Databases
Lab

Conceptual Design

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Entity Relationship Diagram Software

- Lucidchart
- Gliffy
- Visual Paradigm
- Creately
- SmartDraw
- Draw.io
- SqlDBM
- Microsoft Visio
- Edraw Max Online
- Cacoo

Draw.io

https://app.diagrams.net

- Free to use, no-sign up, platform independence web application.
- It allows creating E-R diagrams that meet the graphic rules seen during the theory lessons.
- This is what you will have to use during the exam.

Exercise 1: step-by-step specs (1)

We want to model a system for the management of medical visits to be carried out in different medical clinics.

- Each visit is carried out in one, and only one clinic.
- A clinic is identified by a unique code and has an address and a phone number.
- A clinic can host one or more visits.
- Each visit has a unique code and is carried out at a precise date and time.

…

Exercise 1: step-by-step specs (2)

...

- Each visit may require one or more specialists.
- Each specialist can carry out several visits.
- Each specialist is identified by a unique code and provides the list of his medical specialities, name, surname and phone number.
- Each specialist may need a set of tools.
- Each tool has a unique code and a description.
- A tool can be used by one or more specialists.

...

Exercise 1: step-by-step specs (3)

...

- Each specialist may need several collaborators, each of them is identified by a unique code and has a name and surname.
- A collaborator works with at least one specialist, and he may be responsible for using one or more tools.
- The same tool can be used by several collaborators (but also by no one).

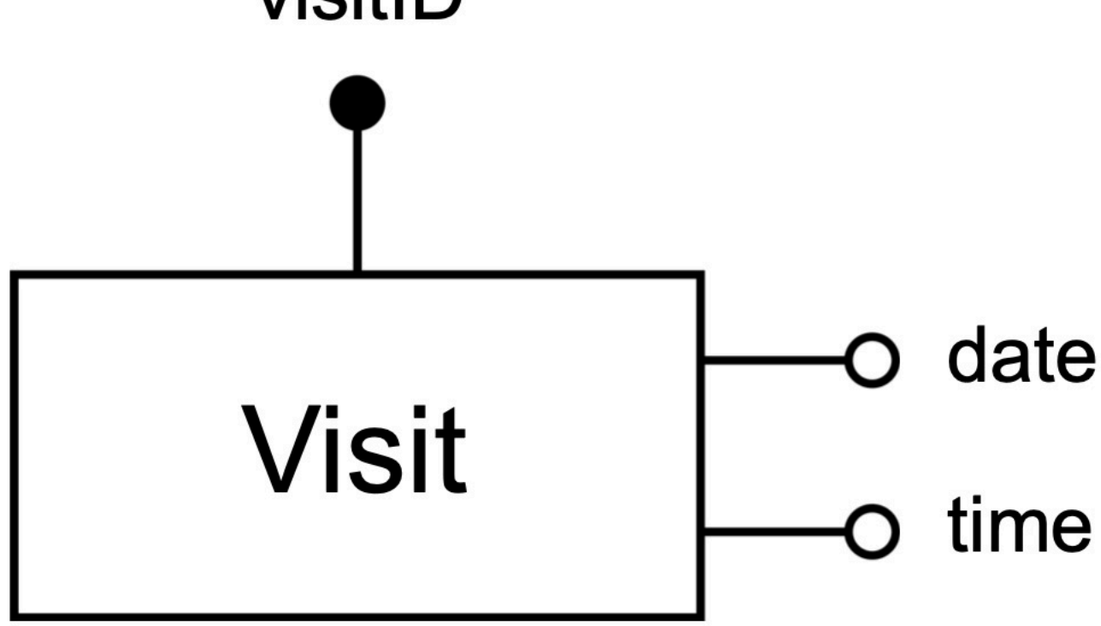
Exercise 1: entities

We can identify five different entities:

- **Visit**
- **Clinic**
- **Specialist**
- **Tool**
- **Collaborator**

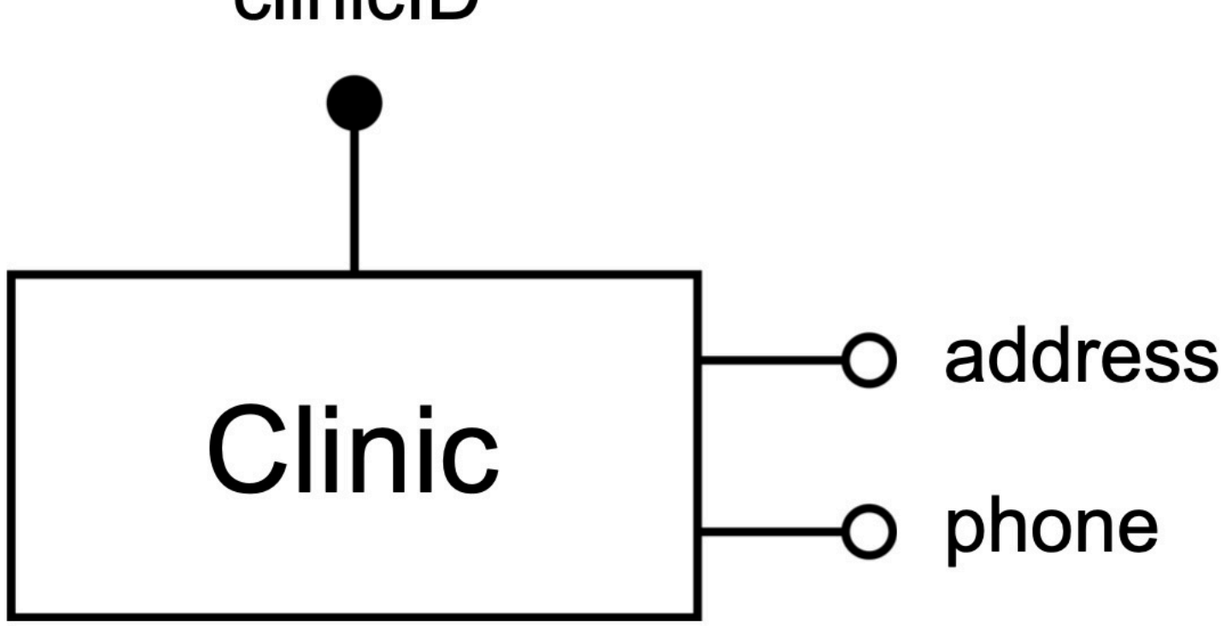
Exercise 1: *Visit*

"*Each visit has a **unique code** and is carried out at a precise **date** and **time**.*"



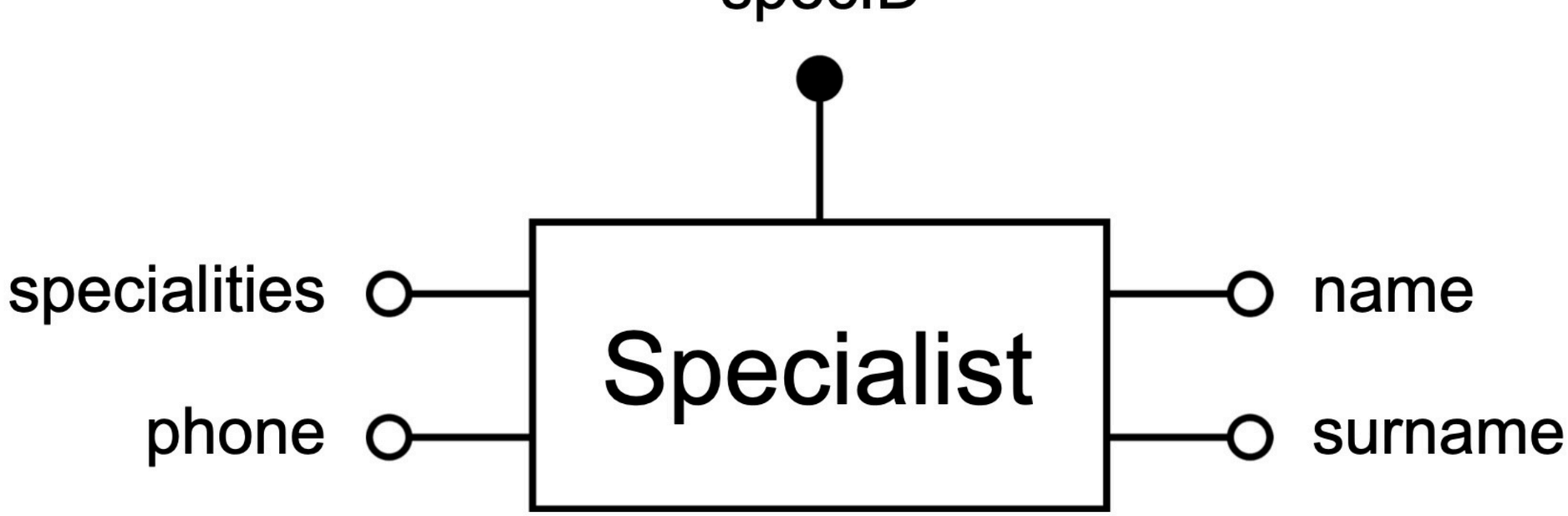
Exercise 1: *Clinic*

"*A clinic is identified by a **unique code** and has an **address** and a **phone number**.*"



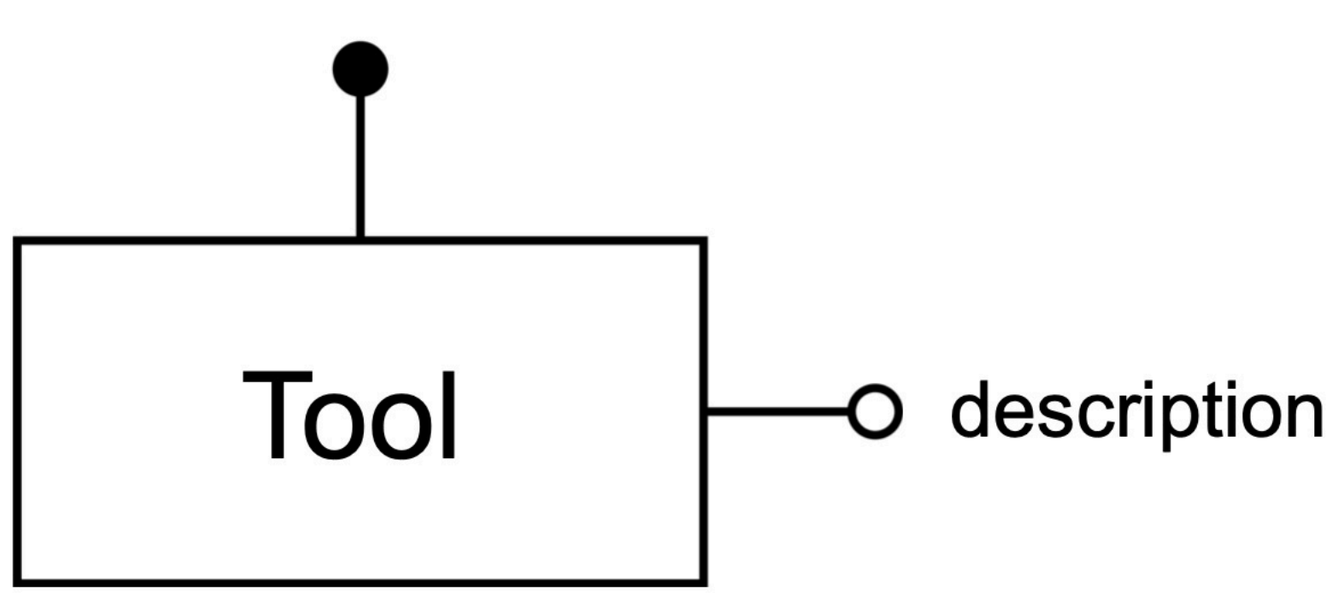
Exercise 1: *Specialist*

"*Each specialist is identified by a* ***unique code*** *and provides the* ***list of his medical specialities***, ***name***, ***surname*** *and* ***phone number***."



