Reference Models

(T2MP)

Index

- **Intuition**
- Wordnet (an alphabet semi-formal model)
- ER models (a knowledge semi-formal model)
- EER models (a knowledge semi-formal model)
- Relational DB (a data semi-formal model)
- Natural language (an alphabet, knowledge and data informal model)

An analogic representation -What do you see?

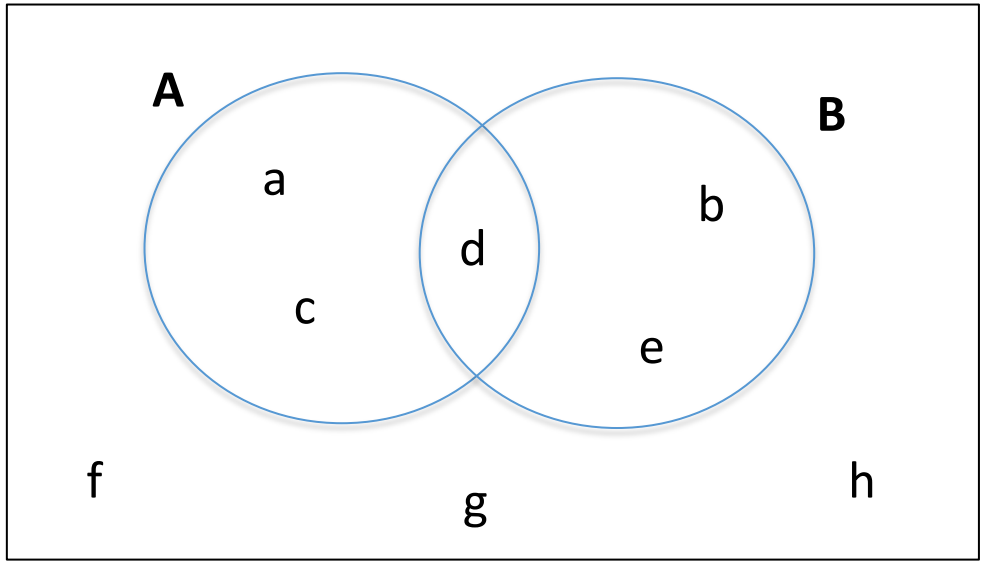
Observation (What can be seen in a picture).
We have the following "things":

- **Entities**, that is, single **things**,e.g., Sofia, a dog
- **Entity properties**, that **is sets of pairs of things**, e.g., a woman with blond hair
- **Entity Relations**, that **is sets of tuples of things**, e.g., a woman talking to a man with a phone, a dog between a woman and a man, a woman friend of a man
- **Entity types**, also called **etypes**, that is **sets (classes) of things with the same properties**, e.g., women, dogs, people, a crowd

We always perceive multiple things, each with **its own characteristics**, grounded in their space-time coordinates

An analogical representation - What do you see?

Observation 1. Analogic representations are formalized using set theory



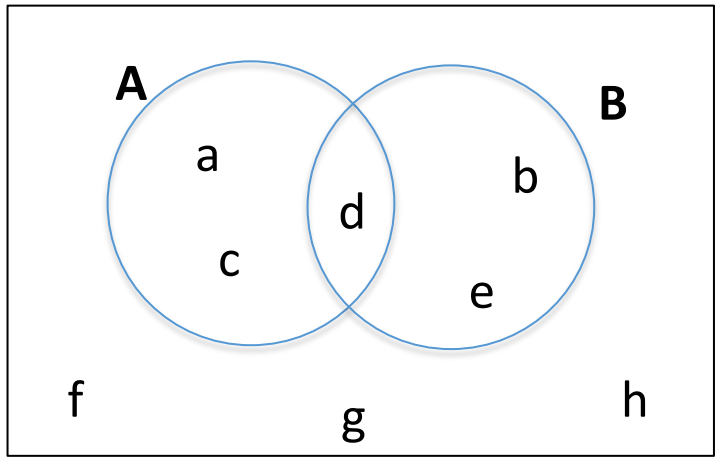
Observation 2 (Percepts, domain). **Percepts** are all the things or combinations of things which can be distinctively perceived, inside the selected **domain** (the box).

Example (Domain). The set of percepts of the picture on the left.

Percepts - definition

Definition (percept) A **percept** is any of the six cases below.

- **Entities,** $e_1, ..., e_n$, perceived as *elements* (e.g., Sofia), of some class (e.g., Thing);
- **Entity properties,** $p_1, ..., p_n$, perceived as *binary relations* between two elements (e.g., Sofia is blond)
- **Entity relations,** $er_1, ..., er_n$, perceived as *n-ary relations* among n elements (e.g., Rocky is between Sofia and Mark)
- **Etypes,** $E_1, ..., E_n$, as *classes* of elements, (e.g., person)
- **Etype properties,** $Ep_1, ..., Ep_n$, as *binary relations* between the subclasses of two classes (e.g., Swedish people are blond)
- **Etype relations,** $Er_1, ..., Er_n$, as *n-ary relations* among subclasses of multiple classes (e.g., breaks happen between lectures)



Observation (Etype properties and relations). Etype properties and relations are entity properties and relations applied to the multiple elements, i.e., a subset, of a class.

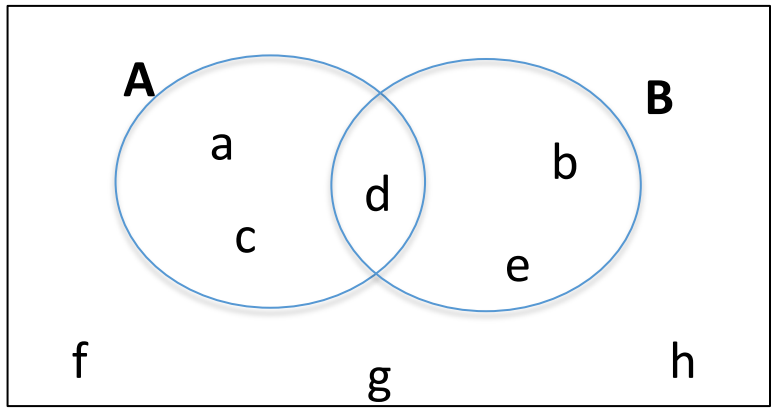
Facts - definition

Definition (Fact). A **fact f** has one of the following five forms

- *Element memberOf Class:* $e_i \in C_j$,
- *Tuple of elements memberOf relation:* $< e_1, \ldots, e_n > \in R^n$,
- *Class subsetOf Class:* $C_i \subseteq C_j$,
- *Relation subsetOf relation:* $R_i^n \subseteq R_j^n$
- *Relation subsetOf tuple of classes and viceversa:*
  - $R^n \subseteq C_1 \times \ldots \times C_n$
  - $C_1 \times \ldots \times C_n \subseteq R^n$

with: $e_i \in E$, $C_i \subseteq E$, $R^n \subseteq E \times \ldots \times E$.

