Databases

Lecture 13

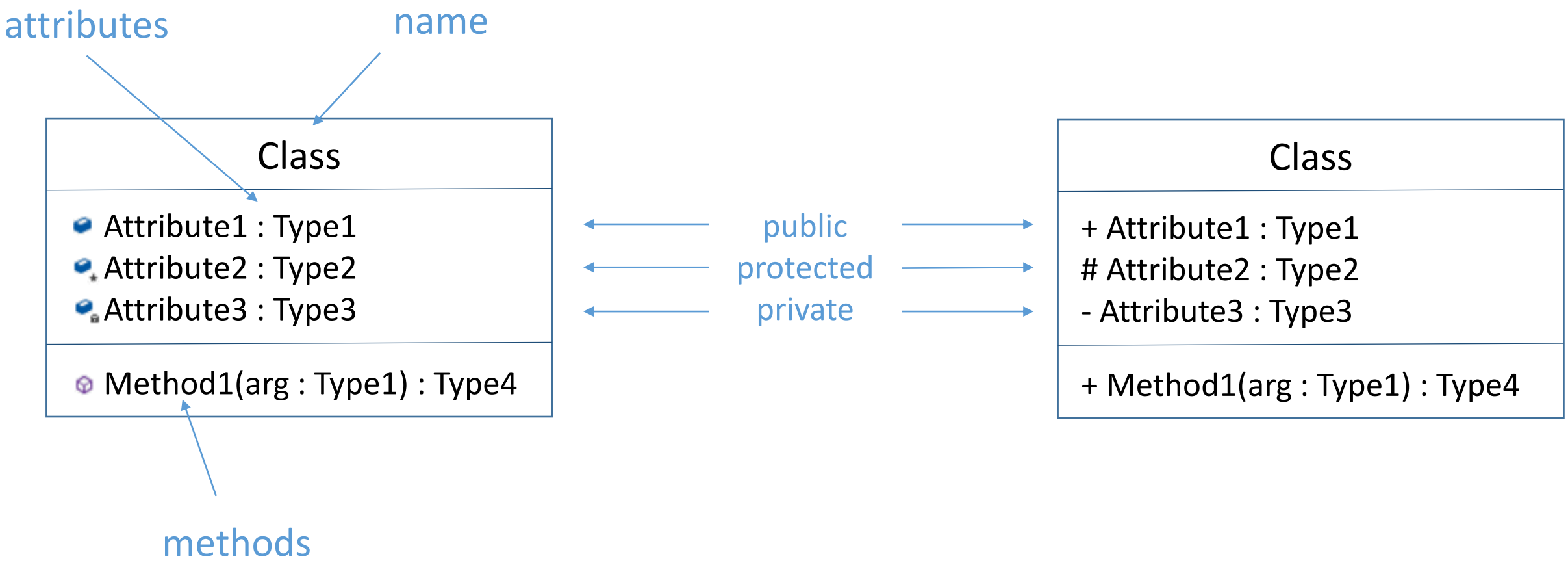
Conceptual Modeling

Sabina S. CS

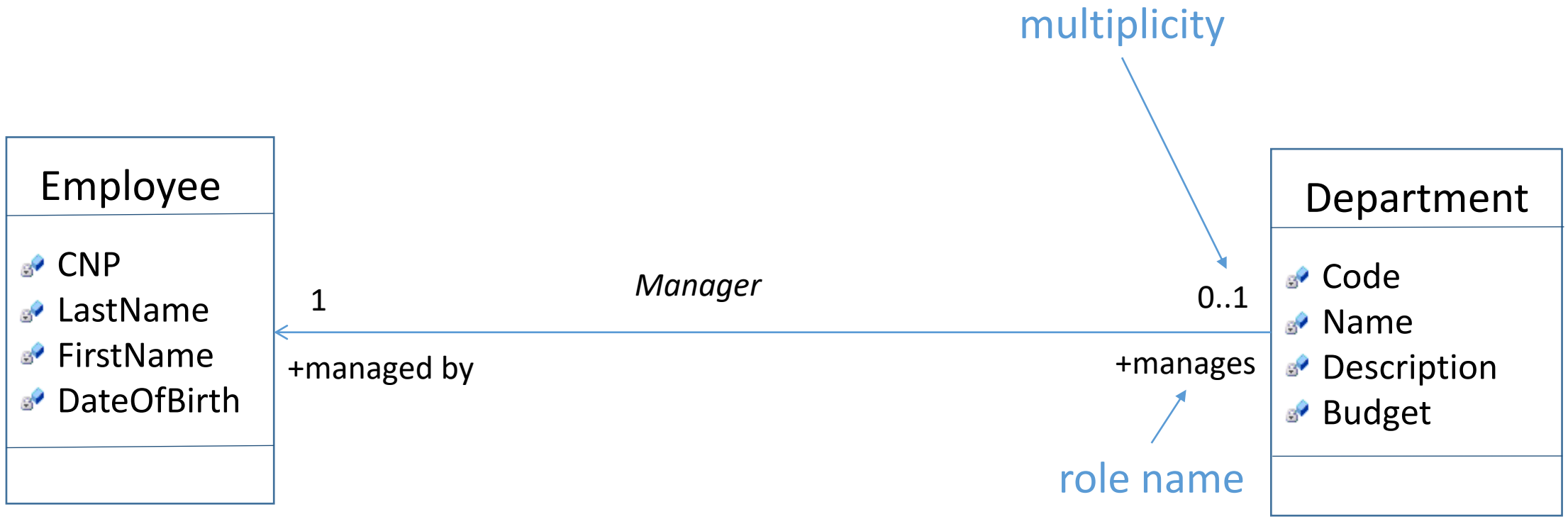
- database design - stages
  - requirements analysis
    - what data will the DB store?
    - what are the main operations to be supported?
    - what apps will be powered by the DB?
  - conceptual DB design
    - high level description of data and integrity constraints
  - logical DB design
    - translate the conceptual DB design to a DB schema in terms of the model supported by the DBMS (e.g., relational)
  - schema refinement
    - normalization
    - eliminate redundancy and associated problems

- database design - stages
  - physical DB design
    - create indexes
    - redesign parts of the schema

