COMP9311: Database Systems

Data Modelling

(textbook: chapters 3 and 4)

Term 3 2021

Week 1 Data Modelling (Part 1)

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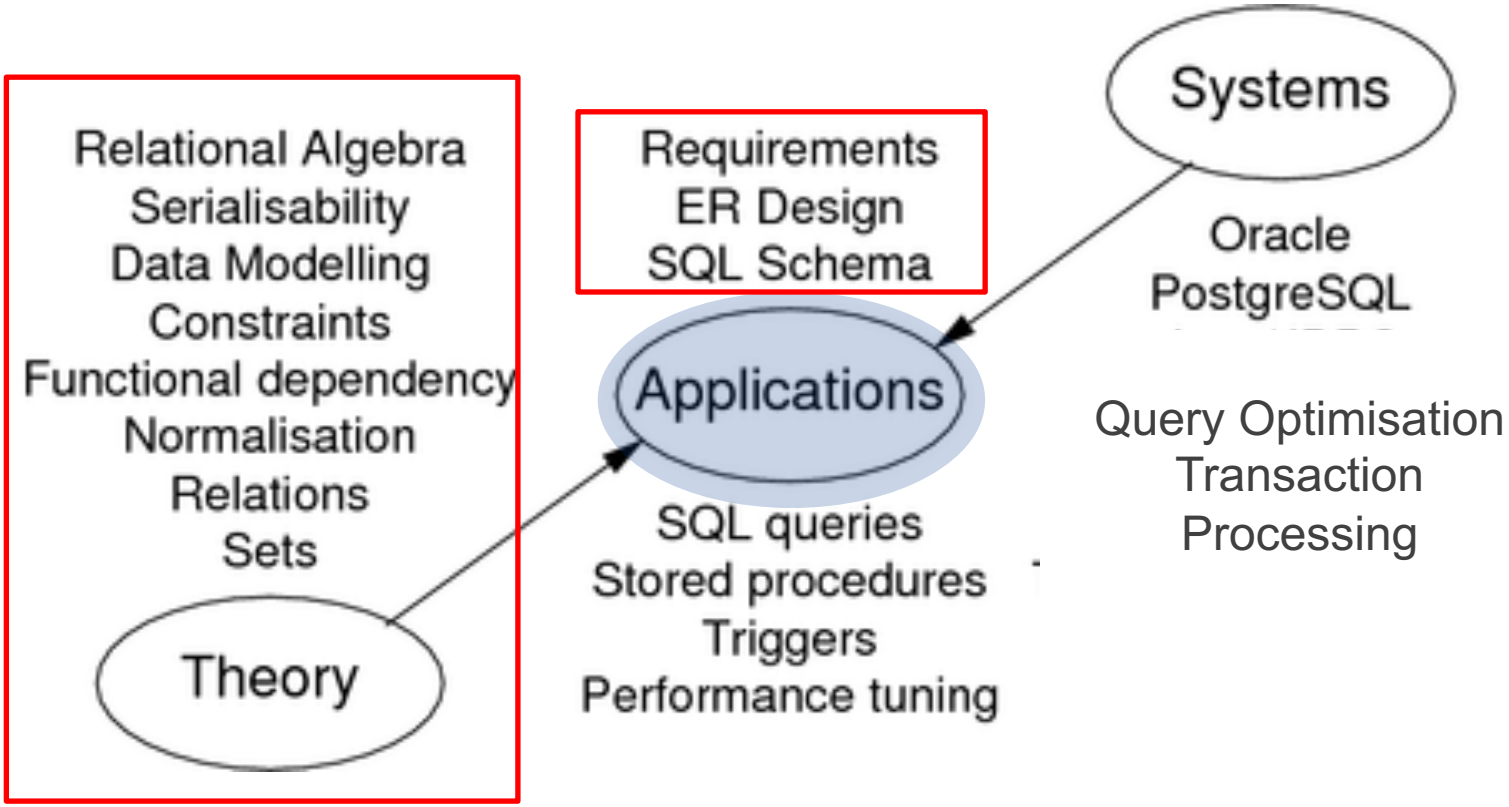
Disclaimer: the course materials are sourced from previous offerings of COMP9311 and COMP3311

Overview of the Databases Field



Database Application Development

A variation on standard software engineering process:

- analyse application requirements
- develop a data model to meet these requirements
- define operations (transactions) on this model
- implement the data model as relational schema
- implement operations via SQL and procedural PLs
- construct an interface to these operations
- At some point, populate the database (may be via interface)

Data Modelling

Aims of data modelling:

- describe what *information* is contained in the database

  (e.g., entities: students, courses, accounts, branches, patients, ...)

- describe *relationships* between data items

  (e.g., John is enrolled in COMP3311, Andrew's account is held at Coogee)

- describe *constraints* on data

  (e.g., 7-digit IDs, students can enrol in no more than four courses per term)

Data modelling is a *design* process

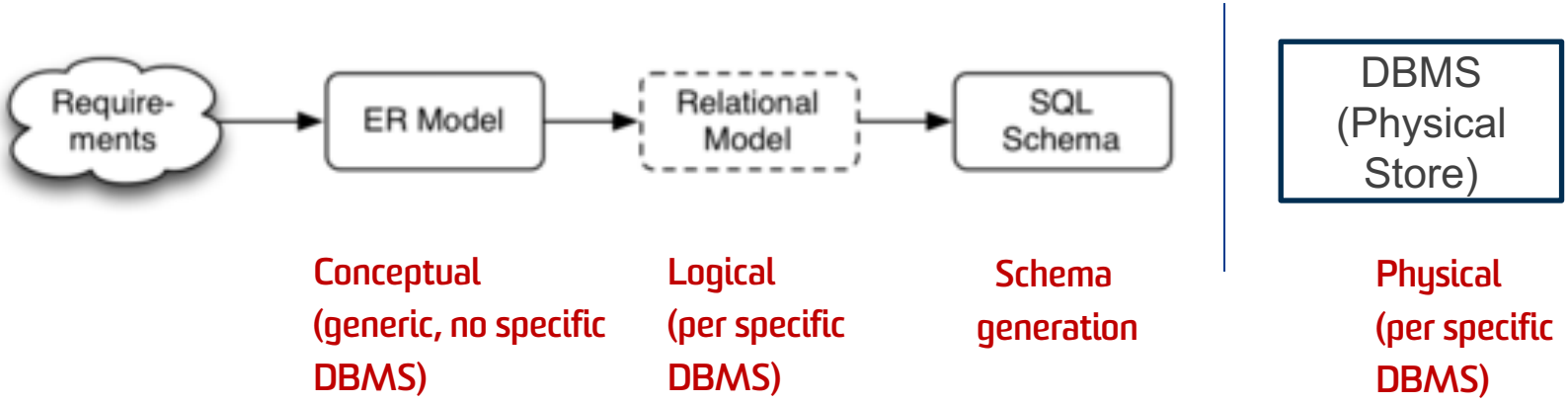
- converts requirements into a data model

