Relational Database Design: E/R-Relational Translation

Introduction to Databases

CompSci 316 Fall 2019

DUKE
COMPUTER SCIENCE

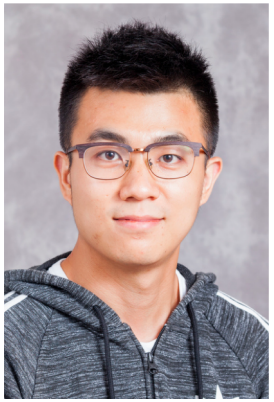
Announcements (Wed. Sep. 4)

- Office hours finalized
  - See website "Help" section

- Gradiance RA exercise due today
  - No late submissions, but we will automatically drop your lowest two scores in the semester
- Gradiance ER exercise assign today; due in a week
- Homework 1 due in 1½ week
  - *Please please please* start early
- Project description to be posted next week

Announcements (Wed. Sep. 4)

- An *experimental* RA debugger for Homework 1 Problem 1
  - Grew out of research from Zhengjie Miao
  - To be released soon
  - You are not required to use it, but the bonus is that
    - It uses the same (hidden) test db as the autograder
    - If your query is wrong, it will "explain" how, with a very simple example db (with tuples drawn from the hidden test db)



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

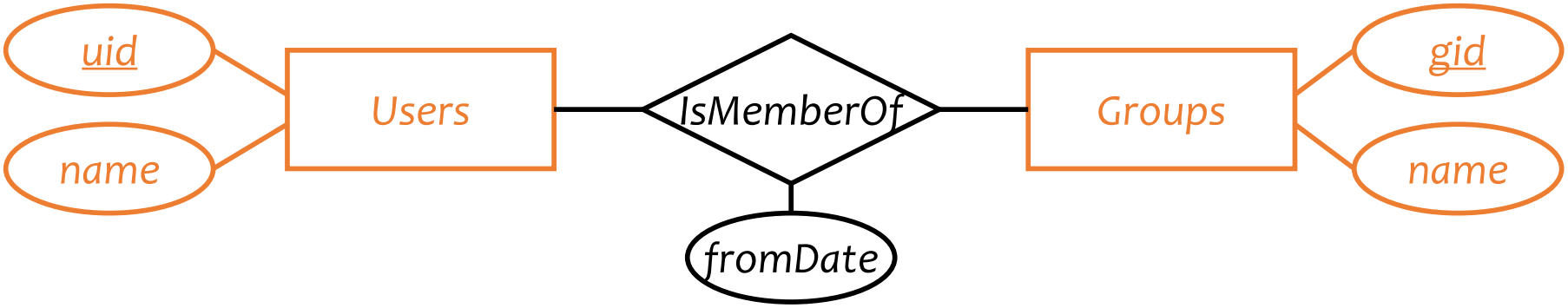
☞Next: translating E/R design to relational schema