- UML class diagram
  - classes

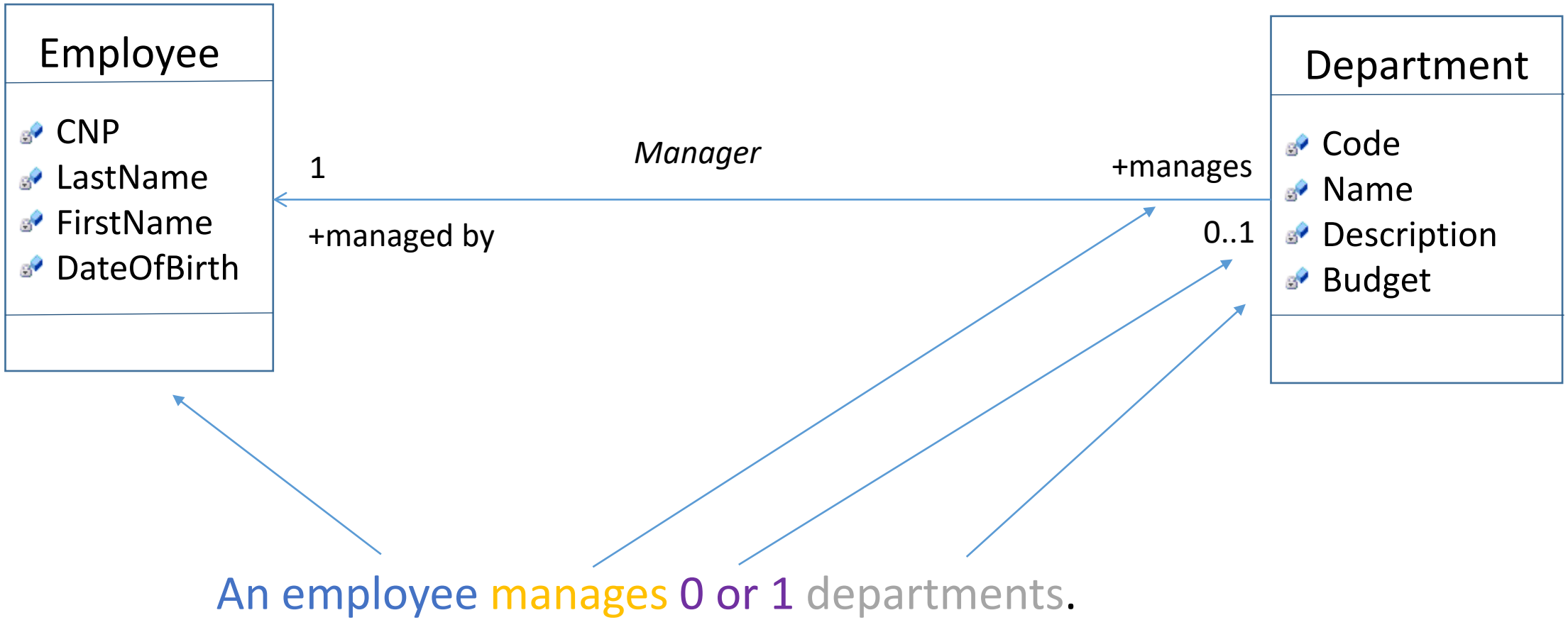


- UML class diagram
  - associations

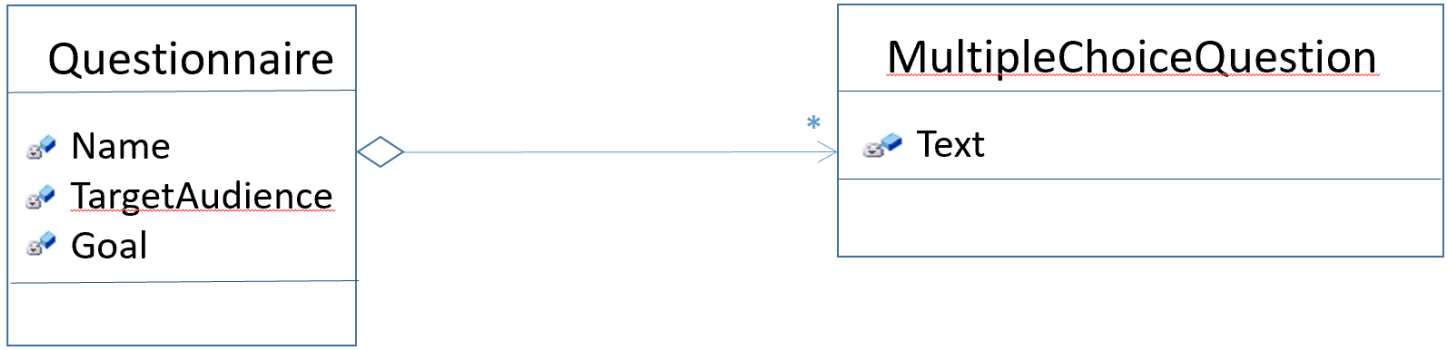


  - navigability – unidirectional, bidirectional
  - multiplicity – examples
    - 0..1
    - 5
    - 0..*
    - 7..10

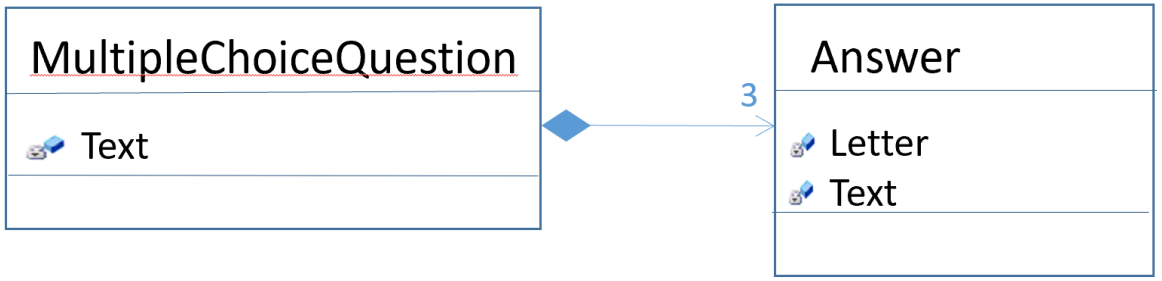
- UML class diagram
  - associations



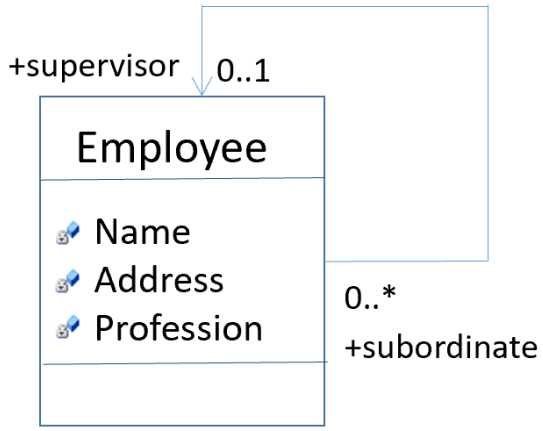
- UML class diagram
  - aggregation



  - composition

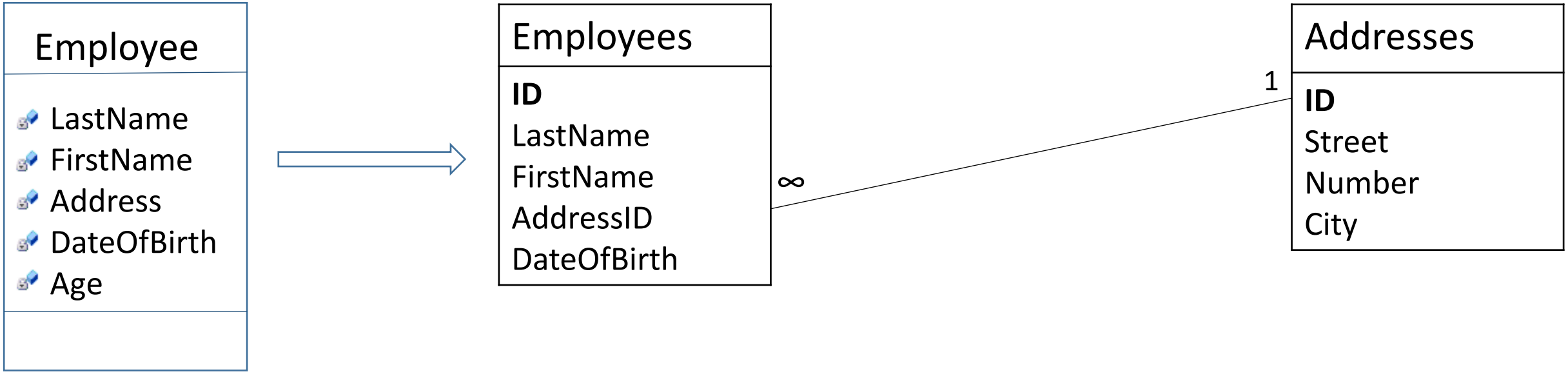


  - reflexive association



- conceptual model => relational database
- 1:1 mapping, i.e., classes become tables
- drawbacks
  - one could create too many tables
    - too many tables => too many join operations
  - necessary tables could be omitted; m:n associations require a third table (join table)
  - inheritance is not properly handled

