Relational Database Design: E/R-Relational Translation

Introduction to Databases

CompSci 316 Fall 2020

DUKE
COMPUTER SCIENCE

Announcements (Tue. Sep. 8)

- HW2 (written + gradiance) due tonight (11:59 pm)
  - No late days for gradiance
  - See late policy for written HWs

- Your team members due tonight
  - Then we will form remaining groups ☺

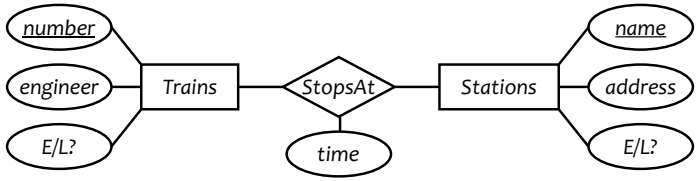
Quick clarifications: RA questions

- What is "some"?
  - At least one
  - e.g., Drinkers frequent some bars that serve beer X
  - = Drinker D in the answer can frequent bar B1, B2, B3. At least one of them should serve X. It is okay if other bars serve X too.
- What is "only"?
  - E.g., Drinkers frequent only bars that serve beer X
  - = If drinker D in the answer frequents a bar B, then B serves X
- What is "every"?
  - E.g., Drinkers frequent every bars that serve beer X
  - = If bar B serves beer X, then drinker D in the answer frequents B.

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

Today



You designed an ER digram

Translate it to a Relational Database

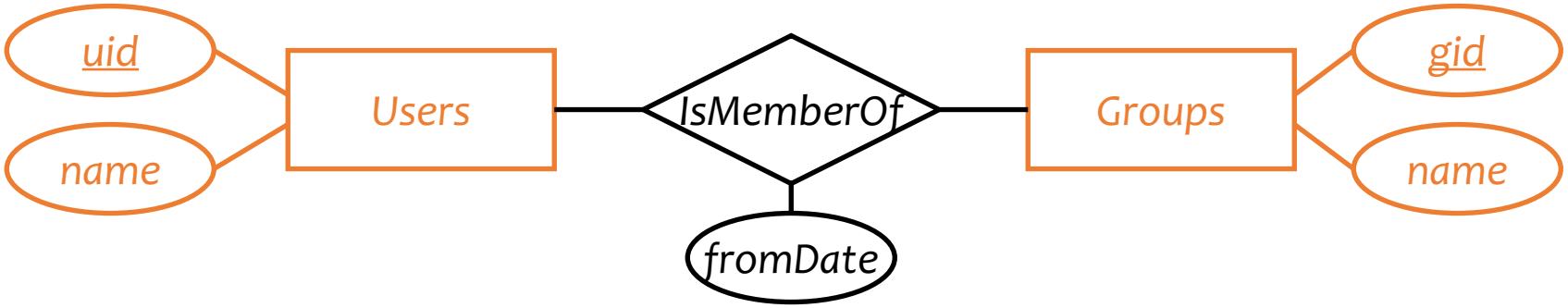
Train (*number*, *engineer*, *type*)
Station (*name*, *address*, *type*)
TrainStop (*train_number*, *station_name*, *time*)