Data Modelling

Kinds of data models:

- *conceptual*: abstract, high-level data model, e.g., ER, ODL (object data language) – user friendly
- *logical*: concrete, for implementation in specific DBMS, e.g., relational
- physical: internal file storage (inside a specific DBMS)

Strategy: design using abstract model; map to logical model, DBMS takes care of the physical model



Some Design Ideas

Consider the following when you work through a design exercise:

- start simple ... evolve design as problem better understood
- identify objects (and their properties), then relationships
- most designs involve kinds (classes) of people
- *keywords in requirements suggest data/relationships*
  (rule-of-thumb: nouns → data, verbs → relationships)
- don't confuse operations/actions with relationships
  (operation: he **buys** a book; relationship: the book **is owned** by him)
- consider all possible data, not just what is available

Example - Gmail Data Model

Consider the Google Mail System:

Let's develop an informal data model for it by identifying:

- the data items involved (objects and their attributes)
- relationships between these data items
- constraints on the data and relationships

Quality of Designs

There is no single "best" design for a given application.

Most important aspects of a design (data model):

- correctness (satisfies requirements accurately)
- completeness (all reqs covered, all assumptions explicit)
- consistency (no contradictory statements)

Potential inadequacies in a design:

- omits information that needs to be included
- contains redundant information ($\Rightarrow$ inconsistency)
- leads to an inefficient implementation
- violates syntactic or semantic rules of data model

Entity-Relationship Data Modelling

In ER, The world is viewed as a collection of inter-related ”entities”.

ER has **three** major modelling **constructs**:

- *entity*: objects (“things”) in your world that you are interested
    - *Person, Restaurants, Books, University Courses,…*
- *attribute*: data item describing a property of interest
    - Person (name, phone number, DOB, …)
- *relationship*: association between entities (objects)
    - Person dines-at Restaurant

Entity-Relationship (ER) Diagrams

ER diagrams are a graphical tool for data modelling.

An ER diagram consists of:

- a collection of *entity set* definitions
- a collection of *relationship set* definitions
- *attributes* associated with entity and relationship sets
- connections between entity and relationship sets

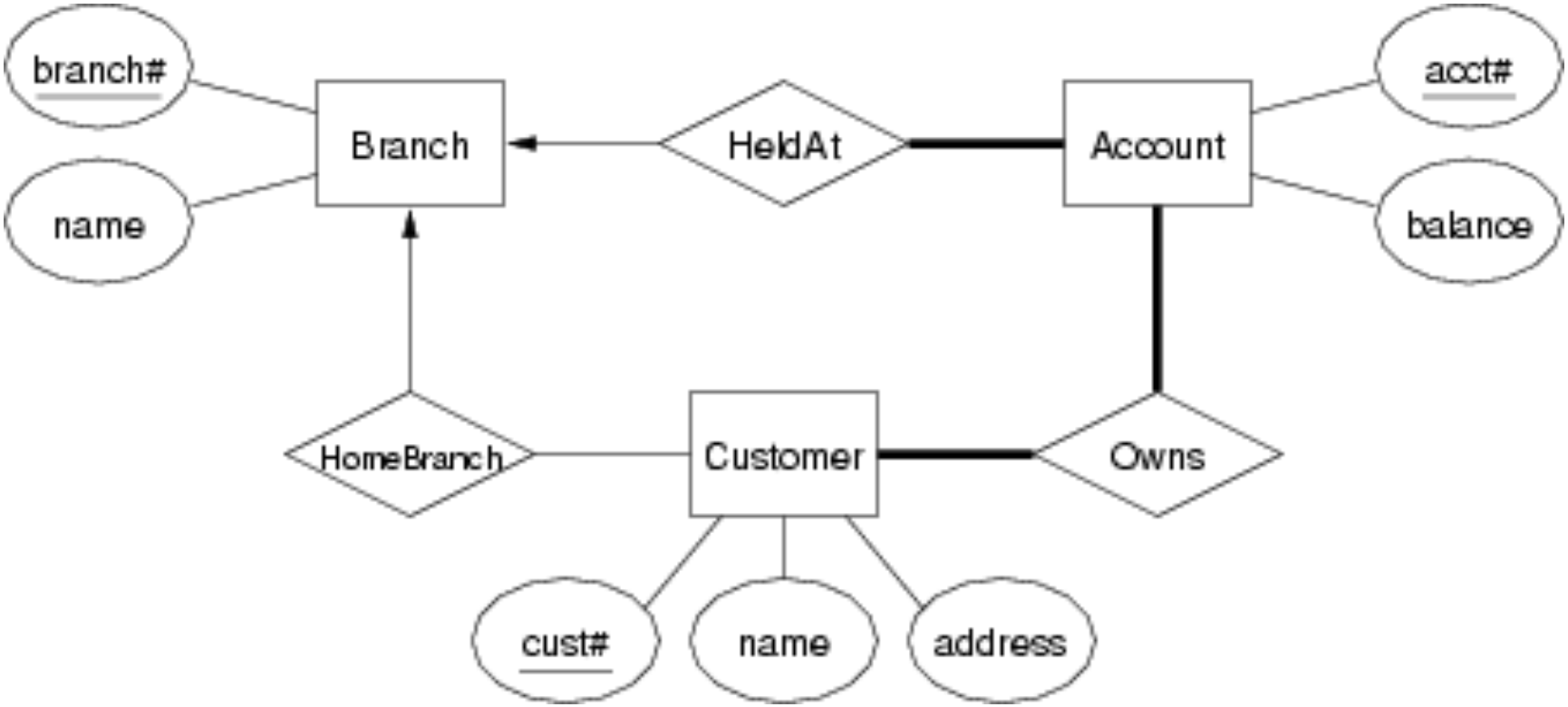
Terminology: when discussing "entity sets", we frequently say just "entity"

The ER model is not a standard, so many variations exist.

Lecture notes use simple notations -> as 'COMP9311 standard'.