- class -> table



- the plural of the class name becomes the name of the table
- simple class attributes become table fields
- composite attributes become tables
- derived attributes are not mapped to table fields
- surrogate keys are added

- class -> table
  - surrogate key
    - key that isn't obtained from the domain of the modeled problem
  - when possible, use integer keys that are automatically generated by the DBMS
    - easy to maintain - the responsibility of the system
    - efficient approach (fast queries)
    - simplified definition of foreign keys
  - possible approach
    - surrogate key name: *ID*
    - foreign key name: *<SingularTableName>ID*

- mapping simple associations
- 1 : 0..1
  - create 1 table per class
  - the key of the *1* table (i.e., table at the *1* end of the association) becomes a foreign key in the 2nd table
  - usually, only one key is automatically generated (the one corresponding to the *1* table)

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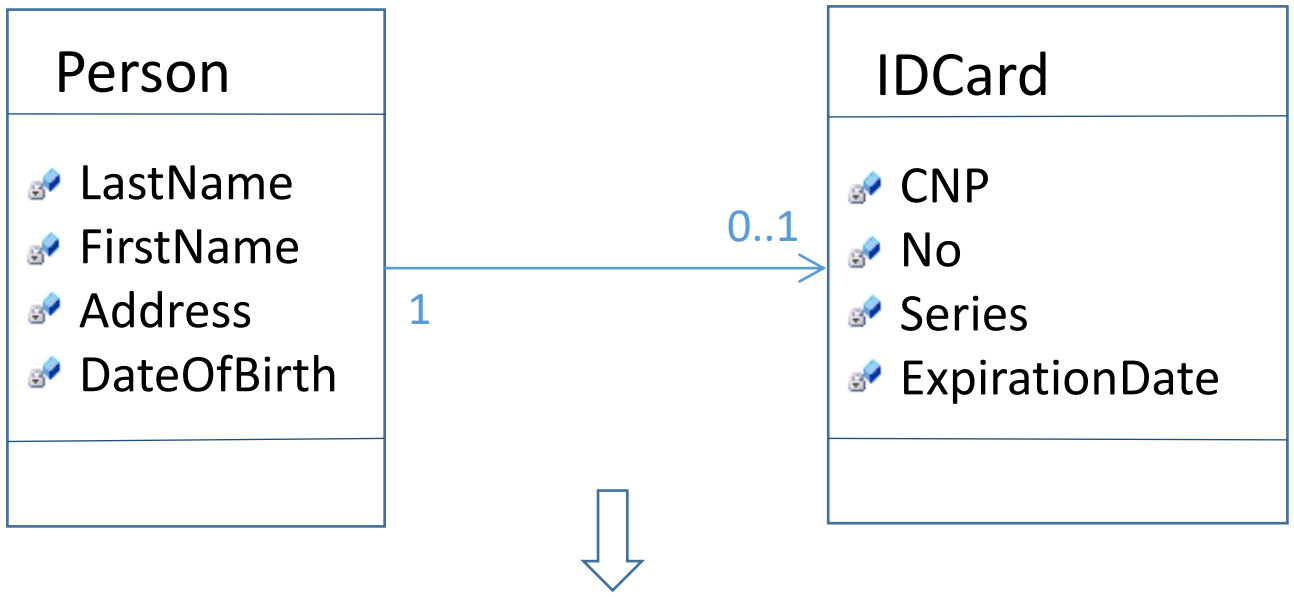
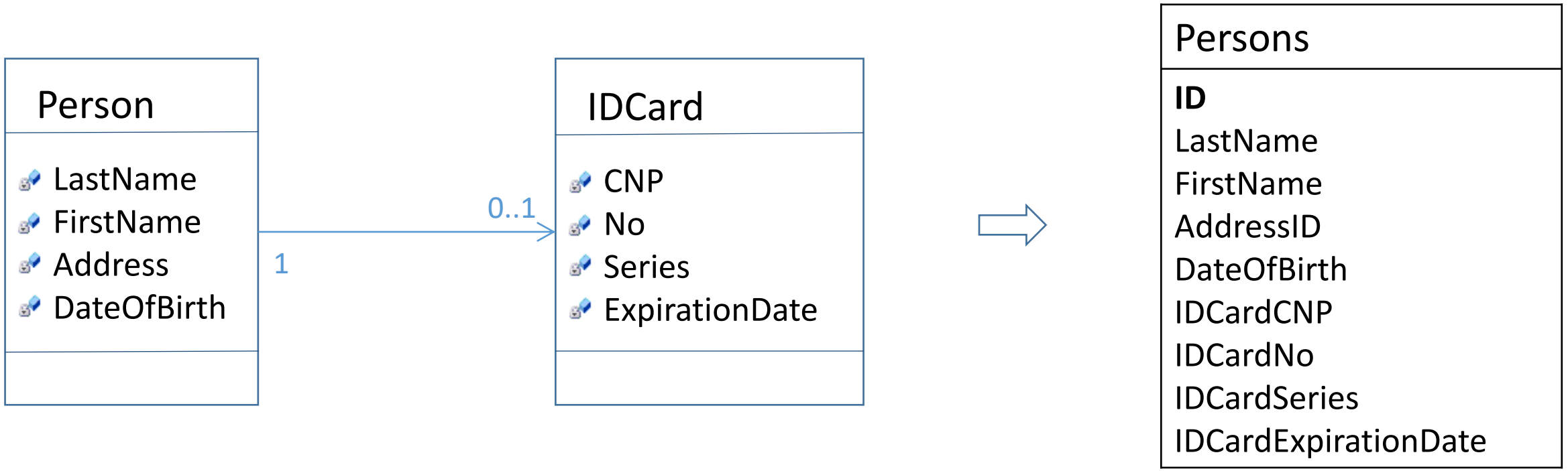
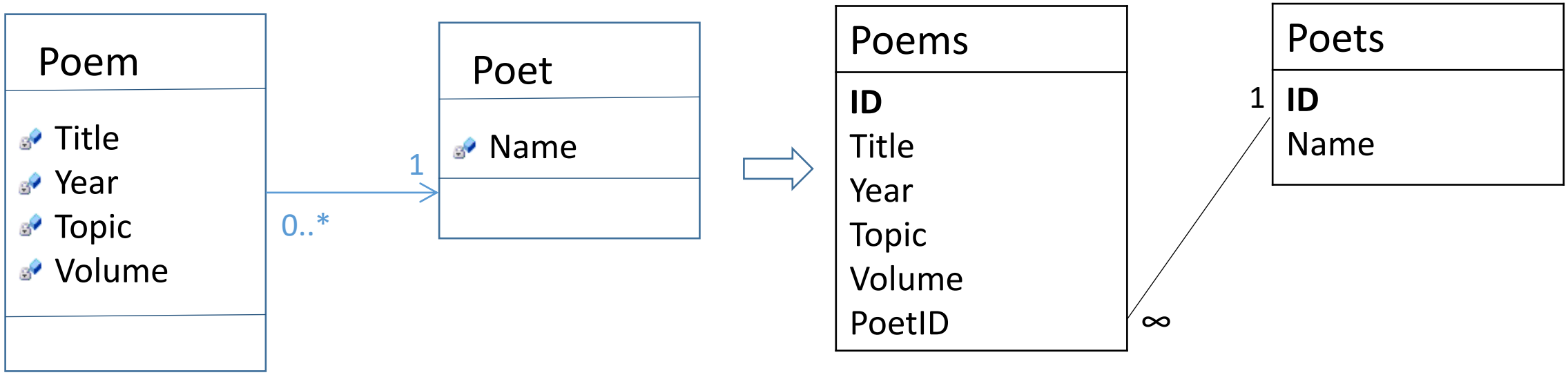
- mapping simple associations
- 1 : 0..1



