Relational Database Design Part II

CompSci 316
Introduction to Database Systems

Announcements (Thu. Sep. 6)

- Homework #1 due in 1.5 week
  - By the end of this lecture, you should be able to complete Problems 1-3, 4(a), X1, X2
- Course project description available this week
  - Choice of "standard" or "open"
  - Team of 1-4, but single-person projects need approval
  - Two milestones + demo/report
  - Milestone #1 due in ~one month, right after fall break

Database design steps: review

- Understand the real-world domain being modeled
- Specify it using a database design model (e.g., E/R)
- Translate specification to the data model of DBMS (e.g., relational)
- Create DBMS schema

☞ Next: translating E/R design to relational schema

E/R model: review

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- Entity sets
  - Keys
  - Weak entity sets
- Relationship sets
  - Attributes on relationships
  - Multiplicity
  - Roles
  - Binary versus *N*-ary relationships
    - Modeling *N*-ary relationships with weak entity sets and binary relationships
  - ISA relationships

Translating entity sets

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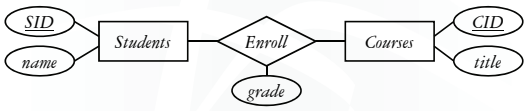
- An entity set translates directly to a table
  - Attributes → columns
  - Key attributes → key columns



Student (<u>*SID*</u>, *name*)

Course (<u>*CID*</u>, *title*)

Translating weak entity sets

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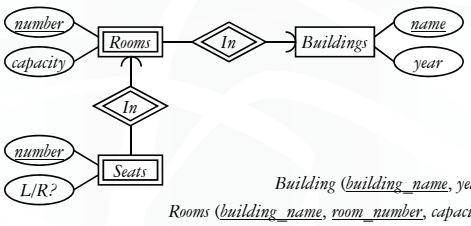
- Remember the "borrowed" key attributes
- Watch out for attribute name conflicts



Building (<u>*building_name*</u>, *year*)

Rooms (<u>*building_name*</u>, <u>*room_number*</u>, *capacity*)

Translating relationship sets

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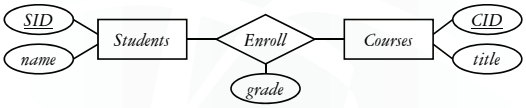
- A relationship set translates to a table
  - Keys of connected entity sets → columns
  - Attributes of the relationship set (if any) → columns
  - Multiplicity of the relationship set determines the key of the table



Enroll (*SID*, *CID*, *grade*)

More examples

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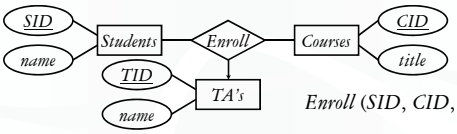
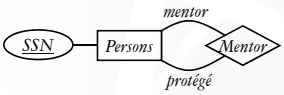


Enroll (*SID*, *CID*, *TID*)



Mentor (*mentor_SSN*, *protégé_SSN*)

Translating double diamonds

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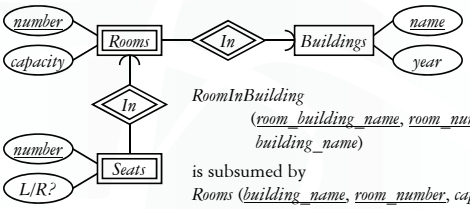
- Recall that a double-diamond (supporting) relationship set connects a weak entity set to another entity set
- No need to translate because the relationship is implicit in the weak entity set's translation



RoomInBuilding (*room_building_name*, *room_number*, *building_name*)

is subsumed by

Rooms (*building_name*, *room_number*, *capacity*)

Translating subclasses & ISA (approach 1)

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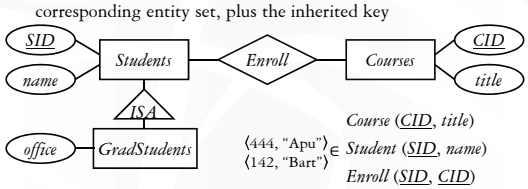
- Entity-in-all-superclasses approach ("E/R style")
  - An entity is represented in the table for each subclass to which it belongs
  - A table includes only the attributes directly attached to the corresponding entity set, plus the inherited key



Course (*CID*, *title*)
⟨444, "Apu"⟩ ⟨142, "Bart"⟩ ∈ *Student* (*SID*, *name*)
Enroll (*SID*, *CID*)
⟨444, "D444"⟩ ∈ *GradStudent* (*SID*, *office*)

Translating subclasses & ISA (approach 2)