E/R model: concepts

- 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

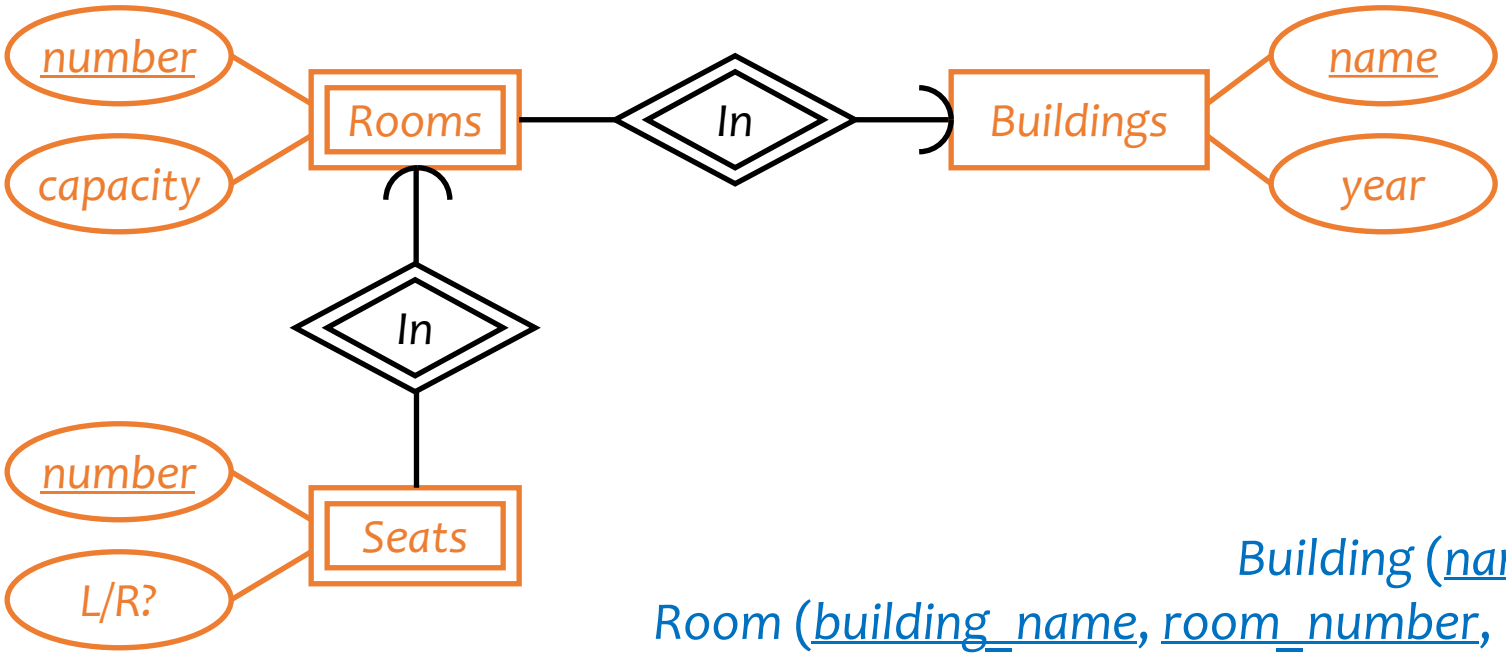


User (uid, name)

Group (gid, name)

Translating weak entity sets

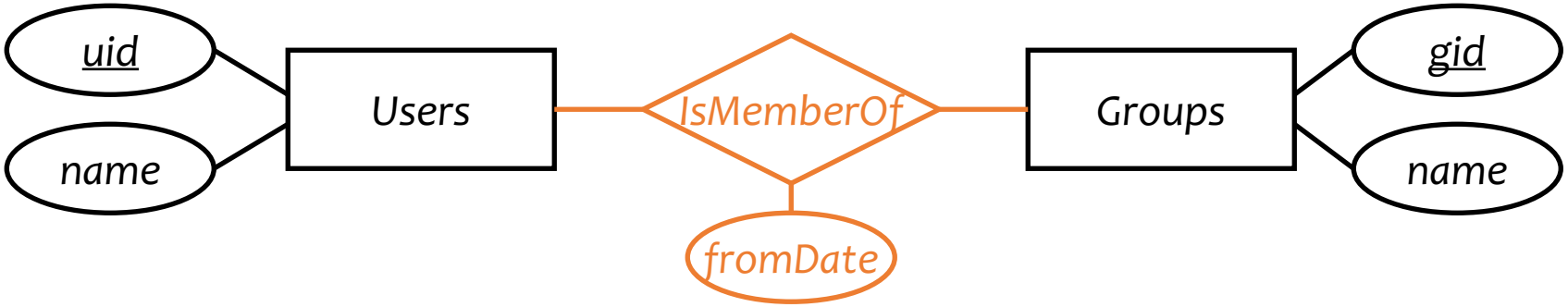
- Remember the "borrowed" key attributes
- Watch out for attribute name conflicts