Reference models - What do they describe?



Observation 1 (Reference models). Reference models are linguistic representations used to describe mental representations. They describe the world in terms of **entities**, **entity properties**, **entity relations**, and **etypes**.

Observation 2 (Reference models). Reference models always use a language.

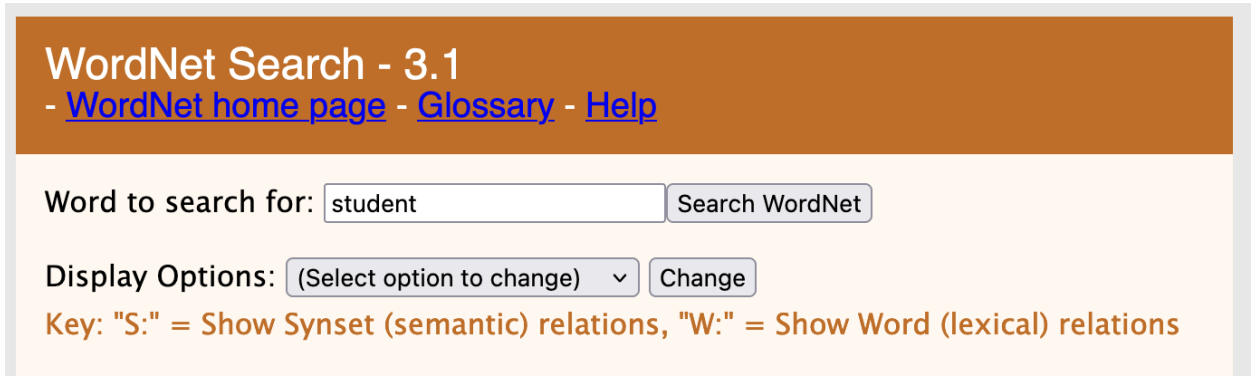
- The intended analogical representation is always left implicit (often called the "intended meaning").
- Some, so called **semi-formal models** (as used in Computer Science) use type L1, L2, L3 languages, as from the Chomsky hierarchy, typically graph languages
- Others, so called **informal models**, use type L0 languages, typically natural languages.

Index

- Intuition
- **Wordnet (an alphabet semi-formal model)**
- ER models (a knowledge semi-formal model)
- EER models (a knowledge semi-formal model)
- Relational DB (a data semi-formal model)
- Natural language (an alphabet, knowledge and data informal model)

Informal definition

- Wordnet is a large lexical database of English words. It organizes each word in sets of words with closely related meanings (synsets).
- It captures the semantic relationship between synsets:
- **Hypernyms**: Broader, more general concept.
- **Hyponyms**: Instance or subtype of a concept.
- **Antonyms**: Two words with contrasting meaning.
- **Meronyms**: Denote components or parts of a whole.
- **Holonyms**: Refers to the whole itself.



Type of facts used in WordNet

- WordNet is an alphabet Reference Model, it deals mainly with Classes (as synsets are set of words) and their relationships.

- So, the facts that it describes are in the form:

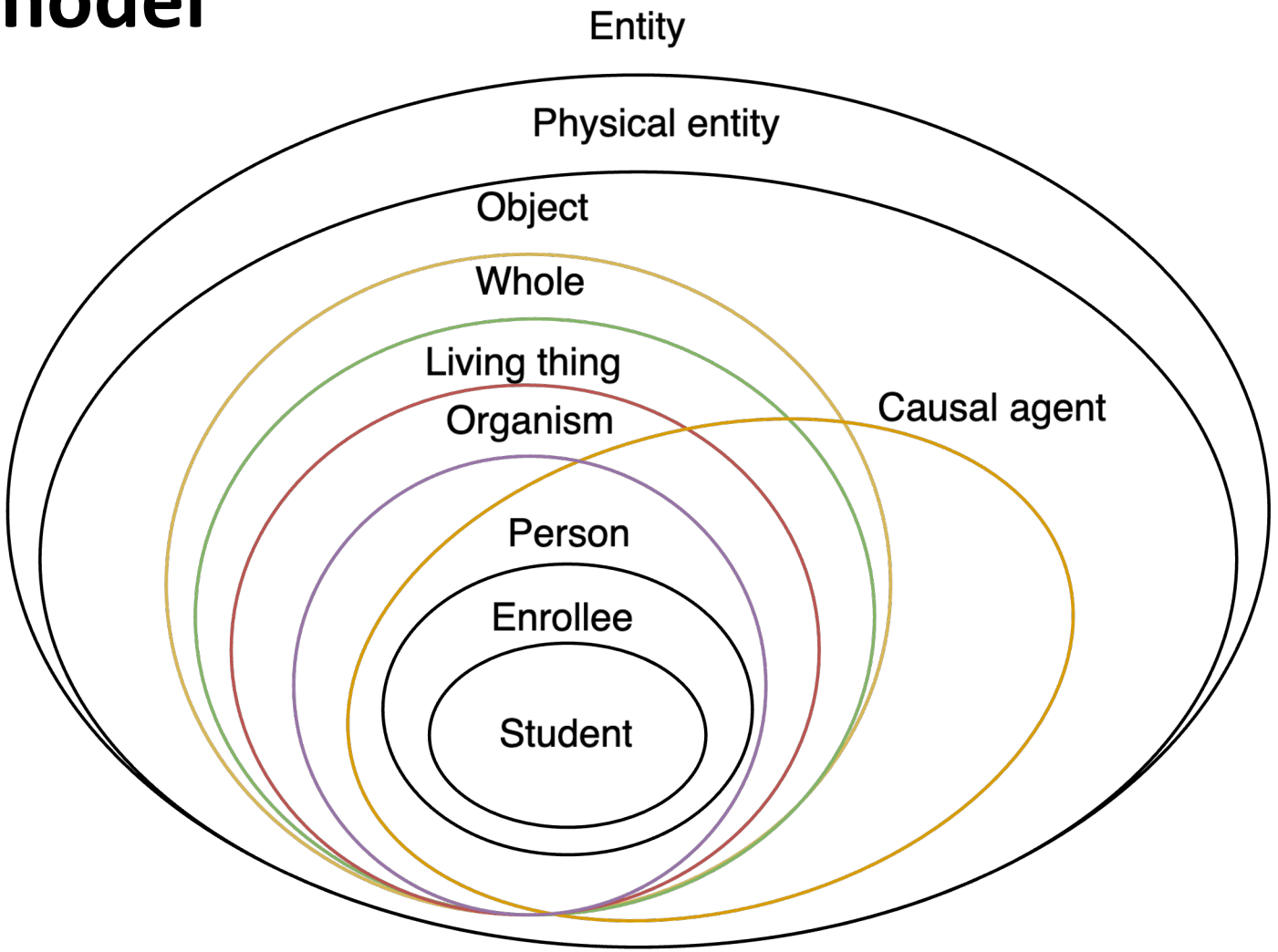
$$C_i \subseteq C_j$$

$$R^n \subseteq C_1 \times \cdots \times C_n$$

Example

- S: (n) **student**, pupil, educatee
  - *direct hyponym* / *full hyponym*
  - *member holonym*
  - *direct hypernym* / ***inherited hypernym*** / *sister term*
    - S: (n) enrollee
      - S: (n) person, individual, someone, somebody, mortal, soul
        - S: (n) organism, being
          - S: (n) living thing, animate thing
            - S: (n) whole, unit
              - S: (n) object, physical object
                - S: (n) physical entity
                  - S: (n) entity
        - S: (n) causal agent, cause, causal agency
          - S: (n) physical entity
            - S: (n) entity