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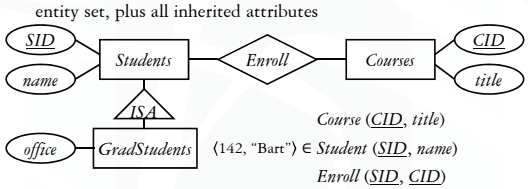
- Entity-in-most-specific-class approach ("OO style")
  - An entity is only represented in one table (corresponding to the most specific entity set to which the entity belongs)
  - A table includes the attributes attached to the corresponding entity set, plus all inherited attributes



Course (*CID*, *title*)
⟨142, "Bart"⟩ ∈ *Student* (*SID*, *name*)
Enroll (*SID*, *CID*)
⟨444, "Apu", "D444"⟩ ∈ *GradStudent* (*SID*, *name*, *office*)

Translating subclasses & ISA (approach 3)

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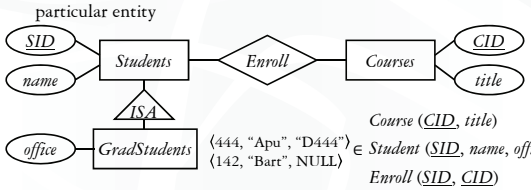
- All-entities-in-one-table approach ("NULL style")
  - One relation for the root entity set, with all attributes found in the network of subclasses (plus a "type" attribute when needed)
  - Use a special NULL value in columns that are not relevant for a particular entity



Course (*CID*, *title*)
⟨444, "Apu", "D444"⟩ ⟨142, "Bart", NULL⟩ ∈ *Student* (*SID*, *name*, *office*)
Enroll (*SID*, *CID*)

Comparison of three approaches

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- Entity-in-all-superclasses
  - *Student* (*SID*, *name*), *GradStudent* (*SID*, *office*)
  - Pro:
  - Con:
- Entity-in-most-specific-class
  - *Student* (*SID*, *name*), *GradStudent* (*SID*, *name*, *office*)
  - Pro:
  - Con:
- All-entities-in-one-table
  - *Student* (*SID*, [type,]*name*, *office*)
  - Pro:
  - Con:

A complete example

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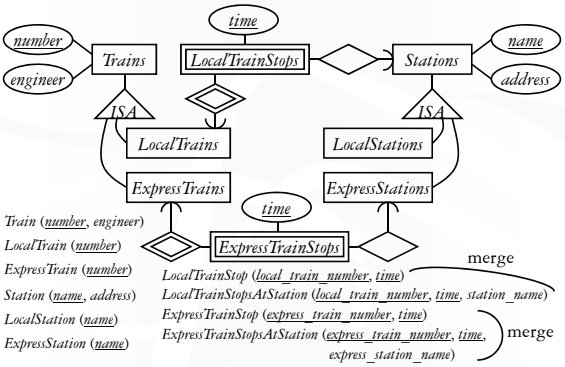

Train (*number*, *engineer*)
LocalTrain (*number*)
ExpressTrain (*number*)
Station (*name*, *address*)
LocalStation (*name*)
ExpressStation (*name*)

LocalTrainStop (*local_train_number*, *time*)
LocalTrainStopsAtStation (*local_train_number*, *time*, *station_name*)
ExpressTrainStop (*express_train_number*, *time*)
ExpressTrainStopsAtStation (*express_train_number*, *time*, *express_station_name*)

merge
merge

Simplifications and refinements

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Train (*number*, *engineer*), *LocalTrain* (*number*), *ExpressTrain* (*number*)
Station (*name*, *address*), *LocalStation* (*name*), *ExpressStation* (*name*)
LocalTrainStop (*local_train_number*, *station_name*, *time*)
ExpressTrainStop (*express_train_number*, *express_station_name*, *time*)

- Eliminate *LocalTrain* table
  - Redundant: can be computed as
    $$\pi_{number}(Train) - ExpressTrain$$
  - Slightly harder to check that *local_train_number* is indeed a local train number
- Eliminate *LocalStation* table
  - It can be computed as $\pi_{number}(Station) - ExpressStation$

An alternative design

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Train (<u>*number*</u>, *engineer*, *type*)
Station (<u>*name*</u>, *address*, *type*)
TrainStop (<u>*train_number*</u>, *station_name*, <u>*time*</u>)

- Encode the type of train/station as a column rather than creating subclasses
- What about the following constraints?
  - Type must be either "local" or "express"
  - Express trains only stop at express stations
  - ☞They can be expressed/declared explicitly as database constraints in SQL (as we will see later in course)
- Arguably a better design because it is simpler!

Design principles

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- KISS
  - Keep It Simple, Stupid
- Avoid redundancy
  - Redundancy wastes space, complicates modifications, promotes inconsistency
- Capture essential constraints, but don't introduce unnecessary restrictions
- Use your common sense
  - Warning: mechanical translation procedures given in this lecture are no substitute for your own judgment