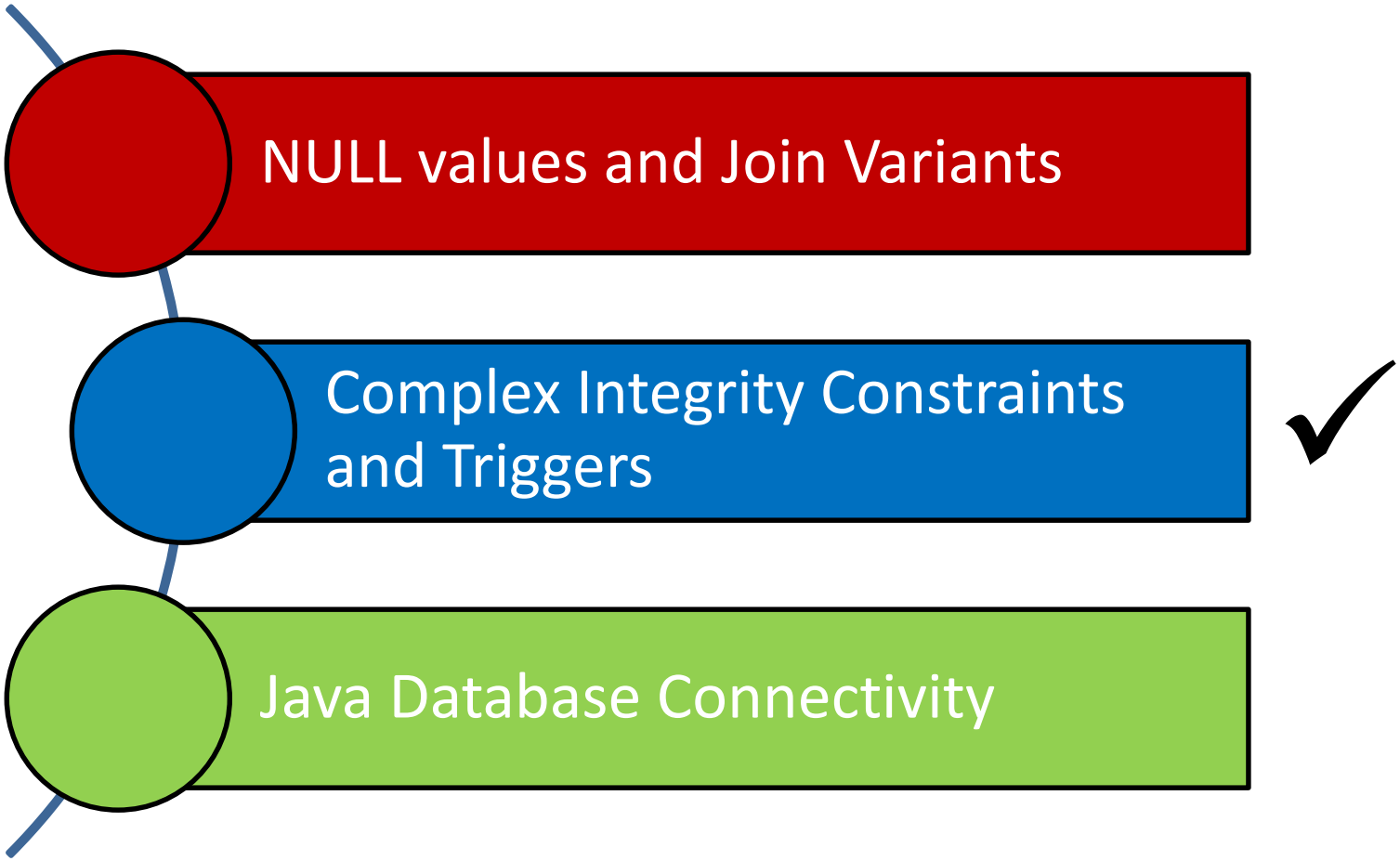
Joins

- The general SQL syntax:

```
select [column list]
from  table_name
   [inner | {left | right | full} outer ] join
    table_name
    on qualification_list
```

