Conceptual Modeling

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SoftEng
http://softeng.polito.it

Licensing Note

IS Aspects

- Information
  - Conceptual modeling
    - UML Class diagrams
    - (Entity-Relationships)
- Process flow
  - Process modeling
    - UML Activity Diagrams
    - BPMN
- Interaction
  - Interaction modeling
    - Use cases

UML

- Unified Modeling Language
- Standardized by OMG
- Several diagrams
  - Class diagrams
  - Activity diagrams
  - Use Case diagrams
  - Sequence diagrams
  - Statecharts

Conceptual modeling

Interaction modeling

Conceptual Modeling

CLASS DIAGRAM

Conceptual Modeling

- Construction of model
  - Providing an optimal description
  - From the stakeholder's perspective

- Is the formalization phase after
  - Requirements elicitation and collection
  - Requirements analysis

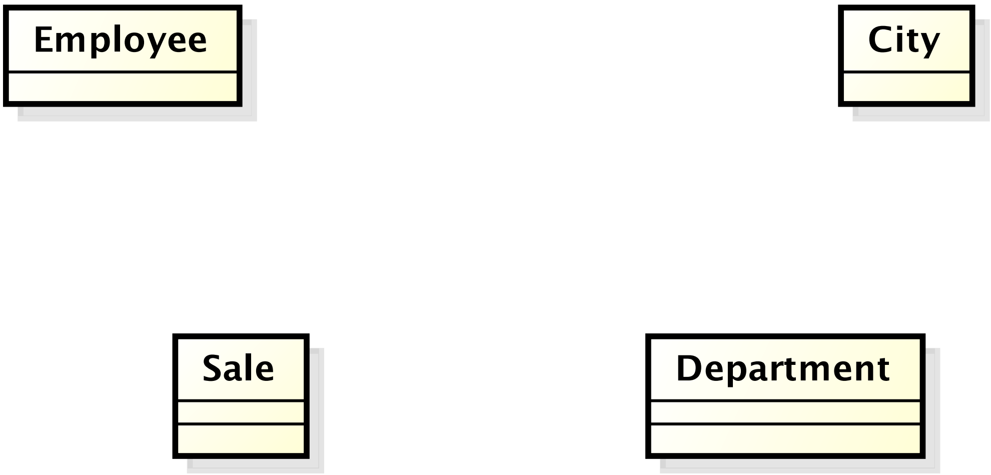
Goal

- Capture
  - Main (abstract) concepts
  - Characteristics of the concepts
    - Data associated to the concepts
  - Relationships between concepts

Class

- A class represents a set of objects
  - Common properties
  - Autonomous existence
  - E.g. facts, things, people
- Use a singular common noun
  - E.g. in an application for a commercial organization CITY, DEPARTMENT, EMPLOYEE, PURCHASE and SALE are typical classes.

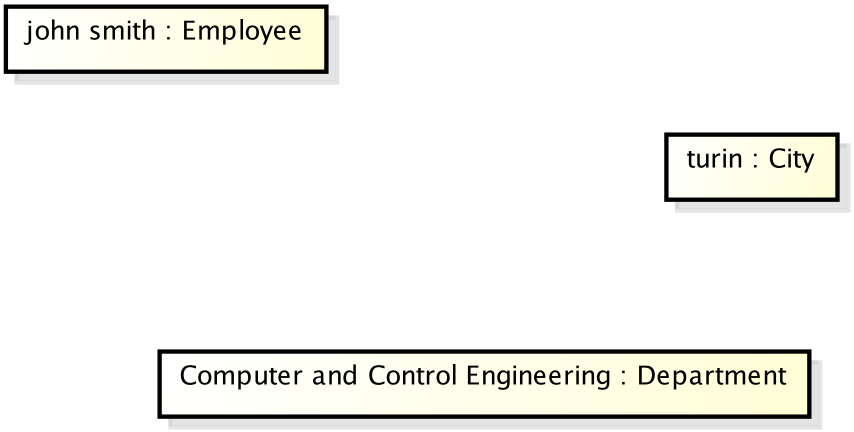
Class - Examples



Object

- Model of a specific item (material or immaterial) within the software system
  - E.g.: a student, an exam, a window
- Characterized by
  - identity
  - attributes (or data or properties)

