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Chapter 7: Entity-Relationship Model

E-R to Relational translation

Database System Concepts, 7th Ed.

Reduction to Relation Schemas

Reduction to Relation Schemas

- Entity sets and relationship sets can be expressed uniformly as *relation schemas* that represent the contents of the database.
- A database which conforms to an E-R diagram can be represented by a collection of schemas.
- For each entity set and relationship set there is a unique schema that is assigned the name of the corresponding entity set or relationship set.
- Each schema has a number of columns (generally corresponding to attributes), which have unique names.

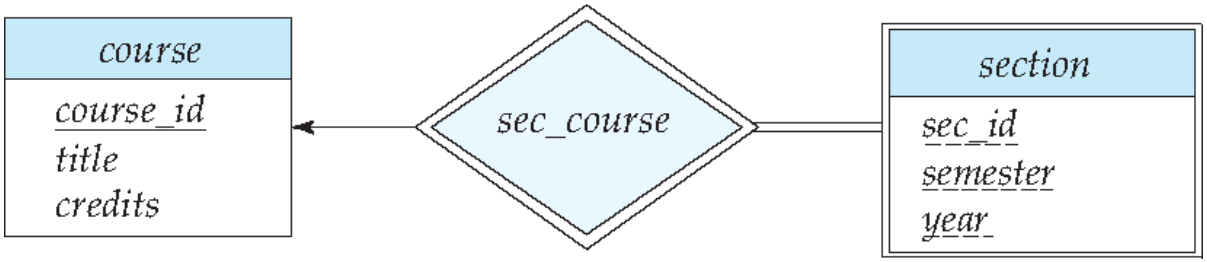
Representing Entity Sets

- A strong entity set reduces to a schema with the same attributes

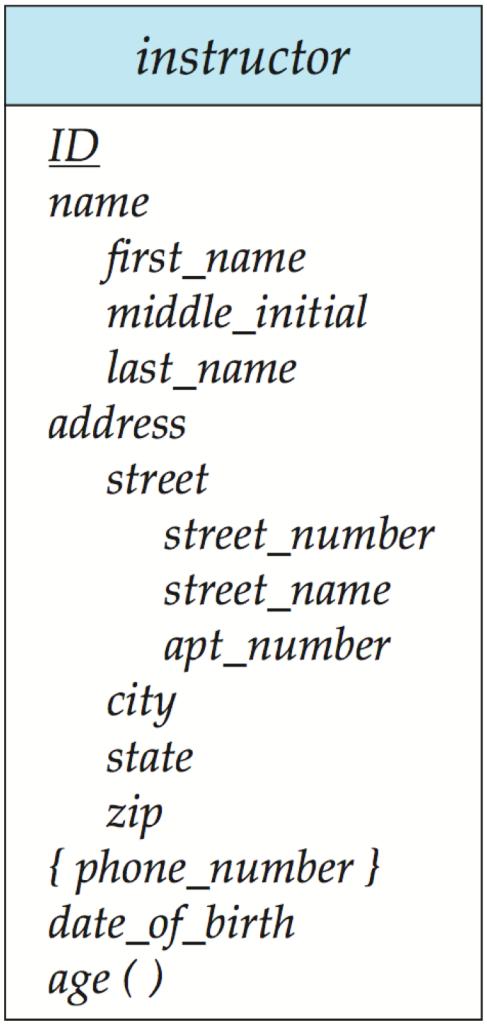
  student(ID, name, tot_cred)

- A weak entity set becomes a table that includes a column for the primary key of the identifying strong entity set

  section (course_id, sec_id, sem, year)



Representation of Entity Sets with Composite Attributes



- Composite attributes are flattened out by creating a separate attribute for each component attribute
  - Example: given entity set *instructor* with composite attribute *name* with component attributes *first_name* and *last_name* the schema corresponding to the entity set has two attributes *name_first_name* and *name_last_name*
    - Prefix omitted if there is no ambiguity (*name_first_name* could be *first_name)*
- Ignoring multivalued attributes, extended instructor schema is
  - *instructor(ID, first_name, middle_initial, last_name, street_number, street_name, apt_number, city, state, zip_code, date_of_birth)*