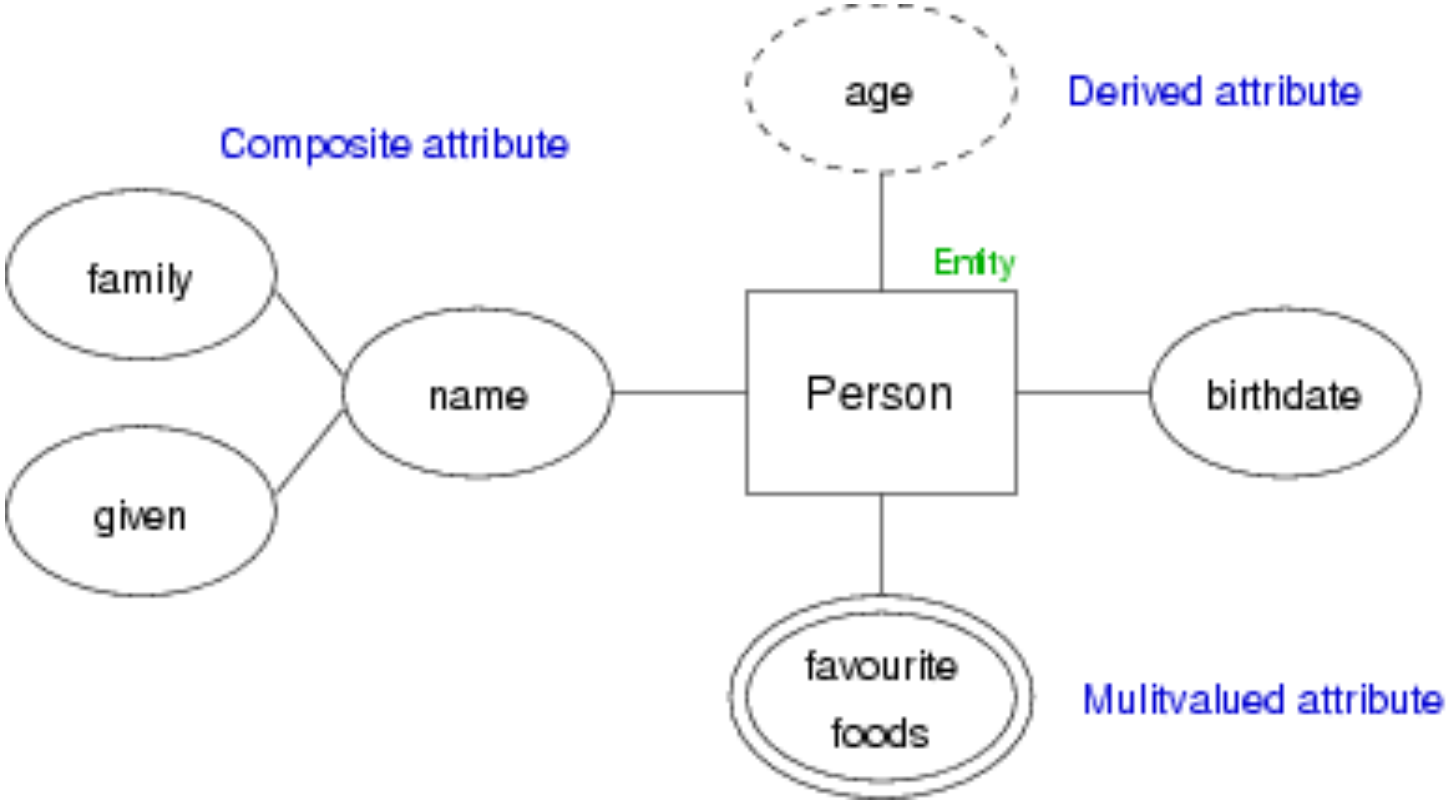
Entity-Relationships

Example ER Diagram: entities, attributes, relationships/connections



Entity-Relationships

Example of attribute notations



Entity Sets and Entity Type

An *entity set* can be viewed as either:

- a set of entities with the same set of attributes
- an abstract description of a class of entities -> a.k.a. *Type* *(Entity Type)*

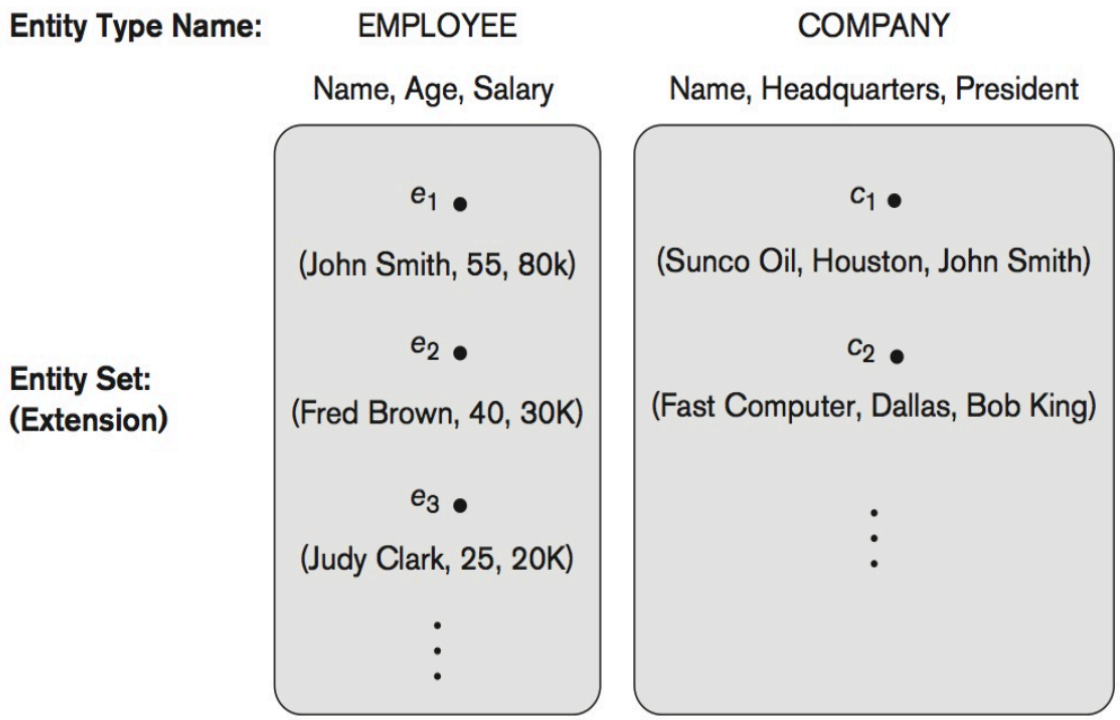


Figure 3.6
Two entity types, EMPLOYEE and COMPANY, and some member entities of each.

Entity Sets and Keys

Entities of an entity type, say EMPLOYEE needs a **key** to distinguish each other in a set.

