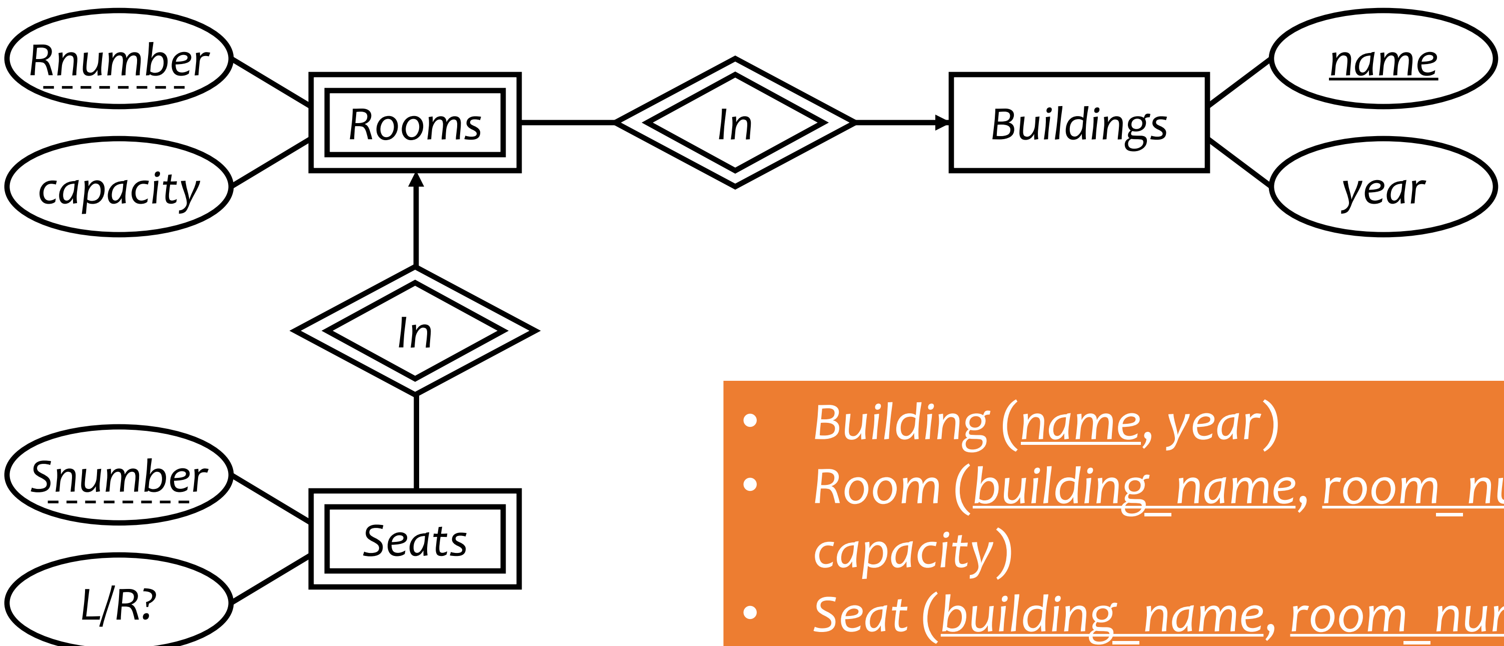
Relational Database Design: E/R-Relational Translation

CS348 Spring 2023

Sections: **002 & 004 only**

E/R Model

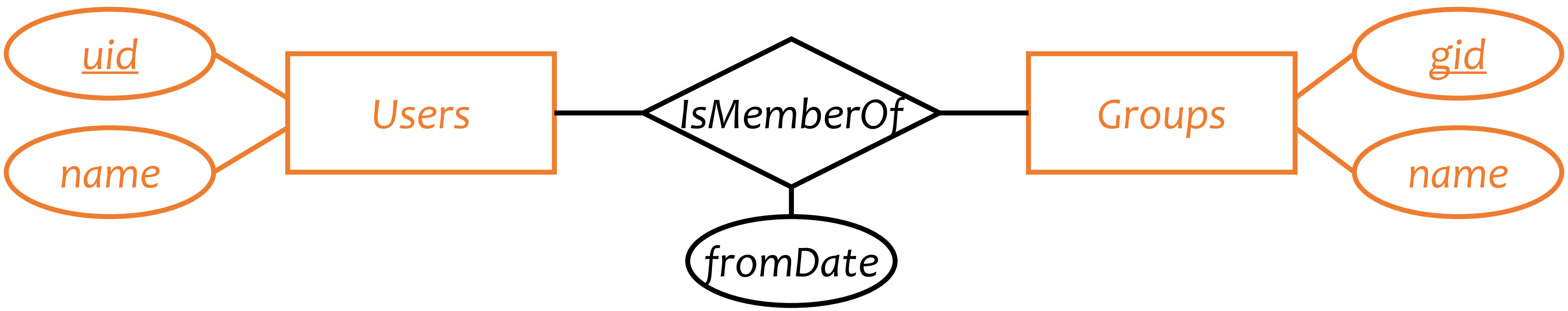
- E/R Concepts
- E/R Schema Design
- Next: Translating E/R to relational schema



- *Building (<u>name</u>, year)*
- *Room (<u>building_name</u>, <u>room_number</u>, capacity)*
- *Seat (<u>building_name</u>, <u>room_number</u>, <u>seat_number</u>, left_or_right)*