Object – Examples



john smith : Employee

turin : City

Computer and Control Engineering : Department

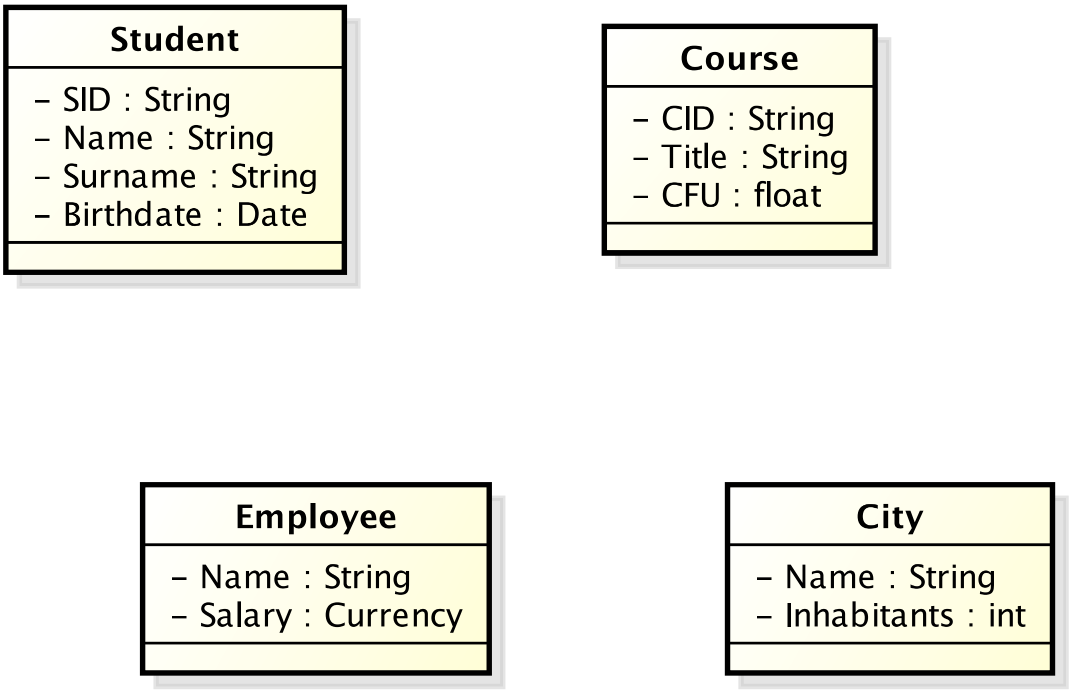
Abstraction levels

Abstract	Concept Entity Class Category Type
Concrete	Instance Item Object Example Occurrence

Attribute

- Elementary property of a class
  - Name
  - Type
- An attribute associates to each object (occurrence of a class) a value of the corresponding type
  - Surname: String
  - ID: Numeric
  - Salary: Currency