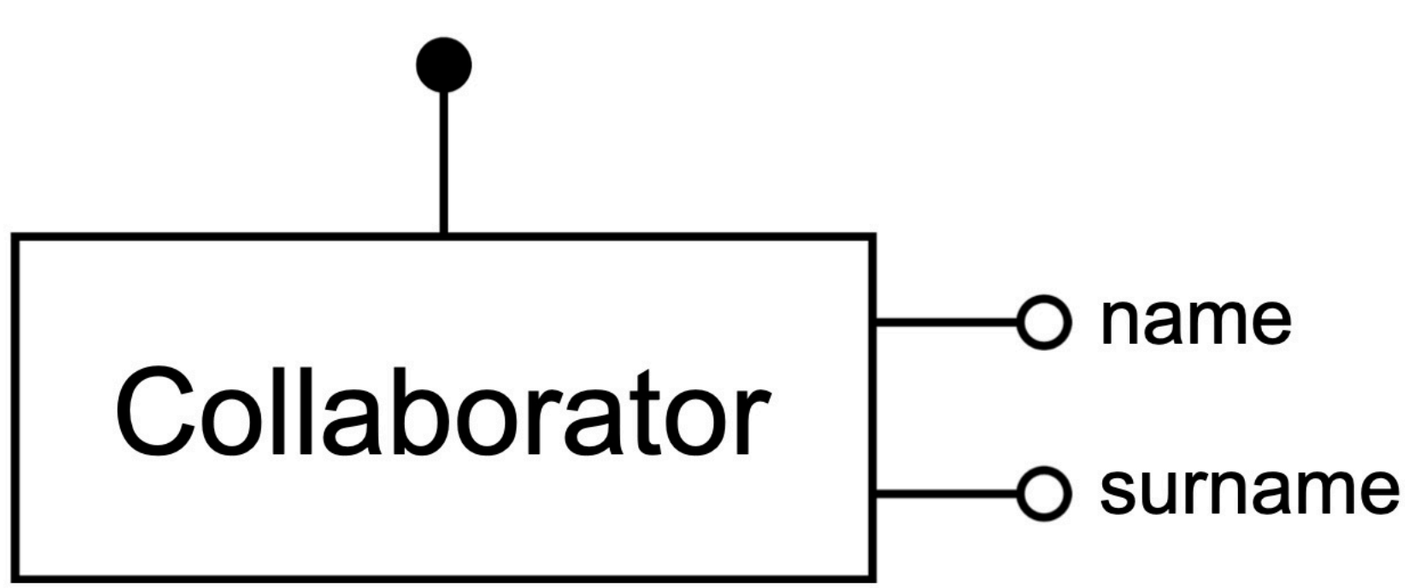
Exercise 1: *Tool*

"*Each tool has a **unique code** and a **description**.*"



Exercise 1: *Collaborator*

"*Each specialist may need several collaborators, each of them is identified by a* ***unique code*** *and has a* ***name*** *and* ***surname****.*"



Exercise 1: relationships

We can identify five relationships among entities:

- **Clinic - Visit**
- **Visit - Specialist**
- **Specialist - Tool**
- **Specialist - Collaborator**
- **Collaborator - Tool**

Exercise 1: *Clinic-Visit*

"*Each visit is carried out in* ***one, and only one*** *clinic.*"

Visit ⇒ Clinic

"*A clinic can host* ***one or more*** *visits.*"

Clinic ⇒ Visit

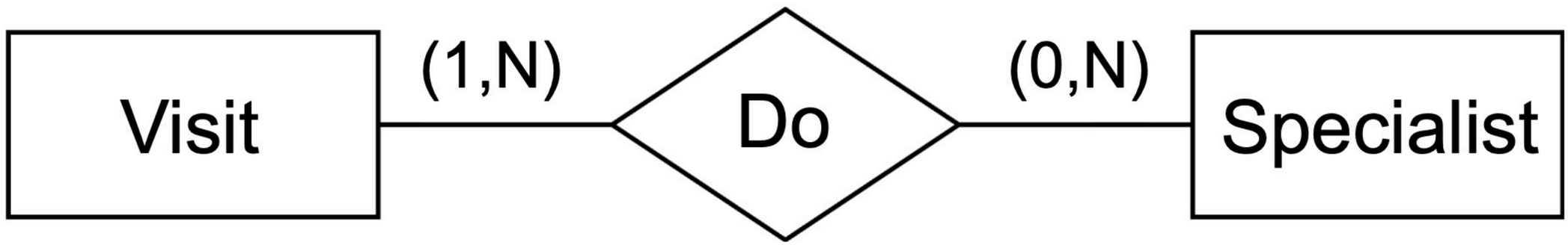
Exercise 1: *Visit-Specialist*

"Each visit may require ***one or more*** *specialists."*

Visit ⇒ **Specialist**

"Each specialist ***can*** *carry out* ***several*** *visits."*

Specialist ⇒ **Visit**



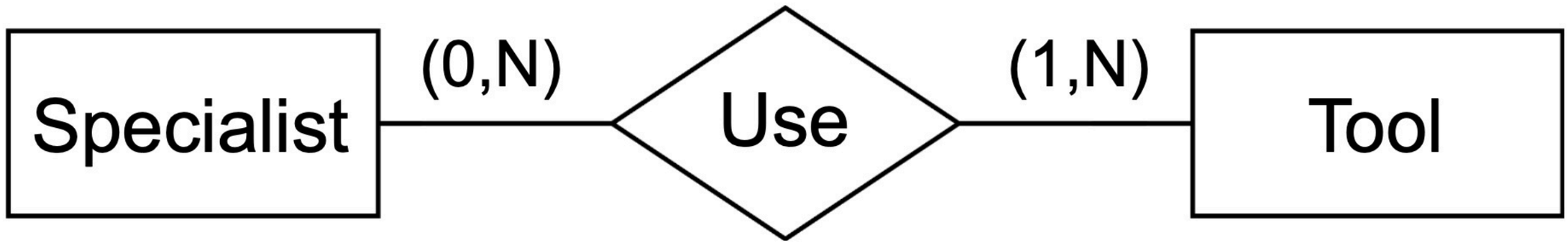
Exercise 1: *Specialist-Tool*

*"Each specialist **may need a set** of tools."*

Specialist ⟹ Tool

*"A tool can be used by **one or more** specialists."*

Tool ⟹ Specialist



Exercise 1: *Specialist-Collaborator*

*"Each specialist **may need several** collaborators, [...]"*

Specialist ⇒ **Collaborator**

*"A collaborator works with **at least one** specialist, [...]"*

Collaborator ⇒ **Specialist**

Exercise 1: *Collaborator-Tool*

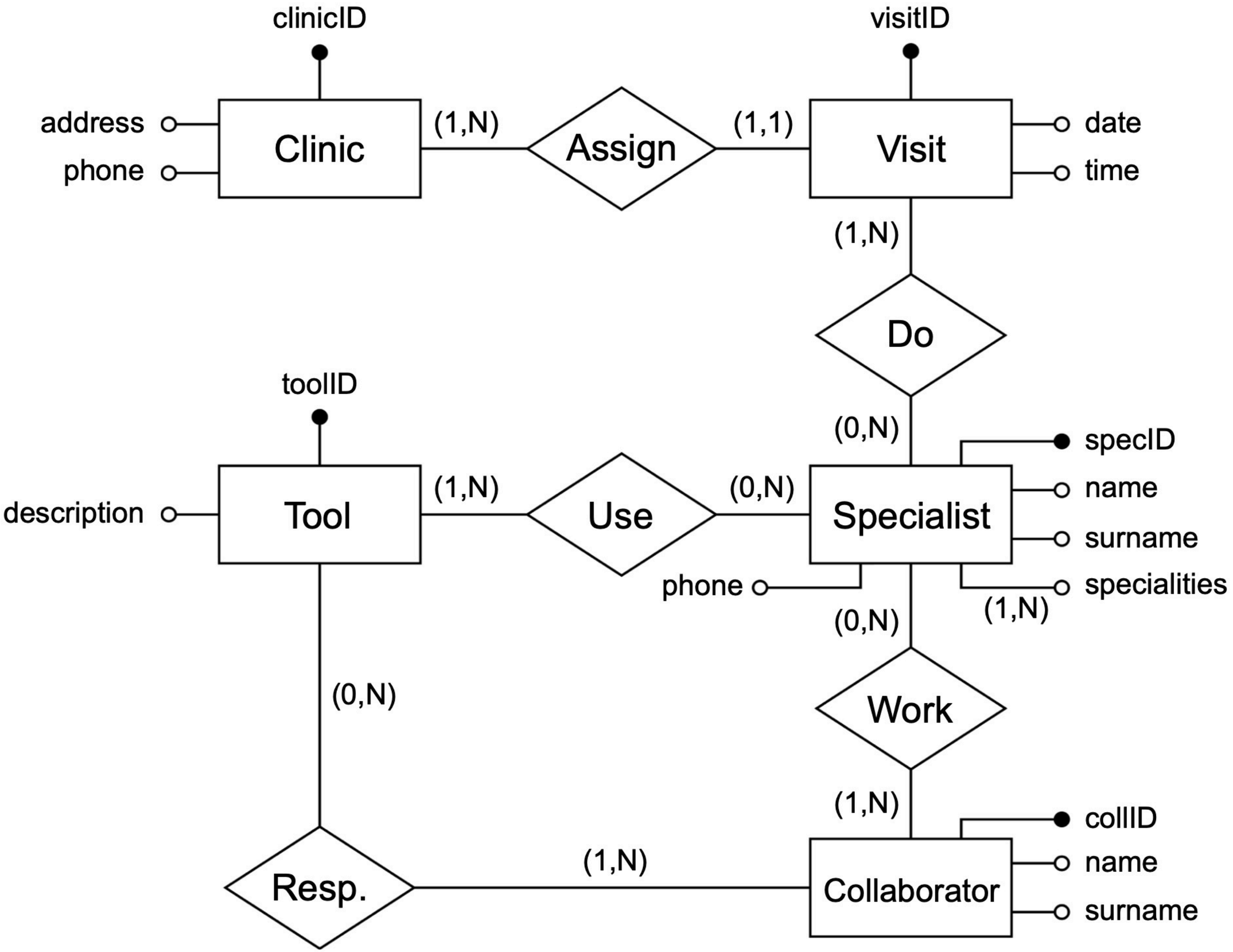
"[...] he may be responsible for using ***one or more*** *tools."*

Collaborator ⇒ **Tool**

"The same tool ***can*** *be used by* ***several*** *collaborators (****but also by no one****)."*

Tool ⇒ **Collaborator**

Exercise 1: final solution



Exercise 2: step-by-step specs (1)

We want to model a system for the management of a gym and its members.

- Each course has a unique name and a fixed price.
- We want to store name, surname and the phone number for all members involved in the gym (both trainers and members).
- Each member has an unique id.

…

Exercise 2: step-by-step specs (2)

…

- We want to know the clients' age to fit the exercises workload.
- Each course is taught by one or two trainers.
- Each course has a maximum number of attendees.
- Each member can buy one or more cards, and each card unlocks some courses that are thus purchased at a global price. The final price for each card must not exceed the sum of the prices of the included courses.

…

Exercise 2: step-by-step specs (3)

...

- Each client can enrol in a course without buying a card.
- Each card is identified by a progressive number, that is unique for each client. The number can be the same for different clients.

Exercise 2: entities

We can identify four different entities:

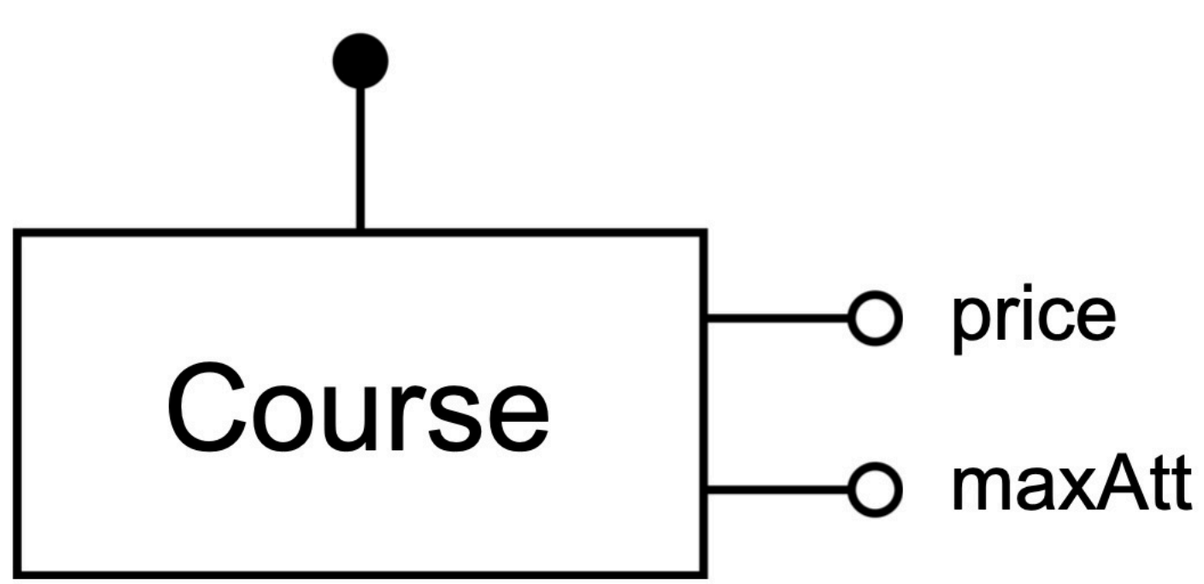
- **Course**
- **Trainer**
- **Client**
- **Card**

Trainer and Client together form a higher level entity, that is the Member. They can be represented through a **generalization**.