Translating entity sets

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

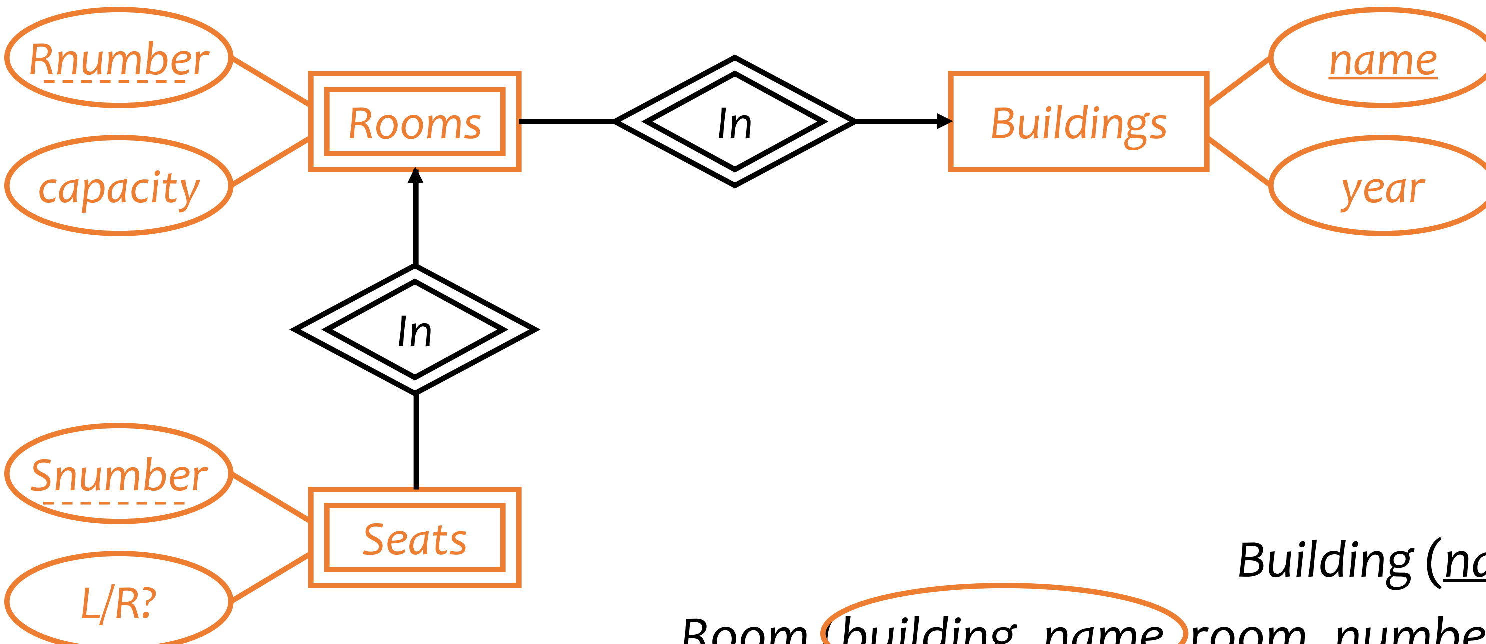


User (<u>uid</u>, name)

Group (<u>gid</u>, name)

Translating weak entity sets

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



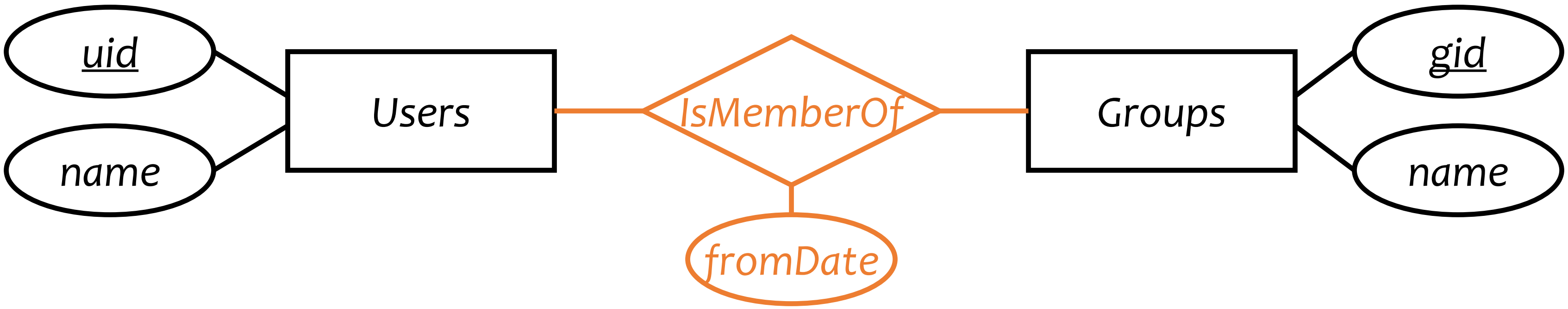
Building (name, year)

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 (<u>uid</u>, <u>gid</u>, fromDate)