Outer Join Type	Description
Left Outer Join	*A* rows without a matching *B* row appear in the result
Right Outer Join	*B* rows without a matching *A* row appear in the result
Full Outer Join	Both *A* and *B* rows without a match appear in the result

Outline



Integrity Constraints- A Review

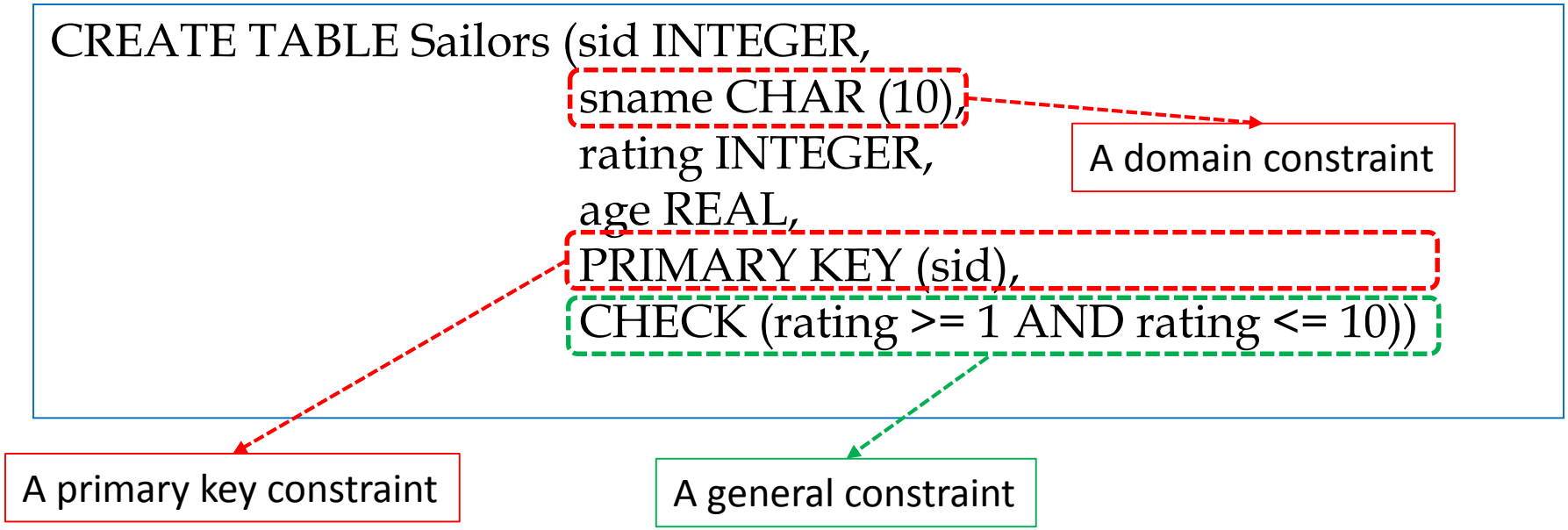
- An Integrity Constraint (IC) describes conditions that every *legal instance* of a relation must satisfy
- Inserts/deletes/updates that violate IC's are disallowed
- ICs can be used to:
  - Ensure application semantics (e.g., *sid* is a key)
  - Prevent inconsistencies (e.g., *sname* has to be a string, *age* must be < 20)

Types of Integrity Constraints- A Review

- IC types:
  - Domain constraints
  - Primary key constraints
  - Foreign key constraints
  - General constraints
    - Useful when more general ICs than keys are involved
    - Can be specified over a *single table* and *across tables*

General Constraints Over a Single Table

- Complex constraints over a single table can be defined using **CHECK** *conditional-expression*