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

Translating relationship sets

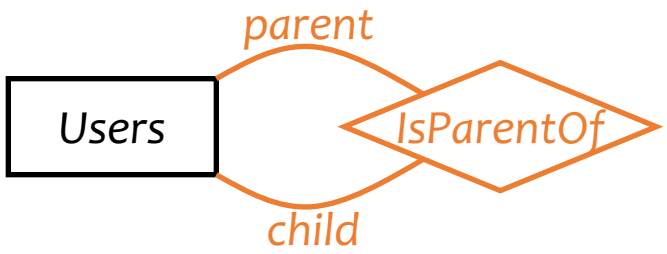
- A relationship set translates to a table
  - Keys of connected entity sets → columns
  - Attributes of the relationship set (if any) → columns
  - Multiplicity of the relationship set determines the key of the table



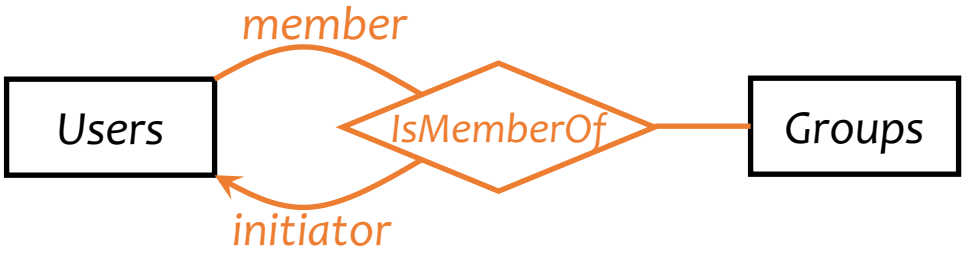
Member (*uid*, *gid*, *fromDate*)

How do the keys change if you have arrow to Users, Groups, or both?

More examples



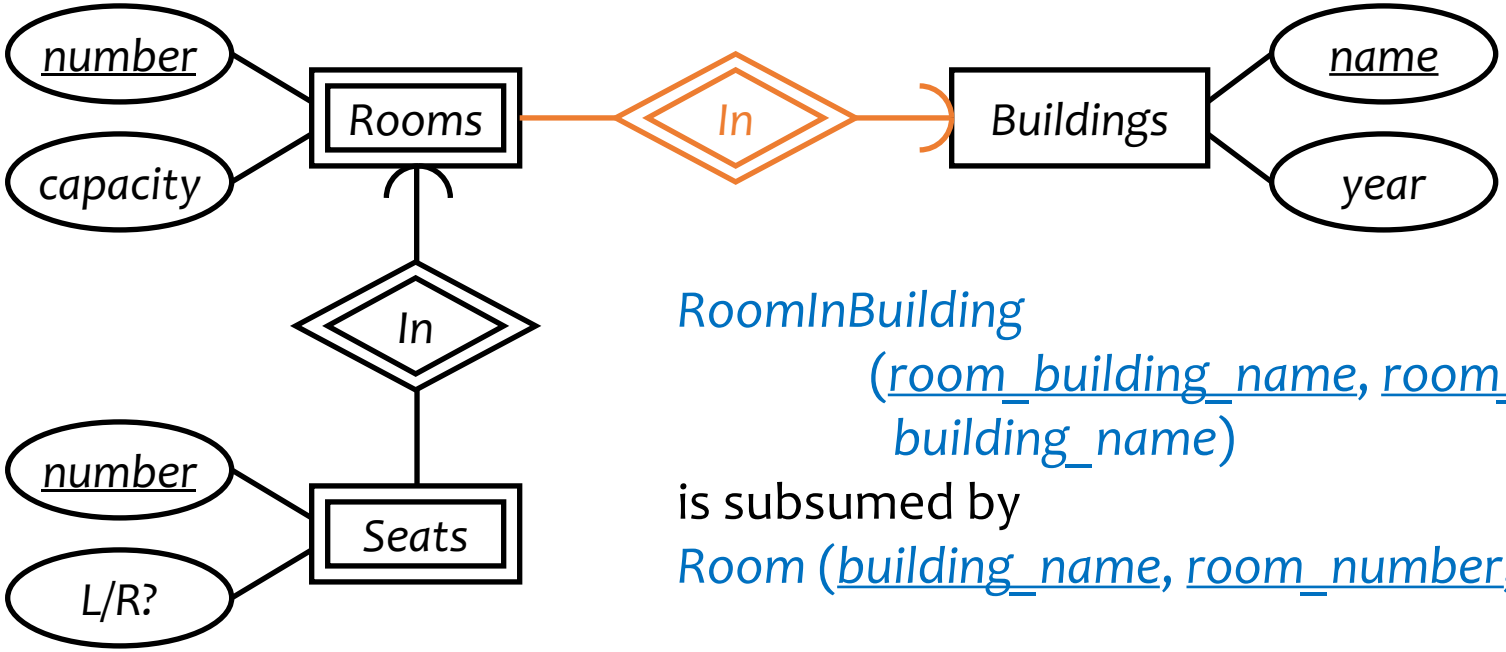
Parent (*parent_uid*, *child_uid*)