- 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

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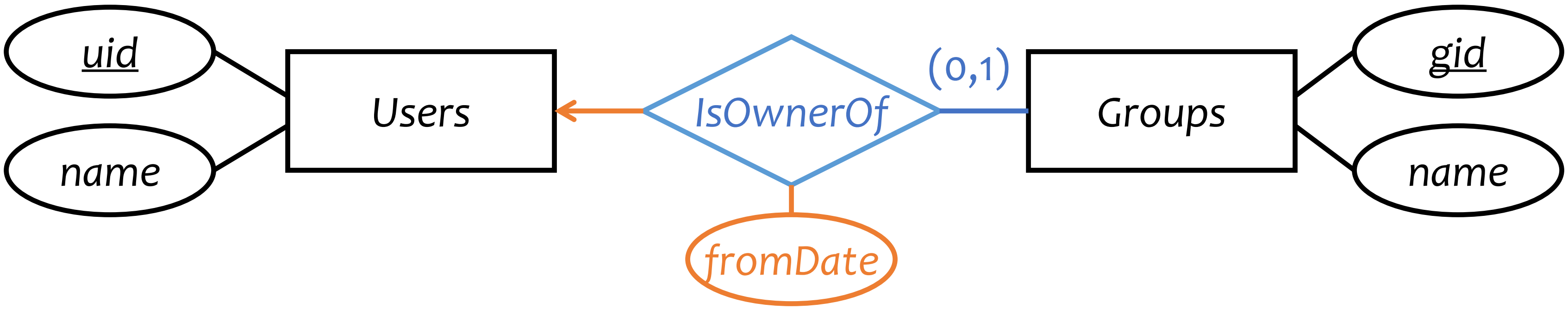
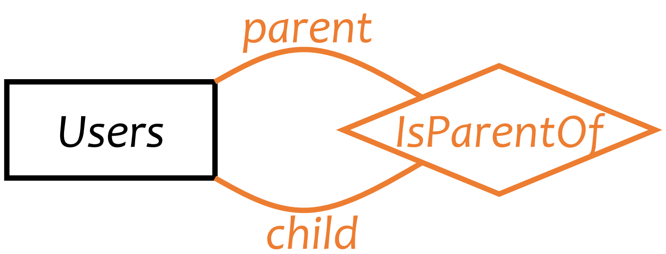


Owner (*uid*, <u>gid</u>, *fromDate*)

- 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

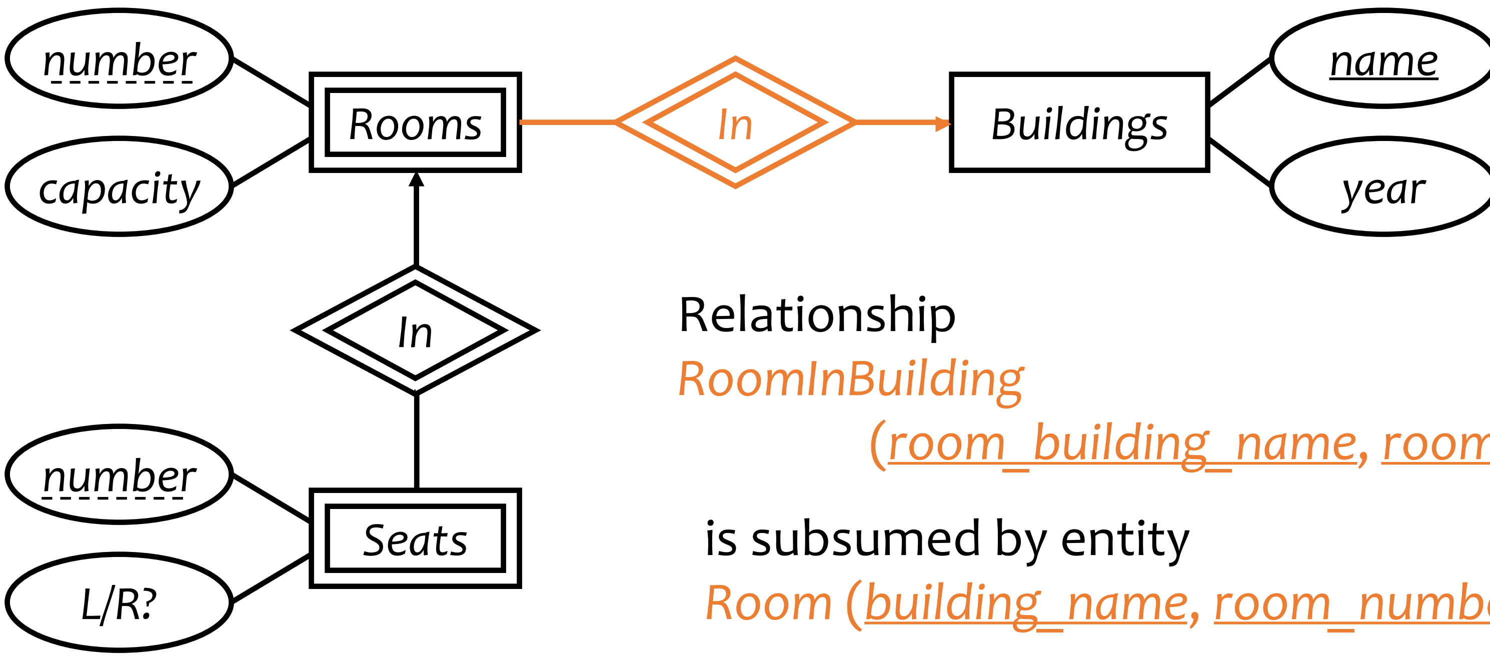
More examples



Parent (*<u>parent_uid</u>*, *<u>child_uid</u>*)

Translating double diamonds?