E/R model: review

- 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

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

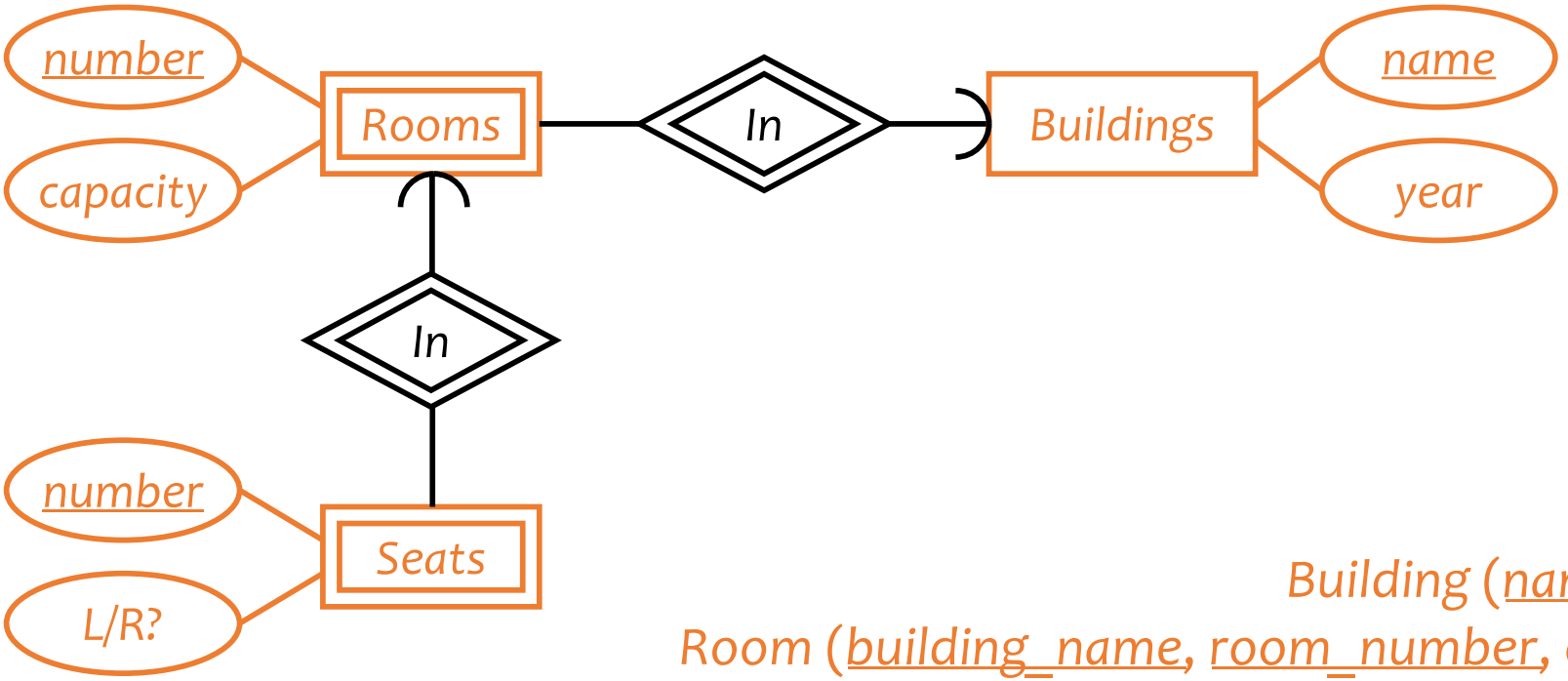


User (uid, name)

Group (gid, name)

Translating weak entity sets

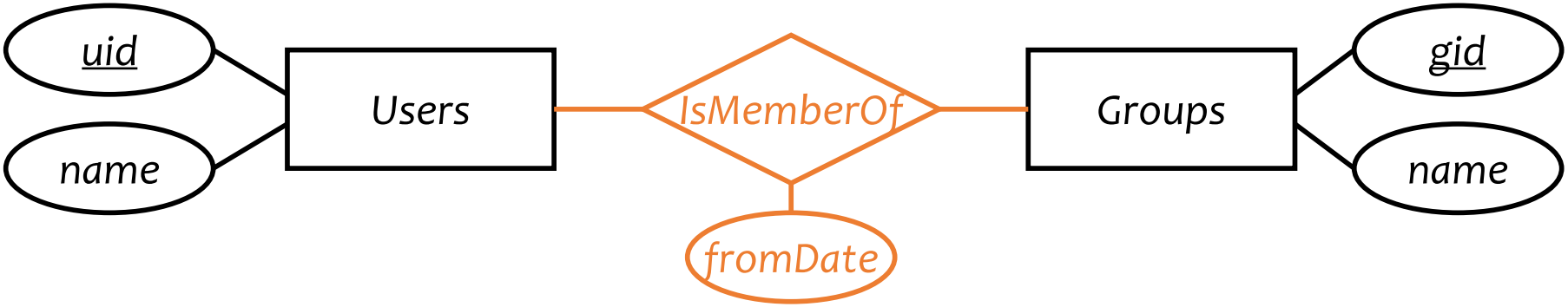
- Remember the "borrowed" key attributes
- Watch out for attribute name conflicts



Building (*name*, *year*)
Room (*building_name*, *room_number*, *capacity*)
Seat (*building_name*, *room_number*, *seat_number*, *left_or_right*)