- mapping simple associations
- 1 : 1
  - create 1 table containing the attributes of both classes
  - this approach can also be used for 1 : 0..1 associations (when only a few objects in the 1st class are not associated with objects in the 2nd class)



- mapping simple associations
- one-to-many
  - create 1 table / class
  - the key of the *1* table becomes a foreign key in the 2nd table



- mapping simple associations
- many-to-many
  - create one table / class
  - create an additional table, i.e., the *join table*
  - the primary keys of the 2 initial tables become foreign keys in the join table
  - the primary key of the join table:
    - composite, containing the 2 foreign keys
    - surrogate key
  - the name of the join table is usually a combination of the names of the 2 initial tables (not mandatory)
  - if an association class exists, its attributes become fields in the join table

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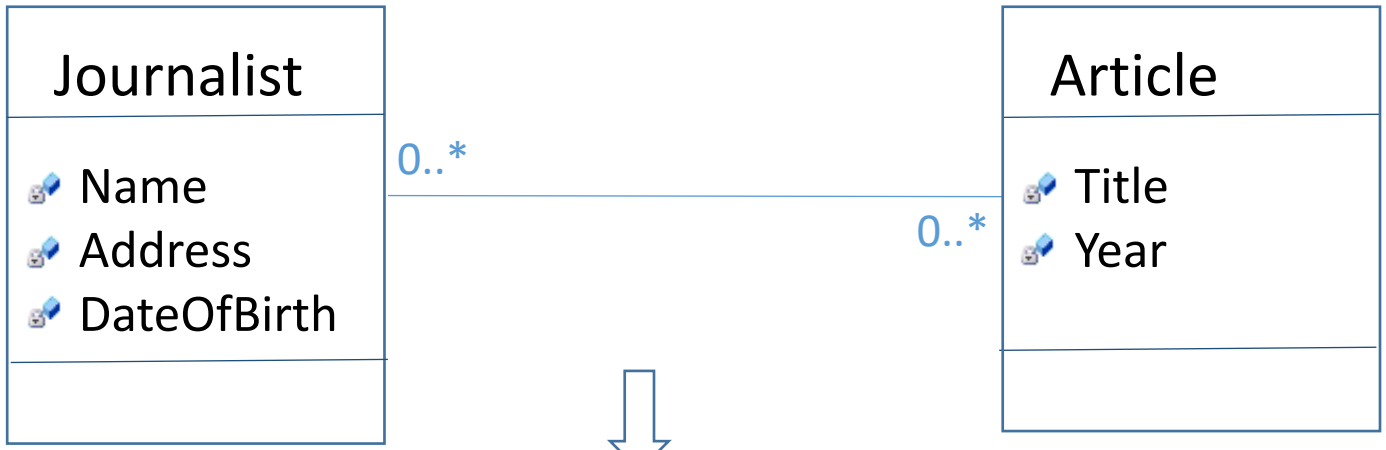
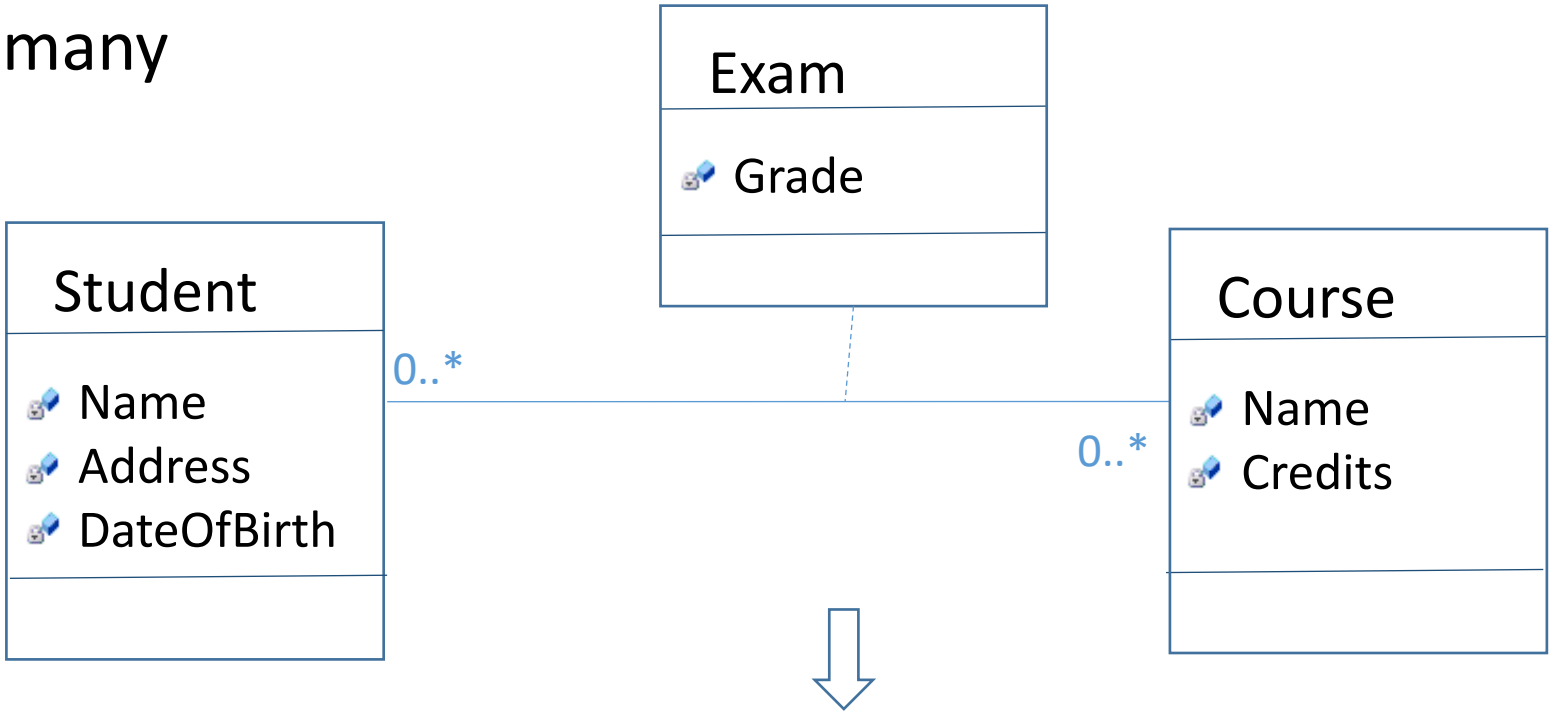
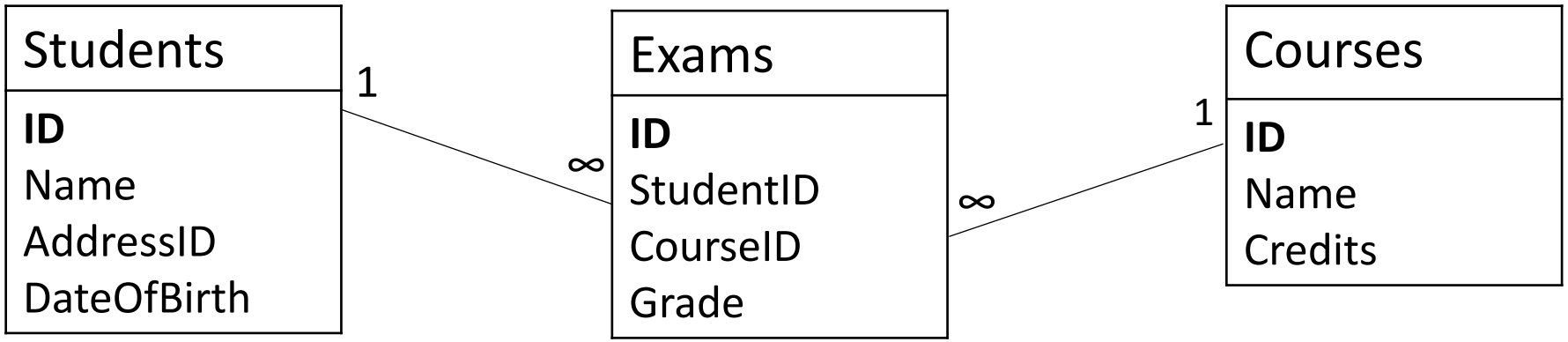
- mapping simple associations
- many-to-many