- No need to translate because the relationship is implicit in the weak entity set’s translation

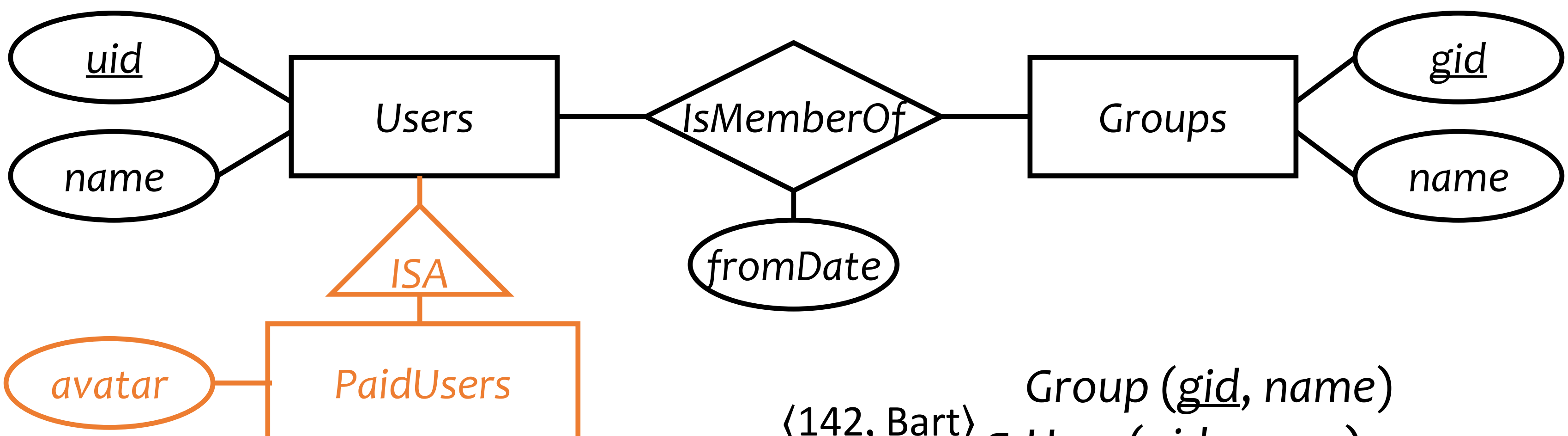


Relationship
RoomInBuilding
(room_building_name, room_number,)

is subsumed by entity
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



Group (<u>gid</u>, name)

⟨142, Bart⟩ ∈ User (<u>uid</u>, name)

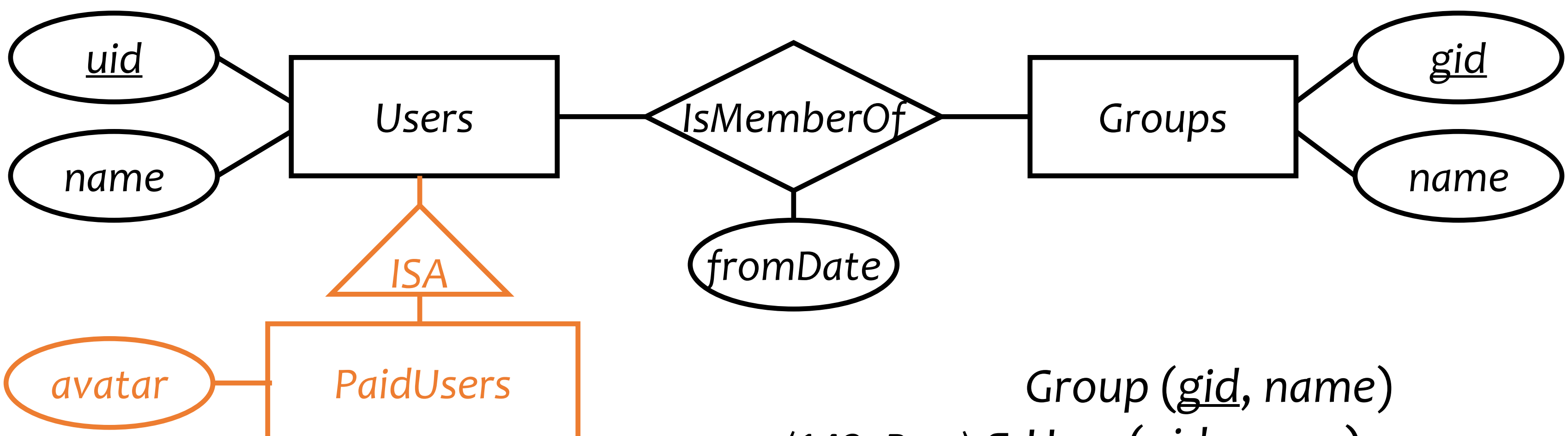
⟨456, Ralph⟩

Member (<u>uid</u>, <u>gid</u>, from_date)

⟨456, ☺⟩ ∈ PaidUser (<u>uid</u>, avatar)

Translating subclasses & ISA: approach 2

- Entity-in-most-specific-class approach
  - 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)

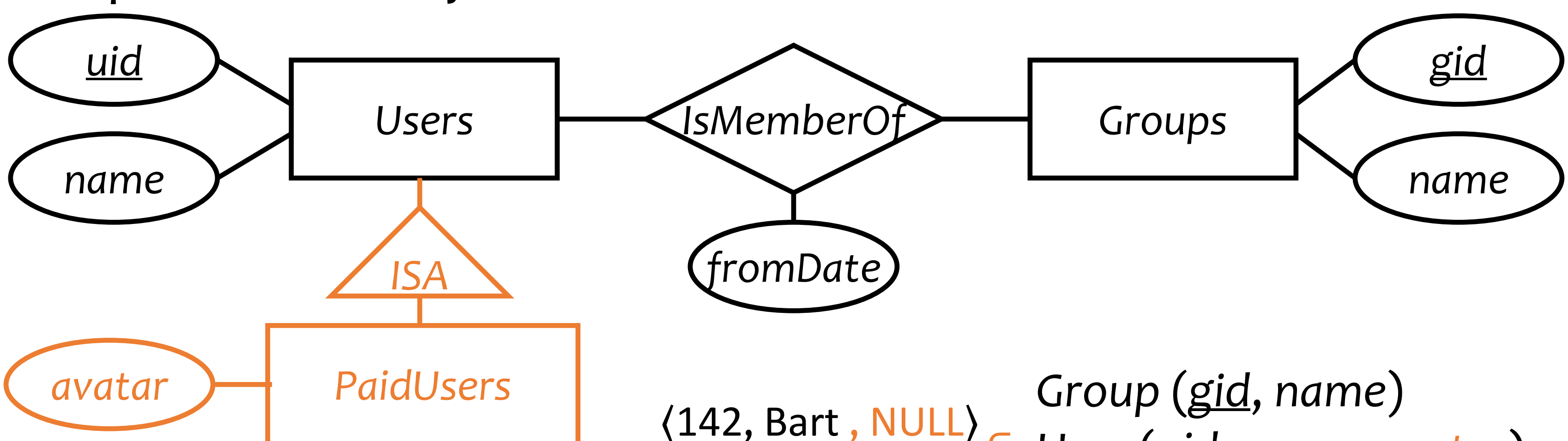
⟨142, Bart⟩ ∈ User (uid, name)