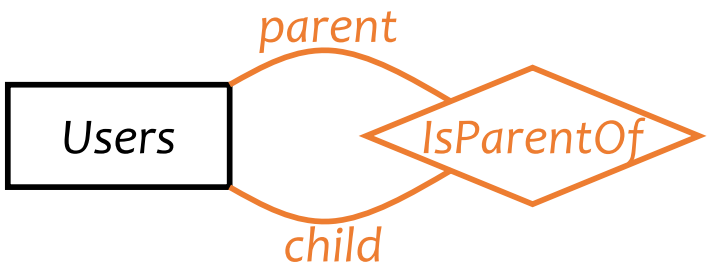
Translating relationship sets

- 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

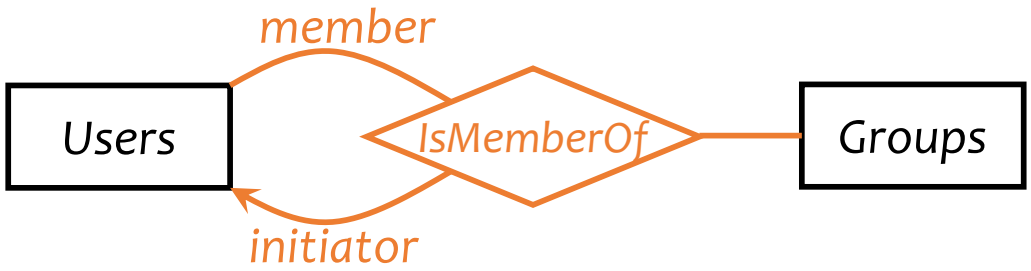


Member (*uid*, *gid*, *fromDate*)

More examples



Parent (*parent_uid*, *child_uid*)

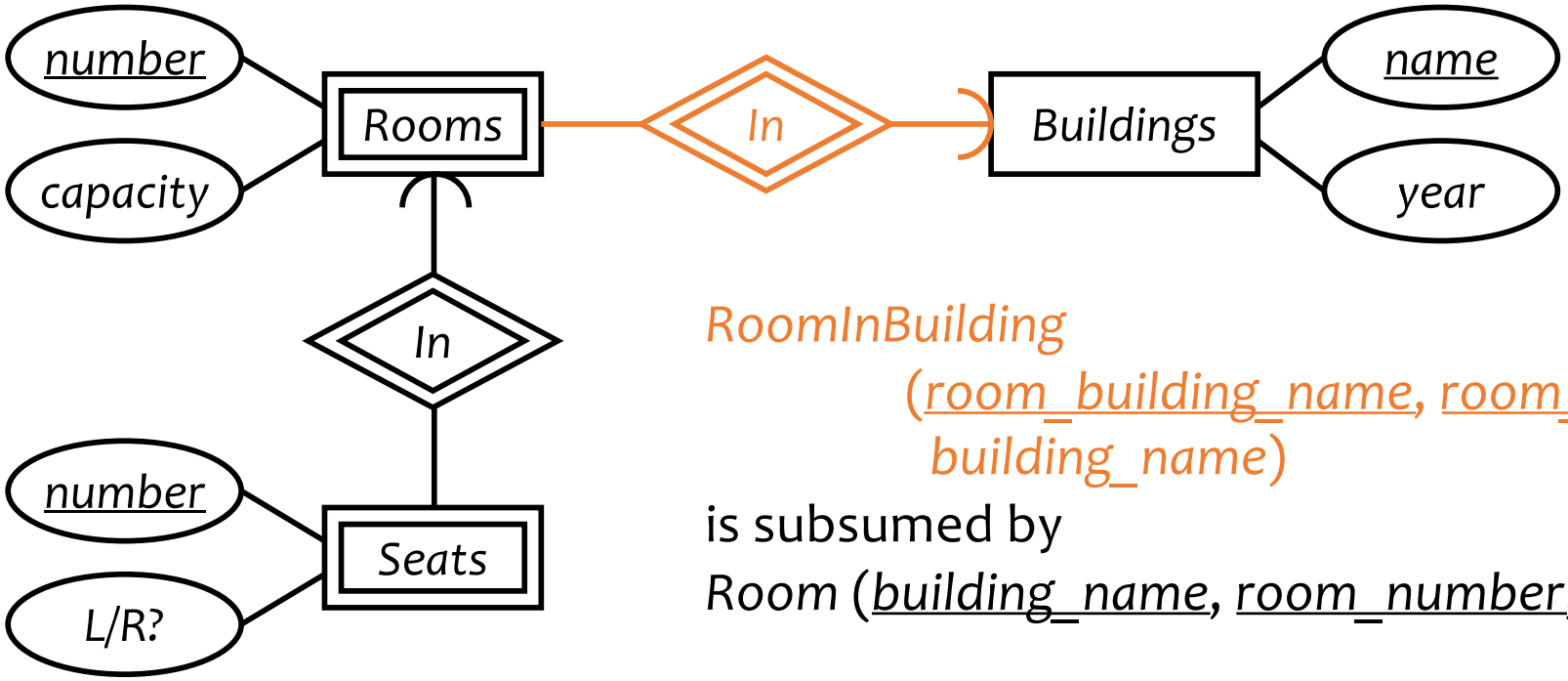


Member (*uid*, *initiator_uid*, *gid*)

Key?