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

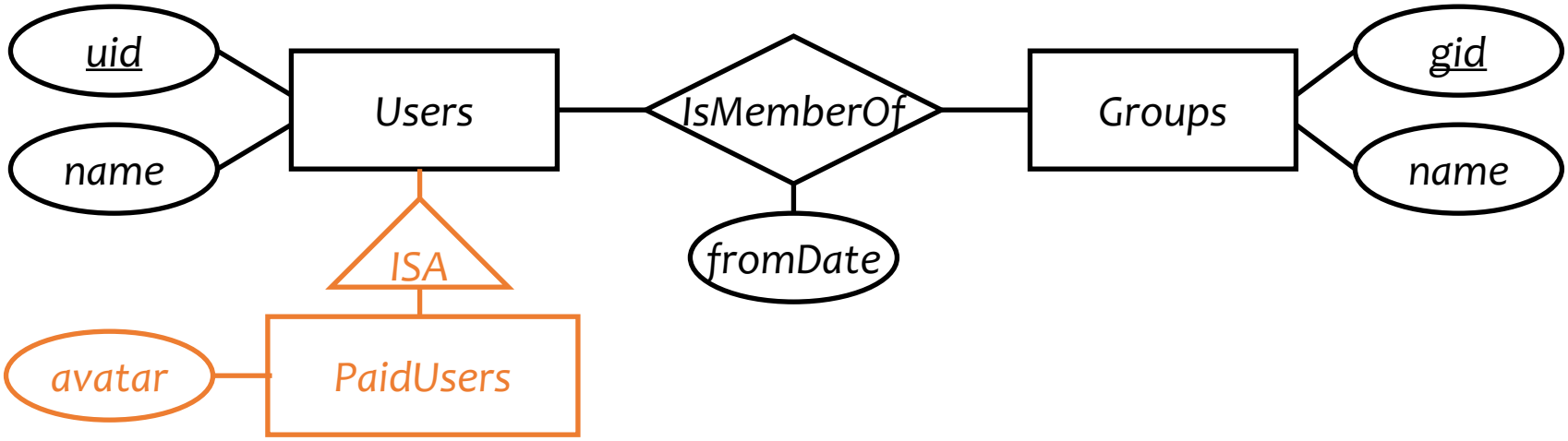
Translating double diamonds?

