Translating Entity-Relationship to Relational Tables

Fall 2015

David Toman

School of Computer Science
University of Waterloo

Databases CS338

E-R Diagram to Relational Schema

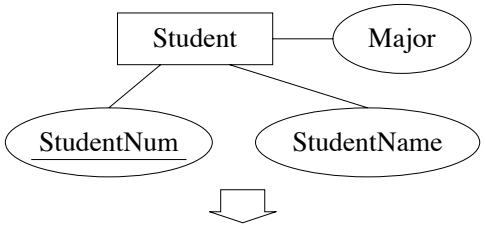
Main ideas:

- 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 $E \leftrightarrow$ row in table E
Primary key of entity set $\rightarrow$ primary key of table
Example:



Student

StudentNum	StudentName	Major

Representing Weak Entity Sets

Weak entity set E translates to table E

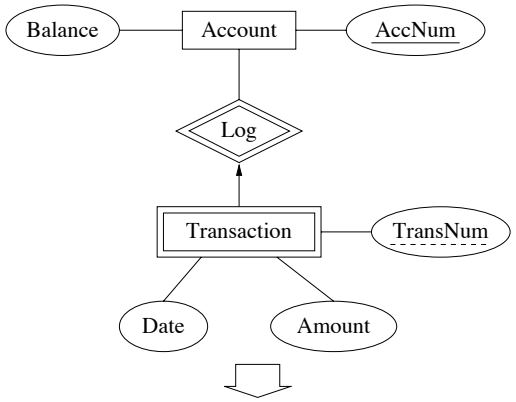
Columns of table E should include

- 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

Representing Relationship Sets

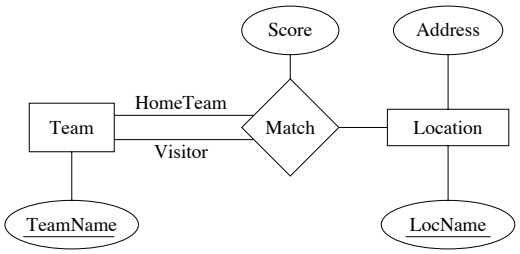
- If the relationship set is an identifying relationship set for a weak entity set then no action needed
- If we can deduce the general cardinality constraint (1,1) for a component entity set E then add following columns to table E
  - Attributes of the relationship set
  - Primary key attributes of 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

Representing Relationship Sets (cont.)

Example:



Team

TeamName

Location

LocName	Address

Match

HomeTeamName	VisitorTeamName	LocName	Score

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

Representing Aggregation

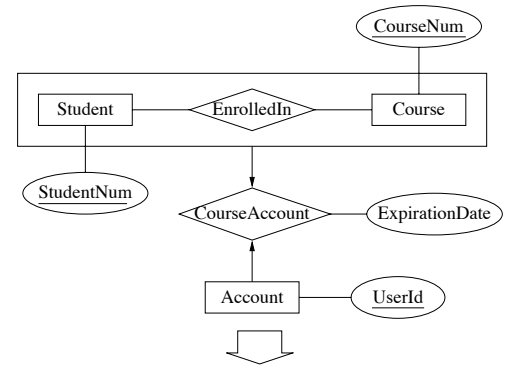
Tabular representation of aggregation of R

$=$ 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

Representing Aggregation (cont.)

Example:



Student

StudentNum

Course

CourseNum

Account

UserId

EnrolledIn

StudentNum	CourseNum

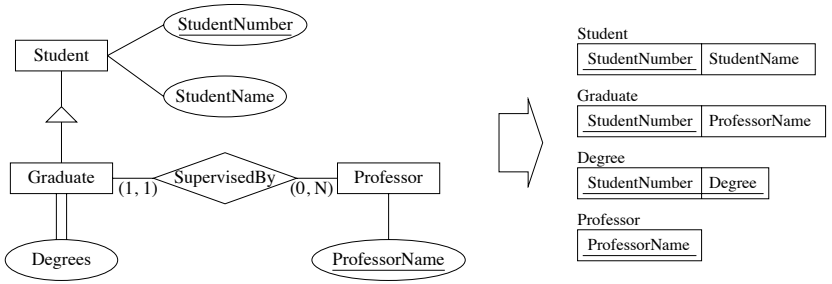
CourseAccount

UserId	StudentNum	CourseNum	ExpirationDate

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

Degree

StudentNumber	Degree

Professor

ProfessorName

Representing Generalization (Approach #1)

Create a table for each lower-level entity set only

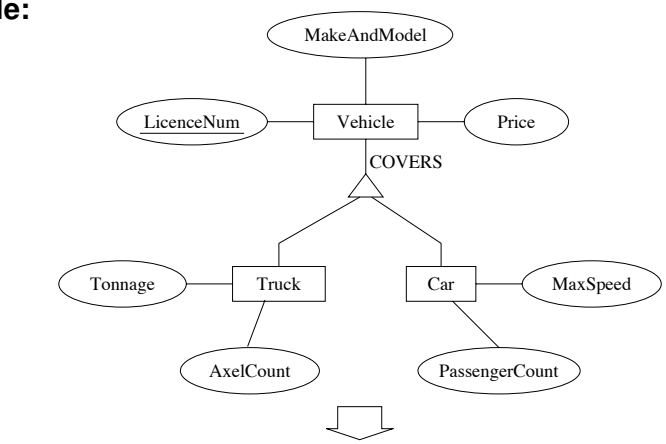
Columns of new tables should include

- 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:



Truck

LicenceNum	MakeAndModel	Price	Tonnage	AxelCount

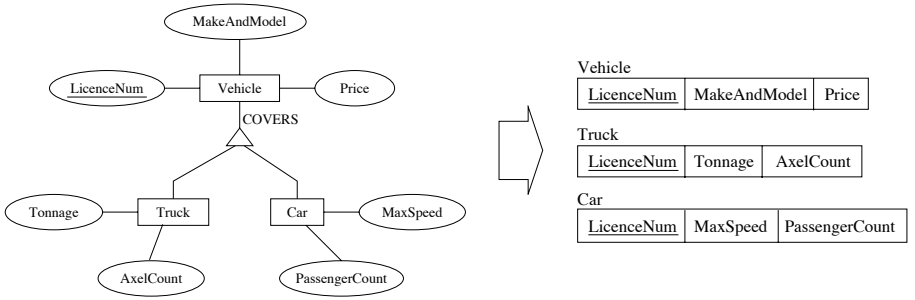
Car

LicenceNum	MakeAndModel	Price	MaxSpeed	PassengerCount

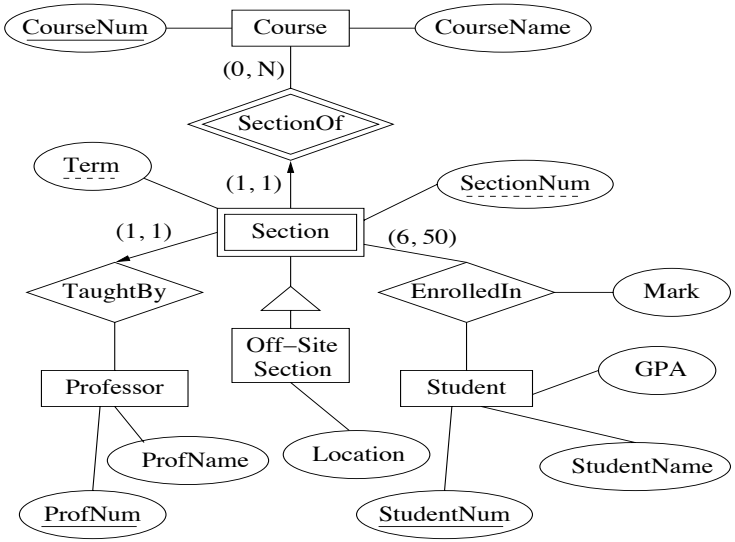
Representing Generalization (Approach #2)

Treat generalization the same as specialization.

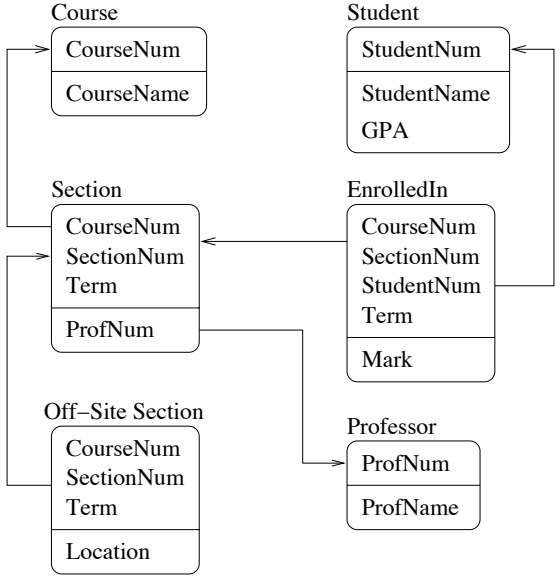
Example:



Example Translation: ER Diagram



Example Translation: Relational Diagram



Defining Relations and Integrity Constraints in SQL

- connected with a table (definition)
  - ⇒ Primary Keys
  - ⇒ Foreign Keys
  - ⇒ `CHECK` constraints
- separate ECA rules (triggers)

Tebles with a Primary Key

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

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

- also creates an unique index on the key

Example

```
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:

```
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 \
sql (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 \
sql (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:

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

- condition is a *simple* search condition
  ⇒ 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
```


Views

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:

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

- Example

```
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
```

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.
- Some views cannot be updated unambiguously.

Conceptual Schema

Persons

NAME	CITIZENSHIP
Ed	Canadian
Dave	Canadian
Wes	American

NationalPastimes

CITIZENSHIP	PASTIME
Canadian	Hockey
Canadian	Curling
American	Hockey
American	Baseball

$\Leftrightarrow$

External Schema

PersonalPastimes

NAME	PASTIME
Ed	Hockey
Ed	Curling
Dave	Hockey
Dave	Curling
Wes	Hockey
Wes	Baseball

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.

Materialized Views

Problem

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

- Solution?
  - Periodically reconstruct the materialized view.
  - Incrementally update the materialized view.
- Example: Data warehouses

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!)