General Constraints Over a Single Table

- How can we *enforce* that "Interlake" boats cannot be reserved?

```
CREATE TABLE Reserves (sid INTEGER,
                       bid INTEGER,
                       day DATE,
                       FOREIGN KEY (sid) REFERENCES Sailors,
                       FOREIGN KEY (bid) REFERENCES Boats,
                       CONSTRAINT noInterlakeRes,
                       CHECK ('Interlake' NOT IN
                              (SELECT B.bname
                               FROM Boats B
                               WHERE B.bid = Reserves.bid)))
```

A foreign key constraint

General Constraints Across Tables-Motivation

- How can we *enforce* that the number of boats plus the number of sailors should not exceed 100?

```
CREATE TABLE Sailors (sid INTEGER,
                      sname CHAR (10),
                      rating INTEGER,
                      age REAL,
                      PRIMARY KEY (sid),
                      CHECK (rating >= 1 AND rating <= 10)
                       CHECK ( ((SELECT COUNT (S.sid)
                                 FROM Sailors S) +
                                (SELECT COUNT (B.bid)
                                 FROM Boats B)) < 100))
```

What if the Sailors table is empty and we insert more than 100 rows into Boats?

General Constraints Across Tables-Assertions

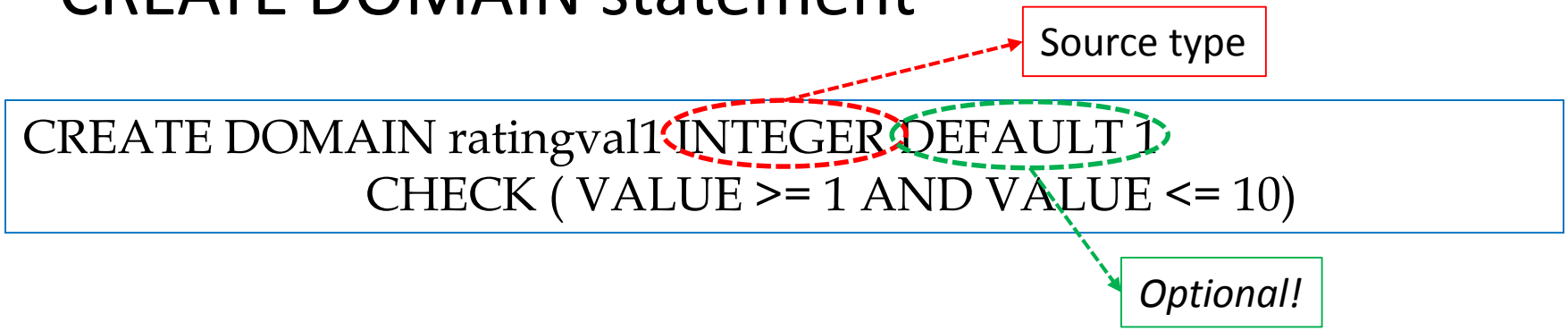
- How can we *enforce* that the number of boats plus the number of sailors should not exceed 100?

```
CREATE ASSERTION  smallClub
CHECK
( (SELECT COUNT (S.sid) FROM Sailors S)
+ (SELECT COUNT (B.bid) FROM Boats B) < 100 )
```

ASSERTION is the right solution; not associated with either table!

New Domains

- Users can define new domains using the CREATE DOMAIN statement




```
CREATE DOMAIN ratingval2 INTEGER DEFAULT 1
                CHECK ( VALUE >= 1 AND VALUE <= 20)
```

ratingval1 and ratingval2 CAN be compared!

Domain constraints will be always enforced (also for new domains)!

Distinct Types

- Users can define new distinct types using the CREATE TYPE statement

```
CREATE TYPE ratingtype1 AS INTEGER
```

```
CREATE TYPE ratingtype2 AS INTEGER
```

ratingtype1 and ratingtype2 CANNOT be compared!

Domain constraints will be always enforced (also for new types)!