- 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



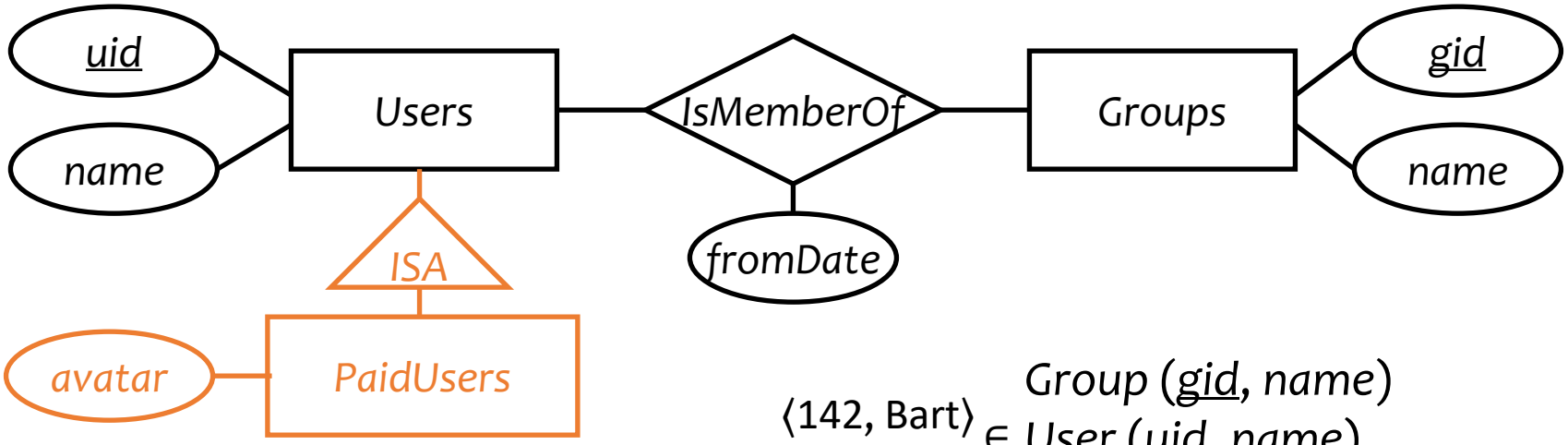
RoomInBuilding
(*room_building_name*, *room_number*, *building_name*)
is subsumed by
Room (*building_name*, *room_number*, *capacity*)

Translating subclasses & ISA



Translating subclasses & ISA: approach 1

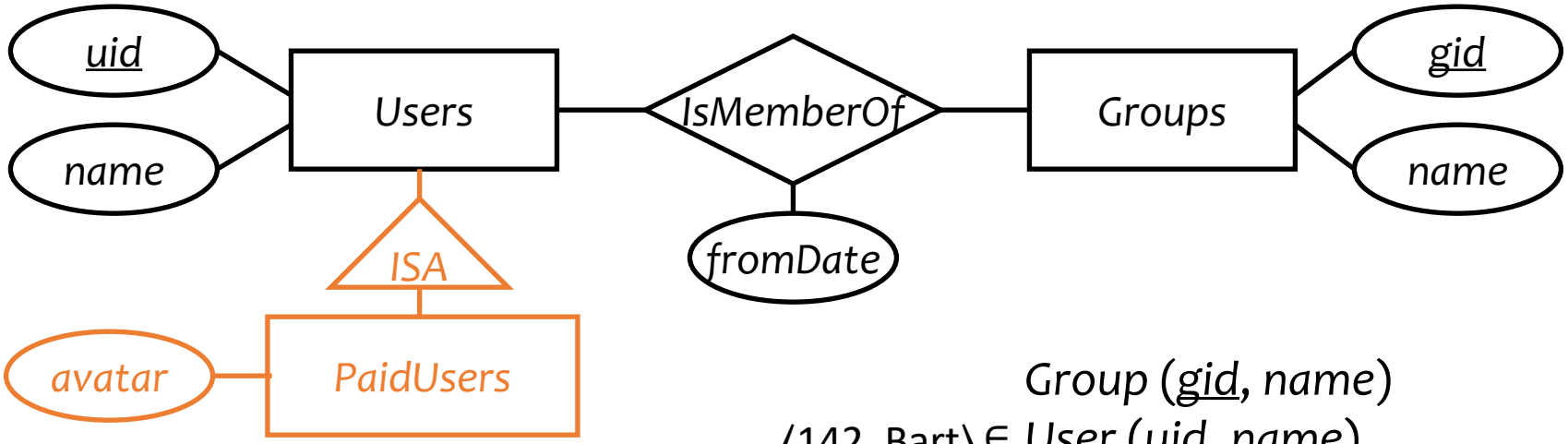
- Entity-in-all-superclasses approach ("E/R style")
  - An entity is represented in the table for each subclass to which it belongs
  - A table includes only the attributes directly attached to the corresponding entity set, plus the inherited key



⟨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*)