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



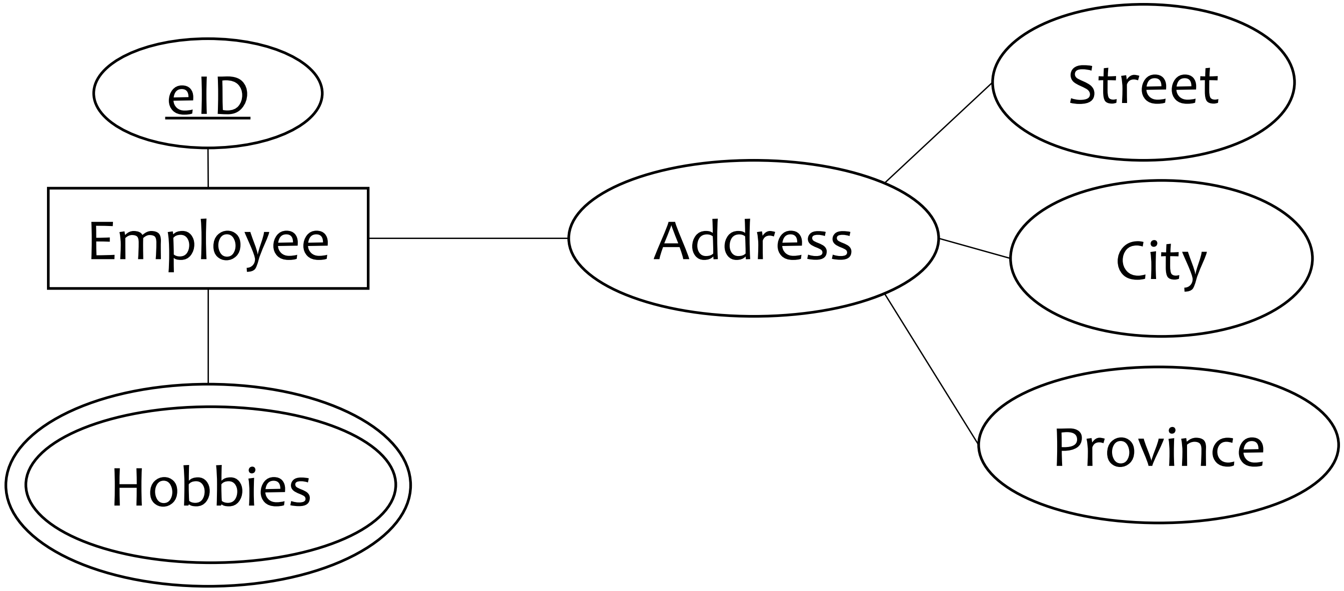
⟨142, Bart , NULL⟩
⟨456, Ralph, ☺⟩ ∈

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

Comparison of three approaches

- Entity-in-all-superclasses
  - *User* (<u>*uid*</u>, *name*), *PaidUser* (<u>*uid*</u>, *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* (<u>*uid*</u>, *name*), *PaidUser* (<u>*uid*</u>, *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* (<u>*uid*</u>, [*type*,]*name*, *avatar*)
  - Pro: Everything is in one table
  - Con: Lots of NULL's; complicated if class hierarchy is complex

Translating composite and multi-valued attributes



Composite:

Employee(eId,… ,Street, City, Province,..)

Multi-valued:

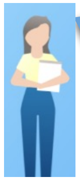
EmployeeHobbies(<u>eID</u>, <u>hobby</u>)