Exercise 2: *Course*

"*Each course has a **unique name** and a **fixed price**.*"

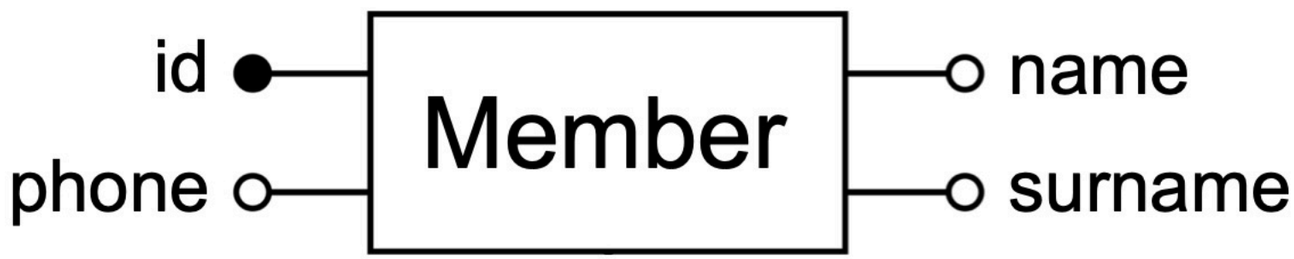
*"Each course has a **maximum number of attendees.**"*



Exercise 2: *Trainer & Client*

"*We want to store **name**, **surname** and the **phone number** for all members involved in the gym (both trainers and members).*"

"*Each member has an **unique id**.*"

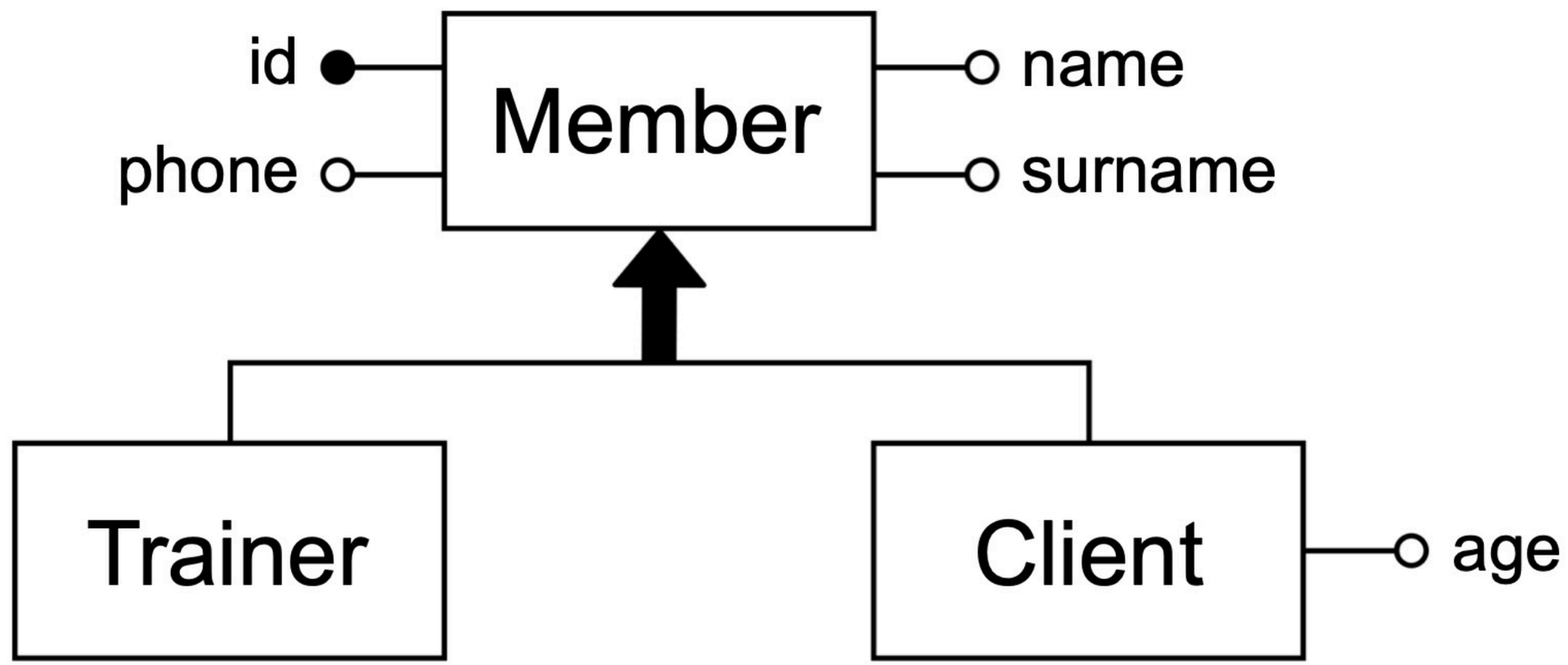


Exercise 2: *Trainer & Client*

"*We want to store **name**, **surname** and the **phone number** for all members involved in the gym (both trainers and members).*"

"*Each member has an **unique id**.*"

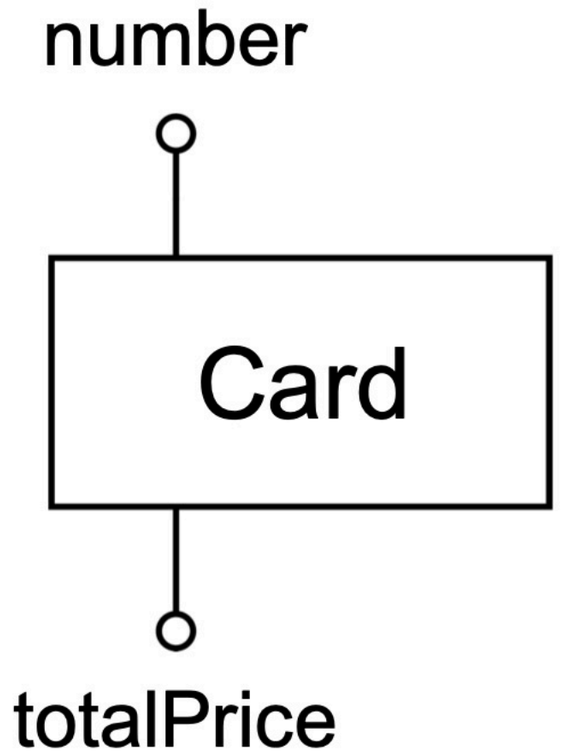
"*We want to know the clients' **age** to fit the exercises workload.*"



Exercise 2: *Card*

*"[...] and each card unlocks some courses that are thus purchased at a **global price**. [...]"*

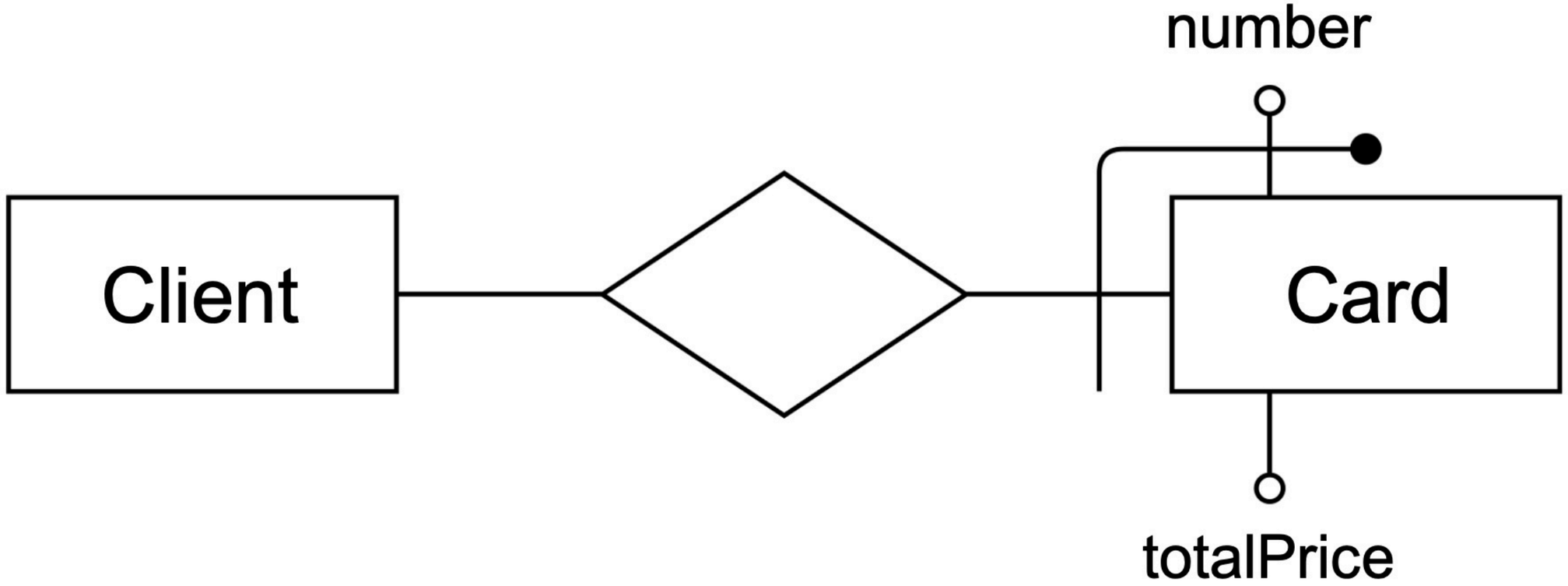
*"Each card is identified by a **progressive number**, that is unique for each client."*



Exercise 2: *Card*

*"[...] and each card unlocks some courses that are thus purchased at a **global price**. [...]"*

*"Each card is identified by a **progressive number**, that is unique for each client. The number can be **the same for different** clients."*



Exercise 2: relationships

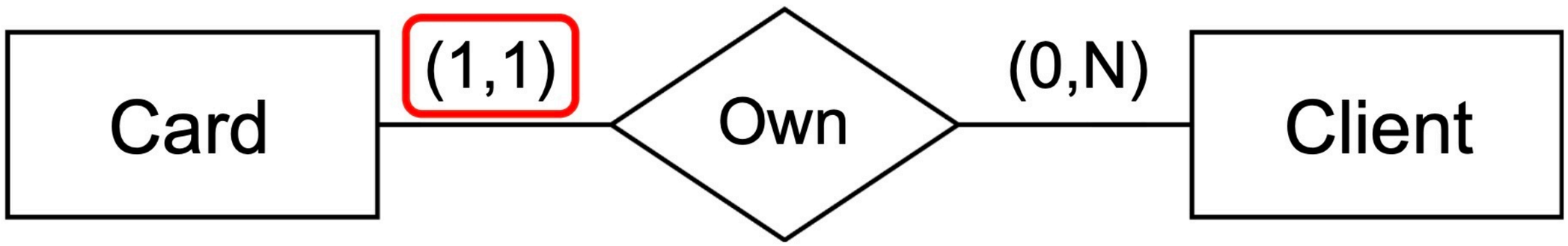
We can identify four relationships among entities:

- **Course - Card**
- **Card - Client**
- **Course - Client**
- **Course - Trainer**

Exercise 2: *Course-Card & Card-Client*

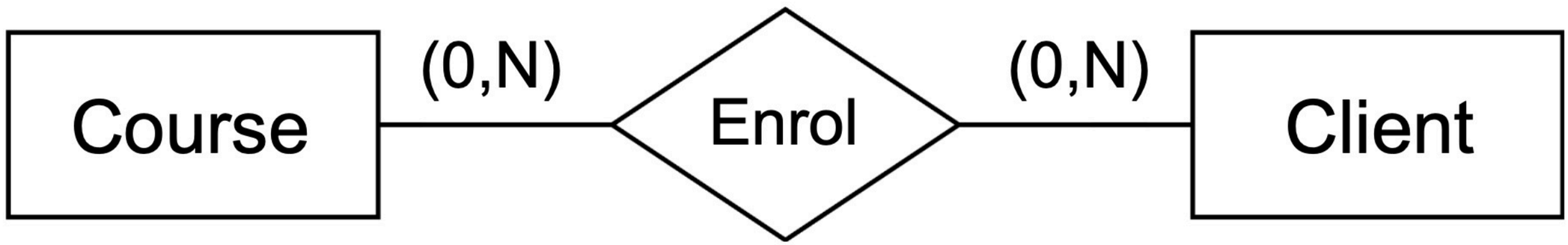
"[...] each card unlocks some courses [...]"

"Each member can buy one or more cards [...]"