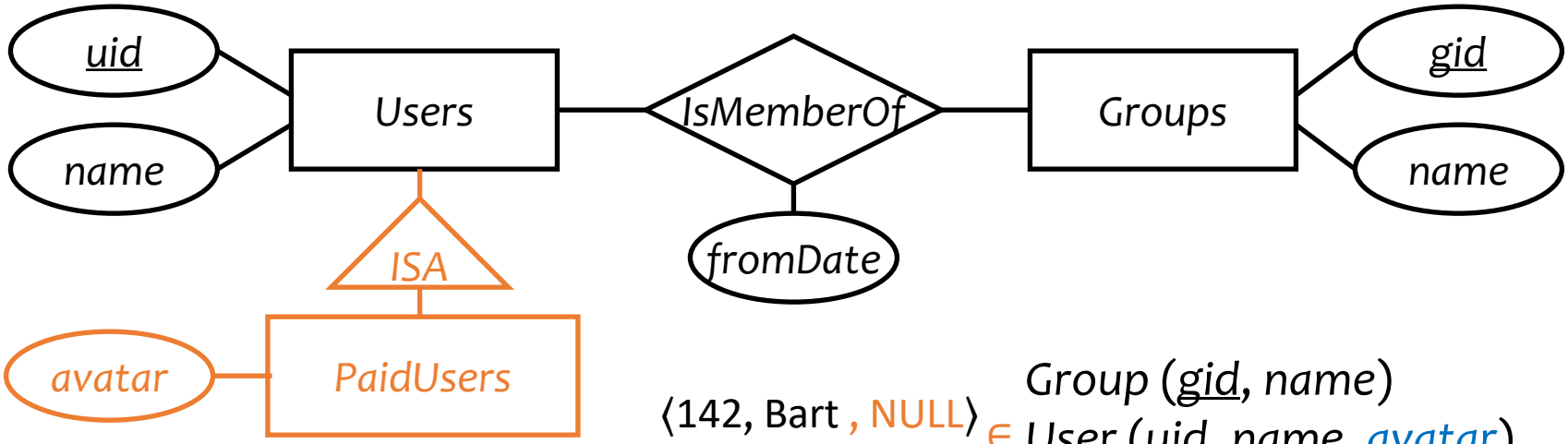
⟨142, Bart⟩ ∈ *User* (*uid*, *name*)

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, ☺⟩ ∈ User (uid, name, avatar)

Group (gid, name)
Member (uid, gid, from_date)