- mapping simple associations
- many-to-many





- mapping inheritance
- a1
  - create one table / class
  - create one view / superclass-subclass pair
  - it generates the largest number of objects (tables, views)
  - flexibility - no impact on existing tables / views when adding other subclasses
  - possible performance problems – every access requires a join through the view
  - can be used when the number of records is relatively small (so performance is not a concern)

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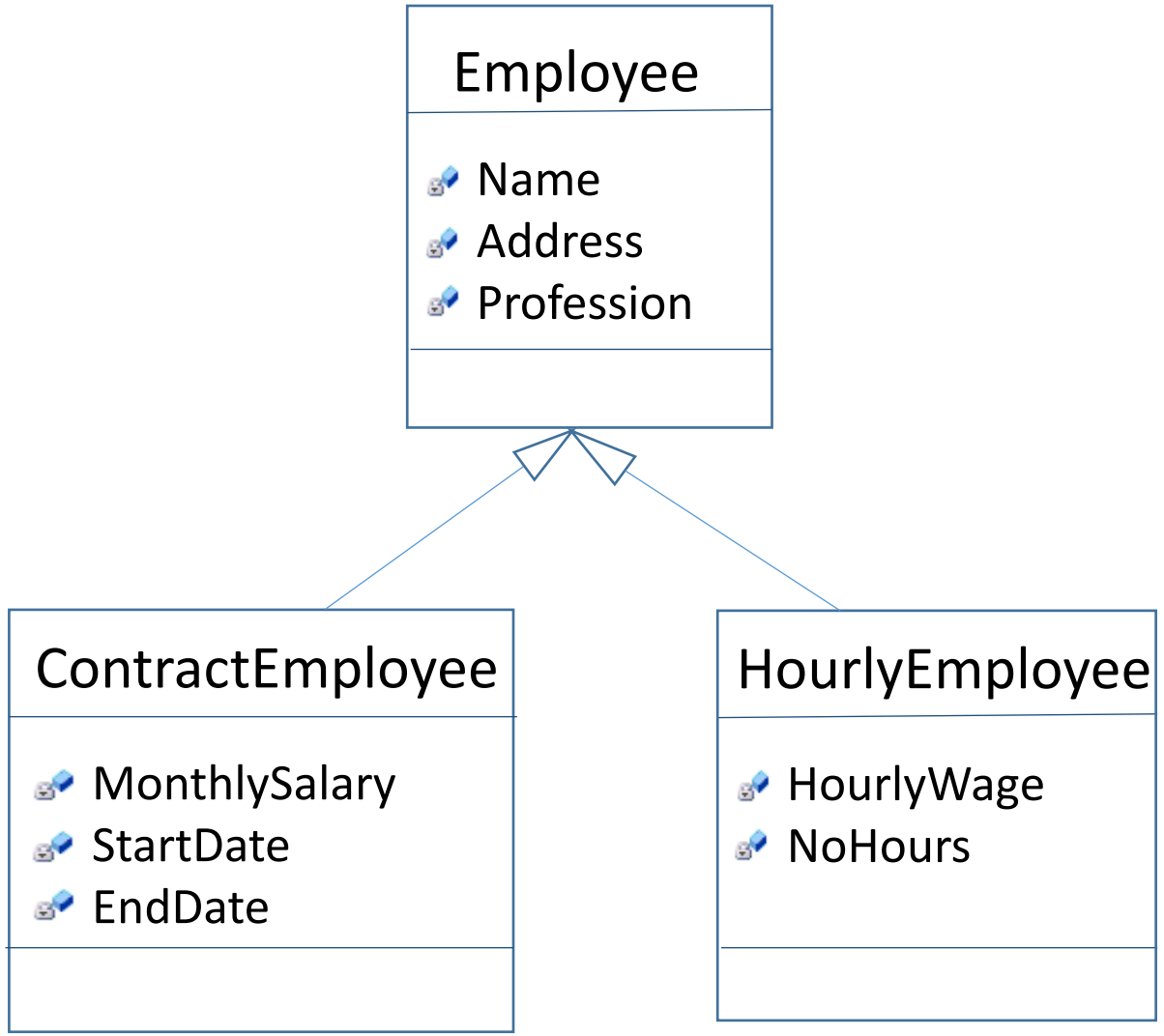
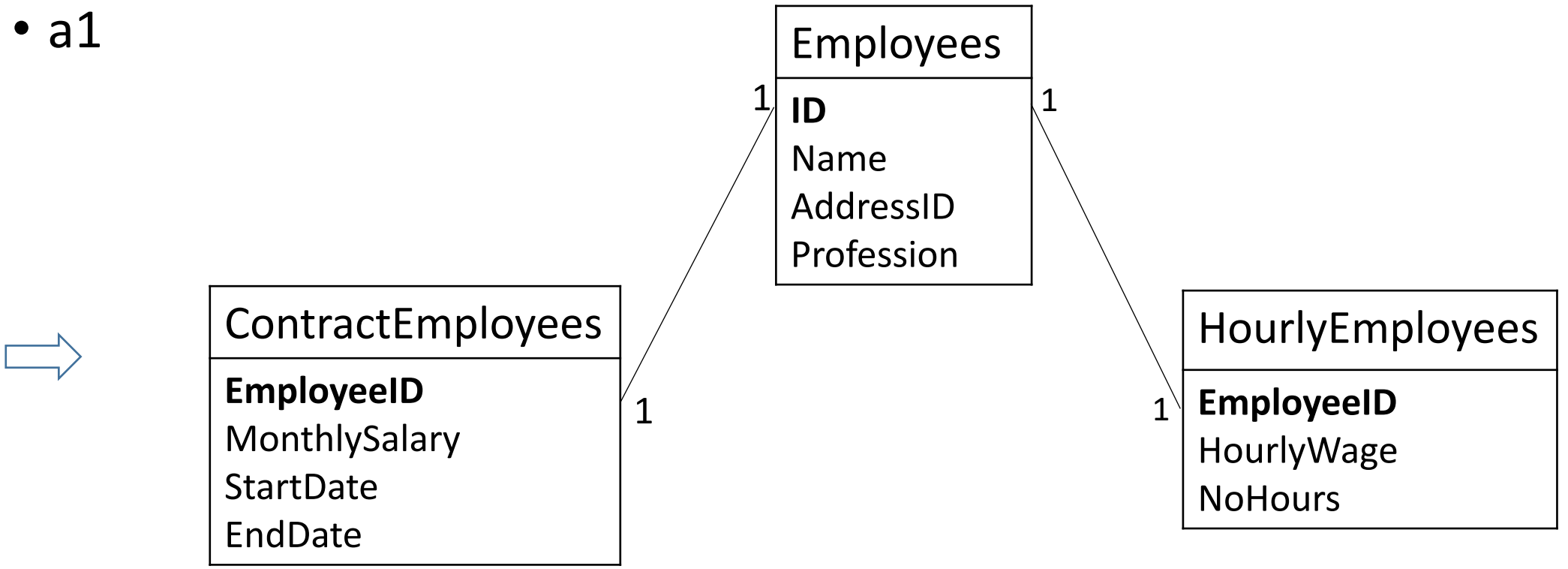
- mapping inheritance
- a1