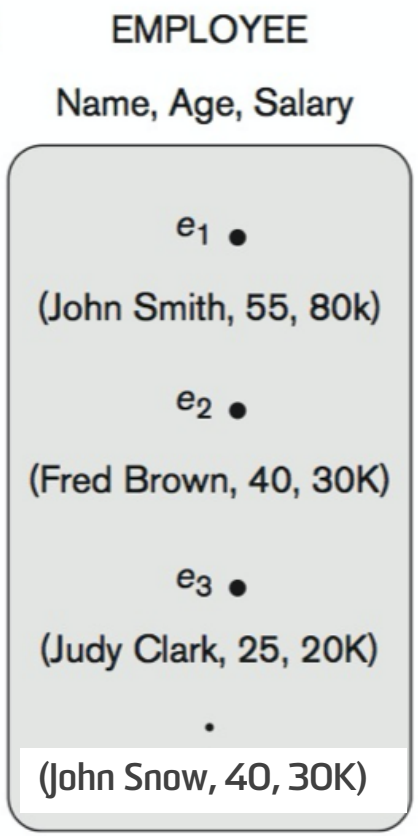
Key (*superkey*): any set of attributes whose set of values are distinct over entity set

- natural (e.g., name+age+salary) or artificial (e.g., employee number)

Candidate key = minimal superkey (no subset is a key)

Primary key = candidate key chosen by DB designer later in the development stage

Keys are indicated in ER diagrams by underlining



Relationship Sets

Relationship: an association among several entities

- e.g., Customer(9876) **is the owner of** Account(12345)
- e.g., Student(0001) **is enrolled in** Course (9311)

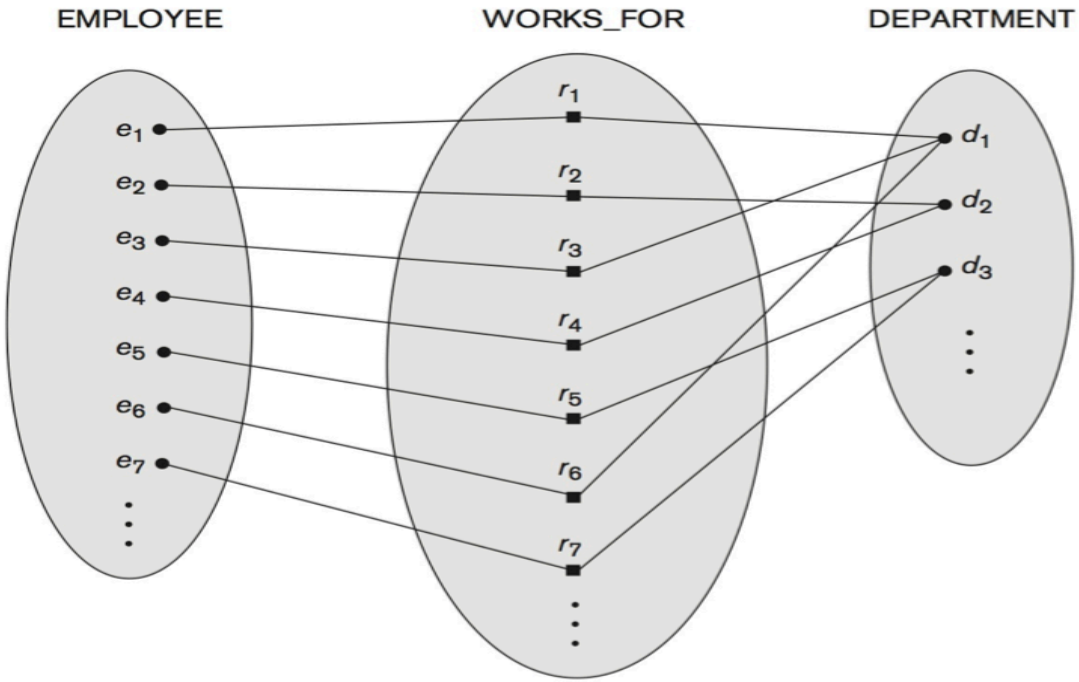
Relationship set: collection of relationships of the same type

- *Degree* = # entities involved in reln (in ER model, ≥ 2)
- *Cardinality* = # associated entities on each side of reln
- *Participation* = must every entity be in the relationship

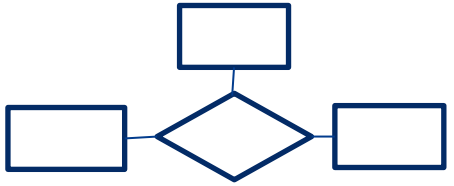
Example: relationship participation

How to think about the relationships more concretely:

Entity "sets", Relationship "sets" and their memberships

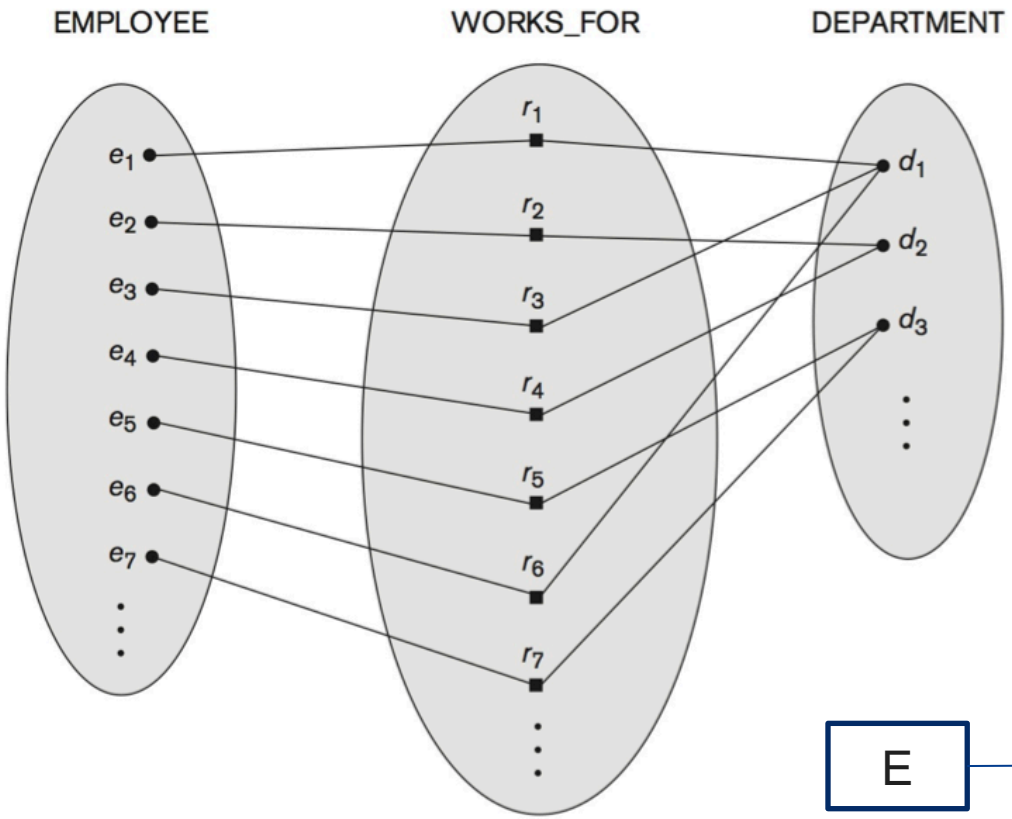


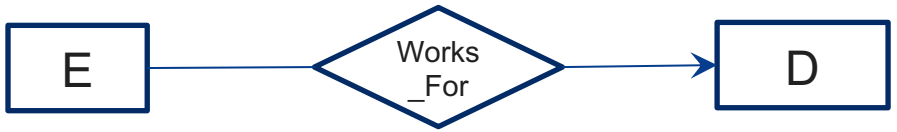
First … Number of Degree in this relationship set?



Placing ‘constraints’ on the relationships

Cardinality (think how many number of *relationship instances* that an entity can participate?) – this should depend on your requirements





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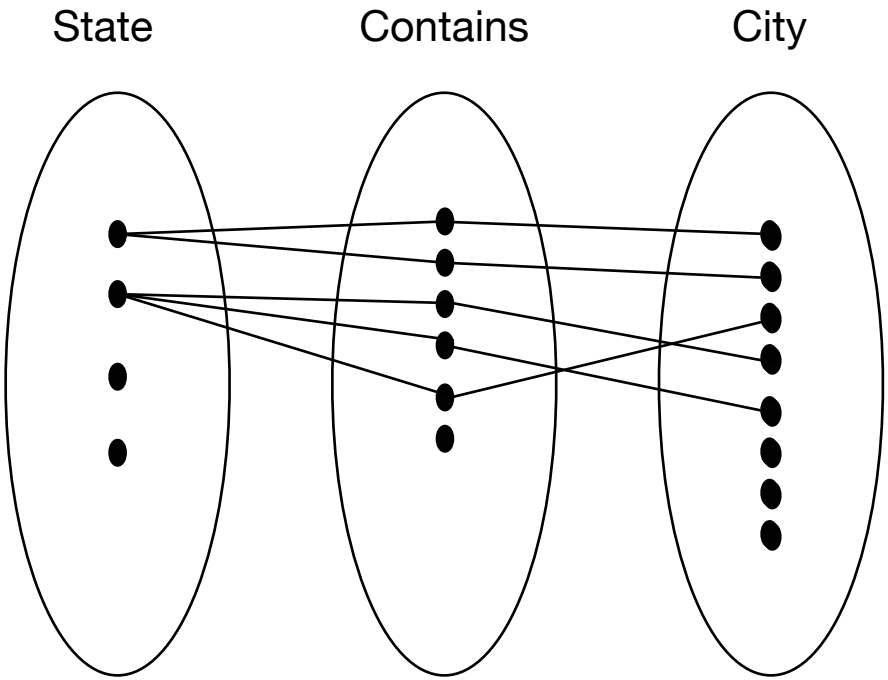

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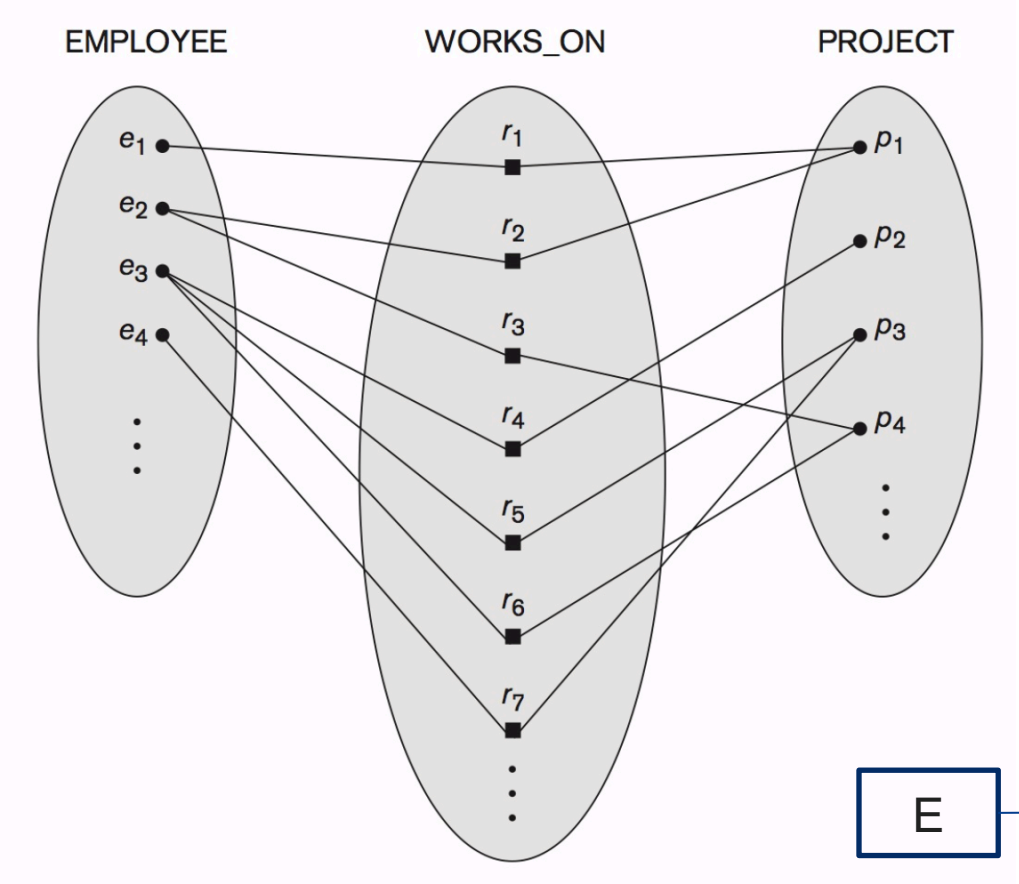