Triggers

- A trigger is a *procedural* code that is automatically executed in response to certain *events* on a particular table or view in a database

- Triggers can be activated either *before* or *after*
  - Insertions
  - Deletions
  - Updates

A Trigger Example

- Set a timestamp field whenever a row in the takes table is updated

TAKES		
SSN	**c-id**	**grade**
123	15-413	A
234	15-413	B

  - First: we need to add our timestamp field

```
ALTER TABLE takes
ADD COLUMN updated TIMESTAMP
```

A Trigger Example

- Set a timestamp field whenever a row in the takes table is updated

TAKES		
SSN	**c-id**	**grade**
123	15-413	A
234	15-413	B

  - Second: we need to create a function that sets the "updated" column with the current timestamp

```
CREATE FUNCTION update_col()
        BEGIN
                NEW.updated = NOW();
                RETURN NEW;
        END
```

A Trigger Example

- Set a timestamp field whenever a row in the takes table is updated

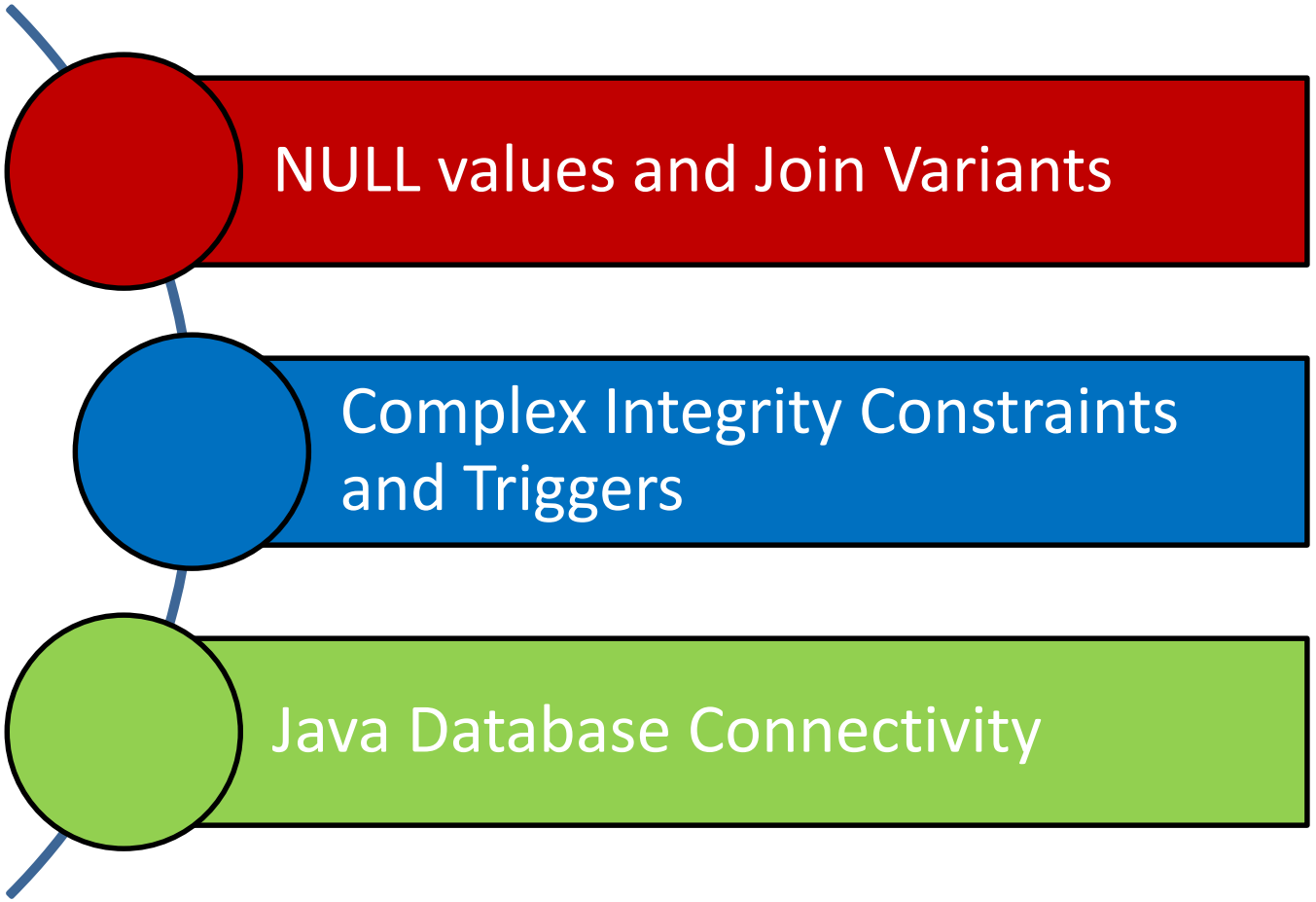
TAKES		
SSN	**c-id**	**grade**
123	15-413	A
234	15-413	B