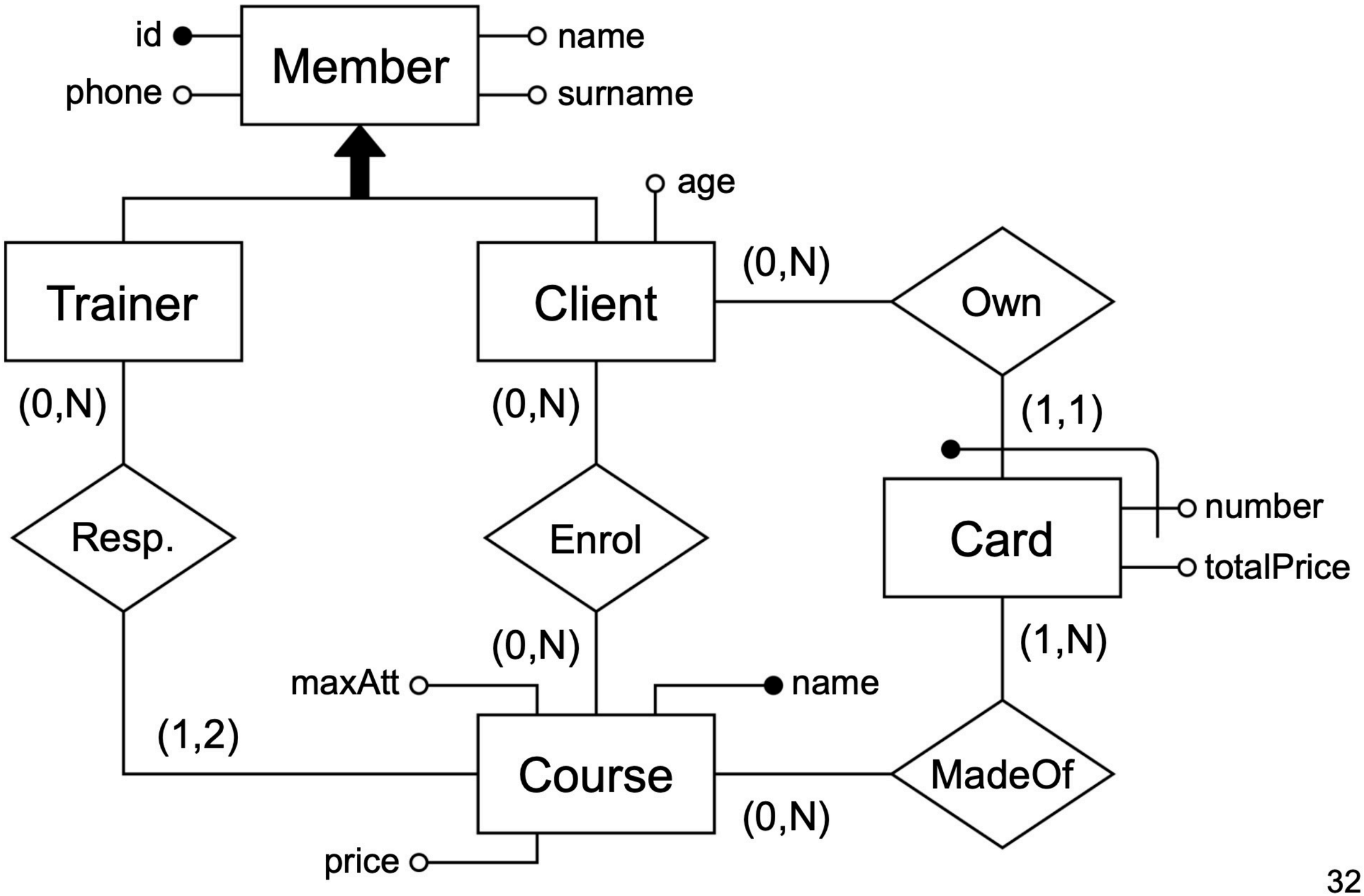
Exercise 2: *Course-Client & Course-Trainer*

"Each client can enrol in a course [...]"



"Each course is taught by one or two trainers."

Exercise 2: E-R diagram



Exercise 2: business rules

Not all the information can be represented in the E-R diagram, however, they must be taken into account.

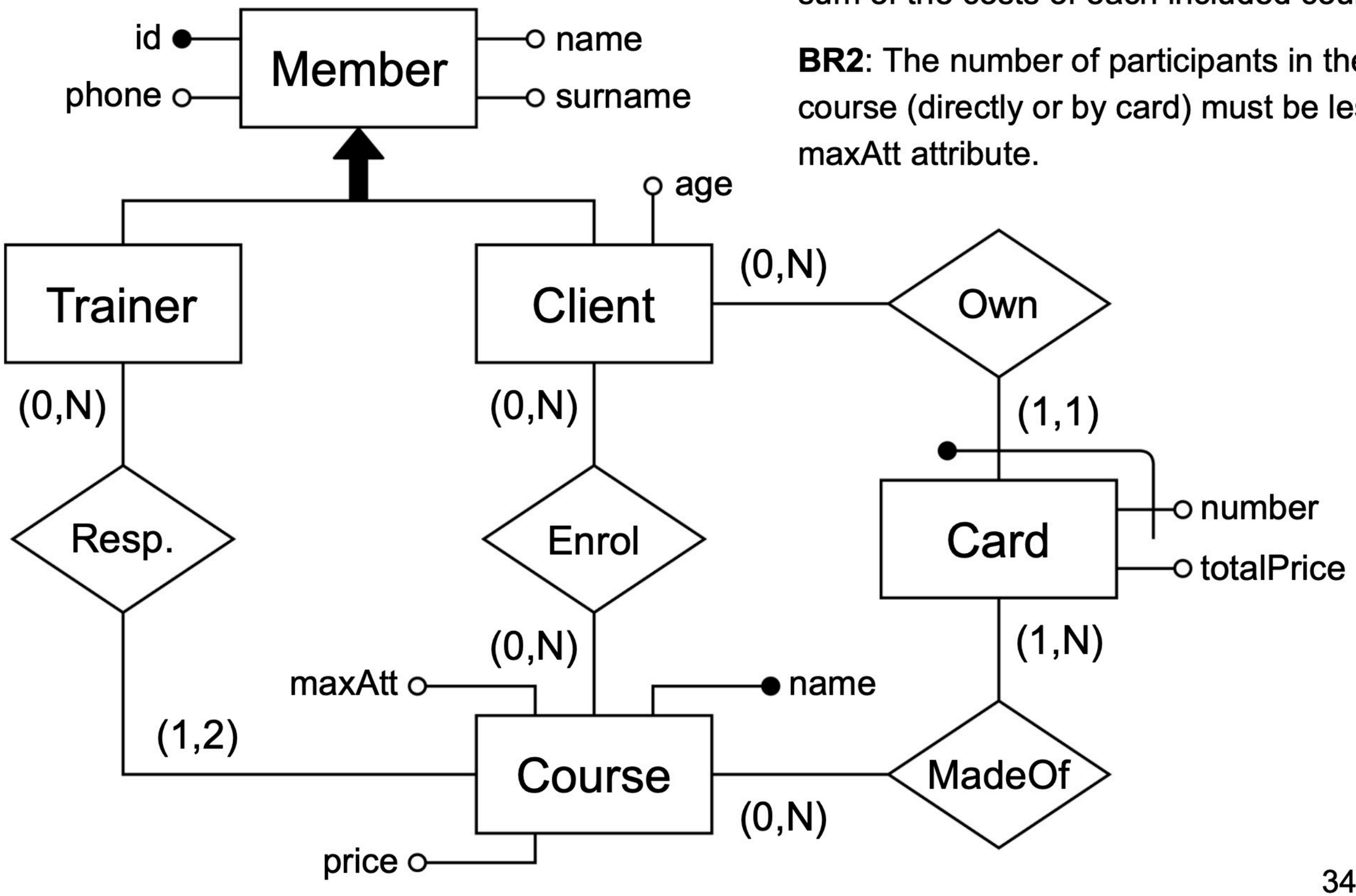
- *"[...] The final price for each card must not exceed the sum of the prices of the included courses."*
- *"Each course has a maximum number of attendees."*

This information forms the **business rules**.

Exercise 2: final solution

BR1: The cost of a card must not exceed the sum of the costs of each included course.

BR2: The number of participants in the course (directly or by card) must be less than maxAtt attribute.



Exercise 3: specs (1)

We want to model a system gathering information about companies within the financial market. A company is identified by a unique code and has a name, share capital and information about its registered office (e.g., city, state). There may be companies with the same name listed on the financial market. A rating agency is characterized by a unique identifier and name. A rating agency cannot be a company listed on the financial market.

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Exercise 3: specs (2)

A company listed on the financial market cannot be a rating agency. A company listed on the financial market issues financial instruments that can be tradeable on the financial market. A financial instrument has a counter value and is issued by one and only one company. A company listed on the financial market issues one or more financial instruments. A financial instrument is characterized by a name and performance.

…

Exercise 3: specs (3)

There may be financial instruments with the same name but not issued by the same company. Financial instruments can be shares, bonds (for which the maturity date is significant) and derivatives. A company listed on the financial market holds a certain percentage of one or more companies listed on the financial market.

…

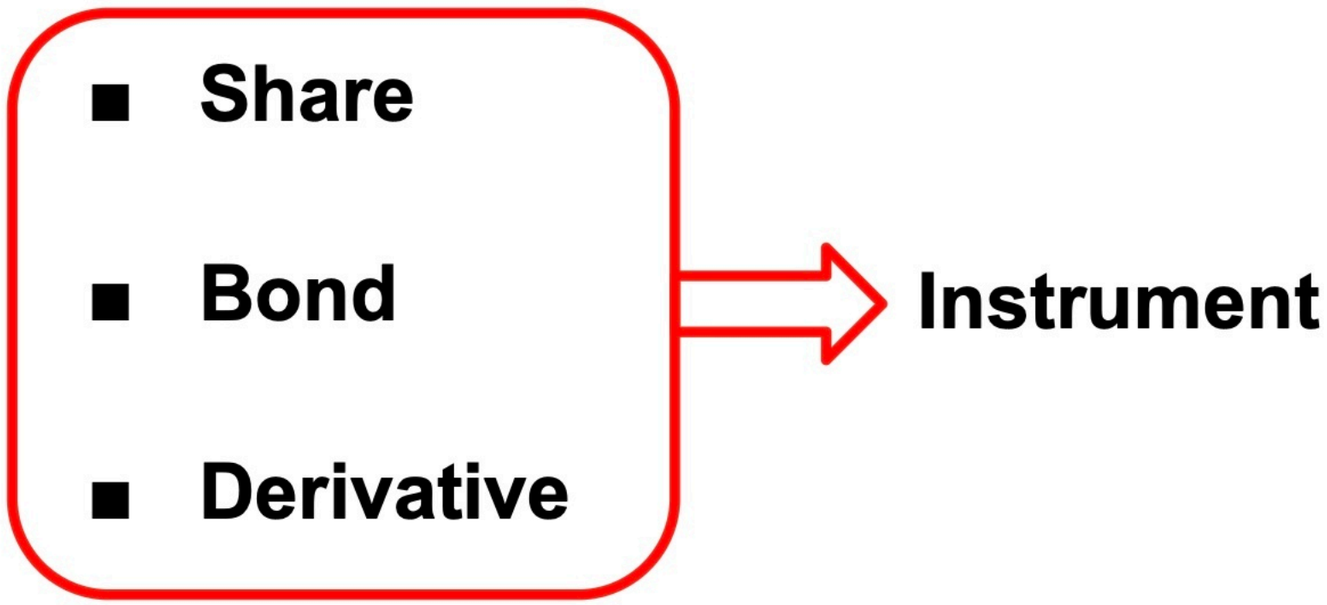
Exercise 3: specs (4)

Percentages of each company listed on the financial market are held by at least one company, the sum of the percentages must be 100%. A rating agency provides a rating value for one or more companies listed on the financial market. A company listed on the financial market is rated by at least one rating agency.

Exercise 3: entities

We can identify five different entities and one generalization:

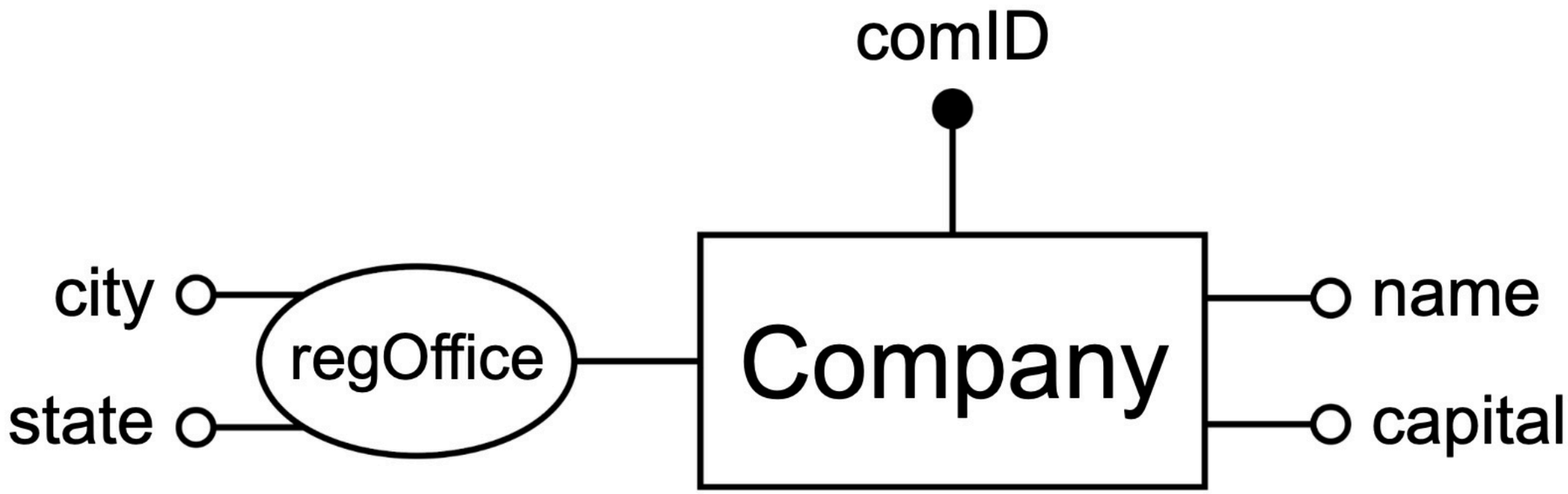
- **Company**
- **Agency**



Exercise 3: *Company*

"*A company is identified by a* ***unique code*** *and has a* ***name***, ***share capital*** *and* ***information about its registered office*** *(e.g., city, state).*"

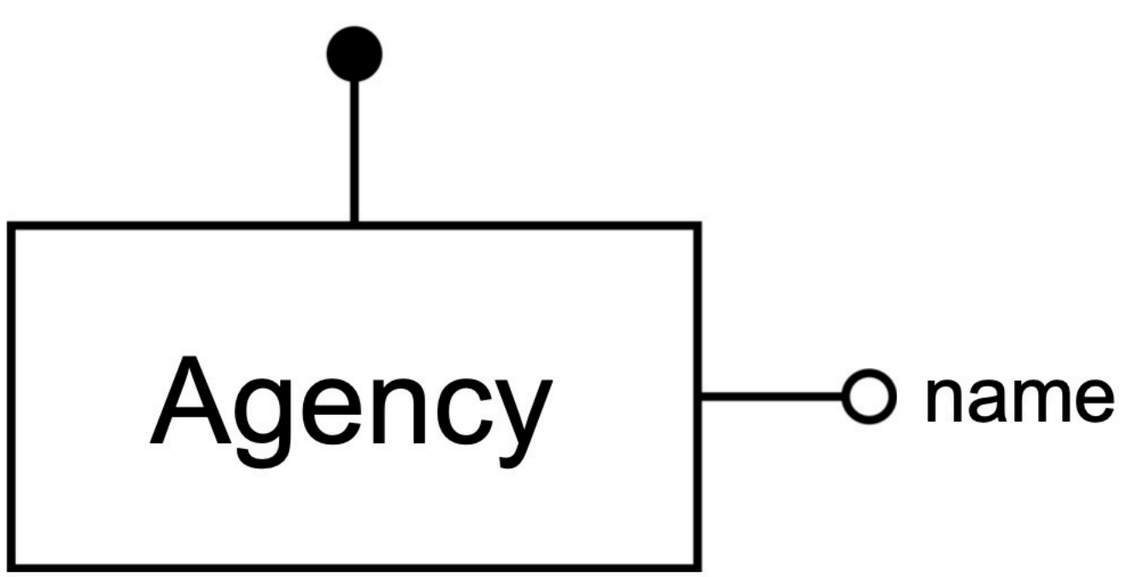
The registered office is a **composite attribute** that includes the city and state.