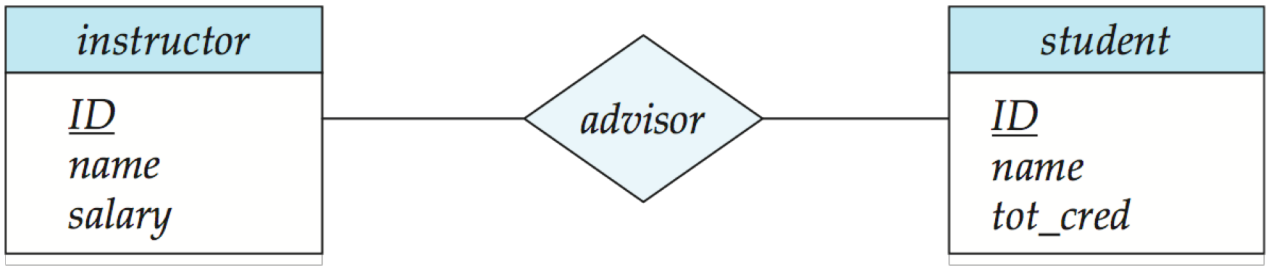
Representation of Entity Sets with Multivalued Attributes

- A multivalued attribute *M* of an entity *E* is represented by a separate schema *EM*
- Schema *EM* has attributes corresponding to the primary key of *E* and an attribute corresponding to multivalued attribute *M*
- Example: Multivalued attribute *phone_number* of *instructor* is represented by a schema:
  inst_phone= (*ID*, *phone_number*)
- Each value of the multivalued attribute maps to a separate tuple of the relation on schema *EM*
  - For example, an *instructor* entity with primary key 22222 and phone numbers 456-7890 and 123-4567 maps to two tuples:
    (22222, 456-7890) and (22222, 123-4567)

Representing Relationship Sets

- A many-to-many relationship set is represented as a schema with attributes for the primary keys of the two participating entity sets, and any descriptive attributes of the relationship set.
- Example: schema for relationship set *advisor*

advisor = (*s_id, i_id*)



A note on the ER-to-relational mapping: the case of one-to-one relationships

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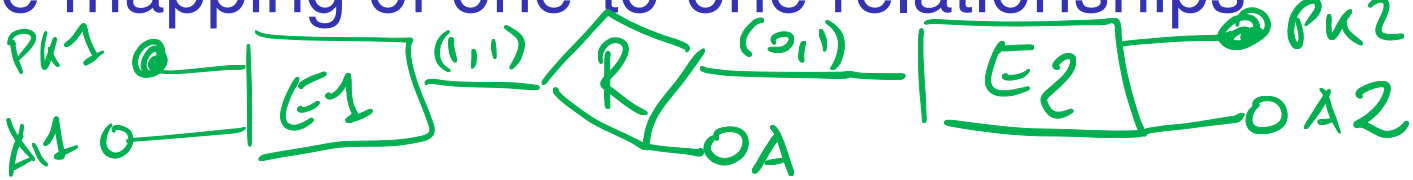
The mapping of one-to-one relationships



We have to distinguish among 3 different cases:

- $E1(\mathbf{PK1}, A1) - (1,1) - R(A) - (0,1) - E2(\mathbf{PK2}, A2)$

  where $PK1$ is the key of entity $E1$, $A1$ is an attribute of $E1$, A is an attribute of relationship R, $PK2$ is the key of entity $E2$, and $A2$ is an attribute of $E2$

  (the case

  $E1(\mathbf{PK1}, A1) - (0,1) - R(A) - (1,1) - E2(\mathbf{PK2}, A2)$

  is completely symmetric, and thus ignored)

- $E1(\mathbf{PK1}, A1) - (0,1) - R(A) - (0,1) - E2(\mathbf{PK2}, A2)$

- $E1(\mathbf{PK1}, A1) - (1,1) - R(A) - (1,1) - E2(\mathbf{PK2}, A2)$

The case of $(1,1)$ – $(0,1)$ relationships

How can we map the following ER schema into a corresponding relational one (introducing no redundancy, and preserving as much as possible information/constraints)?

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Relational schema:

$E1(\underline{PK1}, A1, PK2, A)$ and $E2(\underline{PK2}, A2)$, where $PK2$ is a foreign key of relation $E1$ that refers to the primary key $PK2$ of relation $E2$.

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Relational schema:

$E1(\underline{PK1}, A1, PK2, A)$ and $E2(\underline{PK2}, A2)$, where $PK2$ is a foreign key of relation $E1$ that refers to the primary key $PK2$ of relation $E2$.

