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)

Analogic representations – Things

Observation (What can be seen in a picture: things). The core element of perception is **things**, where:

- Any thing can be clearly **distinguished** from any other thing, e.g., people, objects, dogs, hair;
- There cannot be two things in the **same** spatio-temporal coordinates;
- A thing moves **smoothly** in space-time (facilitates recognition in time);
- We see them multiple times, from **occurrences** (of things) to **things**, modulo ability to recognize two occurrences to be the same thing;
- Things are all **different** from one another (there are no two things which are identical);
- Things are all in **different** mutual relations.

We always perceive **multiple things**, that we can distinguish from one another, grounded in their space-time coordinates

Analogic representations – from Things to Entities

Observation (From things to entities). We call **entity** a single **thing** that we recognize as such,e.g., Sofia, a dog;

- The **specific entity** being recognized from the thing we perceive is largely **arbitrary.** For instance, what do you see in the picture on the right: an organism, an organism which is a alive, a person, a woman, a black person, a black woman, Sofia, a friend, an enemy a victim to kill, …?
- The first motivation underlying the selection of a specific entity is the **partiality** of the input. For instance: did you see the thing from the back, from far away, for a second, …?;
- The second motivation is your **background** (previous knowledge, memory): you are an alien, a social scientist analyzing a specific social phenomenon, a suprematist, a friend, a killer …?
- The third main motivation is the current **purpose**. For instance: you are looking for a form of life, for a friend, for Sofia?
- Partiality, background and purpose are element of the current **context (external, internal, motivational).**

Our perception of an entity out of a thing does not change, it is **stable**, and **as specific as possible**, given the current context. **But changes across contexts**. This is the main source **of representation diversity.**

Analogic representations – Entities

Observation (Entities). We have the following:

- **Entities**, that is, what we perceive from **things**,e.g., Sofia, a dog;
- **Entity types**, also called **etypes**, that is, **multiple entities which** somehow **look the same**, e.g., the etype woman, dog, tree;
- **Entity properties**, that is, **entities with certain characteristics**, e.g., a woman with blond hair, a dogs barking;
- **Property types**, that is, **multiple entities with certain characteristics**, similar among them, e.g., two women with blond hair, two dogs barking;
- **Entity Relations**, that, is **multiple entities in some relation among them**, 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;
- **Relation types**, that is, **groups of multiple entities in some relation among them**, similar among them, e.g., two groups of a man and woman talking to one another with a phone, two couples woman and man, both with a dog in between.

Relations and properties are **identified after** the **identification** of the entity: Do you see a woman which is black (together with a white one) or a black woman?

Analogical representations – Sameness vs. difference

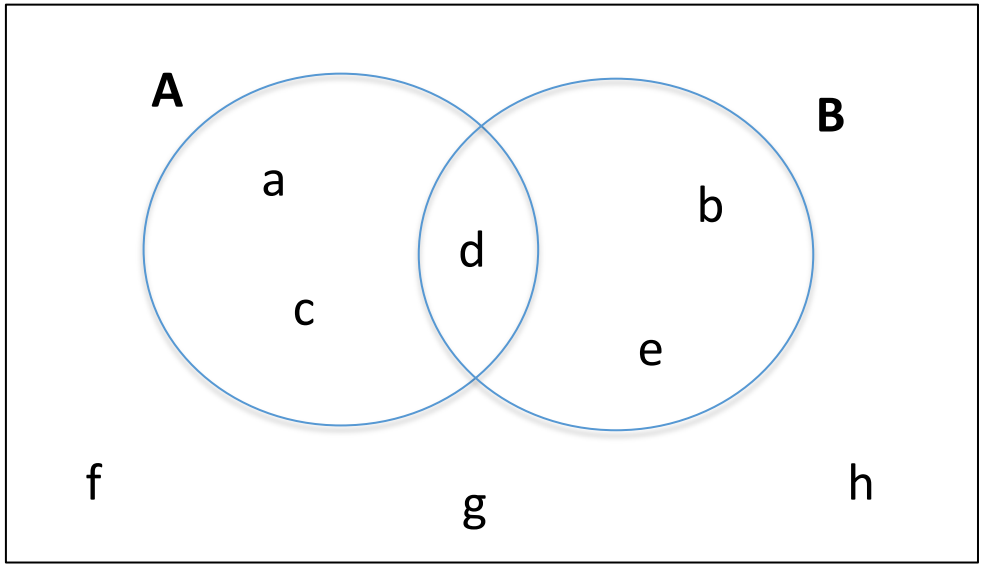
Observation (Entity sameness). Entities are identified by a set of properties which always hold about them. For instance, a black person is no longer a black person if it changes the color of his/he skin.

Observation (Entity difference). What makes an entity identical to itself (more or less, from your selected point of view) makes it different from every other entity:

- We must **distinguish** any **entity occurrence** from any other entity occurrence;
- Given **two distinct occurrences of two entities**, we must decide whether they are occurrences of the **same** entity or of two **different** entities (the two entities must be different if perceived at the same time);
- Given **two distinct entities**, we must decide whether they are members of the **same** etype or of two **different** etypes;
- Given **two distinct entity tuples**, we must decide whether they are the **same** tuple or of two **different** tuples;
- Given **two distinct entity tuples**, we must decide whether they are members of the **same** property type or relation type or of two **different** property types or relation types.

equality / inequality
vs.
similarity / dissimilarity
vs.
sameness / difference
of entities

An analogical representation -What do you see?



Intuition (Analogic representations in set theory). We model analogic representations using **sets,** where things are modeled as **single elements** and groups of things with properties or relations in common are modeled as **sets**.

Percepts – Intuition

Intuition (percept) A **percept** is an entity or a combination of entities which is perceived as distinct from others.