Intended model



Exercise

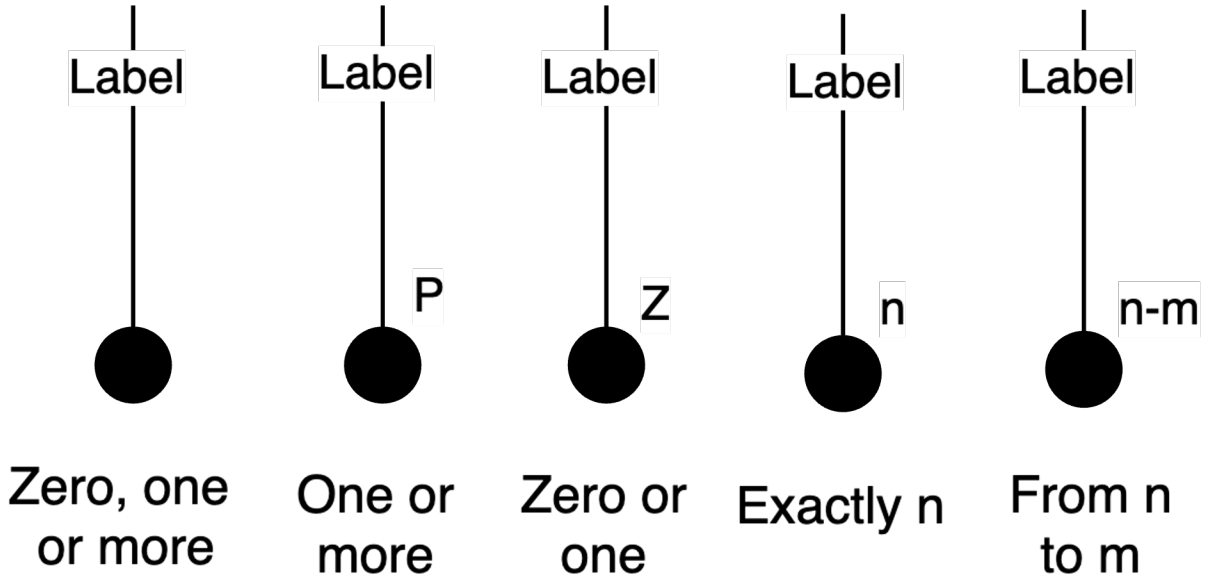
- S: (n) coldness, **cold**, low temperature, frigidity, frigidness
  - *direct hyponym* / *full hyponym*
  - *direct hypernym* / *inherited hypernym* / *sister term*
    - S: (n) temperature
      - S: (n) fundamental quantity, fundamental measure
        - S: (n) measure, quantity, amount
          - S: (n) abstraction, abstract entity
            - S: (n) entity
      - S: (n) physical property
        - S: (n) property
          - S: (n) attribute
            - S: (n) abstraction, abstract entity
              - S: (n) entity
    - S: (n) vasoconstrictor, vasoconstrictive, pressor
      - S: (n) agent
        - S: (n) causal agent, cause, causal agency
          - S: (n) physical entity
            - S: (n) entity
  - ***antonym***
    - W: (n) hotness [Opposed to: coldness]

Index

- Intuition
- Wordnet (an alphabet semi-formal model)
- **ER models (a knowledge semi-formal model)**
- EER models (a knowledge semi-formal model)
- Relational DB (a data semi-formal model)
- Natural language (an alphabet, knowledge and data informal model)

Notation

Entity	
PK	**Primary Key**
	Attribute1 : Type Attribute2 : Type



Type of facts described in ER diagrams

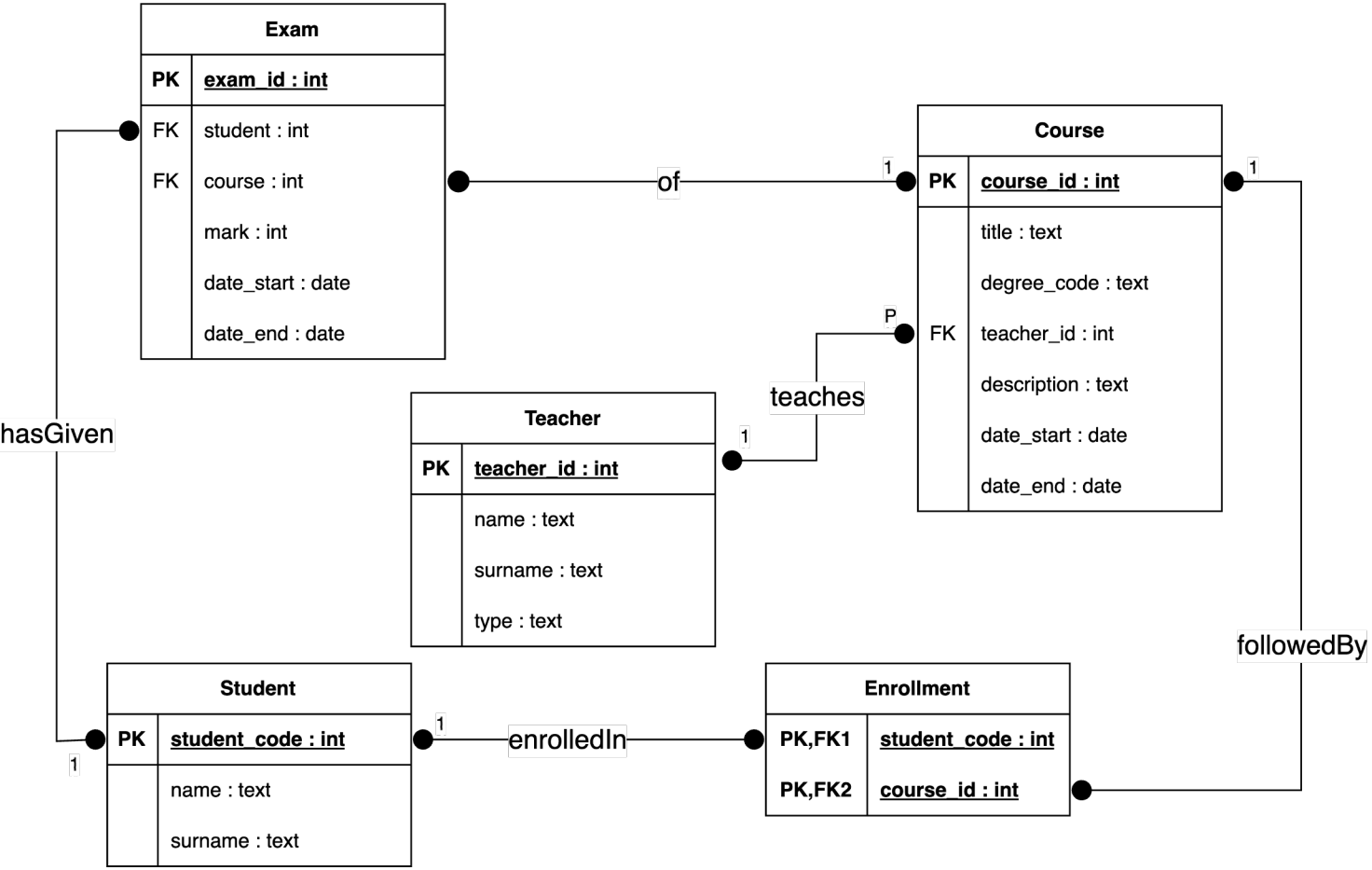
- ER diagrams are knowledge reference models, tables describe a class of entities with their properties, and the arrows represent relationships between the defined classes.