  - Third: we need to Invoke update_col() when a row in the takes table is updated

A ***row-level trigger***; otherwise, it will be a ***statement-level trigger***

```
CREATE TRIGGER update_takes_modtime
        AFTER UPDATE ON takes
        FOR EACH ROW
        EXECUTE PROCEDURE update_col();
```

Outline



Java Database Connectivity

- SQL commands can be *embedded* in host language programs
- A popular data access technology which provides an API for querying and manipulating data in (any) storage system is called Java Database Connectivity (JDBC)
- Direct interactions with a DBMS occurs through a DBMS-specific driver
- A driver is a software program that translates JDBC calls into DBMS-specific calls
  - Drivers do not necessarily interact with a DBMS that understands SQL
  - Thus, a DBMS in JDBC's parlance is usually referred to as data source

Establishing a Connection

- With JDBC, a database is represented by a URL
- With PostgreSQL™, this takes one of the following forms:
  - jdbc:postgresql:*database*
  - jdbc:postgresql://*host*/*database*
  - jdbc:postgresql://*host*:*port*/*database*
- To connect to a database, a Connection instance from JDBC can be used

```
Connection db = DriverManager.getConnection(url, username, password);
```

Establishing a Connection

- A number of additional properties can be used to specify additional driver behavior specific to PostgreSQL™

```
String url = "jdbc:postgresql://localhost/test";
Properties props = new Properties();
props.setProperty("user",“Hammoud");
props.setProperty("password","secret");
props.setProperty("ssl","true");
Connection conn = DriverManager.getConnection(url, props);
```

Equivalently:

```
String url = "jdbc:postgresql://localhost/test?user=Hammoud&password=secret&ssl=true";
Connection conn = DriverManager.getConnection(url);
```

Establishing a Connection

- Putting it all together, you can create the following function:

```
public Connection getConnection() throws SQLException {

        String url = "jdbc:postgresql://localhost/test";
        Properties props = new Properties();
        props.setProperty("user",“Hammoud");
        props.setProperty("password","secret");
        props.setProperty("ssl","true");
        Connection conn = DriverManager.getConnection(url, props);

        System.out.println("Connected to database");
        return conn;
}
```

Creating Tables

- Assume the following students table:

Sid	Name
1	Hammoud
2	Esam

SQL:

```
CREATE TABLE students( sid INTEGER, name CHAR(30), PRIMARY KEY (sid))
```

JDBC:

```
public void createTable() throws SQLException {
        String createT = "create table students (sid INTEGER, " +
                         “name CHAR(30) “ +
                         "PRIMARY KEY (sid))";
        Statement stmt = null;
        try {   stmt = conn.createStatement();
                stmt.executeUpdate(createT);
            } catch (SQLException e) { e.printStackTrace(e); }
        finally { if (stmt != null) { stmt.close(); } }
}
```

Populating Tables

- Assume the following students table:

Sid	Name
1	Hammoud
2	Esam

SQL:

```
INSERT INTO students values (1, 'Hammoud)
INSERT INTO students values (2, 'Esam')
```