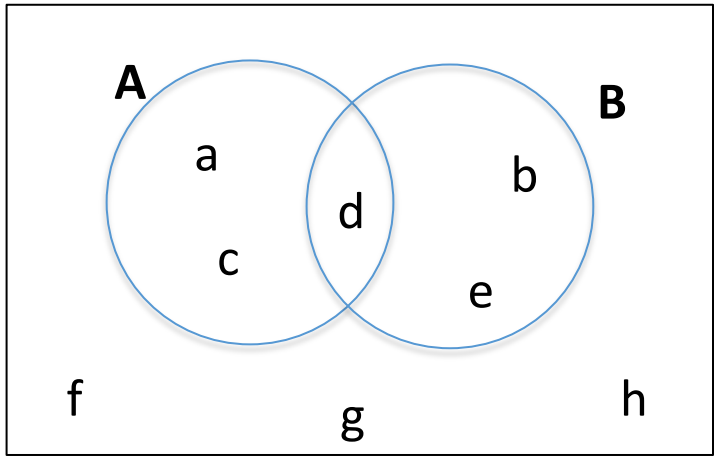
Examples: The percepts described by the sentences below

1. An *entity* you know *(e.g., Rocky)* or don't know (e.g., *woman#1*)
2. The *etype People* populated by entities who are persons (an etype)
3. The *property blond holding* of a *blond* entity (e.g., *person#1)*
4. The *property type blond* holding of the people who are blond (a property of a subset of the etype *people*)
5. The *relation near* holding of Sofia when *near* Paolo (a relation between entities)
6. The *relation type "talking to"* holding of *women talking to men* (a relation between two subsets of the two etypes *woman* and *man*)

Percepts - definition

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

- **Entities,** $e_1, \ldots, e_n$, perceived as distinct *units* (in space and time, e.g., Sofia);
- **Entity properties,** $P_1, \ldots, P_n$, perceived as *relations* between entities (e.g., Sofia is blond)
- **Entity relations,** $R_1, \ldots, R_n$, perceived as *n-ary relations* among entities (e.g., Rocky is between Sofia and Mark)
- **Etypes,** $E_1, \ldots, E_n$, as *classes* of entities, (e.g., person)
- **Property types,** $P_1, \ldots, P_n$, as *classes* of tuples of entities (e.g., Swedish people are blond)
- **Relation types,** $R_1, \ldots, R_n$, as *classes* of tuples of entities (e.g., breaks happen between lectures)



Facts - Intuition

Intuition (Fact) A **fact f** is something, involving percepts, happening at certain spacetime coordinates.

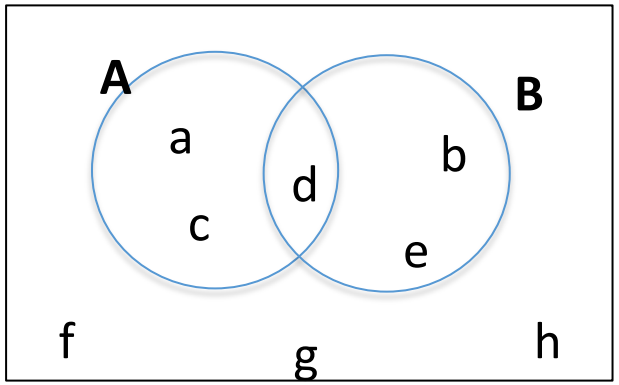
Example (fact). Facts involving percepts and facts denoted by the sentences below

- *Spacetime invariant facts,* e.g., dogs are animals, a woman is a person
- *Time invariant facts,* e.g., there is a church in Trento near the square
- *Space invariant facts,* e.g., moving across continents requires flying
- *Spacetime variant facts,* e.g., Sofia has blond hair, Sofia is a friend of Paolo, Sofia is walking, Paolo is talking to Sofia

Facts – intuition (continued)

Observation 1 (Fact). A **fact** is a **relation** between percepts. All and only the facts are as follows

- A **MemberOf** relation
  - between a unit and a class
  - between a tuple of units and a relation
- A **SubsetOf / SupersetOf** relation
  - between two classes
  - between two relations
  - between a n-ary relation and a tuple of n classes



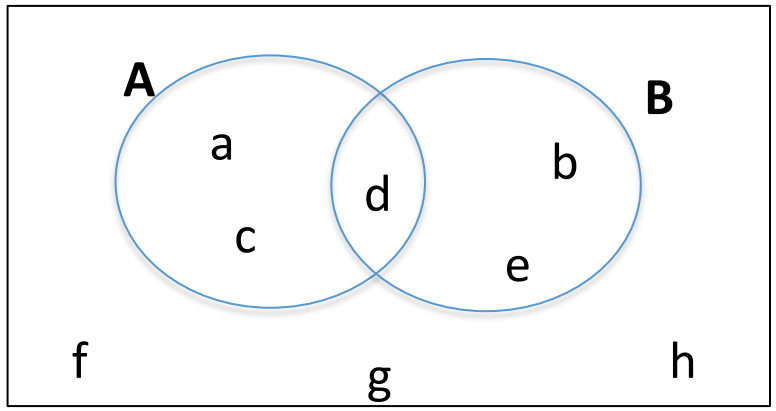
Facts - definition

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

- *Unit memberOf Class:* $u_i \in C_j$,
- *Tuple of Units memberOf relation:* $< u_1, \ldots, u_n > \in R^n$,
- *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: $u_i \in U$, $C_i \subseteq U$, $R^n \subseteq U \times \ldots \times U$.

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.

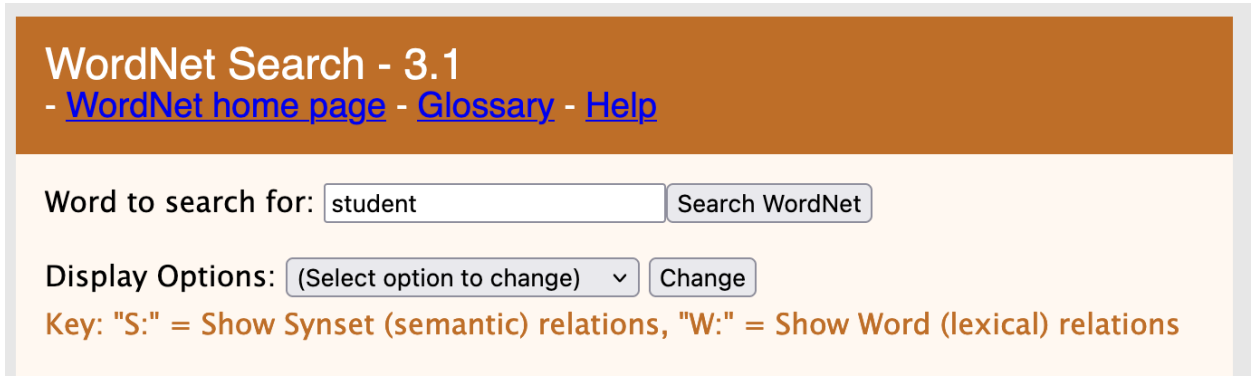
- The intended analogical representation is always left implicit (often called the "intended meaning").
- Some, so called **semi-formal models** (as used in Computer Science) use type L1, L2, L3 languages, as from the Chomsky hierarchy, typically graph languages
- Others, so called **informal models**,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