- So, the facts that it describes are in the form:

$$C_i \subseteq C_j$$

$$R^n \subseteq C_1 \times \cdots \times C_n$$

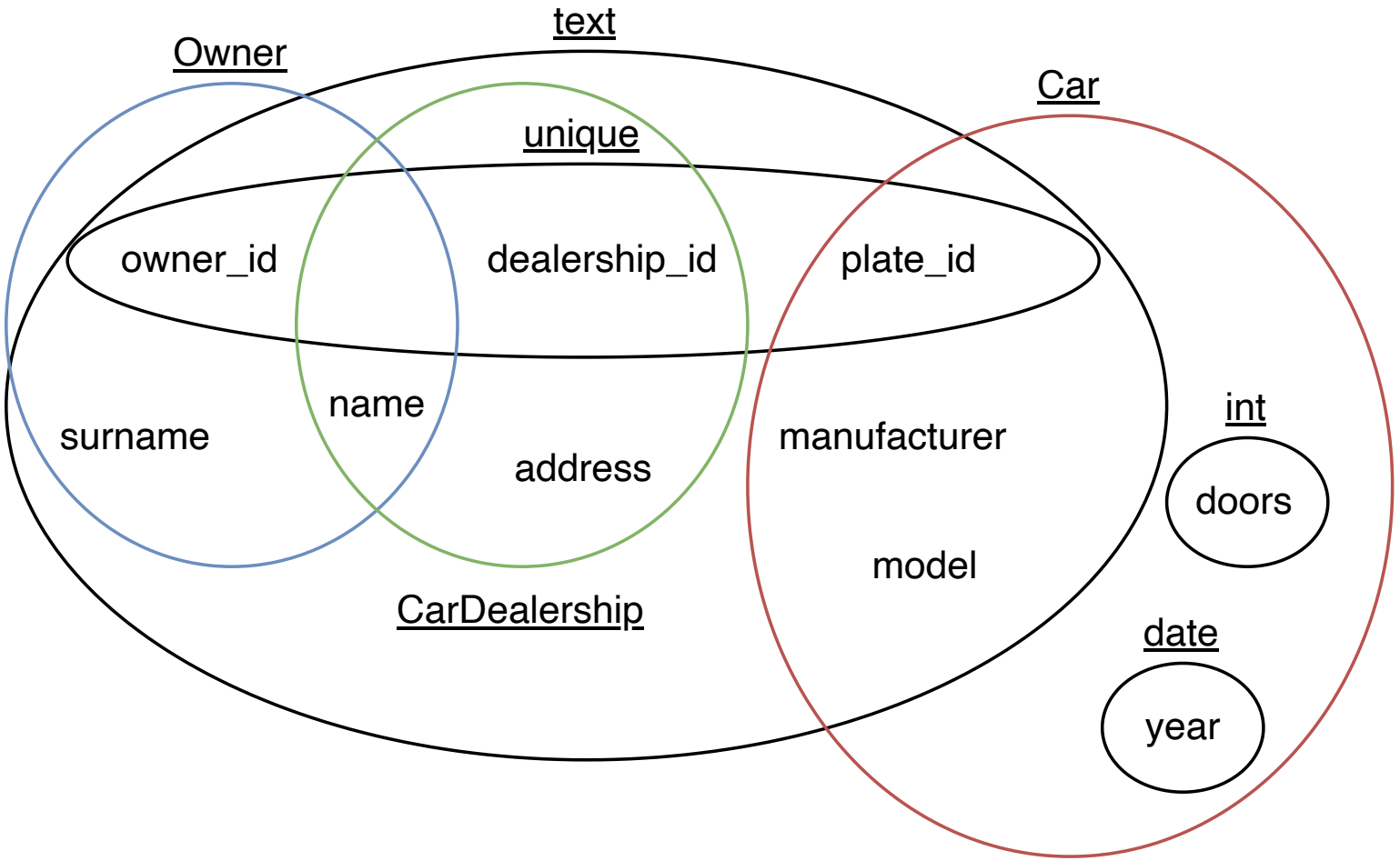
Example



Intended model

"A student is characterized by a unique code, name, and surname, it can be enrolled in no or more than one course, it can have given an exam more than once. A course is characterized by an id, a title, the code of the degree it is taught in, a start and end date, and a description, a course is taught by a teacher, characterized by an id, name, surname, and a type. Lastly, an exam is characterized by an id, a starting, and ending date, the mark given and it refers to the student and relative course."