- mapping inheritance
- a1




```
CREATE VIEW ContractEmployeesComplete(...)
AS
  SELECT Employees.*, MonthlySalary, StartDate, EndDate
  FROM Employees INNER JOIN ContractEmployees
    ON Employees.ID = EmployeeID
```

- mapping inheritance
- a2
  - create one table for the superclass
  - the attributes of the subclasses become fields in the table
  - it generates the smallest number of objects
  - optionally, a subclasses table and a view / subclass can be added
  - usually – best performance
  - when adding a subclass, the existing structure has to be changed
  - "artificial" increase of used space

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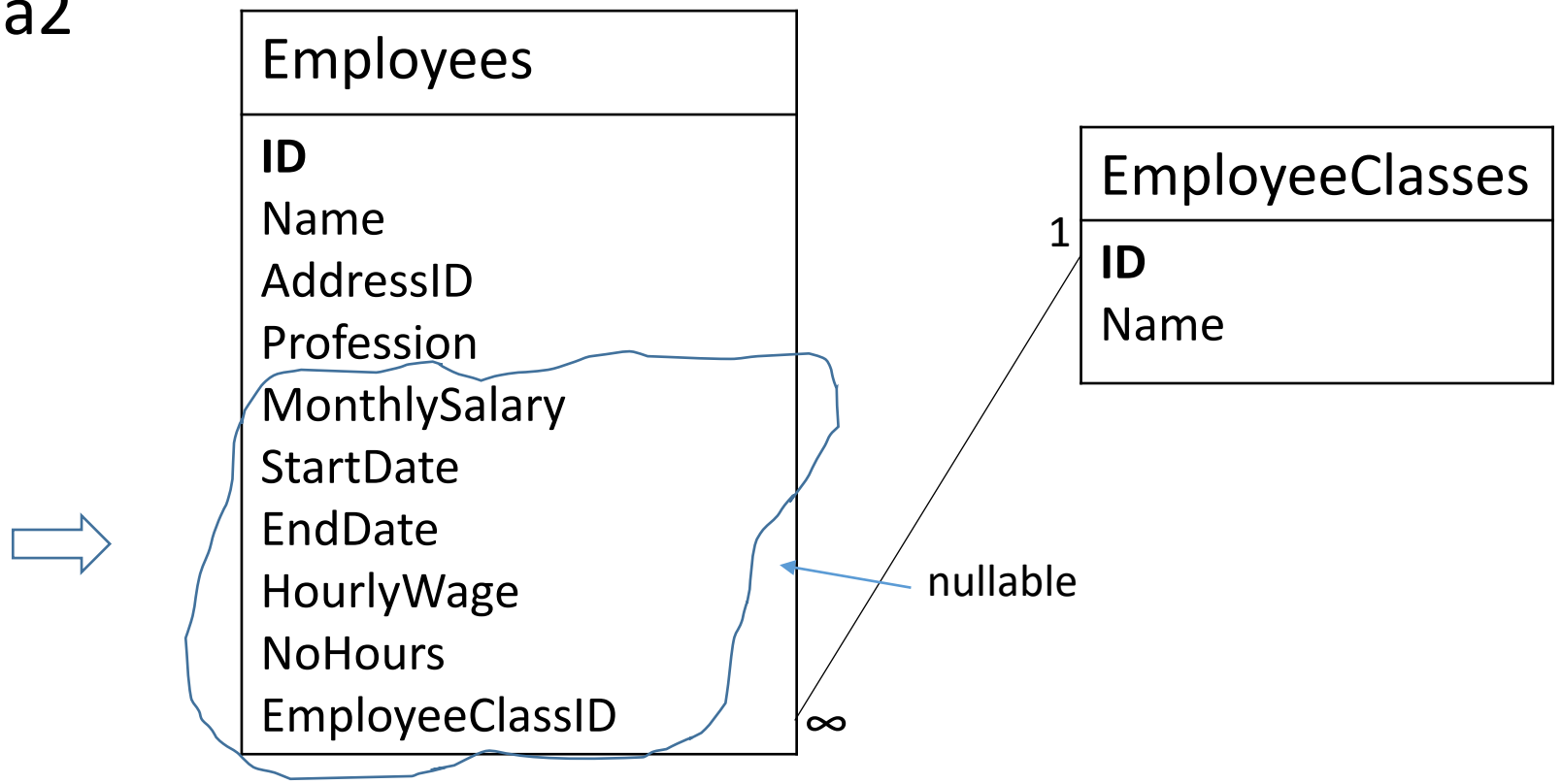
- mapping inheritance
- a2



EmployeeClasses

ID	Name
1	Unknown
2	ContractEmployee
3	HourlyEmployee

```
CREATE VIEW ContractEmployees(...)
AS
   SELECT ID, Name, AddressID, Profession, MonthlySalary, StartDate,
     EndDate
   FROM Employees
   WHERE EmployeeClassID = 2
```

- mapping inheritance
- a3
  - create one table / subclass
  - the attributes of the superclass become fields in each of the created tables
  - satisfactory performance
  - subclasses can be subsequently added without affecting existing tables
  - changing the structure of the superclass impacts all existing tables

->

- mapping inheritance
- a3

ContractEmployees
ID
Name
AddressID
Profession
MonthlySalary
StartDate
EndDate

HourlyEmployees
ID
Name
AddressID
Profession
HourlyWage
NoHours

- mapping aggregation / composition
  - similar to mapping simple associations
  - fixed number of *parts* in a *whole* => can declare the same number of foreign keys in the *whole* table
  - composition - ON DELETE CASCADE option (not required for aggregation)