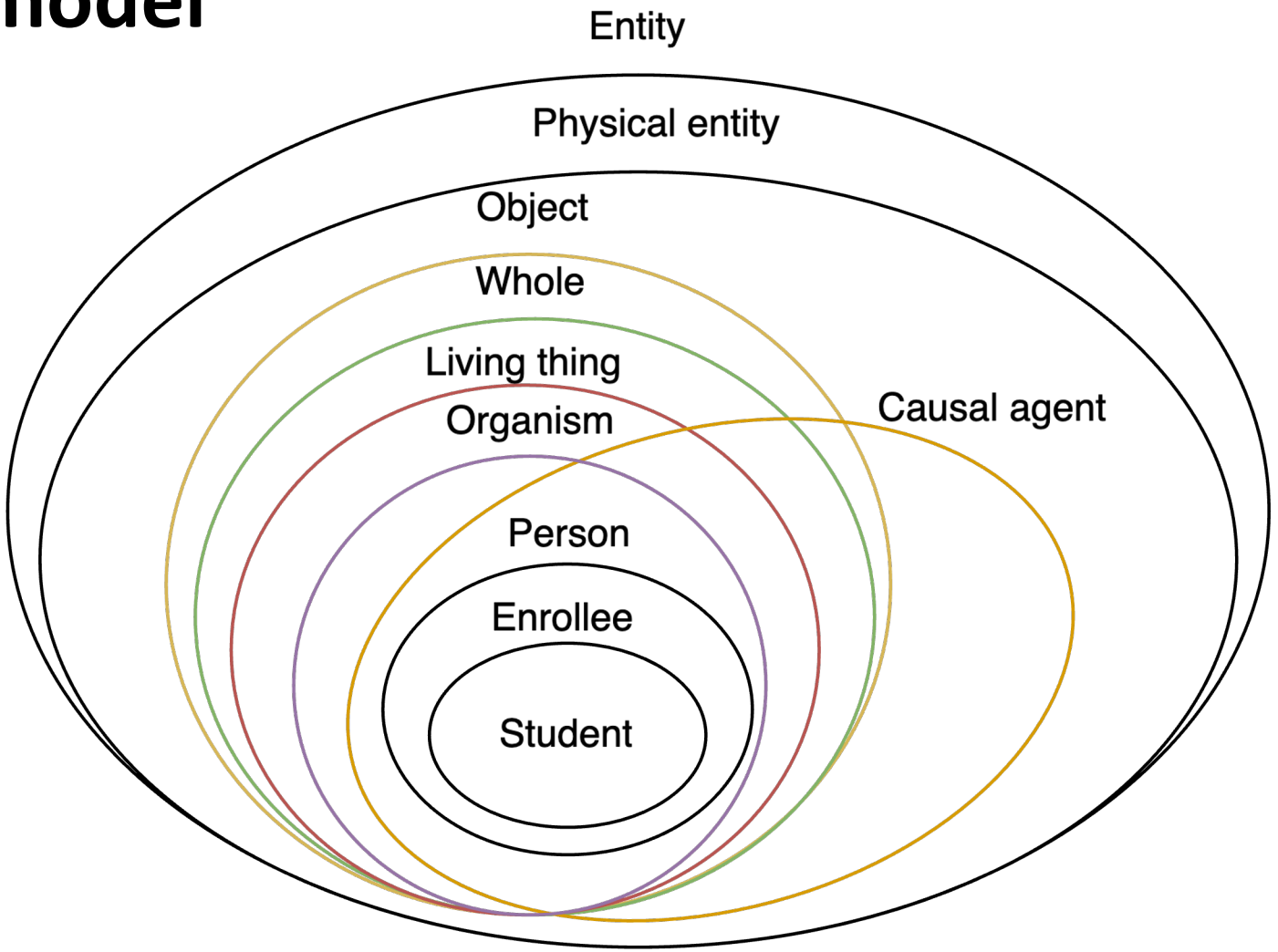
$$C_i \subseteq C_j$$

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

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

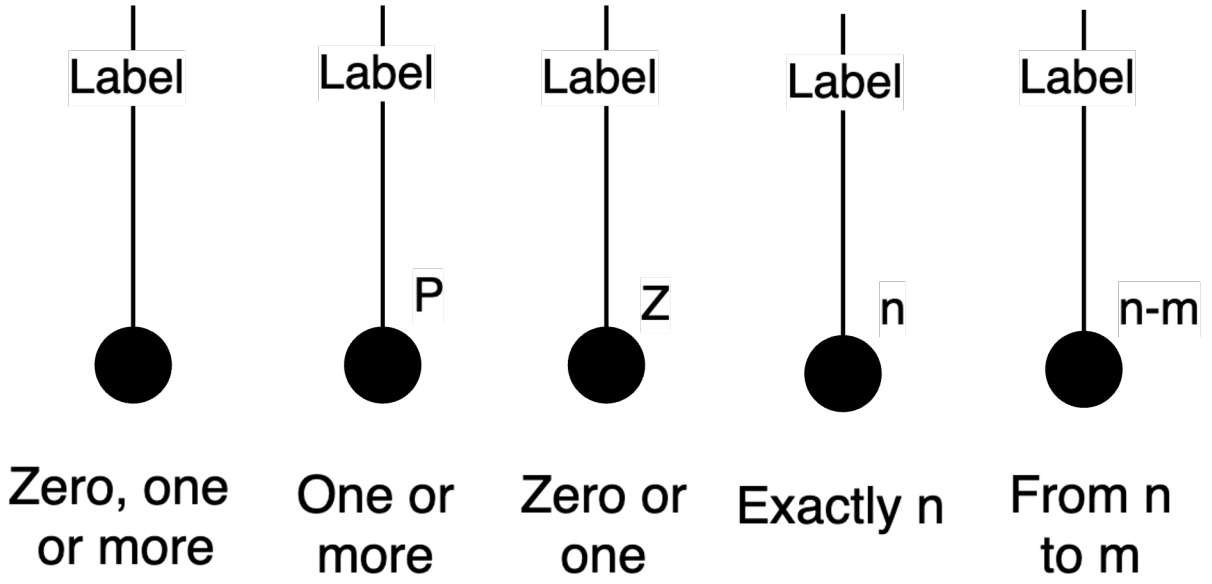
- S: (n) coldness, **cold**, low temperature, frigidity, frigidness
  - *direct hyponym* / *full hyponym*
  - *direct hypernym* / *inherited hypernym* / *sister term*
    - S: (n) temperature
      - S: (n) fundamental quantity, fundamental measure
        - S: (n) measure, quantity, amount
          - 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