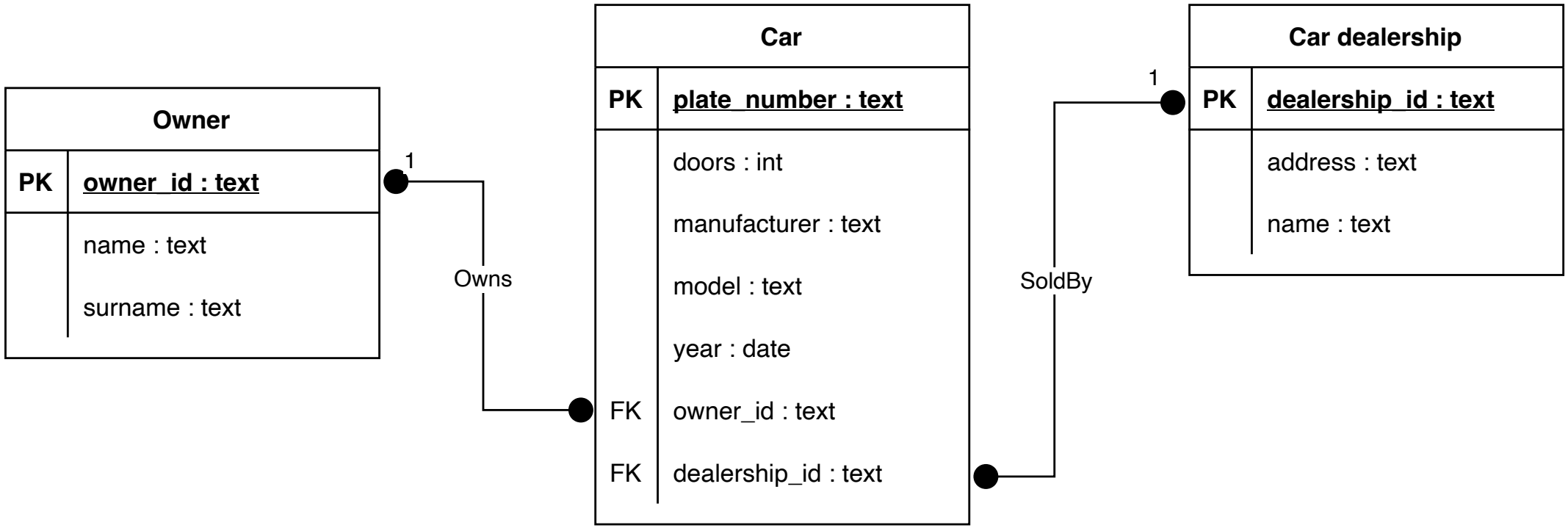
Exercise



Owns = Owner X Car

SoldBy = Car X CarDealership

Exercise

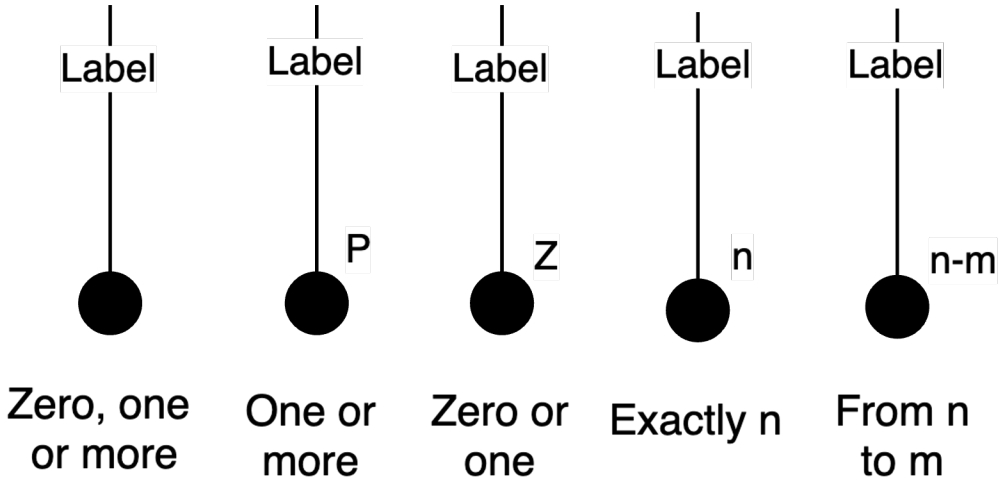

Owner
PK
owner_id : text
name : text
surname : text
1
Owns
Car
PK
plate_number : text
doors : int
manufacturer : text
model : text
year : date
FK
owner_id : text
FK
dealership_id : text
SoldBy
1
Car dealership
PK
dealership_id : text
address : text
name : text

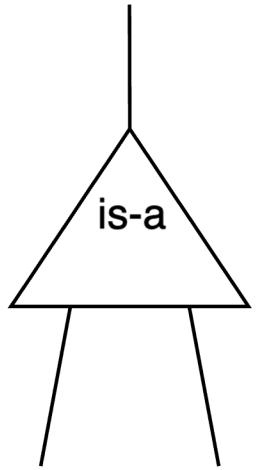
Index

- Intuition
- Wordnet (an alphabet semi-formal model)
- ER models (a knowledge semi-formal model)
- **EER models (a knowledge semi-formal model)**
- Relational DB (a data semi-formal model)
- Natural language (an alphabet, knowledge and data informal model)