Translating double diamonds?

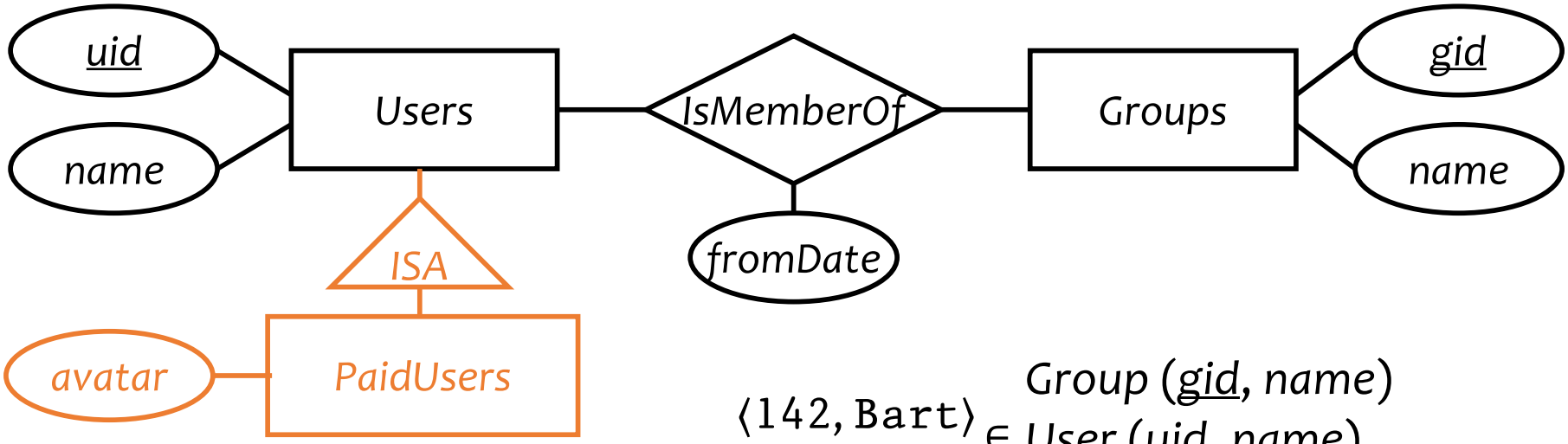
- Recall that a double-diamond (supporting) relationship set connects a weak entity set to another entity set
- No need to translate because the relationship is implicit in the weak entity set's translation



RoomInBuilding
(*room_building_name*, *room_number*, *building_name*)
is subsumed by
Room (*building_name*, *room_number*, *capacity*)

Translating subclasses & ISA: approach 1

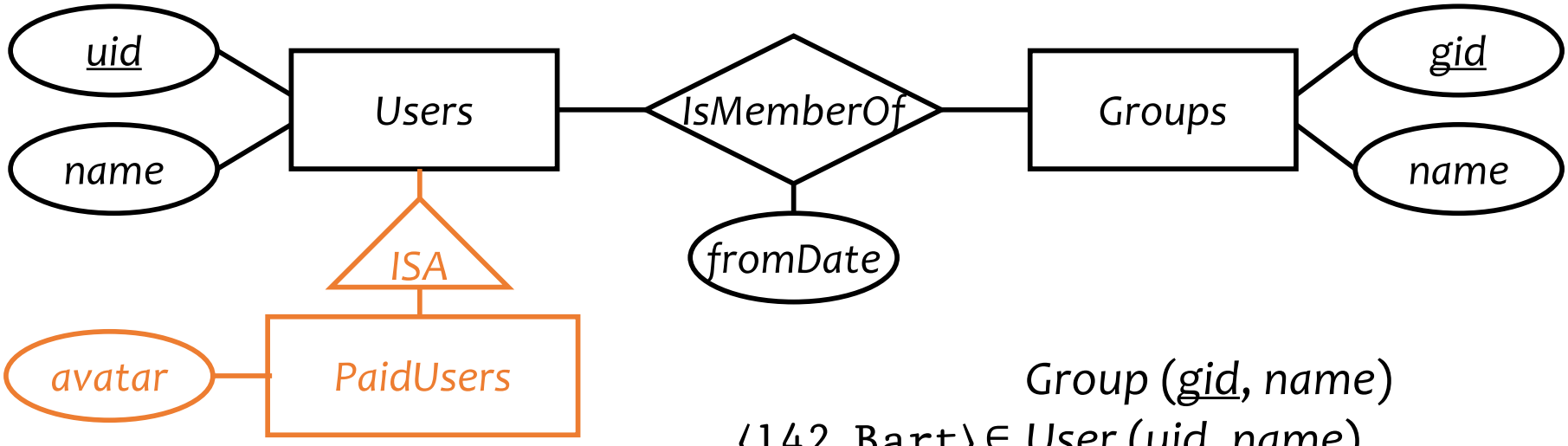
- Entity-in-all-superclasses approach ("E/R style")
  - An entity is represented in the table for each subclass to which it belongs
  - A table includes only the attributes directly attached to the corresponding entity set, plus the inherited key