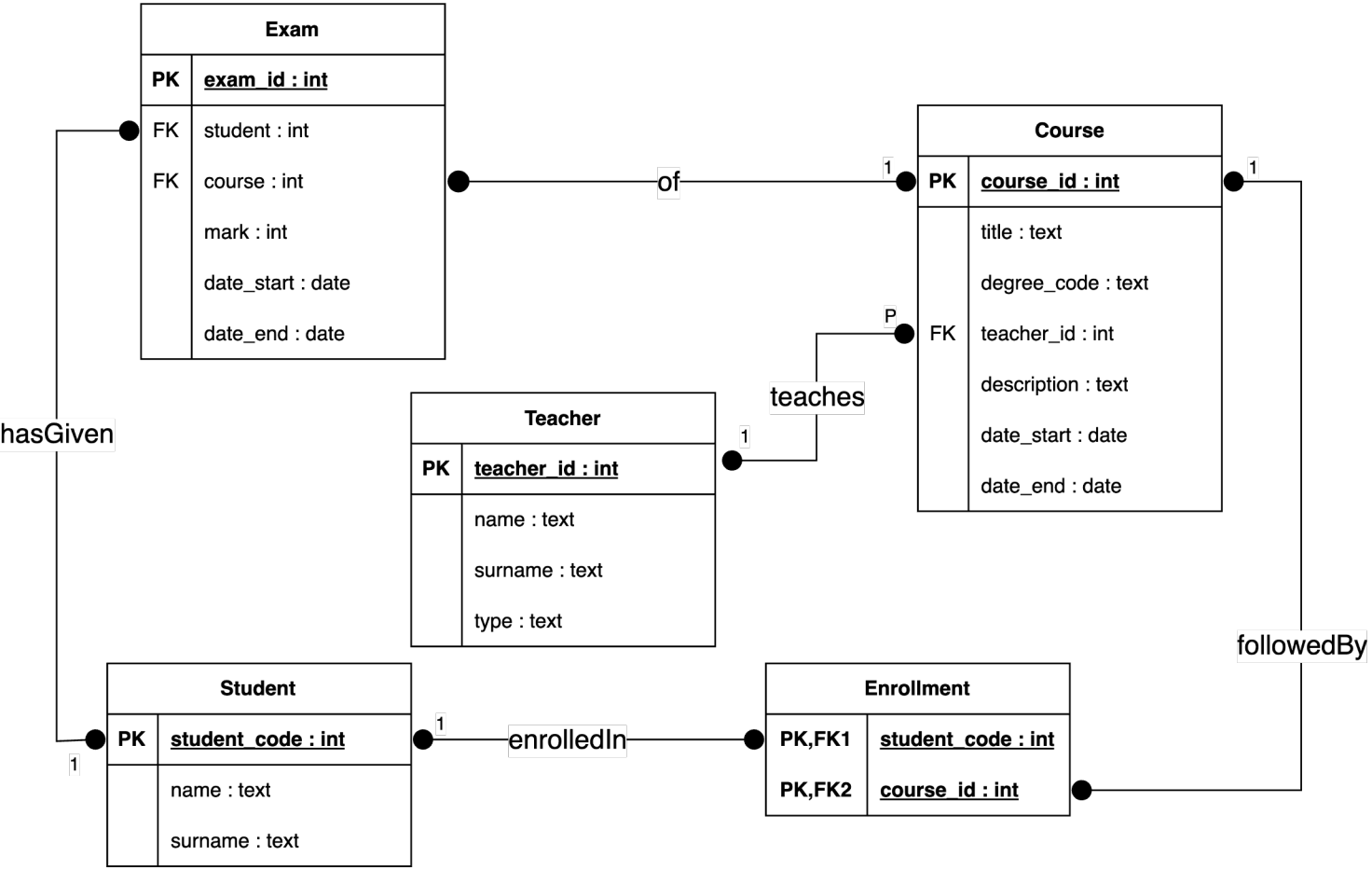
- ER diagrams are knowledge reference models, tables describe a class of entities with their properties, and the arrows represent relationships between the defined classes.