Exercise 3: *Agency*

"*A rating agency is characterized by a **unique identifier** and **name**.*"

code



Exercise 3: *Instrument* (1)

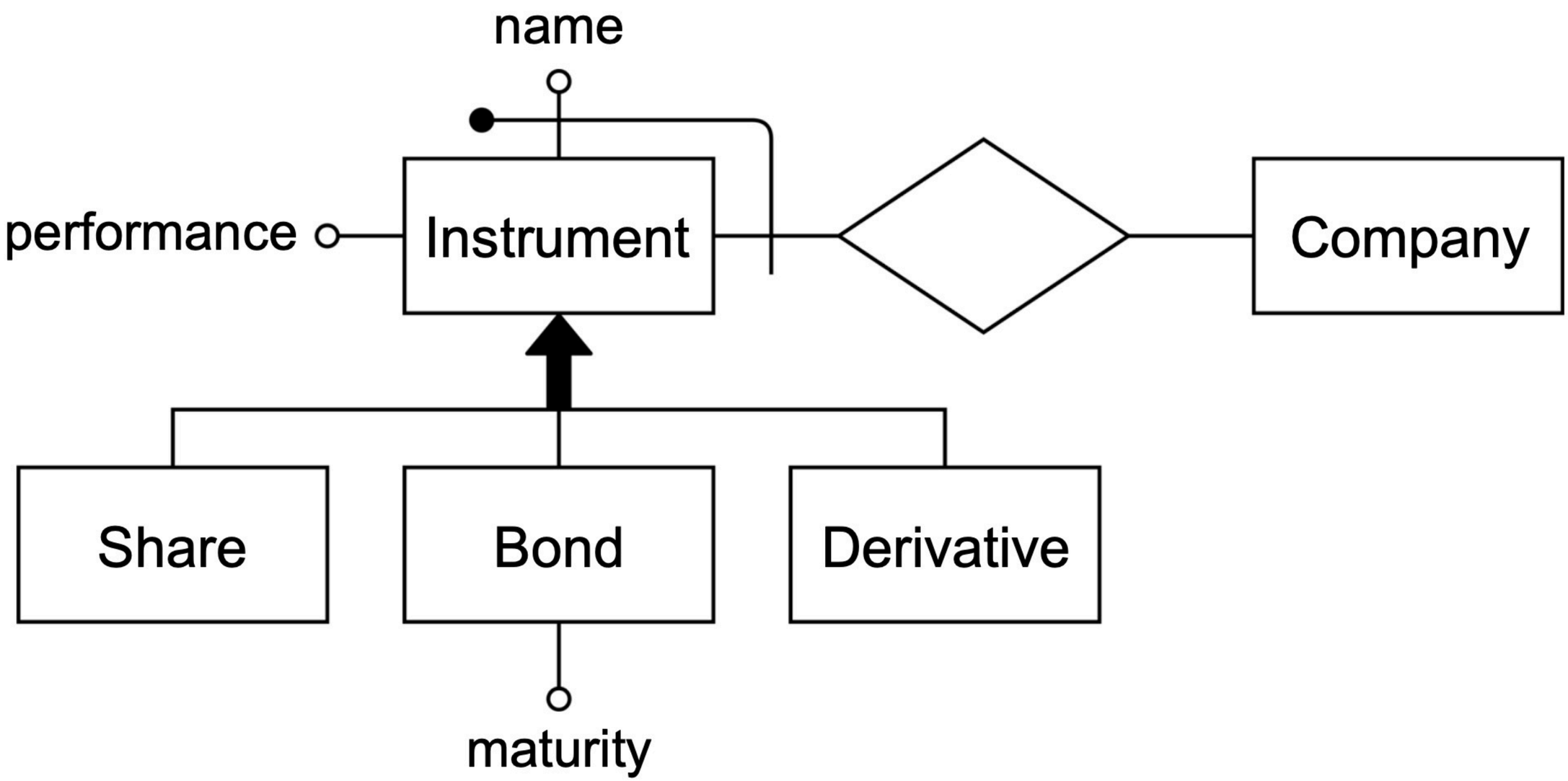
*"A financial instrument is characterized by a **name** and **performance**."*

"There may be financial instruments with the same name but not issued by the same company."

*Financial instruments can be shares, bonds (for which the **maturity date** is significant) and derivatives.*

A financial instrument is a **generalization** and has a **external key** because the name is not unique if not paired to the company.

Exercise 3: *Instrument* (2)



Exercise 3: relationships

We can identify three relationships among entities:

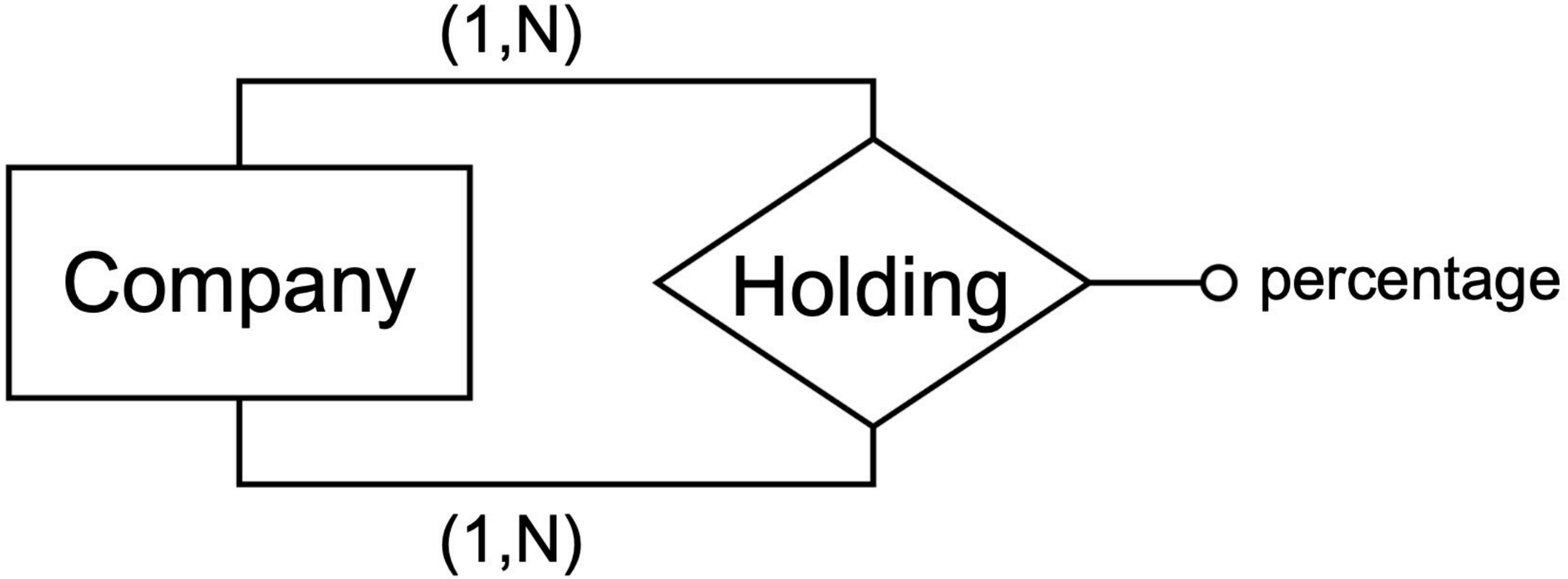
- **Company - Company**
- **Company - Agency**
- **Company - Instrument**

All of them have an attribute.

Exercise 3: *Company-Company*

*"A company listed on the financial market holds a certain percentage of **one or more** companies listed on the financial market."*

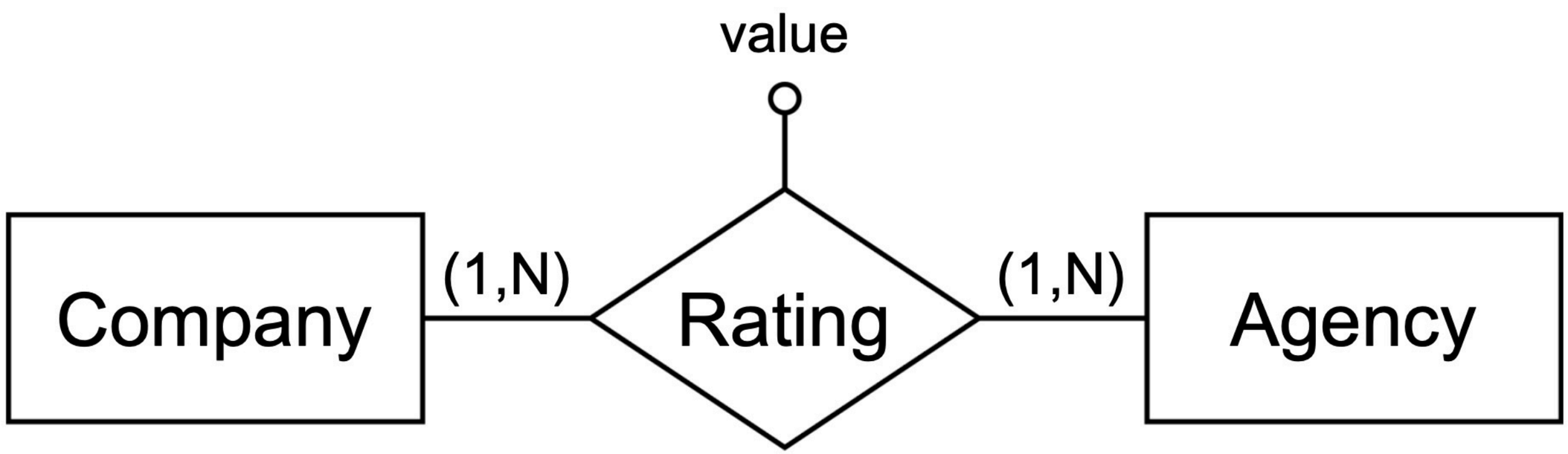
*"Percentages of each company listed on the financial market are held by **at least one** company, [...]"*



Exercise 3: *Company-Agency*

*"A rating agency provides a rating value for **one or more** companies listed on the financial market."*

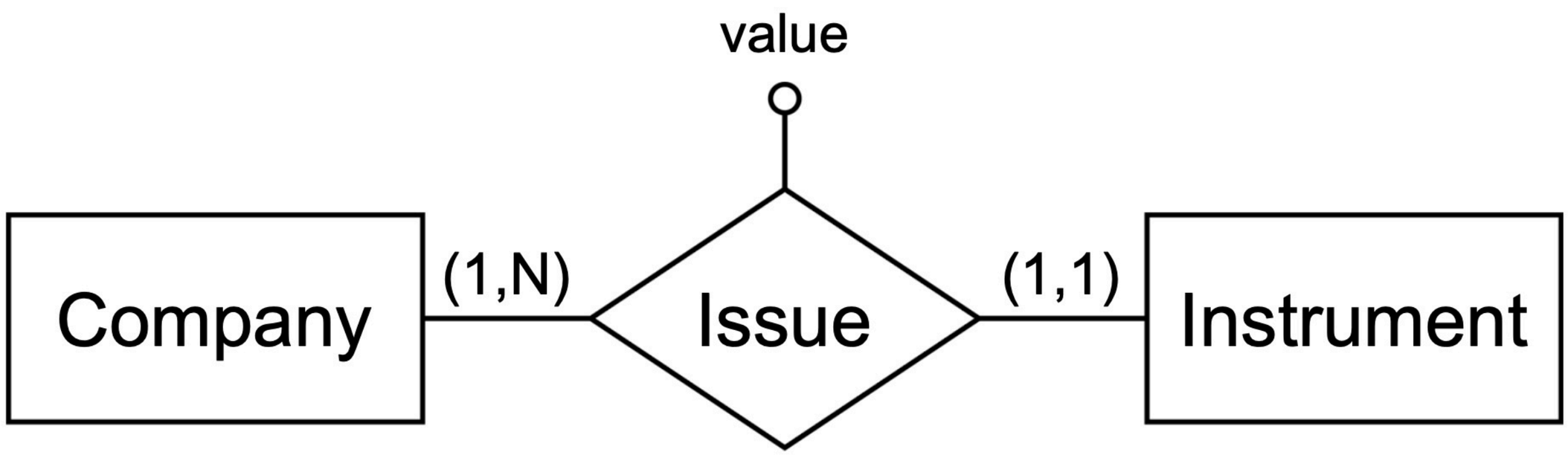
*"A company listed on the financial market is rated by **at least one** rating agency."*