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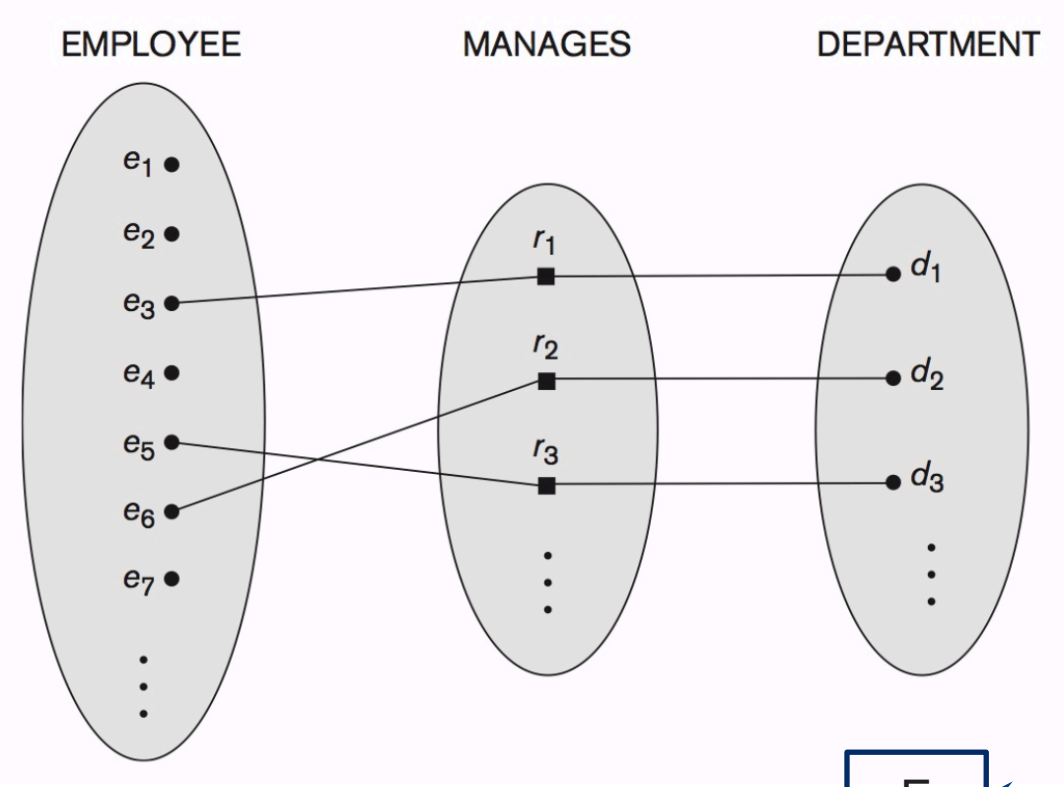


Recursive (or self-referencing) relationships

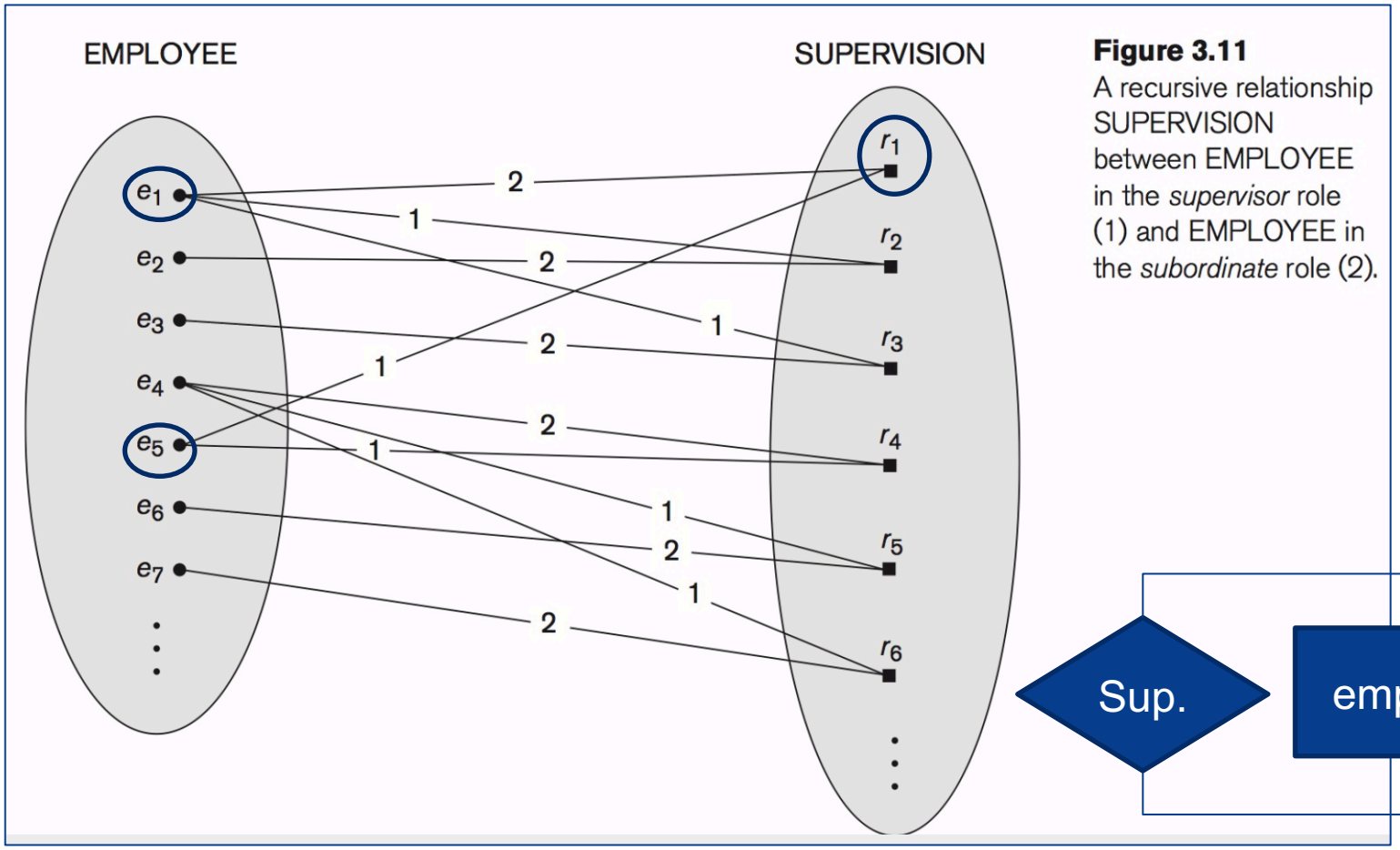
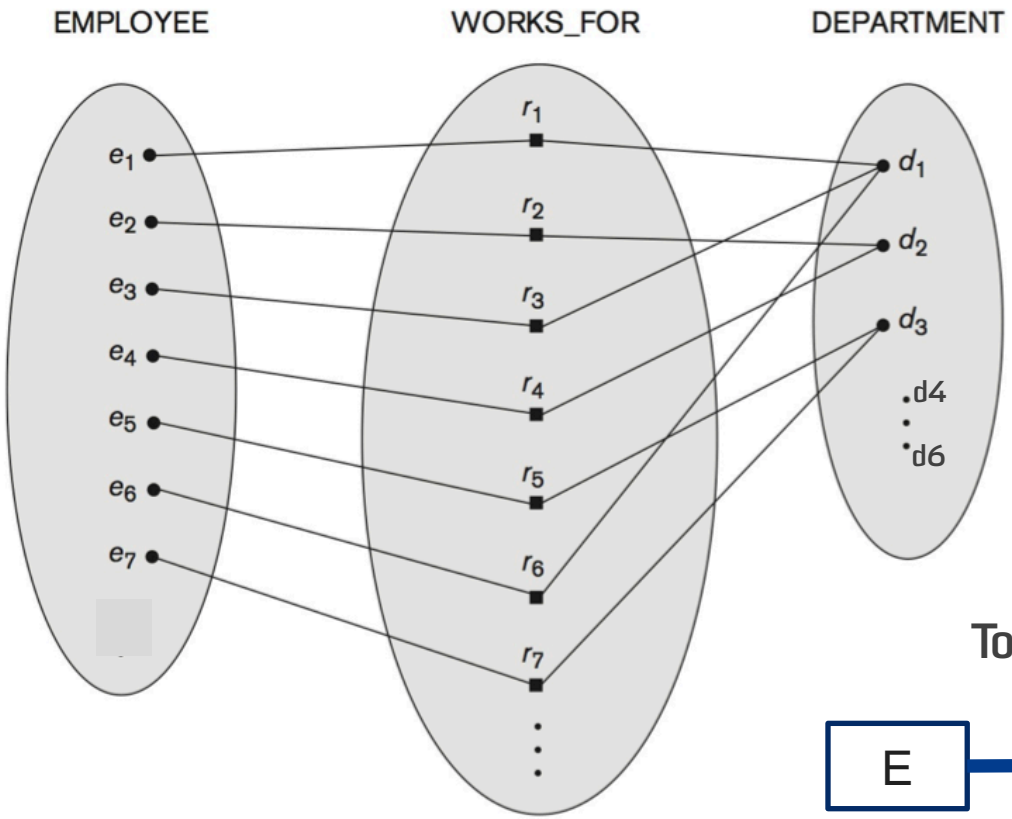