Foreign key: *eId references Employee*

Employee join EmployeeHobbies to get all info

A complete example

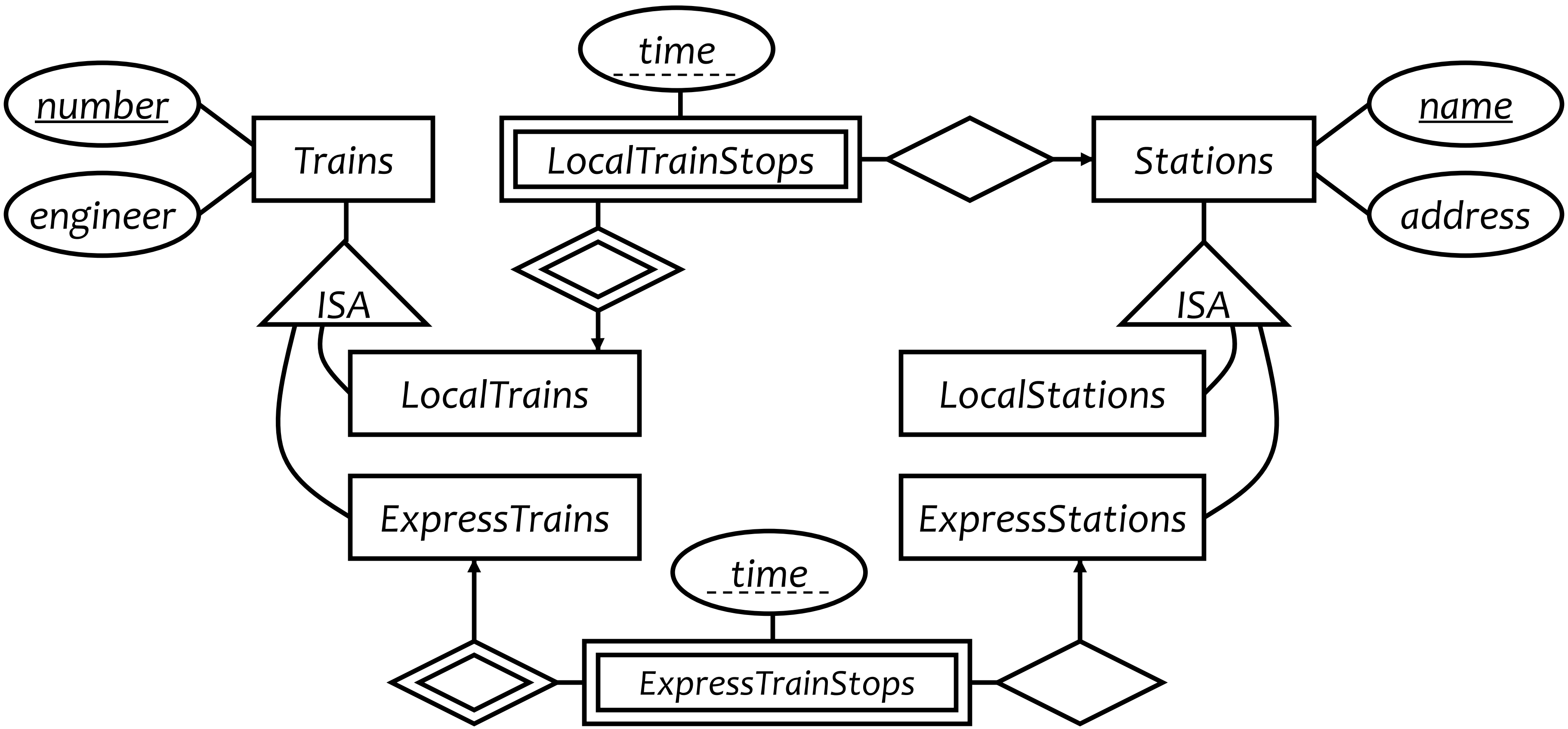
Remember Case study 2 exercise?



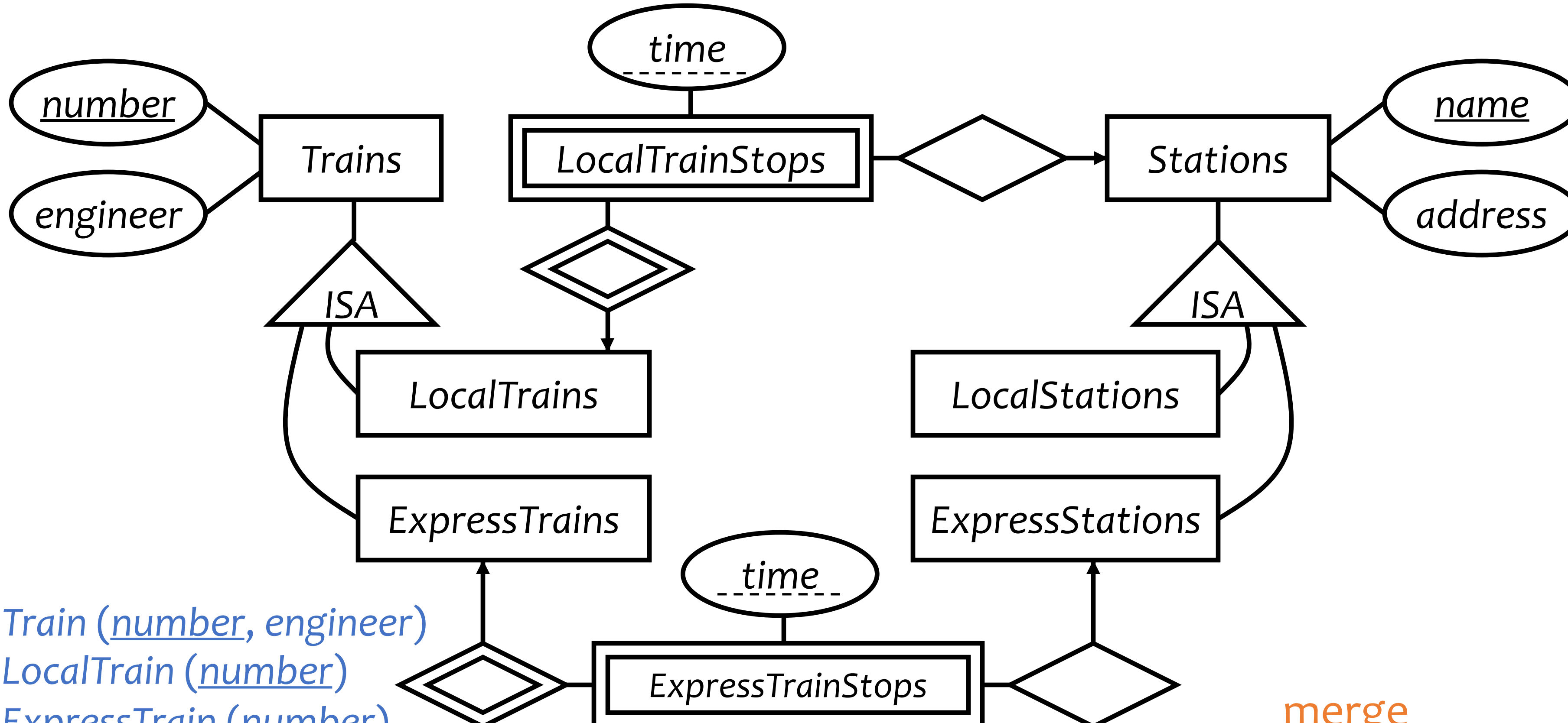
Design a database consistent with the following:

- 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

A complete example



A complete example



Train (number, engineer)
LocalTrain (number)
ExpressTrain (number)

Station (name, address)
LocalStation (name)
ExpressStation (name)

merge

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

Simplifications and refinements

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

An alternative design

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

  ☞Arguably a better design because it is simpler!

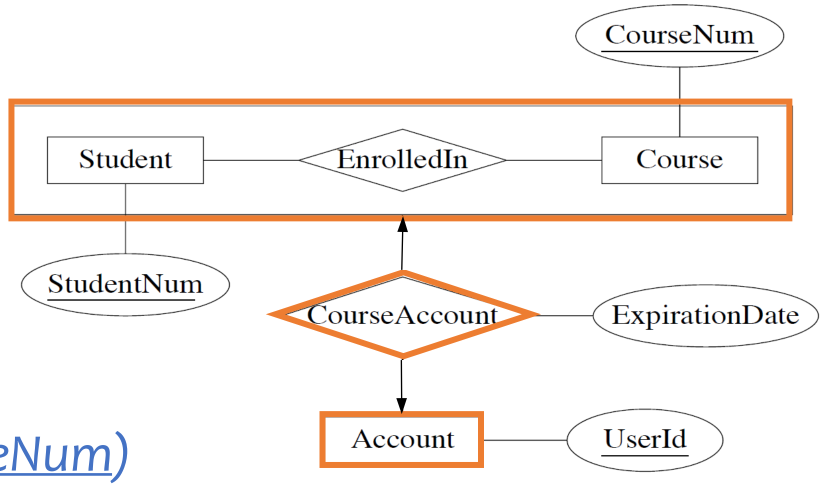
Design principles

- Avoid redundancy
- 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

More examples

- 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*



Student (<u>StudentNum</u>)
Course(<u>CourseNum</u>)
Account(<u>UserID</u>)

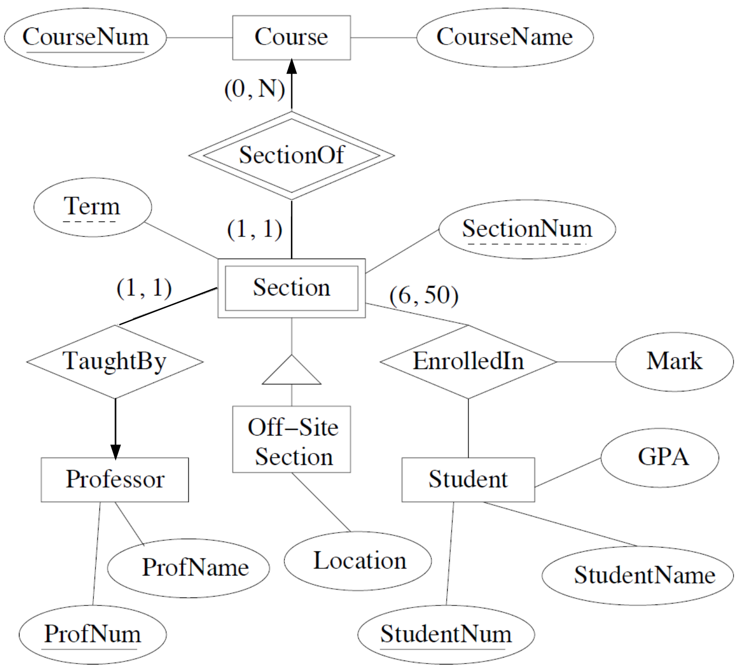
EnrolledIn(<u>StudentNum,CouseNum</u>)

CourseAccount(<u>UserId, StudentNum, CourseNum</u>, ExpirationDate)

One-to-one relationships → We can simply take UserId or (StudentNum, CourseNum) as the key

More examples (Exercise)