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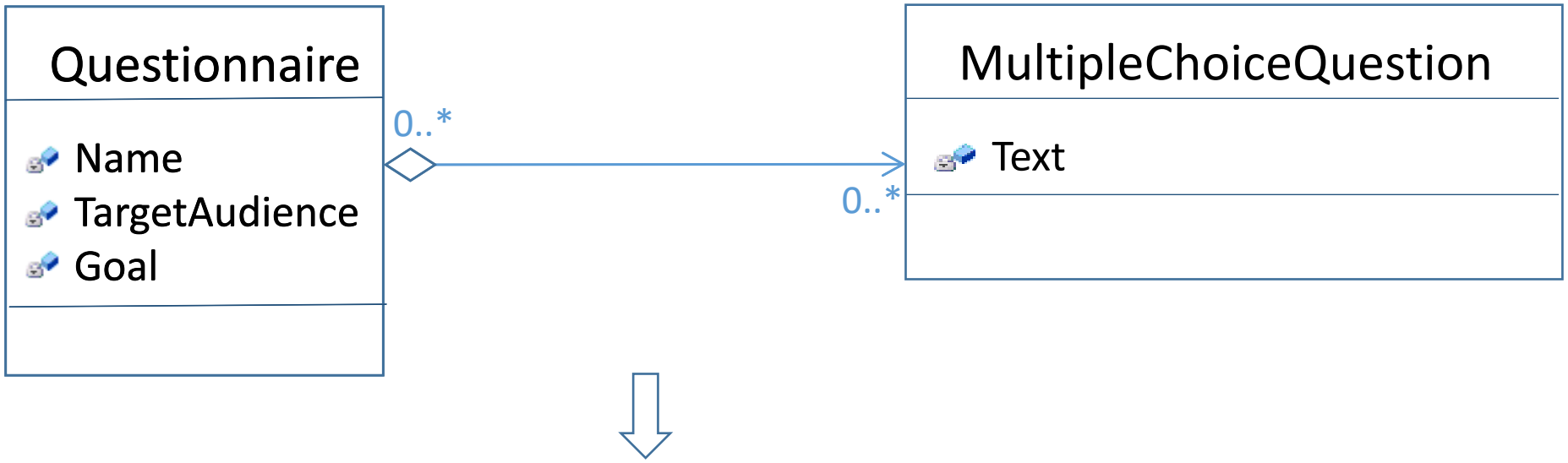
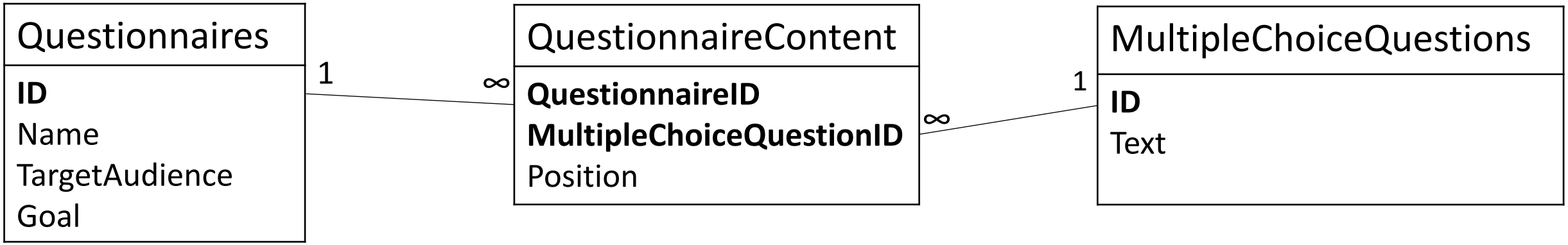
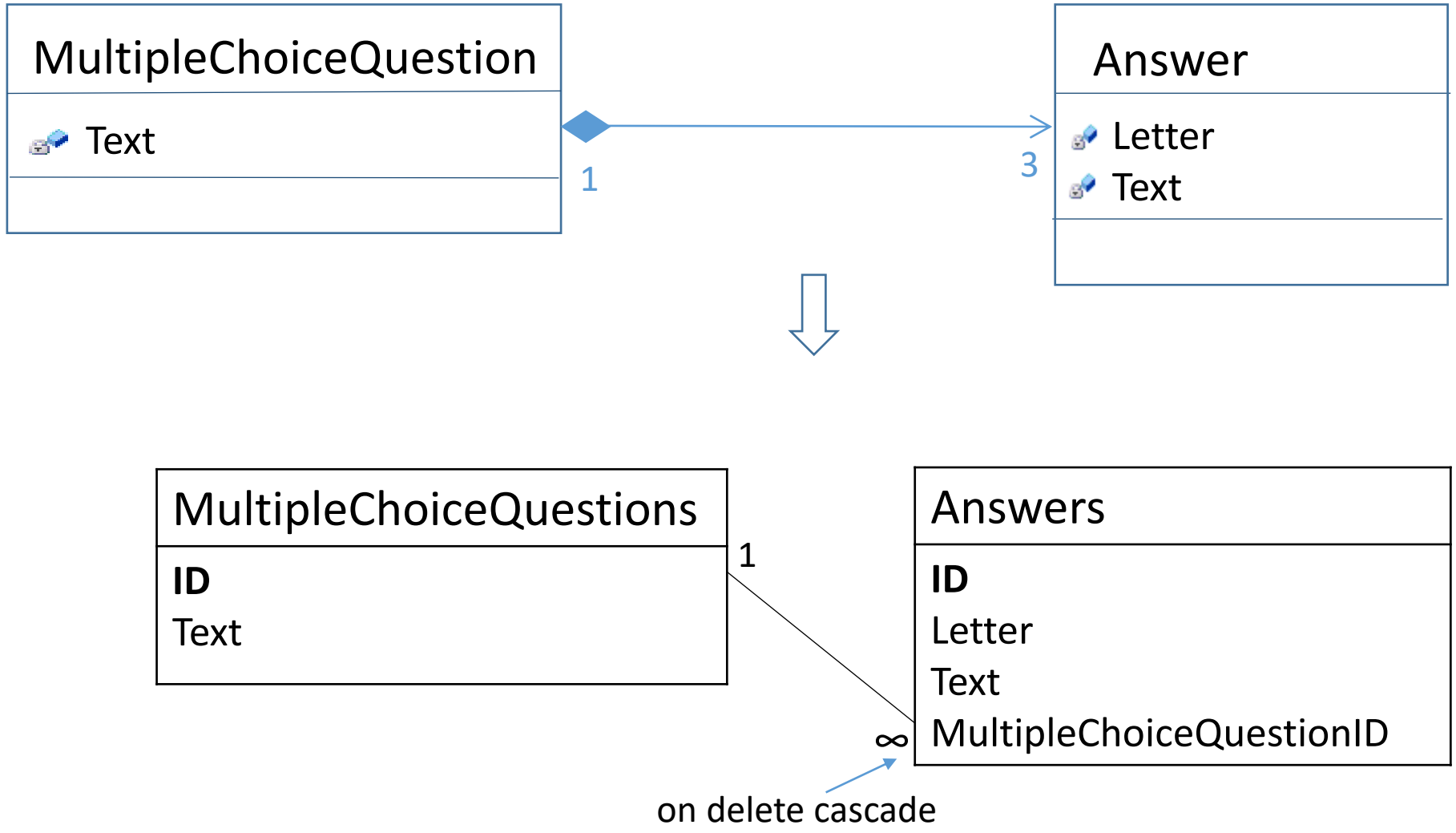
- mapping aggregation / composition