Figure 3.11
A recursive relationship SUPERVISION between EMPLOYEE in the *supervisor* role (1) and EMPLOYEE in the *subordinate* role (2).

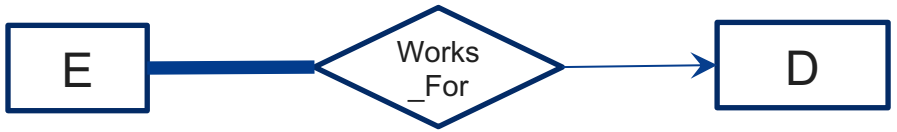
What would the ER diagram look like in this scenario?

Placing ‘constraints’ on the relationships

Participation (think “is it ‘every (or total)’ or ‘some’ entity instances” ?) – this should depend on your requirements



Total Participation of Employee



Placing ‘constraints’ on the relationships

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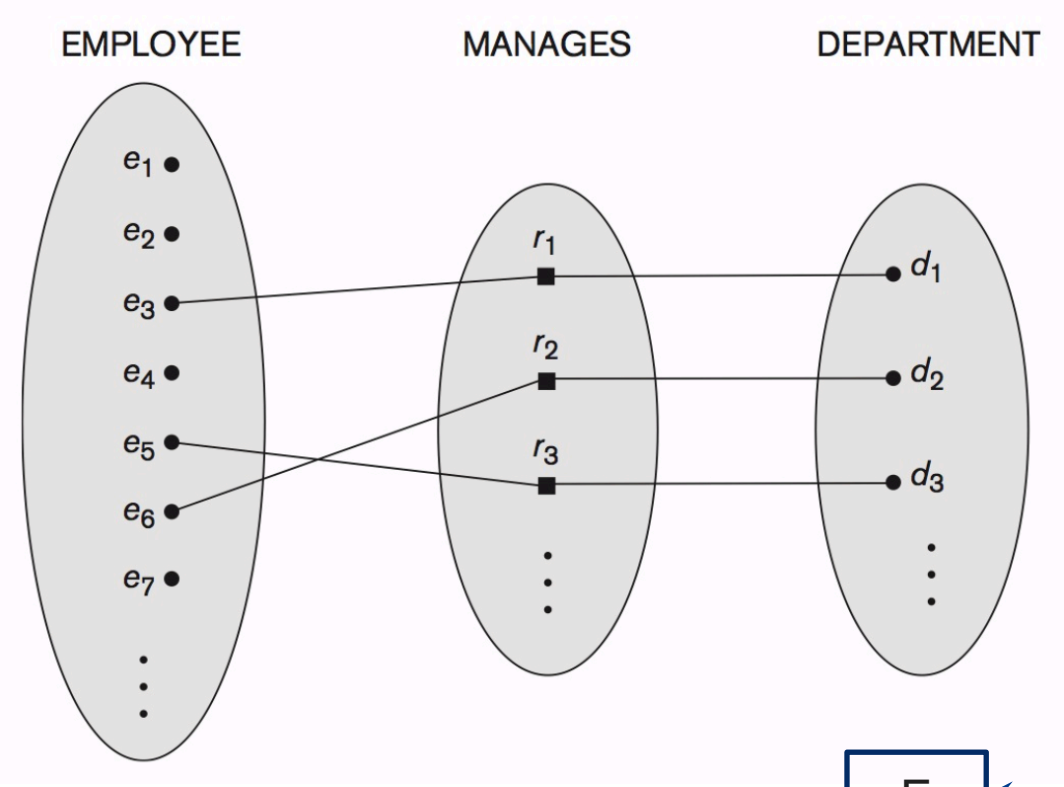
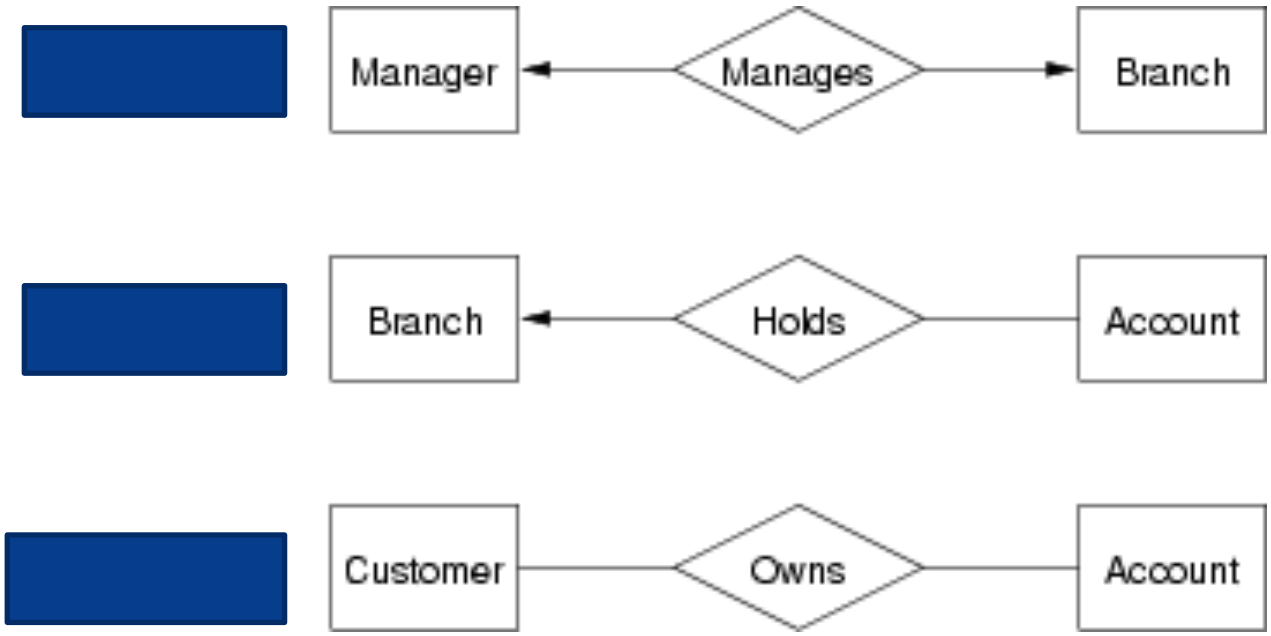


