Translating Entity-Relationship to Relational Tables
Spring 2018

School of Computer Science
University of Waterloo

Databases CS348
Outline

1. ER to Relational Mapping
2. Data Definition in SQL (DDL)
3. Views and View Management
4. Data Security/Control (DCL)
E-R Diagram to Relational Schema

Main ideas:

- Each entity set maps to a new table
- Each attribute maps to a new table column
- Each relationship set maps to either new table columns or to a new table
Representing Strong Entity Sets

Entity set $E$ with attributes $a_1, \ldots, a_n$ translates to table $E$ with attributes $a_1, \ldots, a_n$

Entity of type $E \leftrightarrow \text{row in table } E$
Primary key of entity set $\rightarrow$ primary key of table

**Example:**

Entity set $E$ with attributes $a_1, \ldots, a_n$ translates to table $E$ with attributes $a_1, \ldots, a_n$.
Representing Weak Entity Sets

Weak entity set $E$ translates to table $E$

Columns of table $E$ should include

- Attributes of the weak entity set
- Attributes of the identifying relationship set
- Primary key attributes of entity set for dominating entities

Primary key of weak entity set $\rightarrow$ primary key of table
Representing Weak Entity Sets (cont.)

Example:

Account
AccNum Balance

Transaction
TransNum AccNum Date Amount

Log

Balance

AccNum
Representing Relationship Sets

- If the relationship set is an identifying relationship set for a weak entity set then no action needed

- If we can deduce the general cardinality constraint (1,1) for a component entity set $E$ then add following columns to table $E$
  - Attributes of the relationship set
  - Primary key attributes of remaining component entity sets

- Otherwise: relationship set $R \rightarrow$ table $R$
Representing Relationship Sets (cont.)

- Columns of table $R$ should include
  - Attributes of the relationship set
  - Primary key attributes of each component entity set

- Primary key of table $R$ determined as follows
  - If we can deduce the general cardinality constraint (0,1) for a component entity set $E$, then take the primary key attributes for $E$
  - Otherwise, choose primary key attributes of each component entity set
Representing Relationship Sets (cont.)

Example:

Note that the role name of a component entity set should be prepended to its primary key attributes, if supplied.
Representing Aggregation

Tabular representation of aggregation of $R$

$= \text{tabular representation for relationship set } R$

To represent relationship set involving aggregation of $R$, treat the aggregation like an entity set whose primary key is the primary key of the table for $R$. 
Example:

```
<table>
<thead>
<tr>
<th>Student</th>
<th>EnrolledIn</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>StudentNum</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CourseAccount</th>
<th>ExpirationDate</th>
</tr>
</thead>
<tbody>
<tr>
<td>UserId</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Account</th>
<th>UserId</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EnrolledIn</th>
<th>StudentNum</th>
<th>CourseNum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CourseAccount</th>
</tr>
</thead>
<tbody>
<tr>
<td>UserId</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

(Student of Waterloo)

ER to Relational

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Representing Specialization

Create table for higher-level entity set, and treat specialized entity subsets like weak entity sets (without discriminators)

Example:

**Student**

- StudentNumber
- StudentName

**Graduate**

- StudentNumber
- ProfessorName

**Degrees**

- StudentNumber

**Professor**

- ProfessorName

**ER to Relational**

- Student
  - StudentNumber
  - StudentName

- Graduate
  - StudentNumber
  - ProfessorName

- Degree
  - StudentNumber
  - Degree

- Professor
  - ProfessorName

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## Representing Generalization (Approach #1)

1. **Create a table for each lower-level entity set only**

Columns of new tables should include:
- Attributes of lower level entity set
- Attributes of the superset

The higher-level entity set can be defined as a view on the tables for the lower-level entity sets.
Representing Generalization (Approach #1)

Example:

```
LicenceNum    MakeAndModel    Price    Tonnage     AxelCount
Car
LicenceNum    MakeAndModel    Price    MaxSpeed    PassengerCount
Truck
```
Representing Generalization (Approach #2)

Treat generalization the same as specialization.

Example:

![Diagram of vehicle types with properties and relationships]

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>LicenceNum</th>
<th>MakeAndModel</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck</td>
<td>LicenceNum</td>
<td>Tonnage</td>
<td>AxelCount</td>
</tr>
<tr>
<td>Car</td>
<td>LicenceNum</td>
<td>MaxSpeed</td>
<td>PassengerCount</td>
</tr>
</tbody>
</table>

(Understanding and converting between entity-relationship (ER) models and relational models.)
Example Translation: ER Diagram
Example Translation: Relational Diagram

Course
- CourseNum
- CourseName

Section
- CourseNum
- SectionNum
- Term
- ProfNum

EnrolledIn
- CourseNum
- SectionNum
- StudentNum
- Term
- Mark

Student
- StudentNum
- StudentName
- GPA

Professor
- ProfNum
- ProfName

Off-Site Section
- CourseNum
- SectionNum
- Term
- Location
Outline

1. ER to Relational Mapping
2. Data Definition in SQL (DDL)
3. Views and View Management
4. Data Security/Control (DCL)
Defining Relations and Integrity Constraints in SQL

- connected with a table (definition)
  ⇒ Primary Keys
  ⇒ Foreign Keys
  ⇒ CHECK constraints

- separate ECA rules (triggers)
Tables with a Primary Key

- specifies a attributes of a table (w/types)
- specifies a primary key in a table
- syntax:

  ```sql
  CREATE TABLE <name>
  (
      ... <attributes>,
      PRIMARY KEY ( <list of attr> )
  )
  ```

- also creates an unique index on the key
Example

```sql
create table DEPT
(  ID integer not NULL,
  DeptName char(20),
  MgrNO char(3),
  PRIMARY KEY (ID)
)
```
Example (cont.)

sql => insert into DEPT values \\
sql (cont.) => ( 1 ,’Computer Science’, 000100)
DB20000I  The SQL command completed successfully.

sql => insert into DEPT values \\
sql (cont.) => ( 1 ,’Computer Science’, 000100)
SQL0803N  One or more values in the INSERT or UPDATE statement are not valid because they would produce duplicate rows for a table with a unique index.
SQLSTATE=23505
Foreign Key

- specifies an *referential constraint*

- syntax:

  ```sql
  CREATE TABLE <name>
  ( ... <attributes>,
    FOREIGN KEY ( <attrs> )
    REFERENCES <ref-table>( <attrs> )
    ON DELETE <delete-action>
    ON UPDATE <update action>
  )
  ``

- the actions can be:
  
  - *RESTRICT* – produce an error
  - *CASCADE*  – propagate the delete
  - *SET NULL* – set to “unknown”
Example

create table EMP
    ( SSN integer not NULL,
      Name char(20),
      Dept integer,
      Salary dec(8,2),
      primary key (SSN),
      foreign key (Dept) references DEPT(ID)
        on delete cascade
        on update restrict)
Example (cont.)

db2 => insert into EMP \nsql (cont.) => values ( 999, 'DAVE', 2, 50000 )
SQL0530N The insert or update value of FOREIGN KEY "DAVID.EMP.SQL970916001756640" is not equal to any value of the primary key of the parent table.
SQLSTATE=23503

db2 => insert into EMP \nsql (cont.) => values ( 999, 'DAVE', 1, 50000 )
DB20000I The SQL command completed successfully.
db2 => select * from emp where SSN=999

SSN NAME DEPT SALARY
----------- -------------------- ---- ----------
  999  DAVE          1  50000.00
Example (cont.)

db2 => delete from DEPT where id=1
DB20000I The SQL command completed successfully.
db2 => select * from emp where SSN=999

SSN       NAME       DEPT    SALARY
---------     ---------------  ----    ----------

CHECK constraints

- allow checking for “correct” data:
- syntax:

  ```sql
  CREATE TABLE <name>
  (   ... <attributes>,
      CHECK <condition>
  )
  ```

- condition is a *simple* search condition
  $\Rightarrow$ no subqueries (in DB2)
Example

create table EMP
( SSN integer not NULL,
  Name char(20),
  Dept integer,
  Salary dec(8,2),
  primary key (SSN),
  foreign key (Dept) references DEPT(ID)
    on delete cascade
    on update restrict,
  check ( salary > 0 )
)

db2 => insert into emp values (998, 'DAVE', 1, 0 )
SQL0545N The requested operation is not allowed because a row does not satisfy the check constraint "DAVID.EMP.SQL970916000939620". SQLSTATE=23513
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Definition (View)

A view is a relation whose instance is determined by the instances of other relations.