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

$$C_i \subseteq C_j$$

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

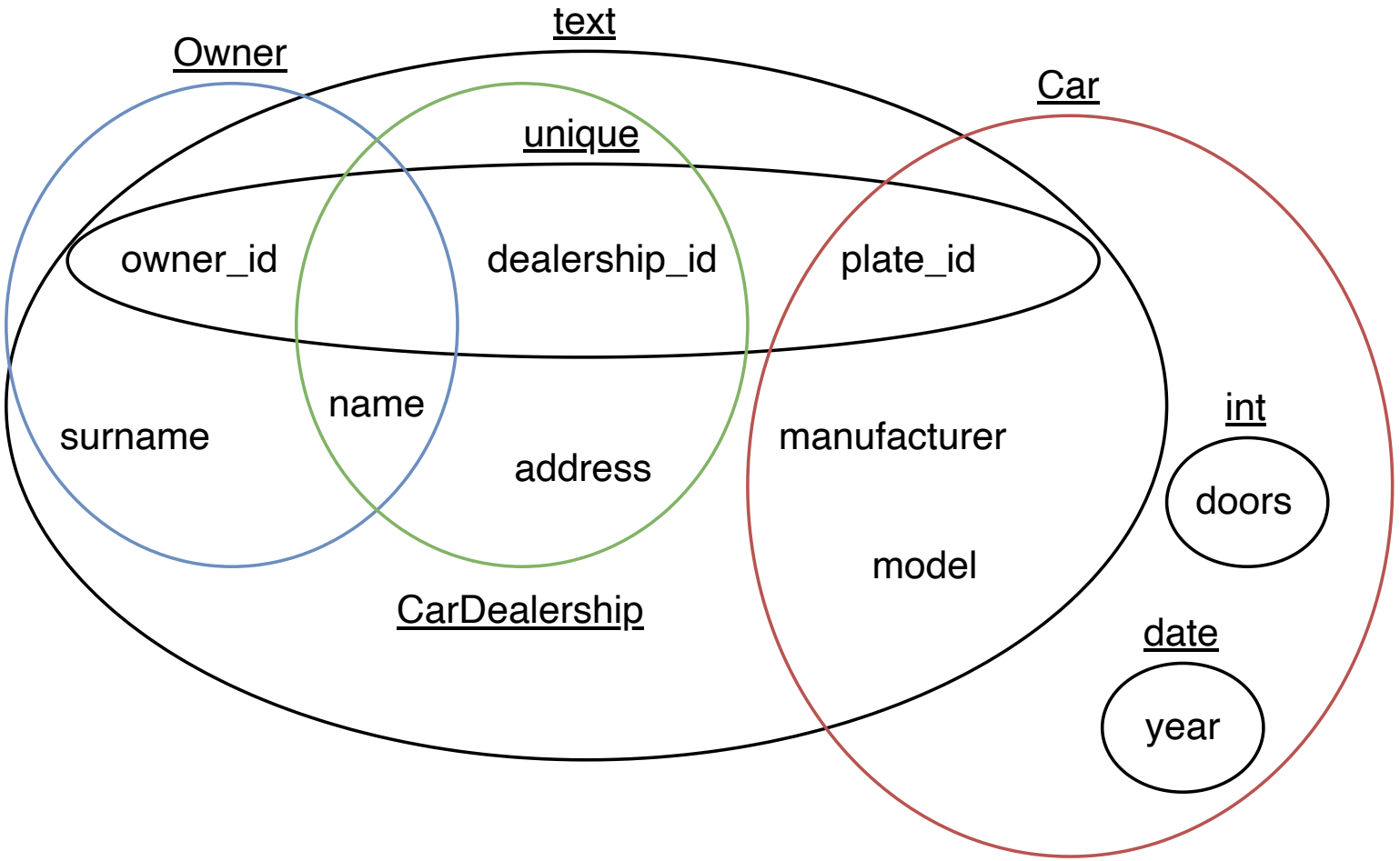
Example



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."

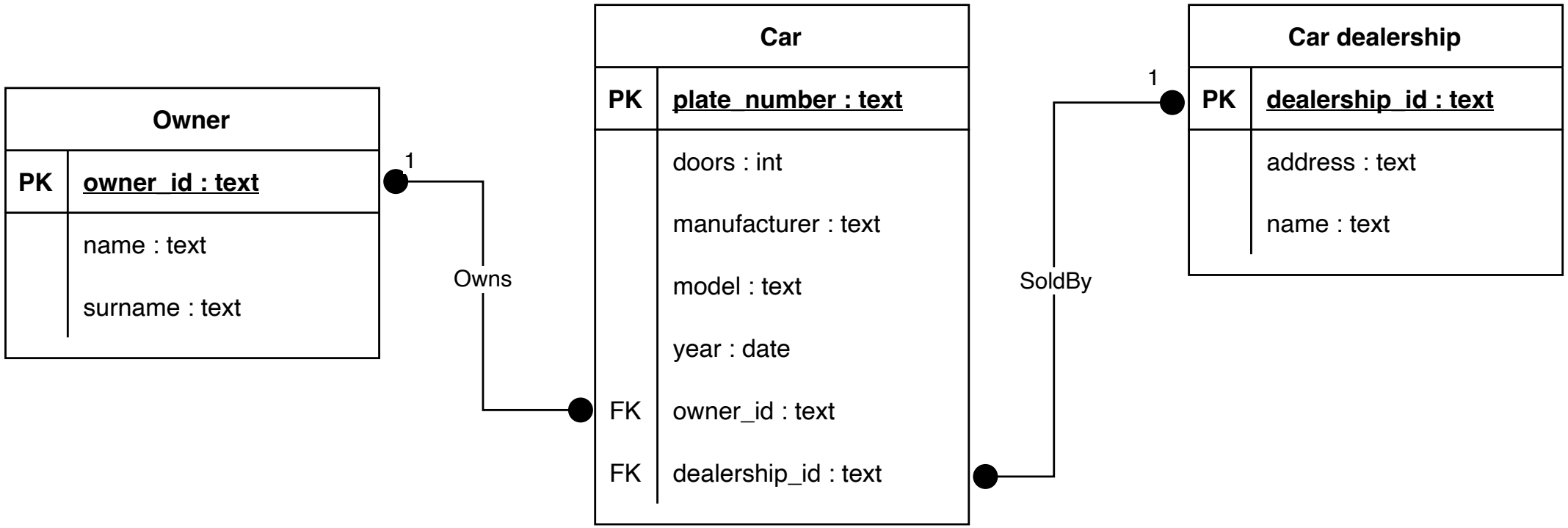
Exercise



Owns = Owner X Car

SoldBy = Car X CarDealership

Exercise

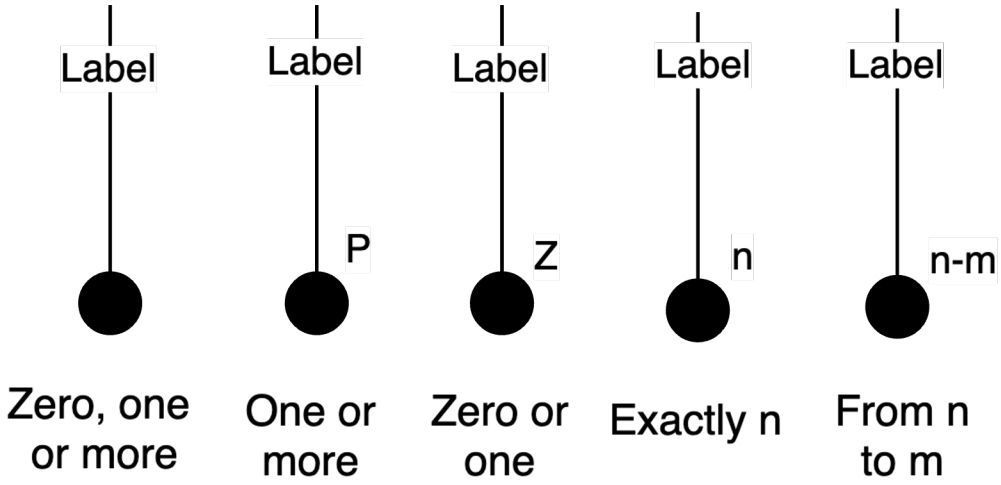

Owner
PK
owner_id : text
name : text
surname : text
1
Owns
Car
PK
plate_number : text
doors : int
manufacturer : text
model : text
year : date
FK
owner_id : text
FK
dealership_id : text
SoldBy
1
Car dealership
PK
dealership_id : text
address : text
name : text