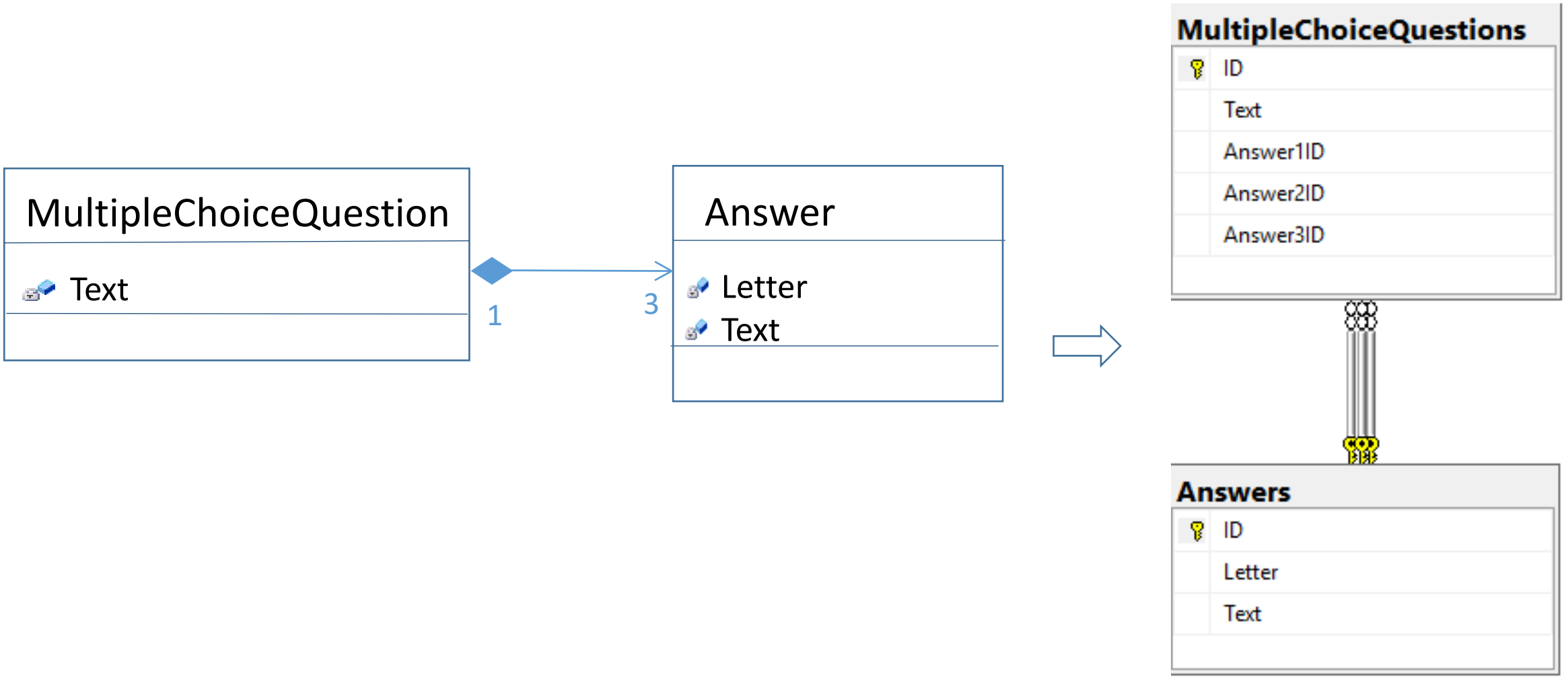


- obs. a questionnaire can also have open answer questions, etc.

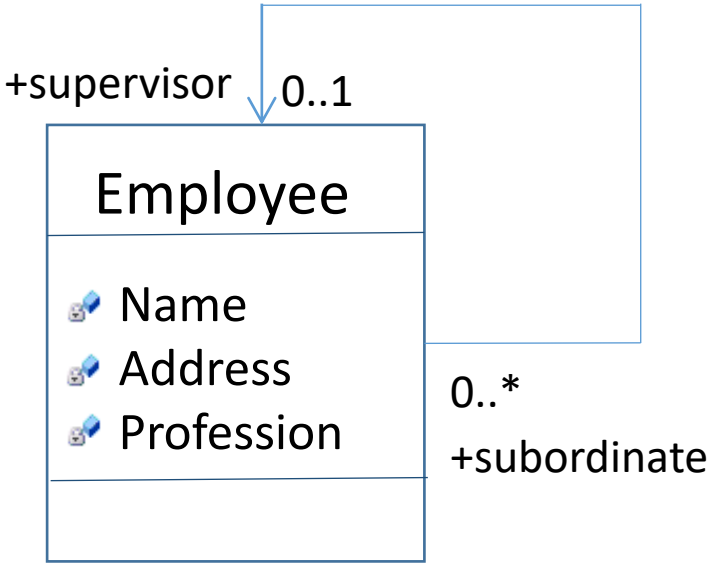
- mapping aggregation / composition

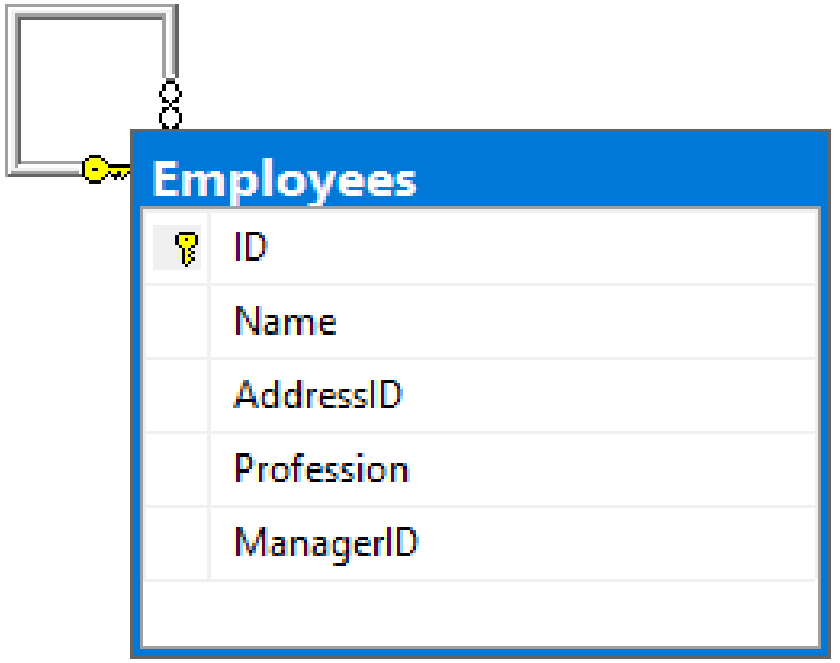


- mapping aggregation / composition

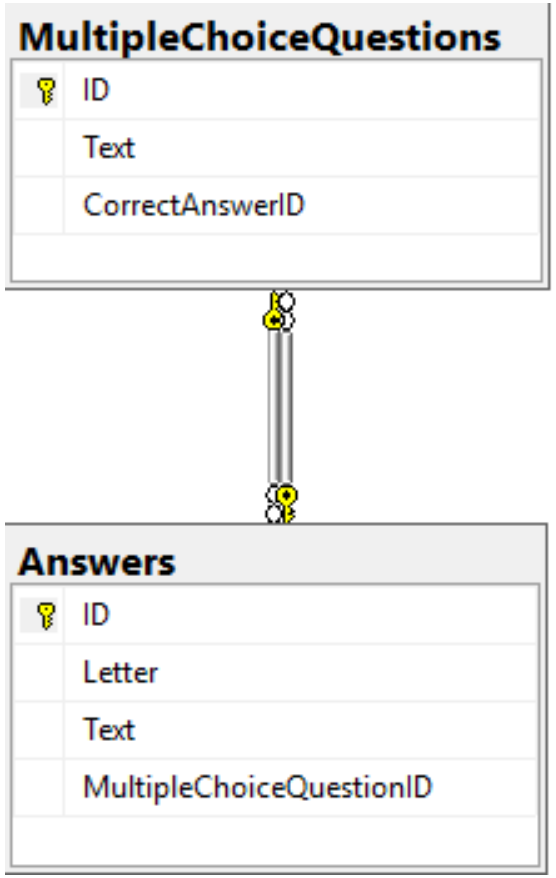


- mapping reflexive associations
- add a new field, referencing the same table (recursive relationship)
- ON DELETE CASCADE - error





Obs. 2 different tables, each with a foreign key referencing the other one, ON DELETE CASCADE - error



Problem

A musical instruments manufacturer relies on a relational database to support its activities. You are asked to design a part of the database schema and answer some questions the management is interested in using the specified database language. The manufacturer produces instruments of different categories. A category has: name (e.g., string, percussion, woodwind, etc.), description, and several subcategories. A subcategory belongs to a category and has a name (e.g., violin, piano, contrabass, etc.). An instrument currently in stock belongs to a subcategory and has: serial number, date of manufacture, color, and price. A customer has: name, score, and type (e.g., music academy, orchestra, etc.). The company takes orders directly from customers, online or by phone. An order is placed by a customer and has: 2 dates – the date when the order was made and the date when it was shipped (*null* for unfulfilled orders), a field indicating whether it's been placed online or by phone, and, for each subcategory of instruments in the order, the number of ordered instruments of each color (e.g., an order for 7 red violins, 3 white violins, 2 white pianos, and a yellow contrabass).

* Write an SQL query for the following task:
For every orchestra that ordered violins in at least 3 different orders, find the total number of ordered instruments – (CustomerID, TotalNumInstruments).

* Write a relational algebra expression for the following task:
Find all the string instruments that are currently in stock and cost less than 2000 lei – (subcategory name, instrument serial number and price).

References

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