⟨142, Bart⟩ ∈ Group (gid, name)
⟨456, Ralph⟩ ∈ User (uid, name)
Member (uid, gid, from_date)
⟨456, ☺⟩ ∈ PaidUser (uid, avatar)

Translating subclasses & ISA: approach 2

- Entity-in-most-specific-class approach ("OO style")
  - An entity is only represented in one table (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



Group (*gid*, *name*)

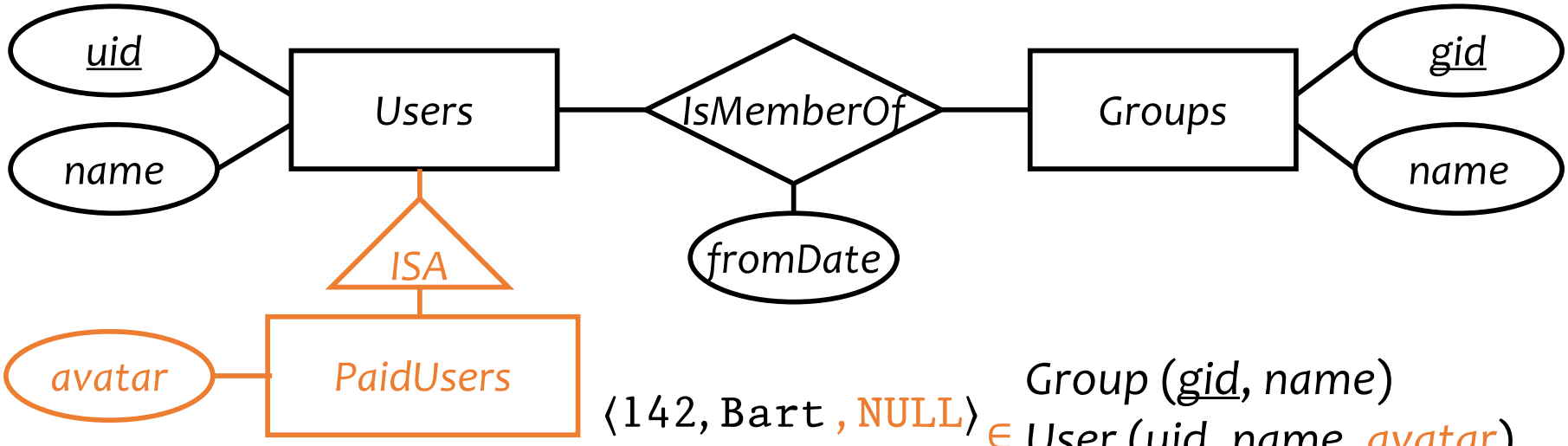
⟨142, Bart⟩ ∈ *User* (*uid*, *name*)

Member (*uid*, *gid*, *from_date*)

⟨456, Ralph, ☺⟩ ∈ *PaidUser* (*uid*, *name*, *avatar*)