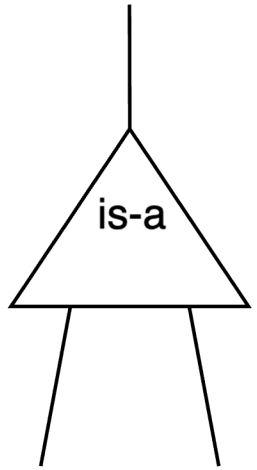
Index

- 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

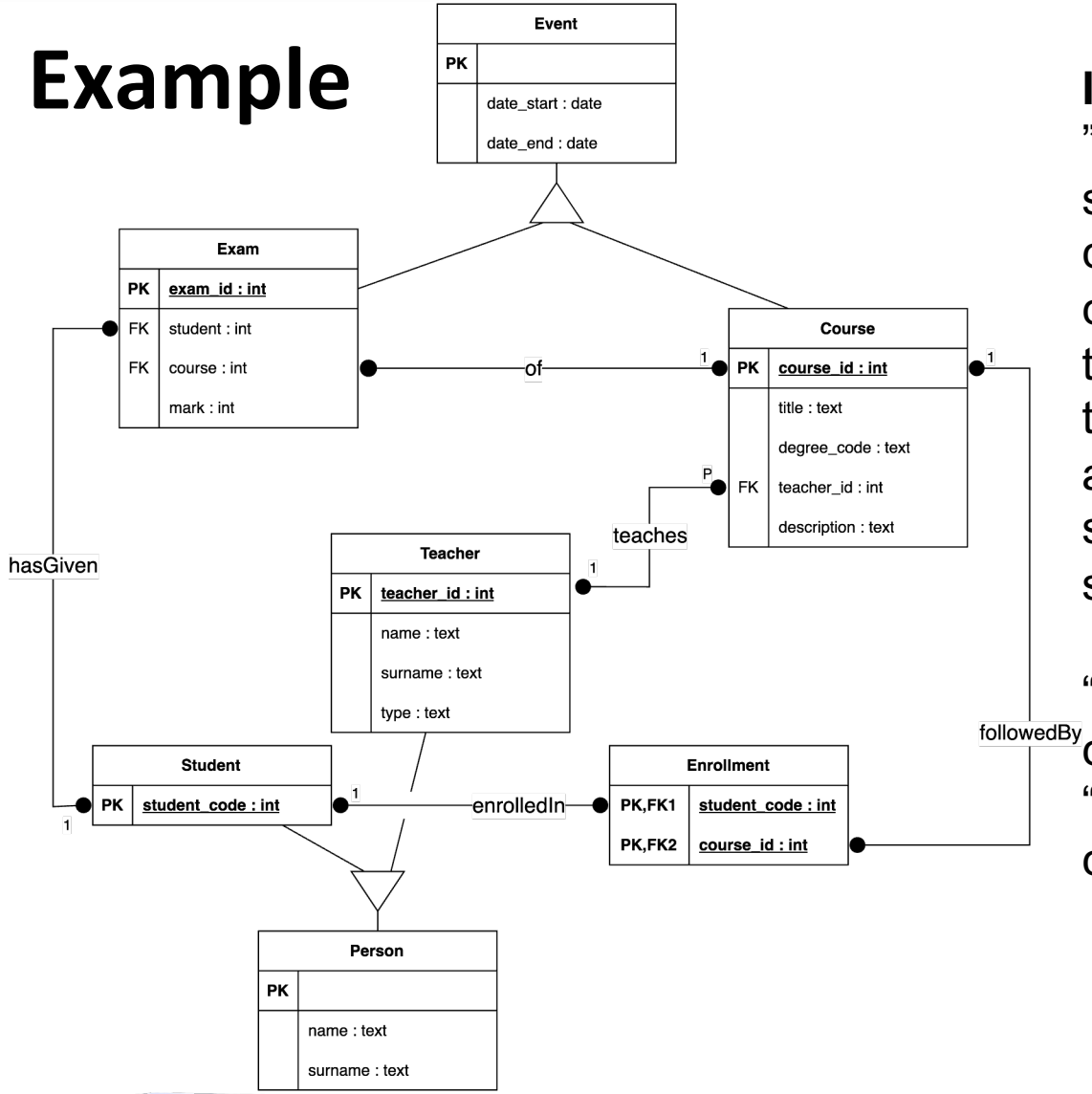
- EER diagrams represent the same things as ER diagrams, plus the subtype-supertype relationships between the classes.