Notation

Entity	
PK	**Primary Key**
	Attribute1 : Type Attribute2 : Type





Type of facts described in EER diagrams

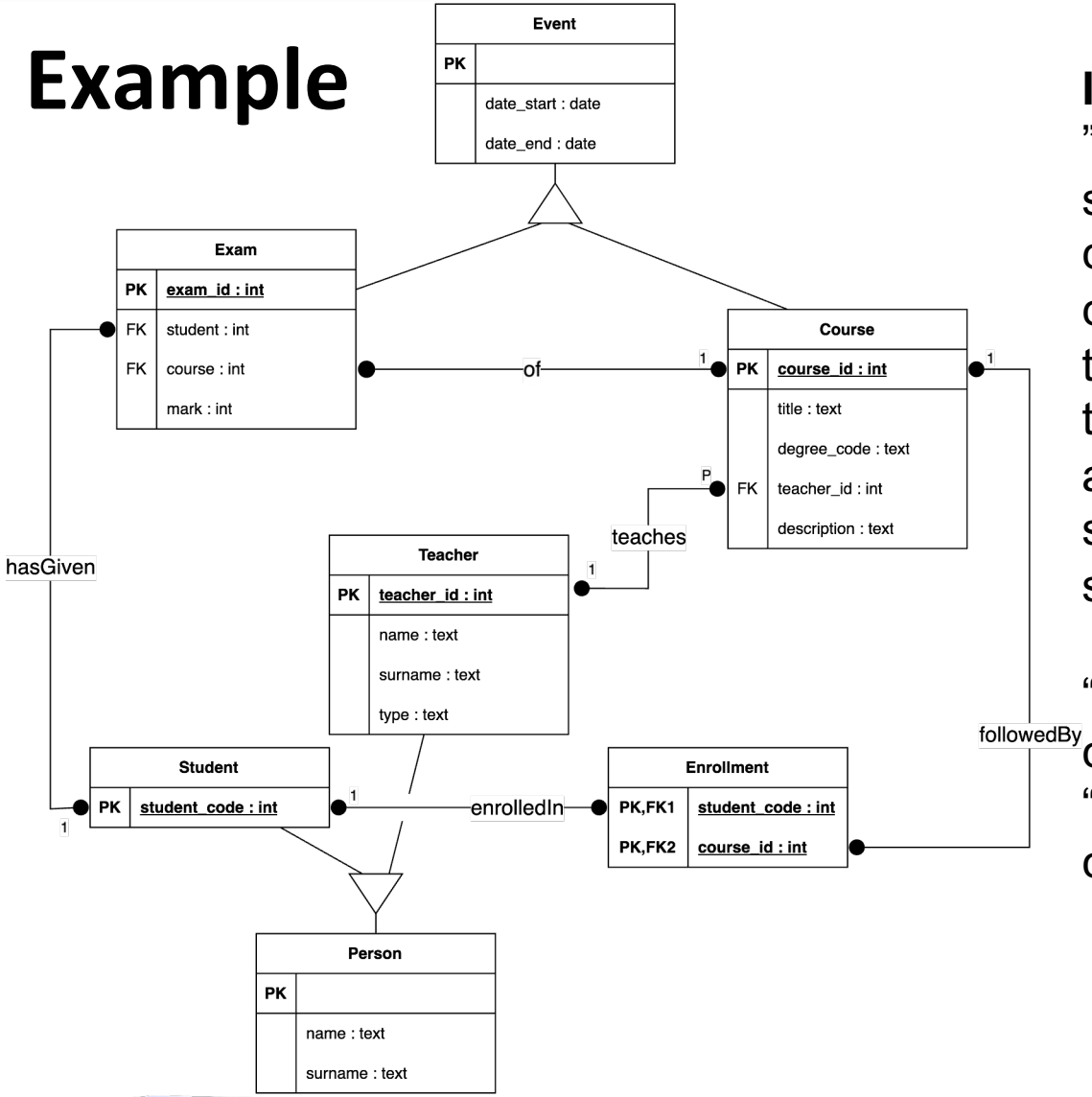
- EER diagrams represent the same things as ER diagrams, plus the subtype-supertype relationships between the classes.

- So, the facts that it describes are in the form:

$$C_i \subseteq C_j$$

$$R^n \subseteq C_1 \times \cdots \times C_n$$

Example

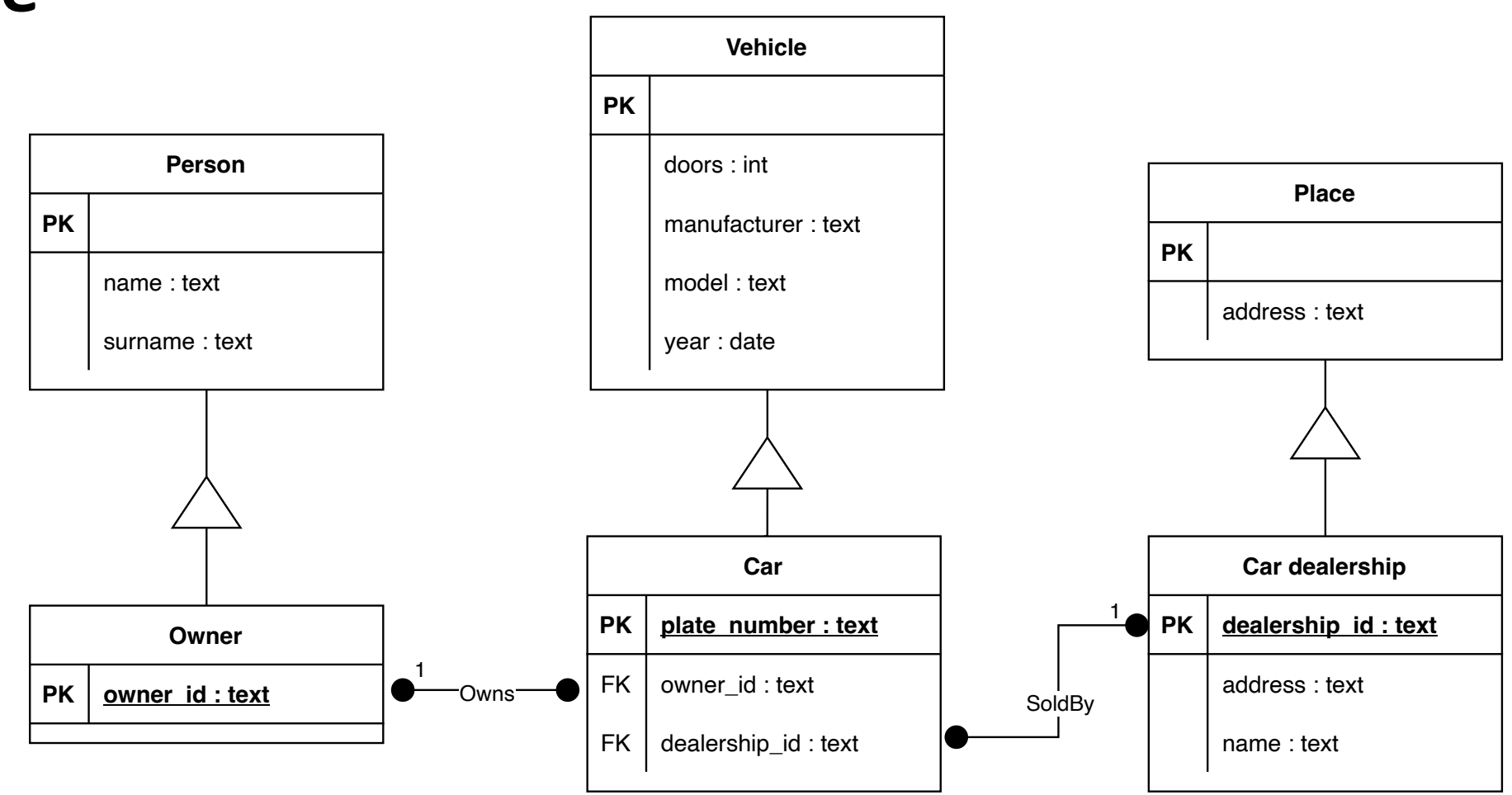


Intended model

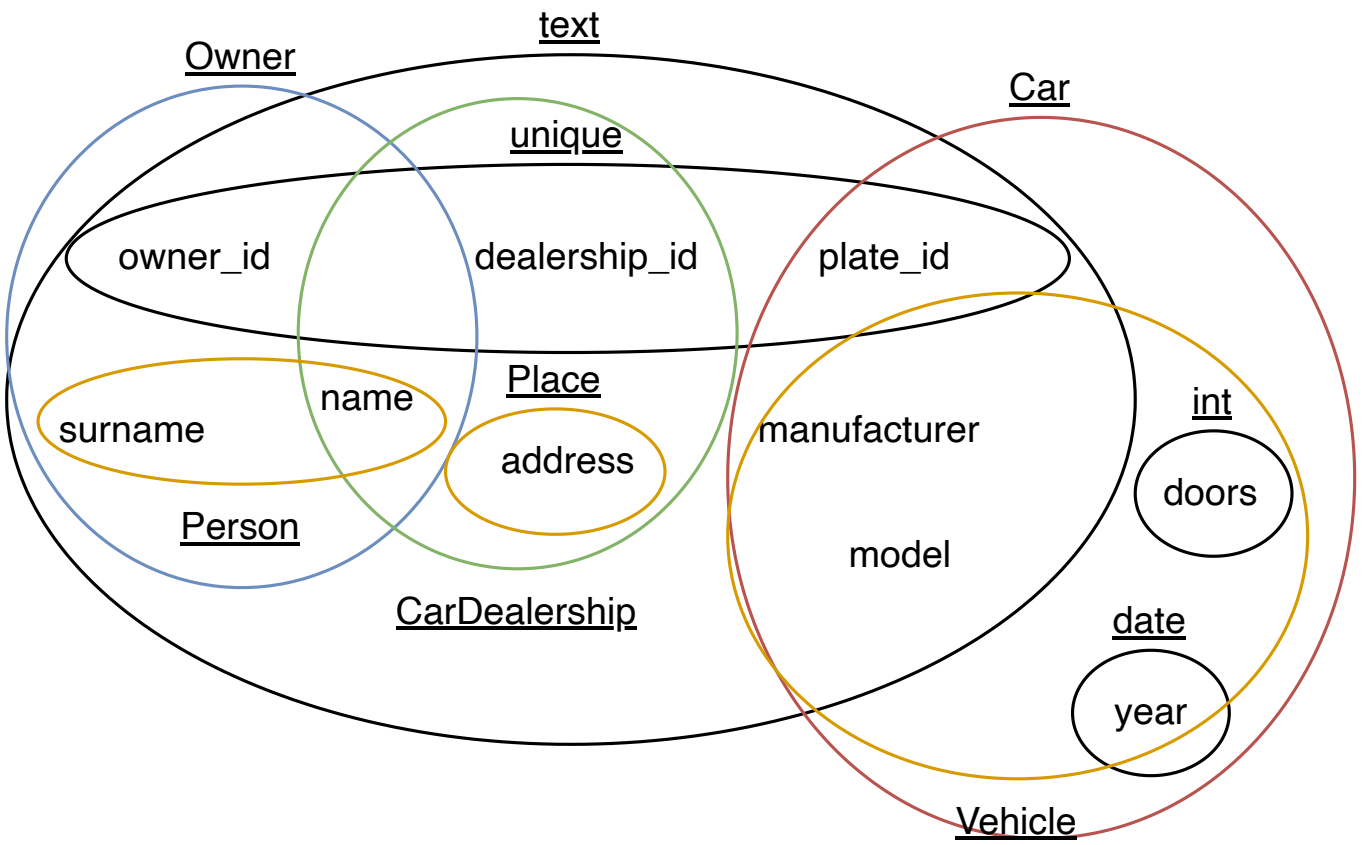
"A student is characterized by a unique code, name, and surname, it can be enrolled in no or more than one course, it can have given an exam more than once. A course is characterized by an id, a title, the code of the degree it is taught in, a start and end date, and a description, a course is taught by a teacher, characterized by an id, name, surname, and a type. Lastly, an exam is characterized by an id, a starting, and ending date, the mark given and it refers to the student and relative course."

"Students and Teachers are a kind of Person, both commonly characterized by a name and a surname."
"Exam and Course are a kind of Event, both commonly characterized by a starting and ending date."

Exercise


Person
PK
name : text
surname : text
Vehicle
PK
doors : int
manufacturer : text
model : text
year : date
Place
PK
address : text
Owner
PK
owner_id : text
1
Owns
Car
PK
plate_number : text
FK
owner_id : text
FK
dealership_id : text
SoldBy
1
Car dealership
PK
dealership_id : text
address : text
name : text

Exercise



Owns = Owner X Car

SoldBy = Car X CarDealership

Person ⊆ Owner
Place ⊆ CarDealership
Vehicle ⊆ Car

Index

- Intuition
- Wordnet (an alphabet semi-formal model)
- ER models (a knowledge semi-formal model)
- EER models (a knowledge semi-formal model)
- **Relational DB (a data semi-formal model)**
- Natural language (an alphabet, knowledge and data informal model)

Relational DB - Informal definition

- In general, a database is an organized collection of data. Relational DBs are databases that are based on the relational model.
- Data in a Relational DB is organized in tables. Each table represents one entity type, the rows of the table represent instances of that entity type, and the columns are their attributes.
- Each row has its own unique key, used to identify it.
- Rows can be related/linked to other rows by adding a column for the primary key of the row they are related/linked to.

Type of facts described in Relational DB

- Relational DBs are a data Reference model; they deal mainly with instances of entities, their properties and to which classes they belong.

- So, the facts that it describes are in the form:

$$e_j \in C_j$$

$$< e_1 , \dots , e_n > \in R^n$$

Example

Enrollment	
student_code	course_id
22036	247091
22048	155840

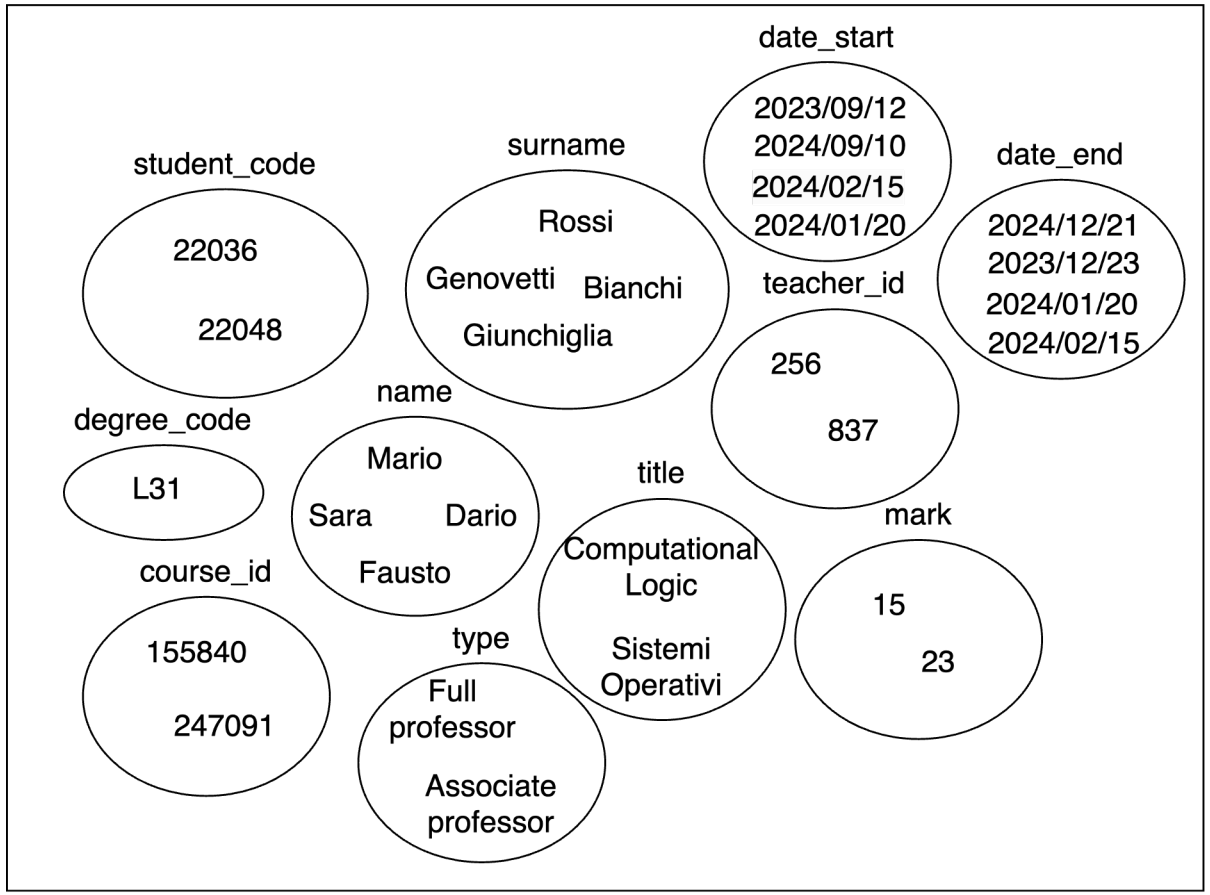
Student		
student_code	name	surname
22036	Mario	Rossi
22048	Sara	Bianchi

Course						
course_id	title	degree_code	teacher_id	description	date_start	date_end
155840	Computational Logic	L31	256	---	2024/09/10	2024/12/21
247091	Sistemi Operativi	L31	837	---	2023/09/12	2023/12/23

Teacher			
teacher_id	name	surname	type
256	Fausto	Giunchiglia	Full professor
837	Dario	Genovetti	Associate professor

Exam					
exam_id	student	course	mark	date_start	date_end
1	22036	247091	15	2024/01/20	2024/01/20
2	22036	247091	23	2024/02/15	2024/02/15

Intended model



<22036, Mario, Rossi> ∈ Student
<837, Dario, Genovetti, AssociateProfessor> ∈ Teacher
…

Exercise

plate_number	doors	manufacturer	model	year	owner_id	dealership_id
HFS 6176	5	Tesla	Model 3	2017	ht-130	TS-7444

owner_id	name	surname
ht-130	Jhon	Black

dealership_id	name	address
TS-7444	Tesla Store	7444 E Hampton Ave Mesa, AZ 85209

Index

- Intuition
- Wordnet (an alphabet semi-formal model)
- ER models (a knowledge semi-formal model)
- EER models (a knowledge semi-formal model)
- Relational DB (a data semi-formal model)
- **Natural language (an alphabet, knowledge and data informal model)**

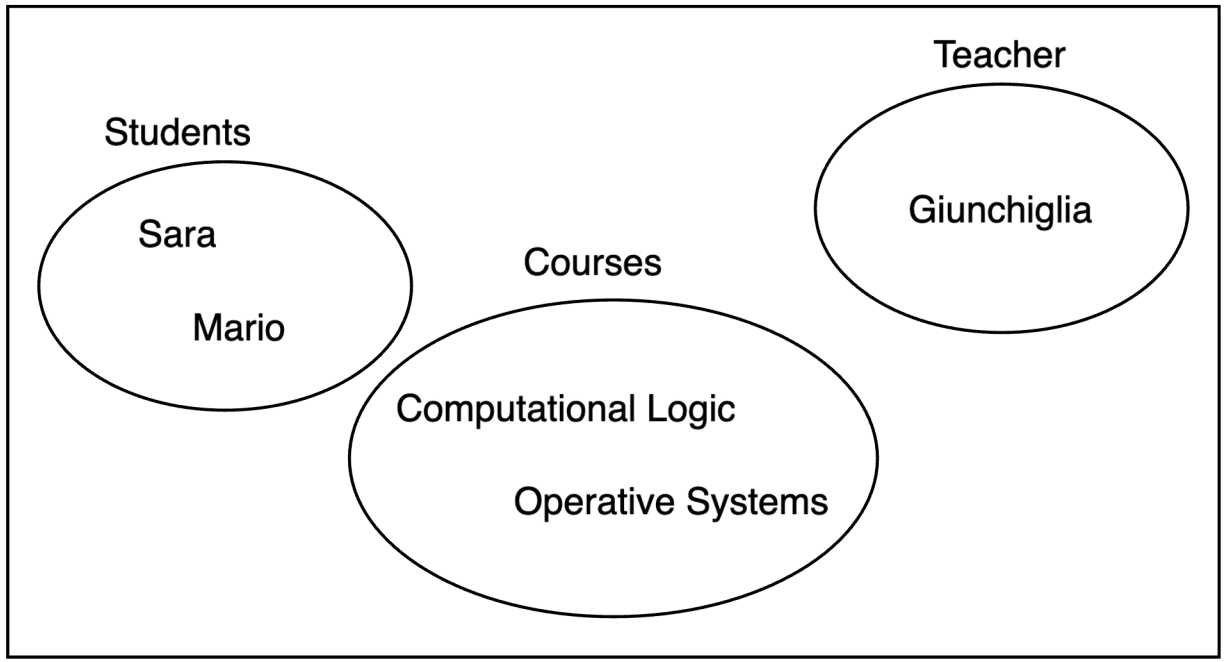
Intuition

- Natural language is an informal model because it has an informal language (L0).

- Natural language has the ability to represent anything. It can represent all that the other models can, but having an informal language, it is susceptible to ambiguity.
- Different from the type of models described earlier, natural language allows us to reason about what it represents.

Example

"Sara and Mario are students at UNITN. Sara is following the Computational Logic course given by full professor Giunchiglia, while Mario followed the Operative Systems course last year and has already taken the exam two times.



Exercise

«Un condominio è un tipo di edificio a più piani che contiene più abitazioni distinte, nello specifico il condominio Dante ha 5 piani, con 4 abitazioni per piano, si trova a Bolzano in Via Dante 19»

Key Notions

- Analogical representations
- Entities, properties, entity relations, etypes
- Percepts and Facts
- Reference models
- Wordnet
- ER models
- EER models
- Relational DB
- Natural Language

Reference Models

(T2MP)