A view has many of the same properties as a table.
- its schema information appears in the database schema
- access controls can be applied to it
- other views can be defined in terms of it
Types of Views

- **Virtual**: Views are used only for querying; they are not stored in the database.
- **Materialized**: The query that makes up the view is executed, the view constructed and stored in the database.
SQL DDL: Views

- General form:

  ```sql
  CREATE VIEW <name>
  [AS] ( <query> )
  ```

- Example

  ```sql
  create view ManufacturingProjects
  ( Select projno, projname, firstnme, lastname
    From project, employee
    Where respemp = empno and deptno = 'D21' )
  ```
Accessing a View

Query a view as if it were a base relation.

```
SELECT projname
FROM manufacturingprojects
```
Accessing a View

Query a view as if it were a base relation.

```
SELECT projname
FROM manufacturingprojects
```

What happens when you query a virtual view?
- At compile time, the view definition is found
- The query over the view is modified with the query definition
- The resulting query is optimized and executed
Updating Views

- Modifications to a view’s instance must be propagated back to instances of relations in conceptual schema.

What does it mean to insert (Darryl, Hockey)?

What does it mean to delete (Dave, Curling)?
Updating Views

- Modifications to a view’s instance must be propagated back to instances of relations in conceptual schema.
- Some views cannot be updated unambiguously.
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Conceptual Schema

<table>
<thead>
<tr>
<th>Persons</th>
<th>External Schema</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAME</td>
<td>NAME</td>
</tr>
<tr>
<td>Ed</td>
<td>Ed</td>
</tr>
<tr>
<td>Dave</td>
<td>Ed</td>
</tr>
<tr>
<td>Wes</td>
<td>Dave</td>
</tr>
<tr>
<td></td>
<td>Dave</td>
</tr>
<tr>
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<td>Wes</td>
</tr>
<tr>
<td></td>
<td>Wes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NationalPastimes</th>
<th>PersonalPastimes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CITIZENSHIP</td>
<td>PASTIME</td>
</tr>
<tr>
<td>Canadian</td>
<td>Hockey</td>
</tr>
<tr>
<td>Canadian</td>
<td>Curling</td>
</tr>
<tr>
<td>American</td>
<td>Hockey</td>
</tr>
<tr>
<td>American</td>
<td>Curling</td>
</tr>
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<tr>
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<td>Curling</td>
</tr>
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<td>Hockey</td>
</tr>
<tr>
<td>American</td>
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**External Schema**

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<th></th>
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<tbody>
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<td>Hockey</td>
</tr>
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<td>Ed</td>
<td>Curling</td>
</tr>
<tr>
<td>Dave</td>
<td>Hockey</td>
</tr>
<tr>
<td>Dave</td>
<td>Curling</td>
</tr>
<tr>
<td>Wes</td>
<td>Hockey</td>
</tr>
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<td>Wes</td>
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</table>

1. What does it mean to insert (Darryl, Hockey)?
2. What does it mean to delete (Dave, Curling)?
View Updates in SQL

According to SQL-92, a view is updatable only if its definition satisfies a variety of conditions:

- The query references exactly one table
- The query only outputs simple attributes (no expressions)
- There is no grouping/aggregation/DISTINCT
- There are no nested queries
- There are no set operations

These rules are more restrictive than necessary.
Problem

When a base table changes, the materialized view may also change.
Materialized Views

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When a base table changes, the materialized view may also change.

Solution?
- Periodically reconstruct the materialized view.
- Incrementally update the materialized view.
Materialized Views

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When a base table changes, the materialized view may also change.

Solution?
- Periodically reconstruct the materialized view.
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Example: Data warehouses
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Data Control Language

assigns *access rights* to database objects

- **Syntax:**
  
  `GRANT <what> ON <object> TO <user(s)>`
  
  `REVOKE <what> ON <object> FROM <user(s)>`

- **<what> ON <object>** can be
  
  - DATABASE: BINDADD, CONNECT, CREATETAB, CREATE_NOT_FENCED, DBADM
  
  - INDEX: CONTROL
  
  - PACKAGE: BIND, CONTROL, EXECUTE
  
  - TABLE/VIEW: ALTER, CONTROL, INDEX, REFERENCES, SELECT, INSERT, DELETE, UPDATE

- **<user(s)>** is a list of
  
  - *(i)* USER <name>
  
  - *(ii)* GROUP <name>
  
  - *(iii)* PUBLIC
Summary

Schema design summary:

1. Create an ER diagram
   ⇒ visualization of the design goals

2. Translate ER-to-Relational

3. Determine FD, MVD, JD, . . .
   ⇒ detect anomalies and decompose
   ⇒ find keys

4. Determine inter-relational constraints
   ⇒ INDs and foreign key constraints

5. Enforce rest of constraints
   ⇒ CHECK declarations
   ⇒ ECA rules (only as the last resort!)