- 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

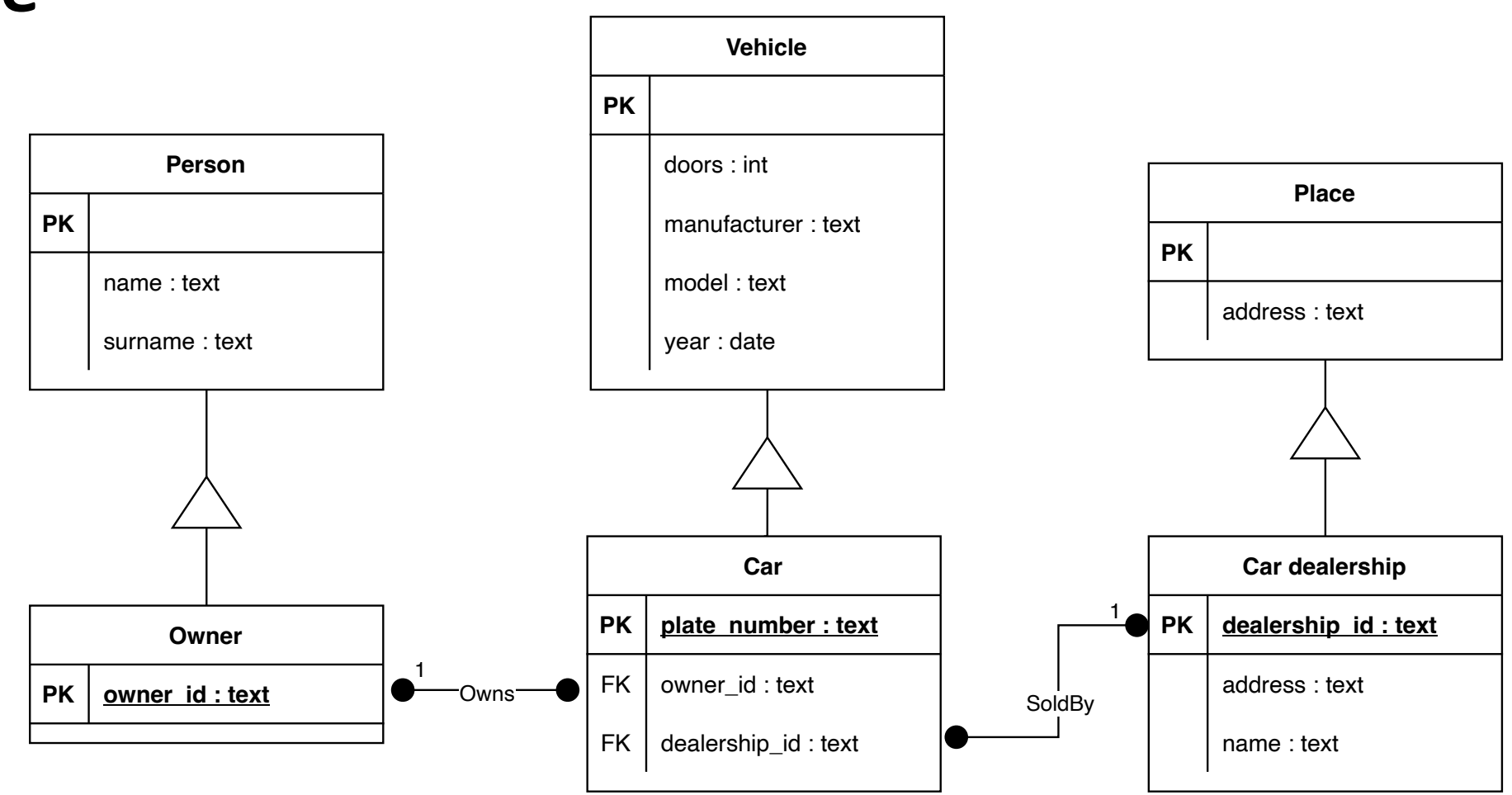


Intended model

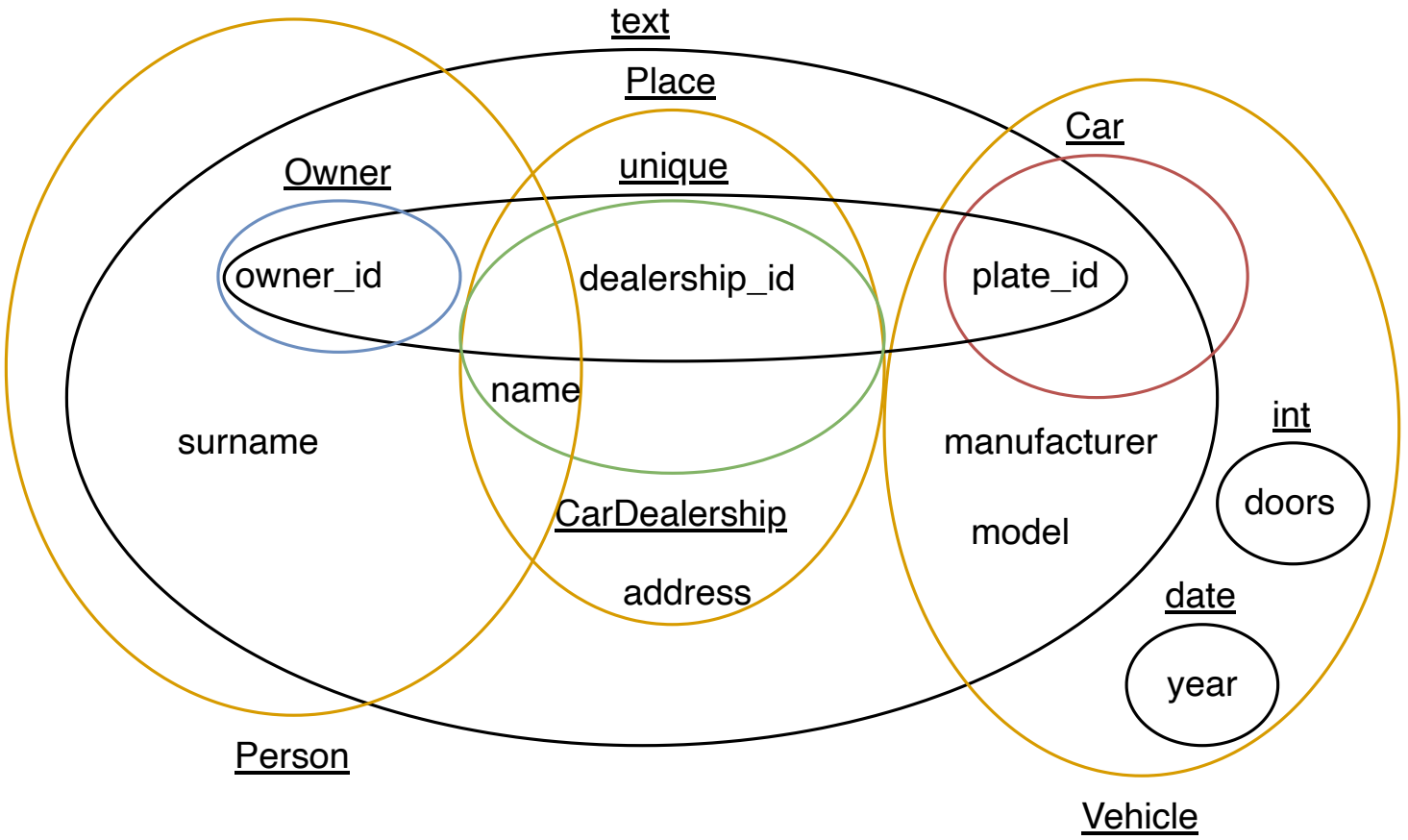
"A student is characterized by a unique code, name, and surname, it can be enrolled in no or more than one course, it can have given an exam more than once. A course is characterized by an id, a title, the code of the degree it is taught in, a start and end date, and a description, a course is taught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