Comparison of three approaches

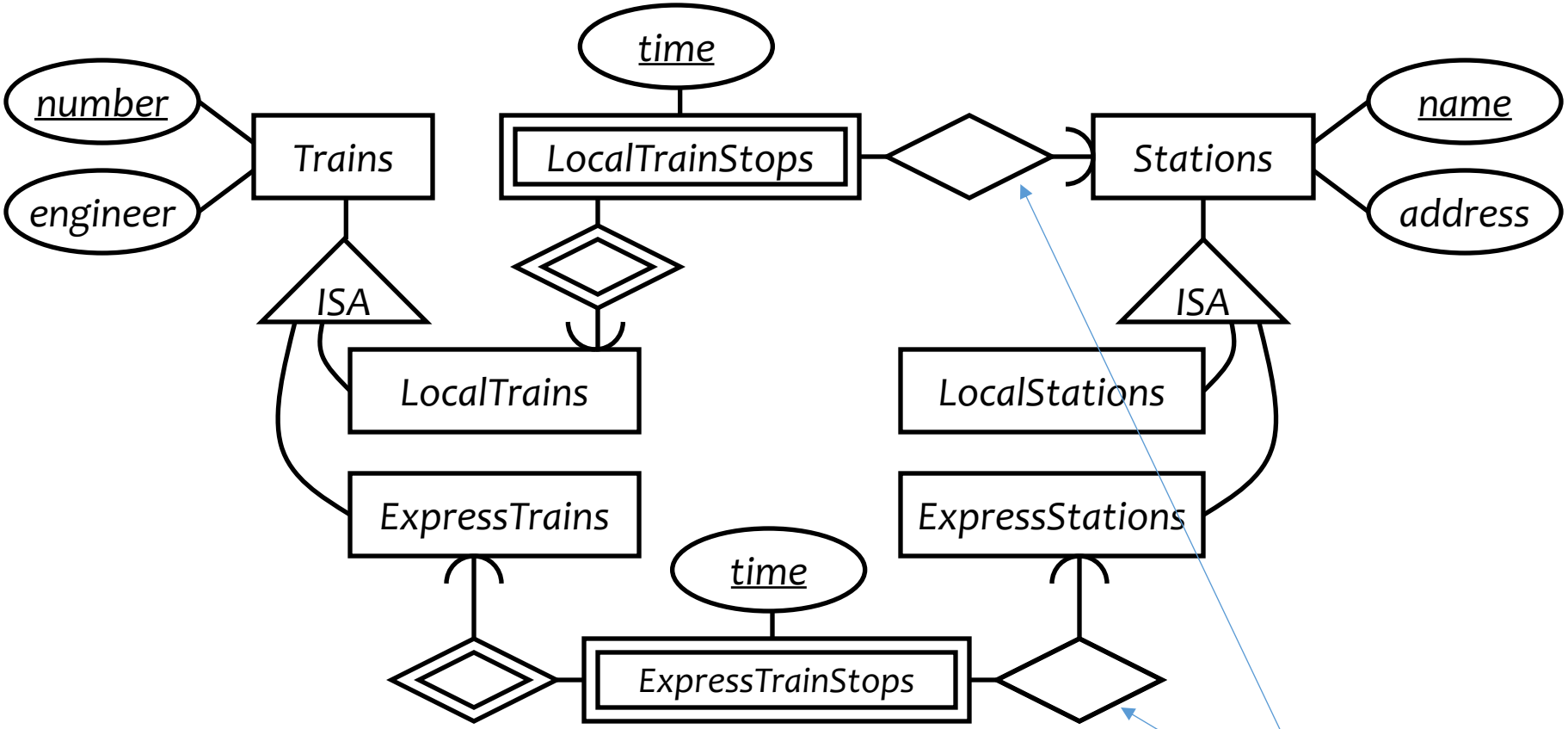
- Entity-in-all-superclasses
  - *User* (*uid*, *name*), *PaidUser* (*uid*, *avatar*)
  - Pro: All users are found in one table
  - Con: Attributes of paid users are scattered in different tables
- Entity-in-most-specific-class
  - *User* (*uid*, *name*), *PaidUser* (*uid*, *name*, *avatar*)
  - Pro: All attributes of paid users are found in one table
  - Con: Users are scattered in different tables
- All-entities-in-one-table
  - *User* (*uid*, [*type*,]*name*, *avatar*)
  - Pro: Everything is in one table
  - Con: Lots of NULL's; complicated if class hierarchy is complex

A complete example

- Design a database consistent with the following:
  - A station has a unique name and an address, and is either an express station or a local station
  - A train has a unique number and an engineer, and is either an express train or a local train
  - A local train can stop at any station
  - An express train only stops at express stations
  - A train can stop at a station for any number of times during a day
  - Train schedules are the same everyday