- $(1,\_)$ on $E1$ side: $PK2$ NOT NULL in $E1$
- $(\_,1)$ on $E1$ side: $PK1$ is the primary key
- $(0,\_)$ on $E2$ side: $PK2$ foreign key in $E1$ referring to the primary key of $E2$
- $(\_,1)$ on $E2$ side: $PK2$ UNIQUE in $E1$

The case of $(0,1)$ – $(0,1)$ relationships

$$E1(\mathbf{PK1}, A1) - (0,1) - R(A) - (0,1) - E2(\mathbf{PK2}, A2)$$

The case of $(0,1)$ – $(0,1)$ relationships

$E1(\mathbf{PK1}, A1)$ – $(0,1)$ – $R(A)$ – $(0,1)$ – $E2(\mathbf{PK2}, A2)$

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Relational schema:

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- $(0, \_)$ on $E1$ side: $PK2$ **can be NULL in** $E1$
- $(\_, 1)$ on $E1$ side: $PK1$ is the primary key
- $(0, \_)$ on $E2$ side: $PK2$ foreign key in $E1$ referring to the primary key of $E2$
- $(\_, 1)$ on $E2$ side: $PK2$ UNIQUE in $E1$

$E1(\underline{PK1}, A1)$ and $E2(\underline{PK2}, A2, PK1, A)$, where $PK1$ is a foreign key of relation $E2$ that refers to the primary key $PK1$ of relation $E1$, works as well.

The case of $(0,1)$ – $(0,1)$ relationships (contn'd)

How do we choose between the two options? Participation of entities in the relationship can be a criterion.

In case the partecipation of both entities in the relationship is very low, a third option is possible

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Relational schema:

$E1(\underline{PK1}, A1)$, $E2(\underline{PK2}, A2)$, and $R(\underline{PK1}, PK2, A)$ (or $R(PK1, \underline{PK2}, A)$), where $PK1$ is a foreign key of relation R that refers to the primary key $PK1$ of relation $E1$ and $PK2$ is a foreign key of relation R that refers to the primary key $PK2$ of relation $E2$.

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- $(0, \_)$ on $E1$ side: $PK1$ foreign key in R referring to the primary key of $E1$
- $(\_, 1)$ on $E1$ side: $PK1$ is the primary key of R
- $(0, \_)$ on $E2$ side: $PK2$ foreign key in R referring to the primary key of $E2$
- $(\_, 1)$ on $E2$ side: $PK2$ UNIQUE in R

The case of $(1,1)$ – $(1,1)$ relationships

No one of the previous solutions works with

$E1(\mathbf{PK1}, A1)$ – $(1,1)$ – $R(A)$ – $(1,1)$ – $E2(\mathbf{PK2}, A2)$

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Relational schema:

$R(\underline{PK1}, A1, PK2, A2, A)$ (or $R(PK1, A1, \underline{PK2}, A2, A)$)

The case of $(1,1)$ – $(1,1)$ relationships

No one of the previous solutions works with

$E1(\mathbf{PK1}, A1)$ – $(1,1)$ – $R(A)$ – $(1,1)$ – $E2(\mathbf{PK2}, A2)$

Relational schema:

$R(\underline{PK1}, A1, PK2, A2, A)$ (or $R(PK1, A1, \underline{PK2}, A2, A)$)

- $(1,\_)$ on $E1$ side: $PK2$ NOT NULL in R
- $(\_,1)$ on $E1$ side: $PK1$ is the primary key (UNIQUE)
- $(1,\_)$ on $E2$ side: $PK1$ is the primary key (NOT NULL)
- $(\_,1)$ on $E2$ side: $PK2$ UNIQUE in R

The case of one-to-many and many-to-many relationships

A similar analysis can be done for the cases of both one-to-many and many-to-many relationships

Such an analysis allows one to determine

- which constraints can be directly encoded in the relational schema, and
- which ones need to be explicitly forced.

Redundancy of Schemas

- Many-to-one and one-to-many relationship sets that are total on the many-side can be represented by adding an extra attribute to the "many" side, containing the primary key of the "one" side
- Example: Instead of creating a schema for relationship set *inst_dept*, add an attribute *dept_name* to the schema arising from entity set *instructor*