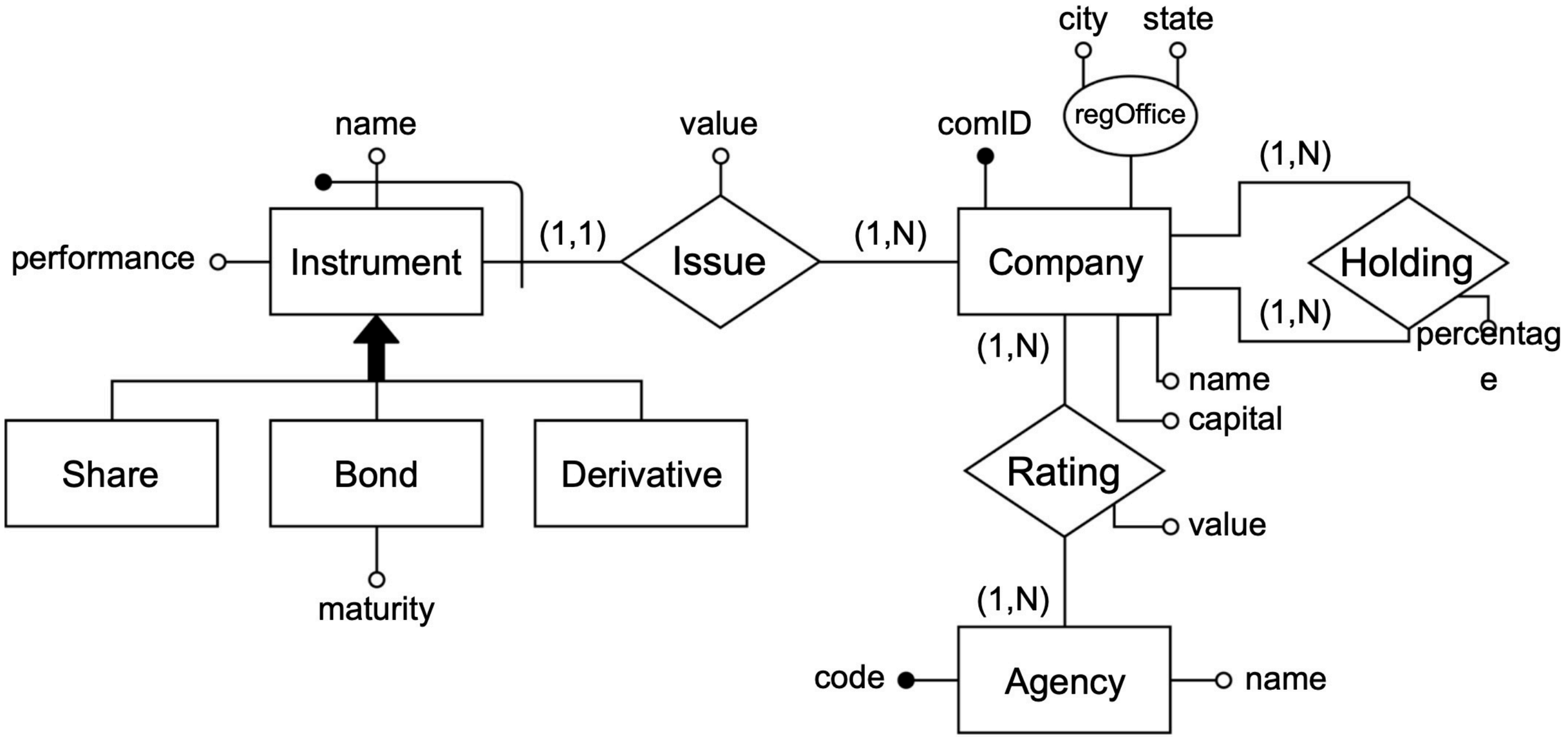
Exercise 3: *Company-Instrument*

*"A financial instrument has a counter value and is issued by **one and only** one company."*

*"A company listed on the financial market issues **one or more** financial instruments."*



Exercise 3: final solution



BR: For each company, the sum of the "percentage" values must be equal to 100.

Exercise 4: specs

We want to model the borrowing and returning system of a library. Readers attending the library have a card on which is written the name and address. They ask for borrow for books that are catalogued in the library. Books have a title, a list of authors and can exist in several copies. All books in the library are identified by a code. Following a request, the responsible check the loans archive. If the book is available, the volume is searched on the shelves and it is then classified as borrowed. Once the volume has been recovered, it is given to the reader, who proceeds with the consultation. After consultation, the book is returned, relocated and re-classified as available. For a loan, the time and date of borrowing and returning are recorded.

Exercise 4: analysis

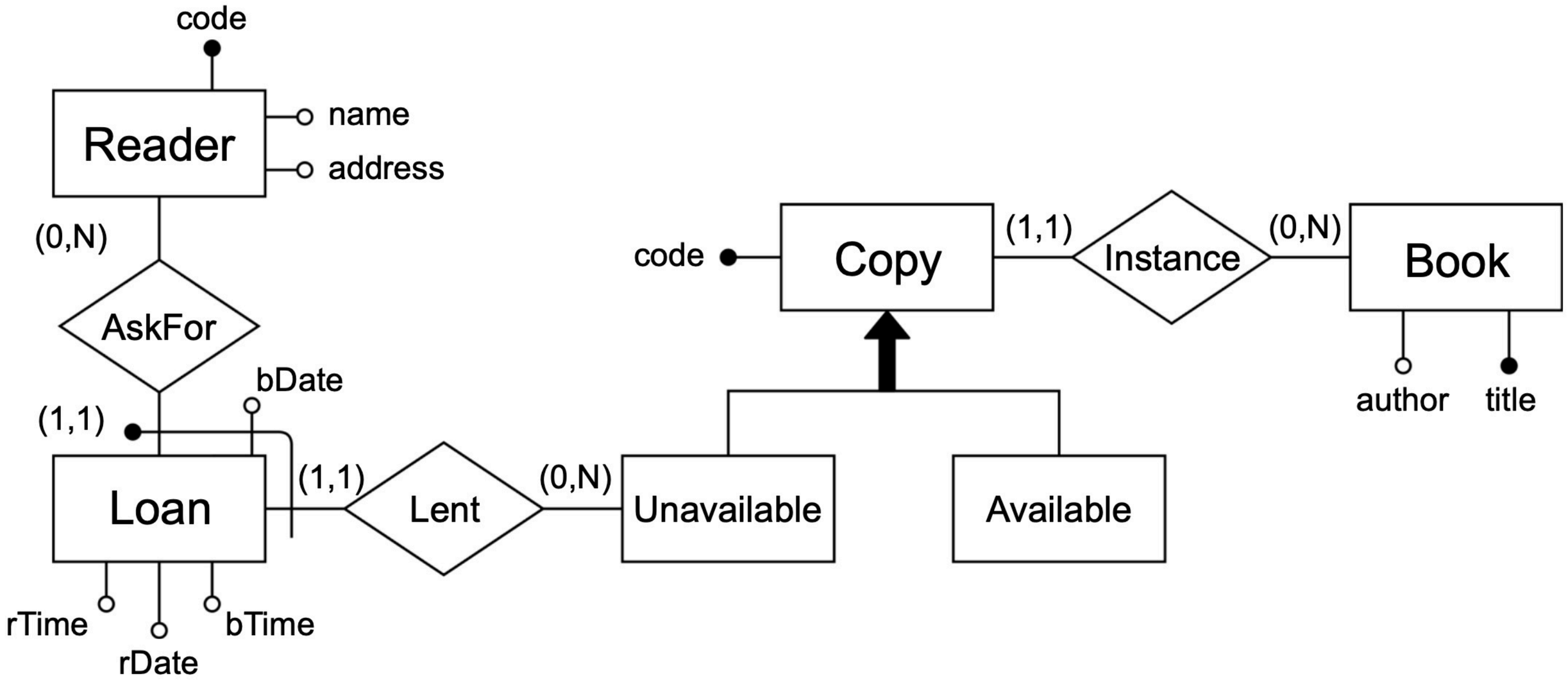
Reader: Readers attending the library have a card on which is written the name and address. They ask for borrow for books that are catalogued in the library.

Book: Books have a title, a list of authors and can exist in several copies.

Copy: All books in the library are identified by a code. Following a request, the responsible check the loans archive. If the book is available, the volume is searched on the shelves and it is then classified as borrowed.

Loan: Once the volume has been recovered, it is given to the reader, who proceeds with the consultation. After consultation, the book is returned, relocated and re-classified as available. For a loan, the time and date of borrowing and returning are recorded.

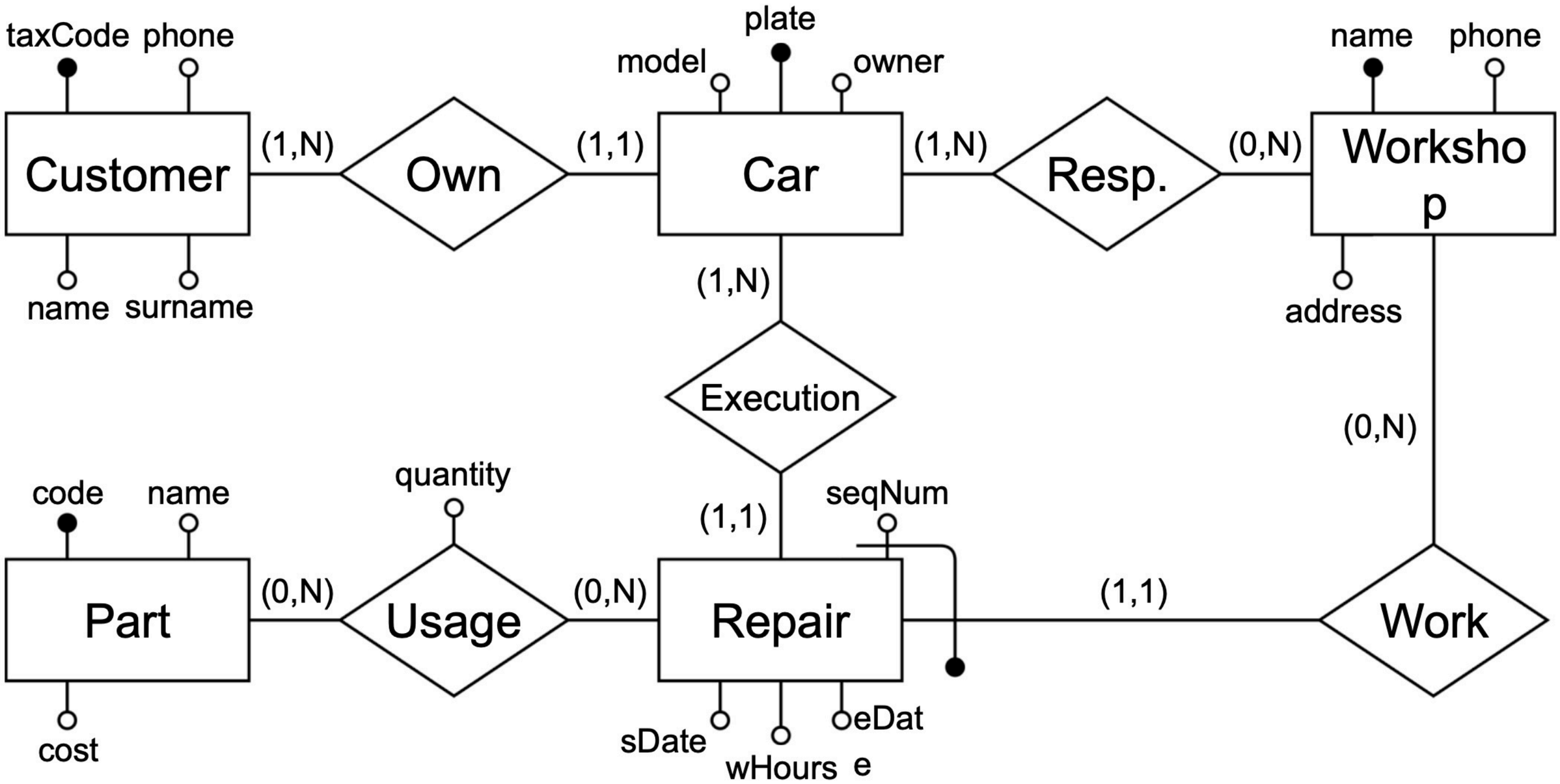
Exercise 4: final solution



Exercise 5: specs

We want to model a system for a chain of workshops. The following information is of interest. Workshops are identified by name and have an address and phone number. Cars have a license plate, a model (a string of characters) and owner. Customers (i.e., car owners) have a tax code, and a name, a surname, and a phone number. Each customer can own more than one car. Repairs are identified through a sequential number unique within the respective workshop. Repairs also have a start and end dates, the list of used spare parts (with quantities) and the number of working hours. Spare parts are identified through the code and have a name and a unit cost.