- Draw the ER diagram and translate into relational model

A complete example: ER diagram

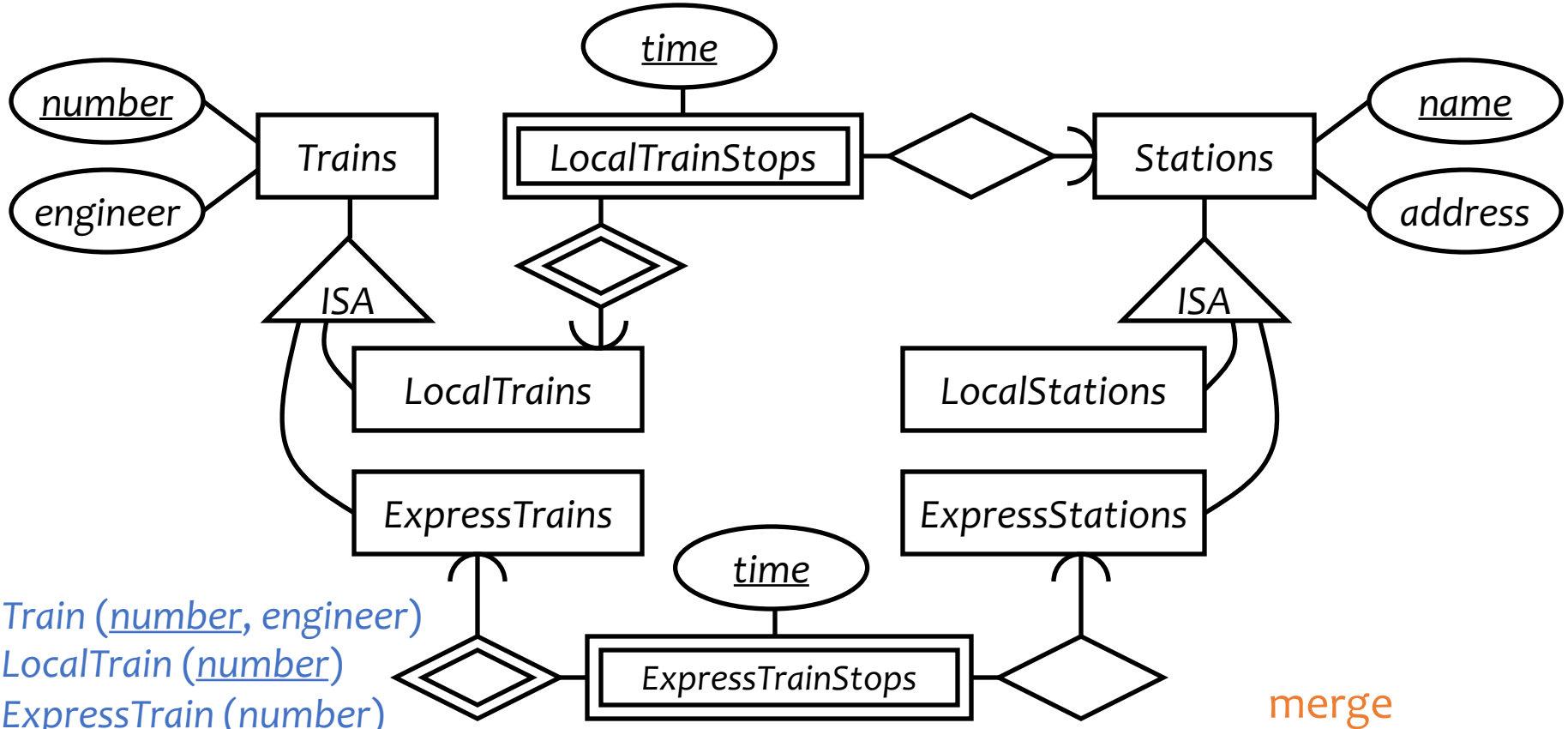


Why no double diamond?

Next, Relational Design!

Train no. and time uniquely determine the stop

A complete example: ER diagram



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

- *10 to 8 relations*

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 $\pi_{number}(Station) - ExpressStation$

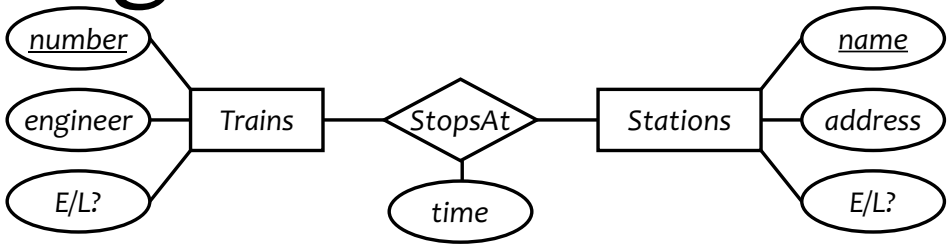
- 8 to 6 relations, still 6 (and more work for queries)!

An alternative design

Train (number, engineer, type)

Station (name, address, type)

TrainStop (train_number, station_name, time)



Not a good ER diagram, but giving a simpler design, with more taks for DBMS/SQL

- 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 (we will see soon)
- Arguably a better design because it is simpler!

Warning: mechanical translation procedures given in this lecture are no substitute for your own judgment!

What is a "Good" design often depends on your requirements, expected actions, and datasets

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

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