Partial (E) and Total (D)

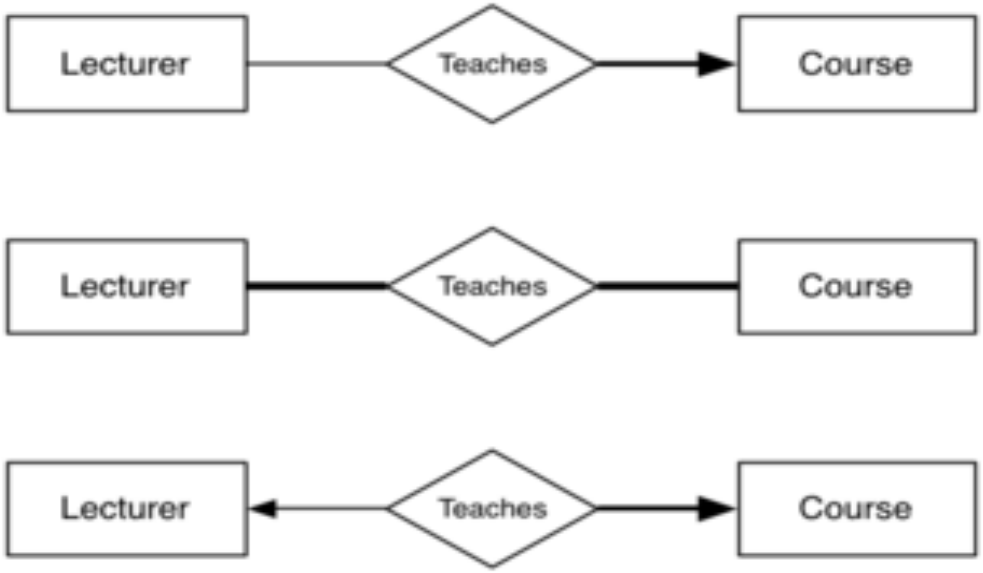
Exercise 2: Relationship Semantics

Relationships – degree and cardinality



Exercise 2: Relationship Semantics

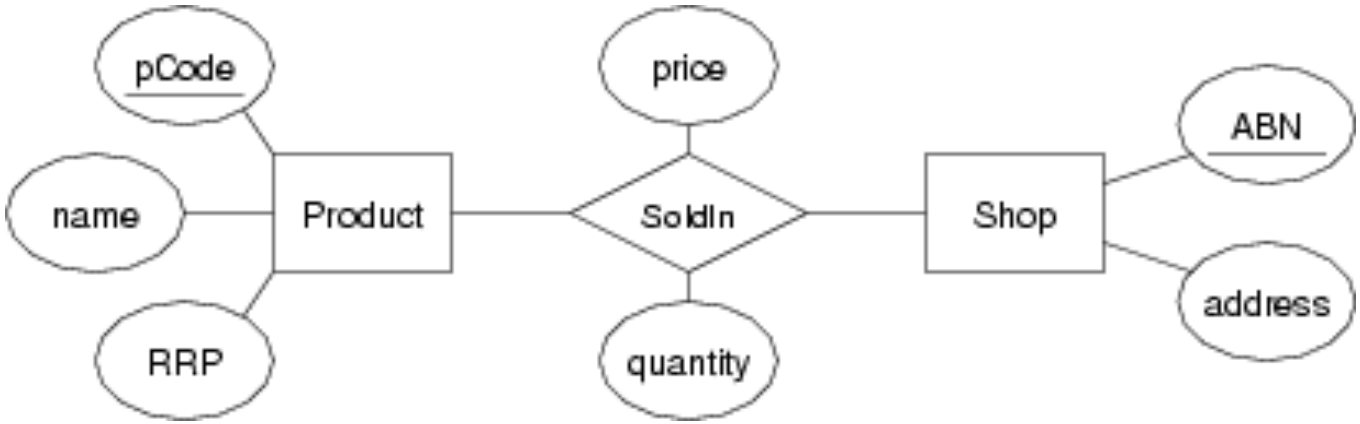
Describe precisely the scenarios implied by the following relationships: (degree, cardinality and participation)



Relationship with attributes

In some cases, a relationship needs associated attributes.

Example:



(Price and quantity are related to products in a particular shop)