JDBC:

```
public void populateTable() throws SQLException {
        Statement stmt = null;
        try {
        stmt = conn.createStatement();
        stmt.executeUpdate( "insert into students values(1, 'Hammoud')");
        stmt.executeUpdate( "insert into students values(2, 'Esam')");
        } catch (SQLException e) {}
        finally { if (stmt != null) { stmt.close(); } }
}
```

Querying Tables

- Assume the following students table:

Sid	Name
1	Hammoud
2	Esam

SQL: SELECT sid, name from students

JDBC:

```
public static void viewTable() throws SQLException {
    Statement stmt = null;
    String query = "select sid, name from students";
    try {
    stmt = conn.createStatement();
    ResultSet rs = stmt.executeQuery(query);
    while (rs.next()) {
            int sID = rs.getInt("sid");
            String sName = rs.getString("name");
            System.out.println(sName + "\t" + sID); }
    } catch (SQLException e ) {} finally { if (stmt != null) { stmt.close(); } }
}
```

A "cursor" that points to one row of data at a time

Columns retrieved by names

Querying Tables

- Assume the following students table:

Sid	Name
1	Hammoud
2	Esam

SQL: SELECT sid, name from students

JDBC:

```
public static void viewTable() throws SQLException {
        Statement stmt = null;
        String query = "select sid, name from students";
        try {
        stmt = conn.createStatement();
        ResultSet rs = stmt.executeQuery(query);
        while (rs.next()) {
                int sID = rs.getInt(1);
                String sName = rs.getString(2);
                System.out.println(sName + "\t" + sID); }
        } catch (SQLException e ) {} finally { if (stmt != null) { stmt.close(); } }
}
```

OR: Columns retrieved by numbers

Cursor Methods

- Methods available to move the cursor of a result set:
  - next()
  - previous()
  - first()
  - Last()
  - beforeFirst()
  - afterLast()
  - relative(int rows)
  - absolute(int row)

By default, you can call only next()!

Updating Tables

- By default, ResultSet objects cannot be updated, and their cursors can only be moved forward

- ResultSet objects can be though defined to be *scrollable* (the cursor can move backwards or move to an absolute position) and *updatable*

```
public void modifyStudents() throws SQLException {
        Statement stmt = null;
        try {
         /* stmt = con.createStatement();  */
        stmt = con.createStatement(ResultSet.TYPE_SCROLL_SENSITIVE,
                                   ResultSet.CONCUR_UPDATABLE);
        ResultSet uprs = stmt.executeQuery( "SELECT * FROM students");
        while (uprs.next()) {
                String old_n = uprs.getString("name");
                uprs.updateString( "name", "Mohammad" + old_n);
                uprs.updateRow(); }
        } catch (SQLException e ) {} finally { if (stmt != null) { stmt.close(); } }
}
```

Result Set Types

- TYPE_FORWARD_ONLY (the default)
  - The result set is not scrollable
- TYPE_SCROLL_INSENSITIVE
  - The result set is scrollable
  - The result set is insensitive to changes made to the underlying data source while it is open
- TYPE_SCROLL_SENSITIVE
  - The result set is scrollable
  - The result set is sensitive to changes made to the underlying data source while it is open

Result Set Concurrency

- The concurrency of a ResultSet object determines what level of update functionality is supported

- Concurrency levels:
  - CONCUR_READ_ONLY (the default)
    - The result set cannot be updated
  - CONCUR_UPDATABLE
    - The result set can be updated

Prepared Statements

- JDBC allows using a PreparedStatement object for sending SQL statements to a database

- This way, the same statement can be used with different values many times

```
…
String sql = “INSERT into students values (?, ?)”;
PreparedStatement ps = conn.prepareStatement(sql);
ps.clearParameters();
ps.setInt(1, 111);
ps.setString(2, “Hammoud”);
int numRows1 = ps.executeUpdate();

ps.setInt(1, 222);
ps.setString(2, “Esam”);
int numRows2 = ps.executeUpdate();
…
```

1

2

More about JDBC in the upcoming two recitations!

Next Class

Storing Data: Disks and Files