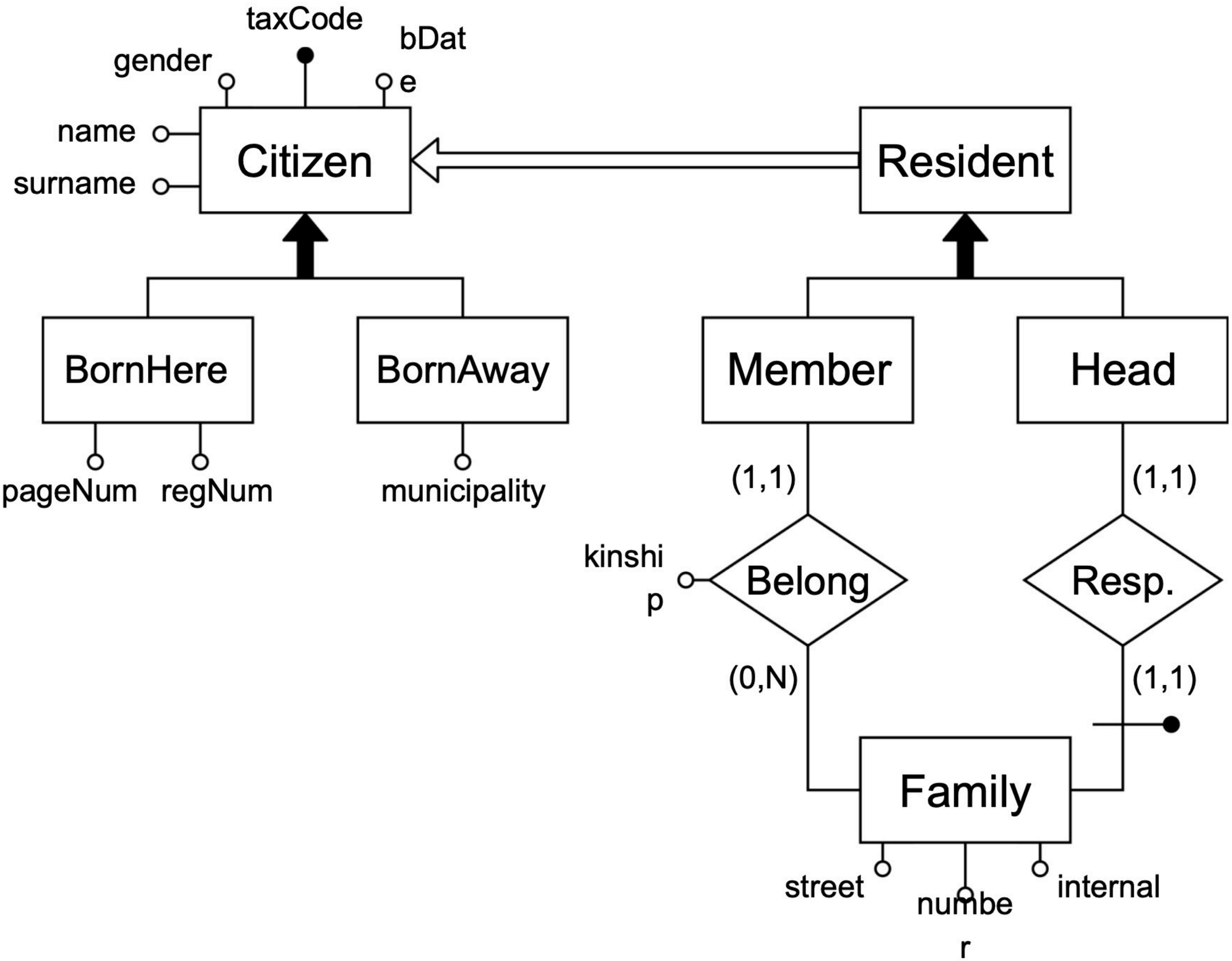
Exercise 5: final solution



Exercise 6: specs

We want to model a system for the registry office of the municipality of Somewhere. The system stores information about citizens and families. The system has to store data on residents and citizens born in the municipality. Every citizen is identified by the tax code and has name, surname, gender and date of birth. For the citizens born in the municipality, the system stores the registration details (i.e., registration number and page). For those born in another municipality, the system stores the place of birth. Each resident family has one and only one head of the family and some members. For each member, the system stores the degree of kinship (e.g., spouse, child, parent or other). Each resident citizen belongs to one and only one family. All family members have the same domicile (i.e., address, house number, internal).

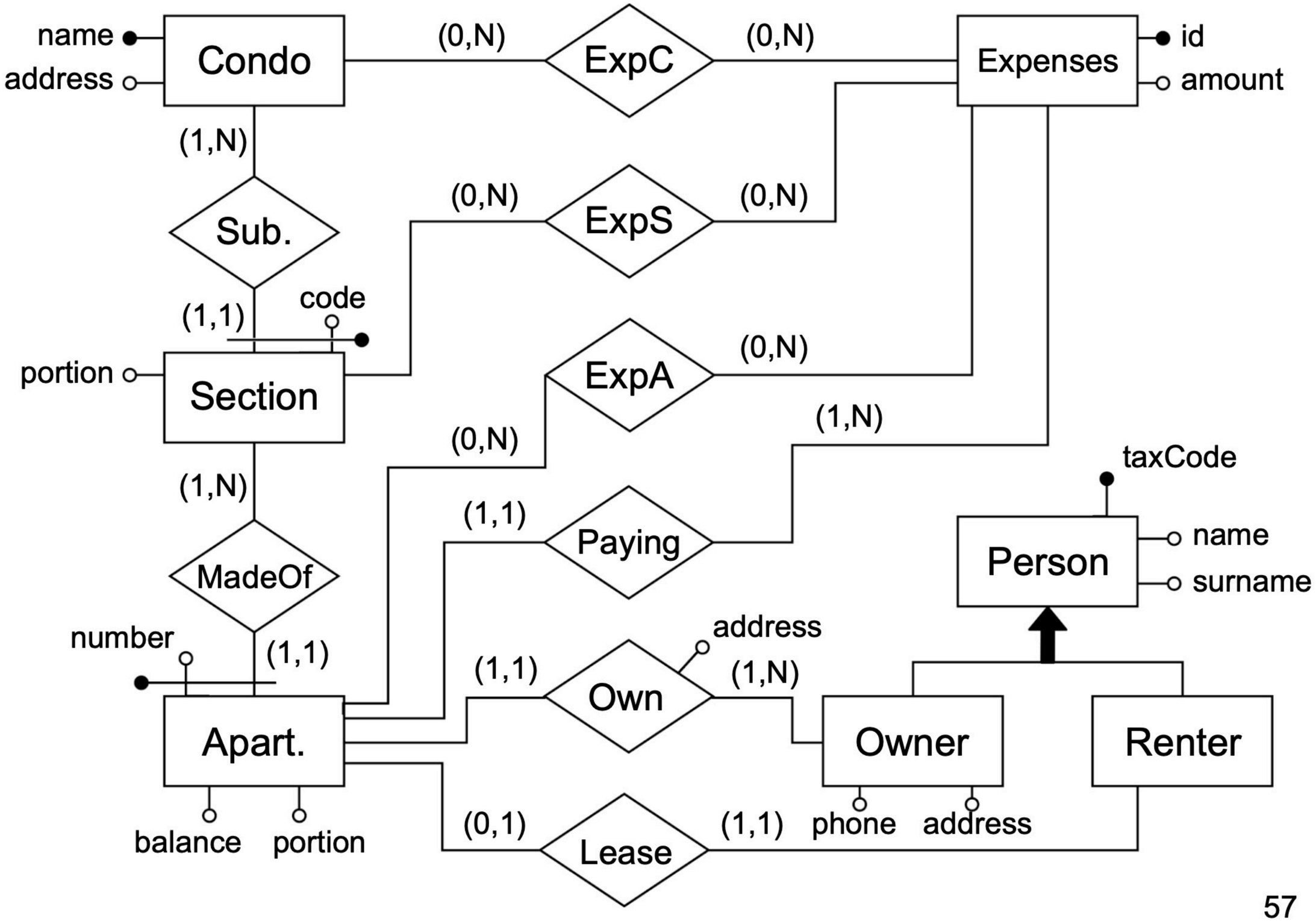
Exercise 6: final solution



Exercise 7: specs

We want to model a system to manage a condominium administrator's archive. Each condominium has a name which identifies it, an address and includes one or more sections, each of which includes a set of apartments. If there is more than one section, they are identified through a code and the name of the condominium. A section also includes a value which represents the fraction of the expenses of the condominium that are the responsibility of the apartments included in that section. Each apartment is identified through the section and a number. Each apartment has a value which indicates the fraction of the expenses of the section that are the responsibility of the apartment. Each apartment has an owner. The system has to store the name, surname, tax code and the correspondence address of each owner. Each owner has only one tax code, but they can own several apartments. Thus, they may also have different addresses for different apartments. In many cases, the address of the owner is the same as the address of the condo. For accounting, the system has to track the expenses incurred by the condominium and the payments made by the owners. Each expense is associated with the whole condominium, or with a section or a single apartment. Each payment is related to one and only one apartment. The system stores payments and expenses for the current financial year of annual duration. For each apartment, the previous financial years are summarized in a single value (the previous balance) that indicates the debt or credit of the owner. It is always possible to check the current balance for each apartment, that is defined as the sum of the previous balance, the payments and the expenses to be paid.

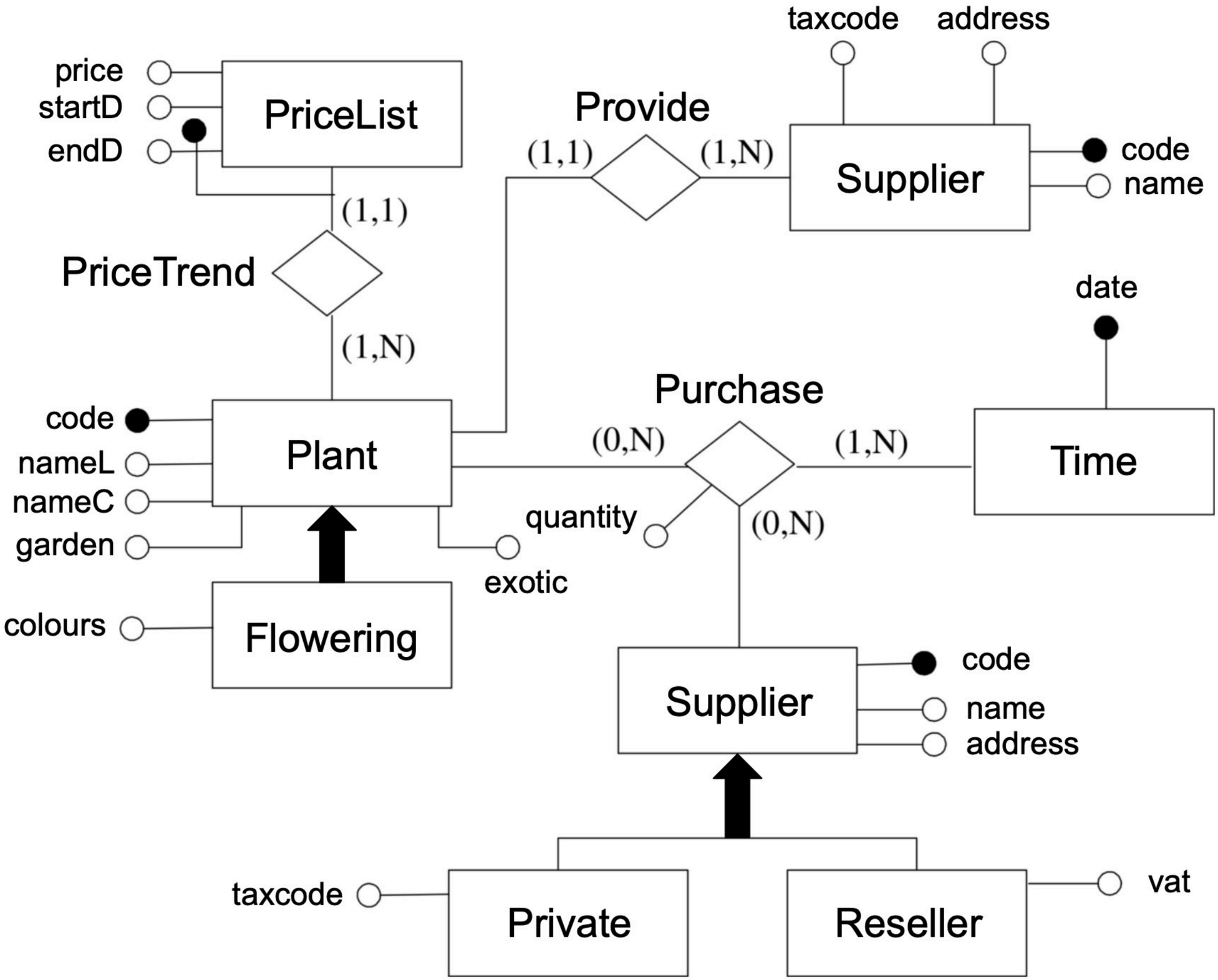
Exercise 7: final solution



Exercise 8: specs

We want to model a system for the management of the wholesale of plants. The store deals with different species of plants. Each plant is identified by a unique code. Moreover, it is known the Latin name, the common name and whether it is typically a garden-plant or houseplant and whether it is an exotic species or not. The plants can be green or flowering. In the case of flowering plant species, all the colours in which each species is available are known. Customers are identified by a customer-code and can be private individuals or resellers. Private customers also have the tax code, the name and the address, while each reseller has the VAT number, the name and the address. Suppliers are identified by a supplier code and have a name, the tax code and the address. A supplier can provide different species of plants. However, plants of the same species are always purchased from the same supplier. We want to save of all purchases made by each customer, tracking the date, quantity and specie. We also want to track the price list, that is the prices assumed over time by each species of plants.