Owner ⊆ Person
CarDealership ⊆ Place
Car ⊆ Vehicle

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

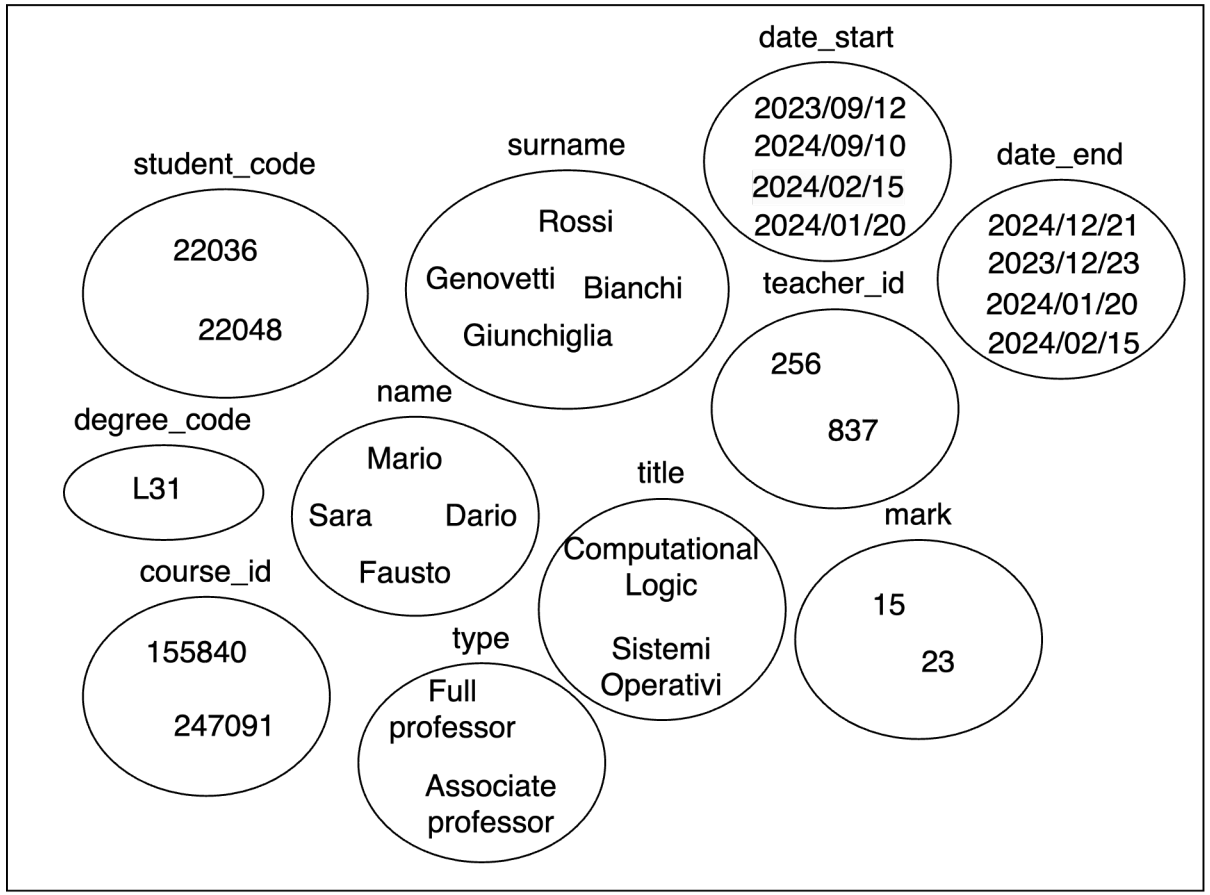
Student		
student_code	name	surname
22036	Mario	Rossi
22048	Sara	Bianchi

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)**

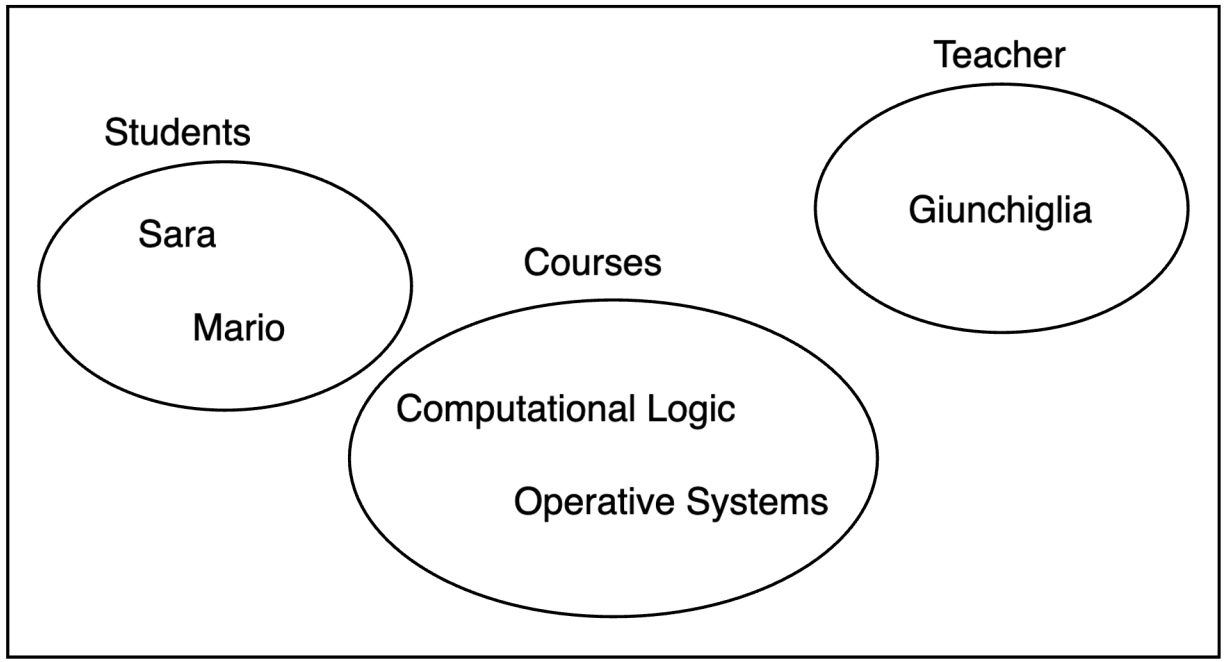
Intuition

- 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)