Translating subclasses & ISA: approach 3

- 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



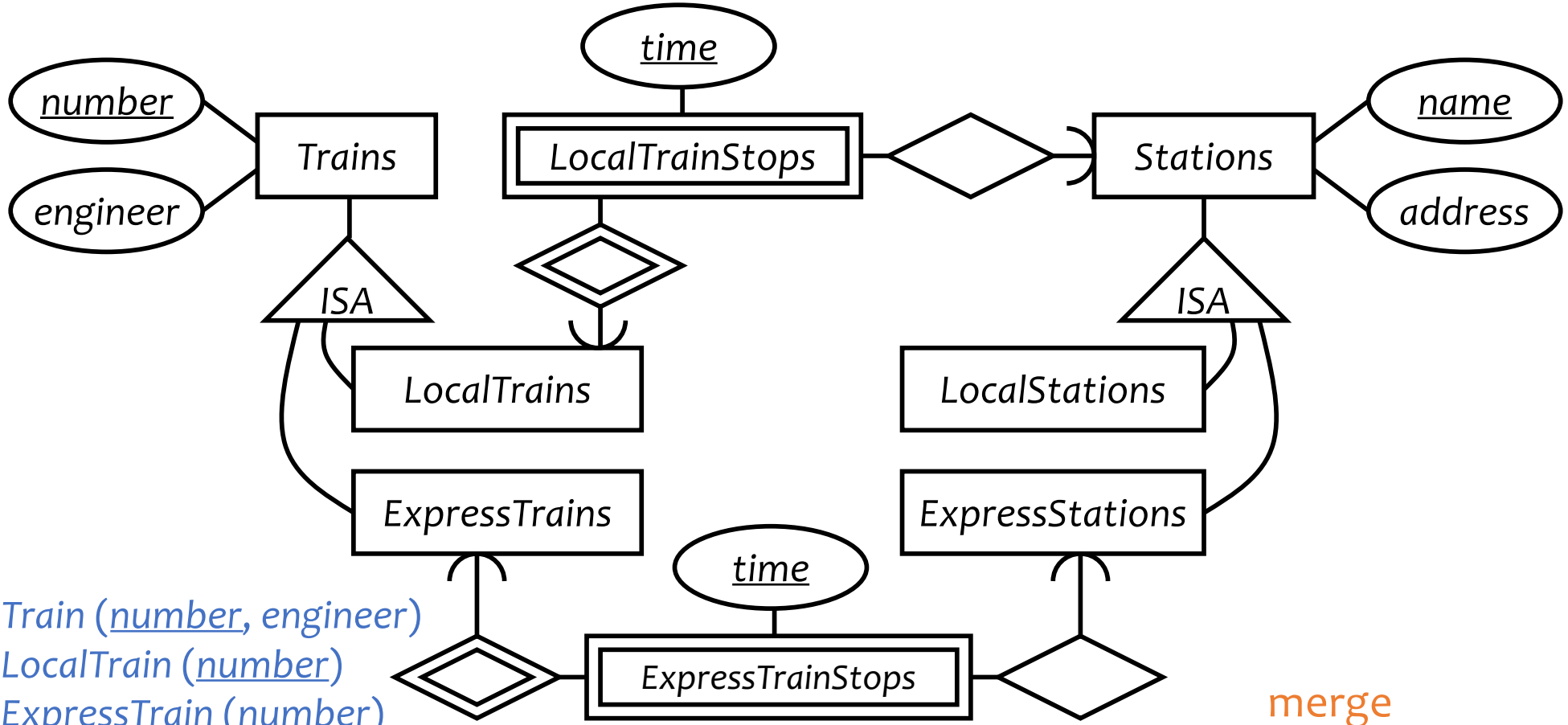
⟨142, Bart , NULL⟩
⟨456, Ralph, ☺⟩ ∈

Group (*gid*, *name*)
User (*uid*, *name*, *avatar*)
Member (*uid*, *gid*, *from_date*)

Comparison of three approaches

- Entity-in-all-superclasses
  - *User* (*uid*, *name*), *PaidUser* (*uid*, *avatar*)
  - Pro:
  - Con:
- Entity-in-most-specific-class
  - *User* (*uid*, *name*), *PaidUser* (*uid*, *name*, *avatar*)
  - Pro:
  - Con:
- All-entities-in-one-table
  - *User* (*uid*, [*type*,]*name*, *avatar*)
  - Pro:
  - Con:

A complete example



Train (<u>number</u>, *engineer*)
LocalTrain (<u>number</u>)
ExpressTrain (<u>number</u>)

Station (<u>name</u>, *address*)
LocalStation (<u>name</u>)
ExpressStation (<u>name</u>)

LocalTrainStop (<u>local_train_number</u>, <u>time</u>)
LocalTrainStopsAtStation (<u>local_train_number</u>, <u>time</u>, *station_name*)
ExpressTrainStop (<u>express_train_number</u>, <u>time</u>)
ExpressTrainStopsAtStation (<u>express_train_number</u>, <u>time</u>, *express_station_name*)

merge

merge

Simplifications and refinements

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

- 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

Train (*number*, *engineer*, *type*)

Station (*name*, *address*, *type*)

TrainStop (*train_number*, *station_name*, *time*)

- 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

- 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

http://ungenius.files.wordpress.com/2010/03/thehomer.jpg