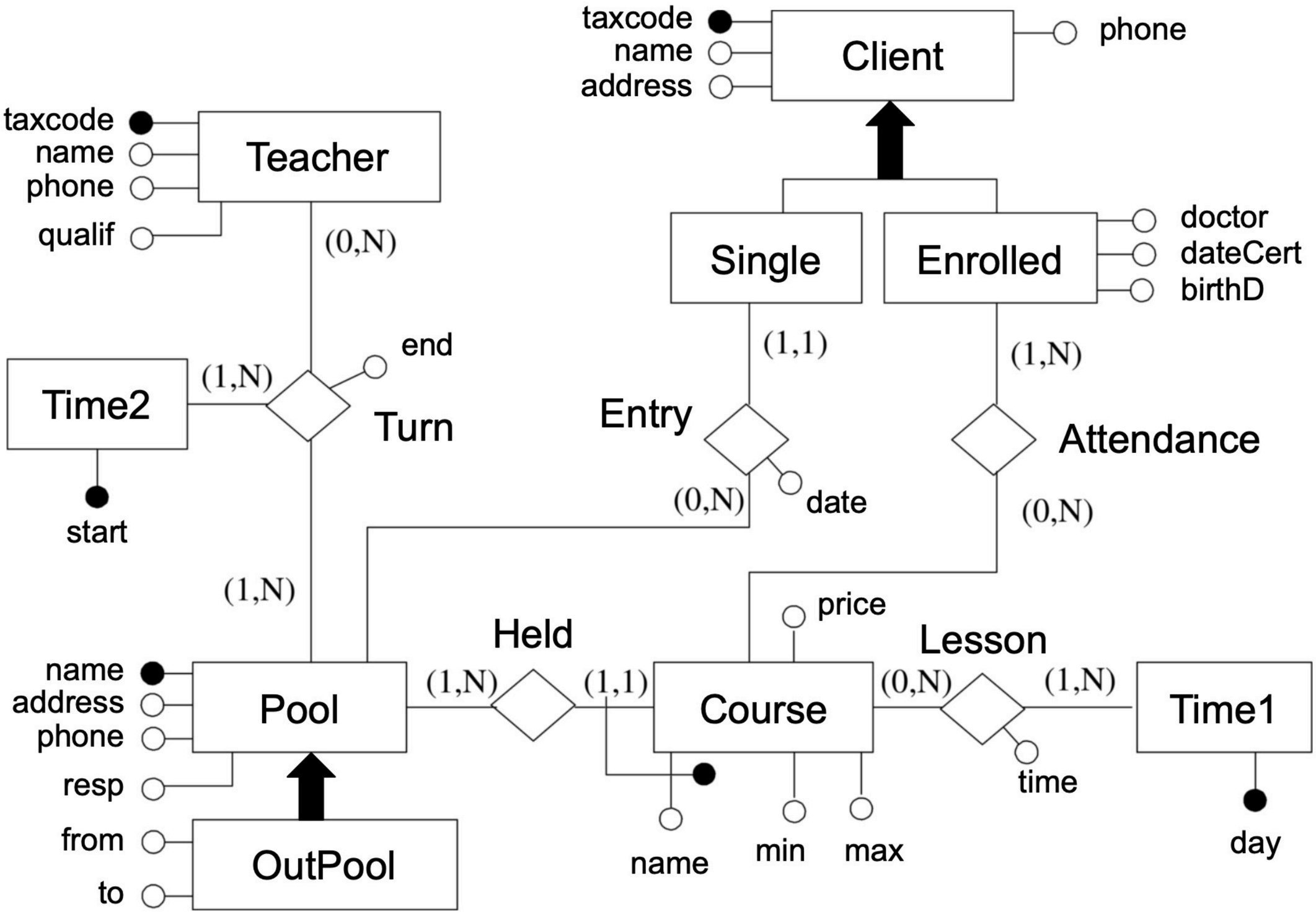
Exercise 8: final solution



Exercise 9: specs

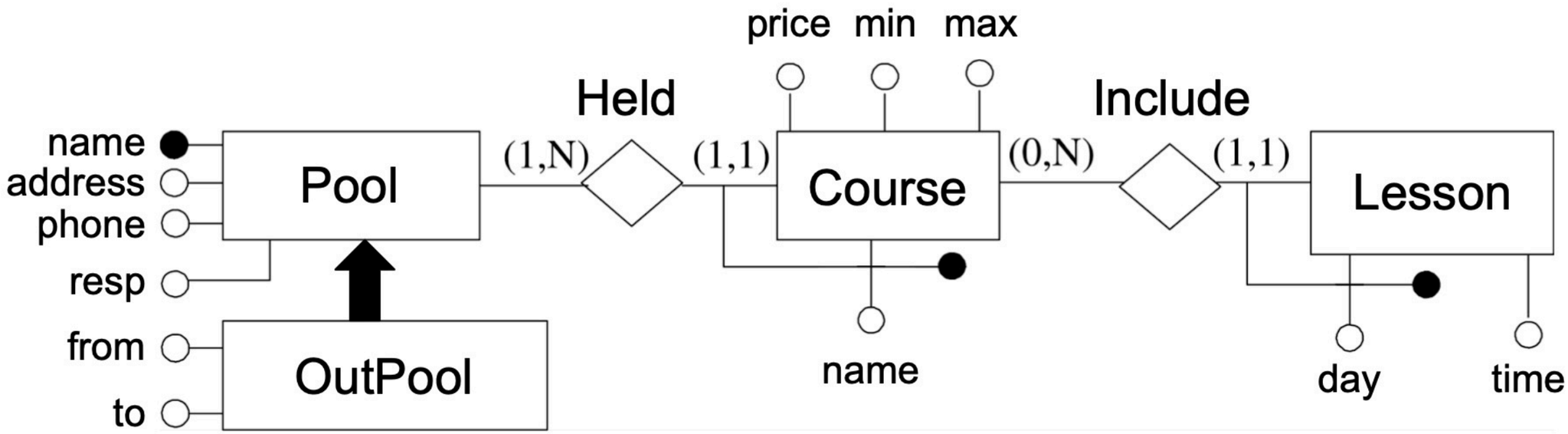
We want to model the system containing information on the swimming pools managed by the municipality of Swimland. The pools are uniquely identified by name and have an address, a telephone number, and it is known the name of a responsible. If the pool has an outdoor pool, the database contains information on when this pool can be used (e.g. from March to September). Courses are organised at the pools and courses of the same type can be held at different pools. Each course has a cost, the maximum and the minimum number of participants and the days and time of the week it takes place. Let us assume that at each pool each course is held only once a day, but several times during the week. The teaching staff works in rotation at the various swimming pools. Each teacher has a tax code, a name, a mobile phone number, if available, and the list of the teacher's qualifications. Within the database, we want to keep track of all the time intervals in which a teacher has worked at each pool. The same teacher may have worked at the same pool at different time intervals. Pools can be attended either by course participants or in the "single entry" mode for free swimming (only people who have never attended courses are registered for single entry). Clients are identified by their fiscal code and have a name, an address and a telephone number. Course participants must present a medical certificate. Therefore, for course participants, the database contains the information of the doctor who drew up the certificate, the presentation date, the age of the subject, and the list of courses in which he/she is enrolled. For other "single entry" clients we want to track the date and the swimming pool on which the last entry was made.

Exercise 9: final solution



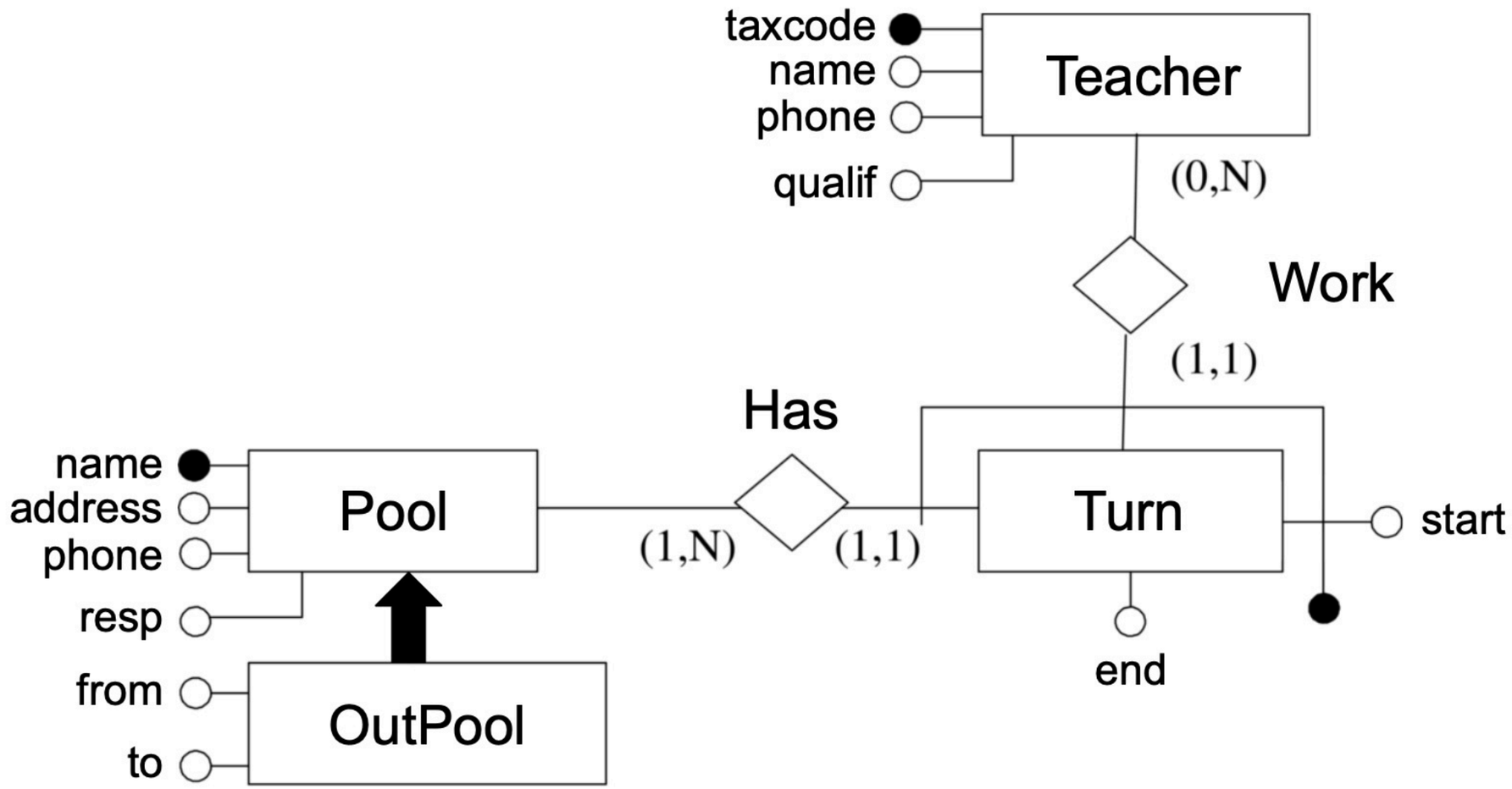
Exercise 9: extra 1

An alternative representation of the relationship *Lesson*.



Exercise 9: extra 2

An alternative representation of the relationship *Turn*.



Exercise 10: specs

We want to model the database of a chain of videotapes rental service. Each store is identified by a unique code and has an address and a telephone number. The database contains information about all the employees. Each employee has a tax code, a name, a qualification and an address. The social security number allows to uniquely identify the employees. Employees can be moved from one store to another according to their needs; it is, therefore, necessary to keep track of all the time intervals during which an employee has served at a store and the position they held during that period (e.g. cashier or clerk). The movies are identified by the title and the name of the director. It is also known the year, the list of the main actors, the current renting cost, and the "remake" list. For each film, it is known the location within each store. In particular, it is known the sector, the position within the sector and the number of copies. Each sector is identified by a unique code within the store. For each film, it is known the distribution centres and the relative cost. These distribution centres are characterised by a name, an address and are identified by a numerical code.

Exercise 10: final solution