- ER Diagram

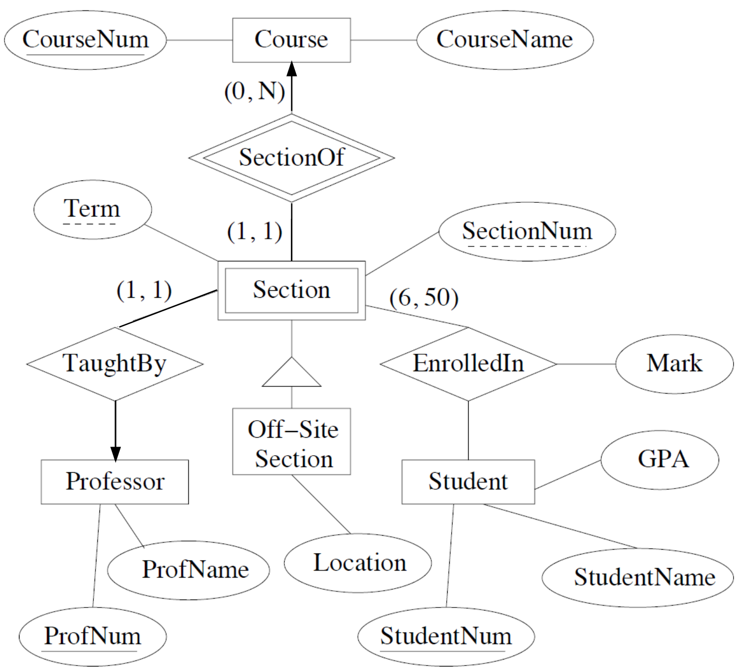


Relational Schema

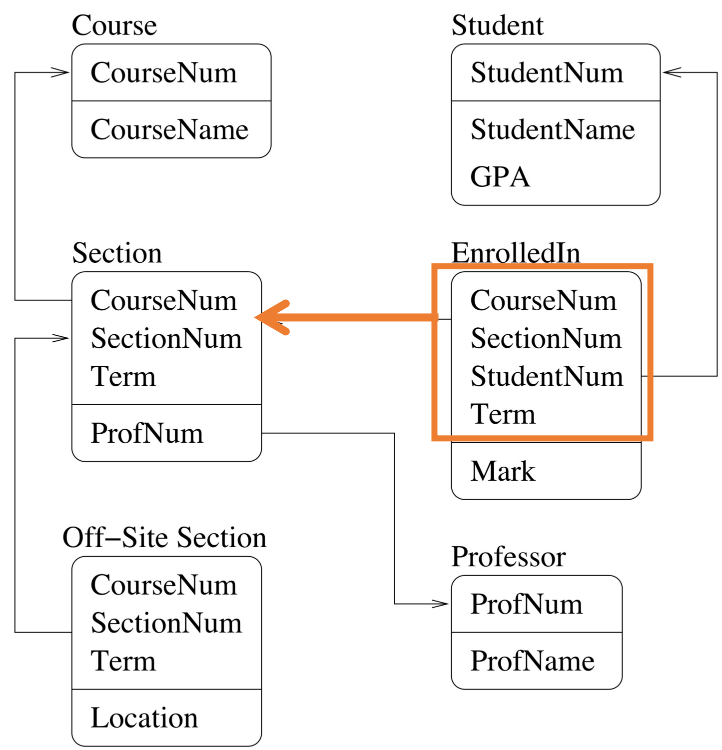
?

More examples

- ER Diagram

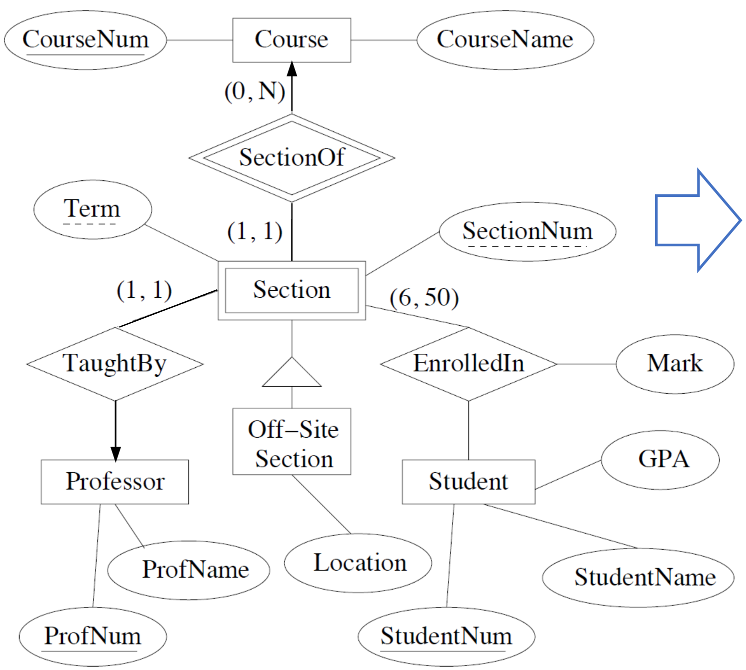


Relational Diagram



More examples

- ER Diagram



Relational DDL Commands

CREATE TABLE Course
(CourseNum INTEGER PRIMARY KEY,
CourseName CHAR(50));

CREATE TABLE Professor
(ProfNum INTEGER PRIMARY KEY,
ProfName CHAR(50));

CREATE TABLE Section
(CourseNum INTEGER NOT NULL REFERENCES Course(CourseNum),
SectionNum INTEGER NOT NULL,
Term INTEGER NOT NULL,
PRIMARY KEY(CourseNum, SectionNum, Term),
ProfNum INTEGER NOT NULL REFERENCES Professor(ProfNum));

CREATE TABLE Off-SiteSection
(CourseNum INTEGER NOT NULL,
SectionNum INTEGER NOT NULL,
Term INTEGER NOT NULL,
FOREIGN KEY(CouseNum,SectionNum,Term) REFERENCES
Section(CouseNum,SectionNum,Term),
Location CHAR(50));

CREATE TABLE EnrolledIn
(CourseNum INTEGER NOT NULL,
SectionNum INTEGER NOT NULL,
Term INTEGER NOT NULL,
StudentNum INTEGER NOT NULL REFERENCES Student(StudentNum),
FOREIGN KEY(CouseNum,SectionNum,Term) REFERENCES
Section(CouseNum,SectionNum,Term),
Primary Key(CouseNum,SectionNum,Term,StudentNum),
Mark INTEGER);

CREATE TABLE Student
(StudentNum INTEGER PRIMARY KEY,
StudentName CHAR(50),
GPA FLOAT);

Database Design

- Entity-Relationship (E/R) model
- Translating E/R to relational schema
- Next lecture (ONLINE): Relational design principles