Attribute – Example



Student
- SID : String
- Name : String
- Surname : String
- Birthdate : Date

Course
- CID : String
- Title : String
- CFU : float

Employee
- Name : String
- Salary : Currency

City
- Name : String
- Inhabitants : int

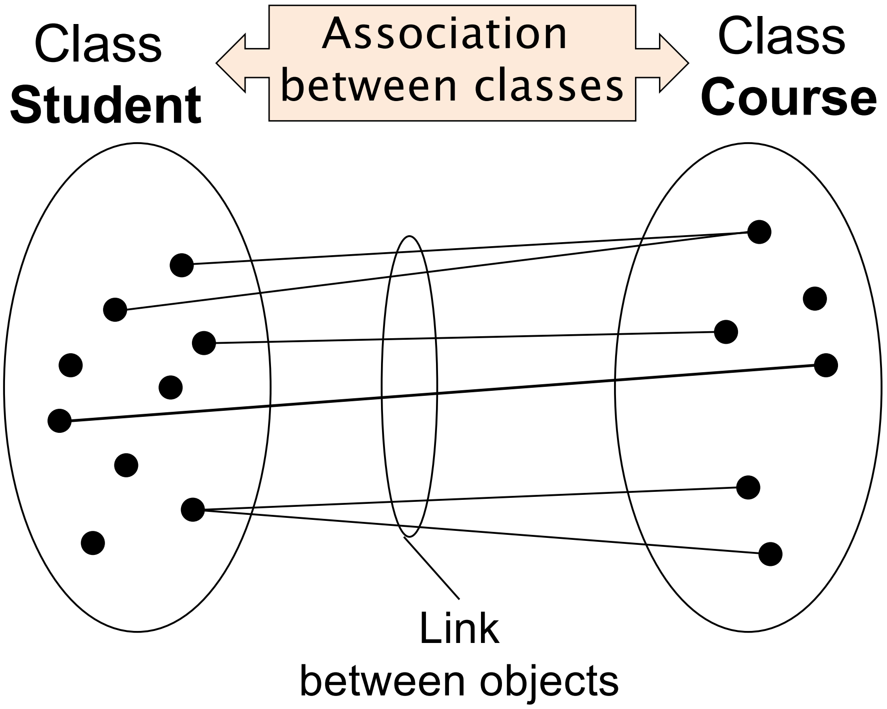
Attribute Types

Type	Description
`int`	Integer number
`float`	Real number
`boolean`	Logical value (T/F, Yes/No)
`String`	Character string/ Text
`Date`	Date (day-month-year)
`Time`	Time (hours:minutes:seconds)
`Currency`	Currency values

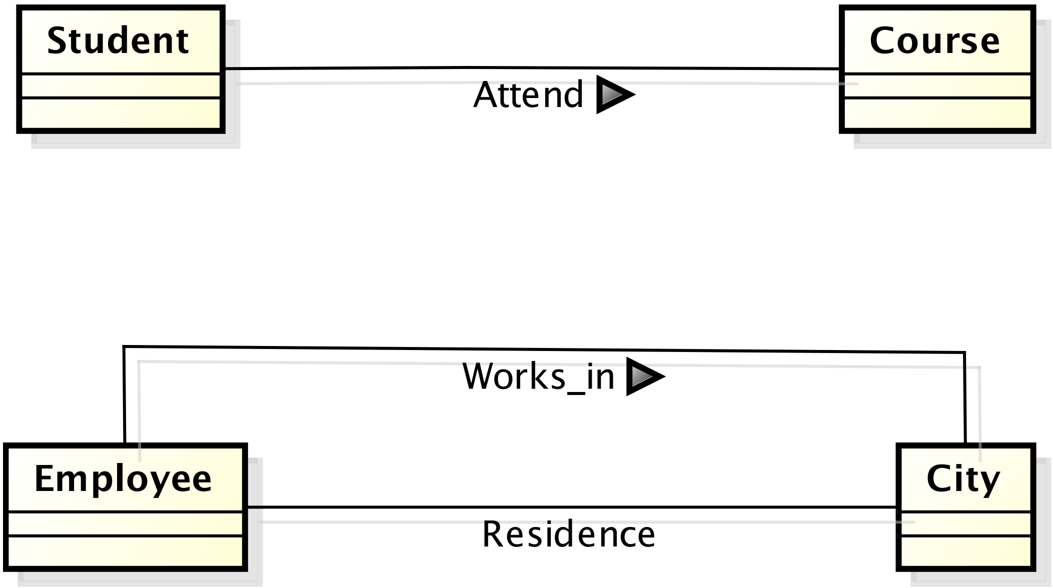
Association

- Represent logical links between two classes.
- An occurrence of an association is a pair of occurrences of entities, one for each involved class
  - Residence can be an association between the classes City and Employee;
  - Exam can be an association between the classes Student and Course.

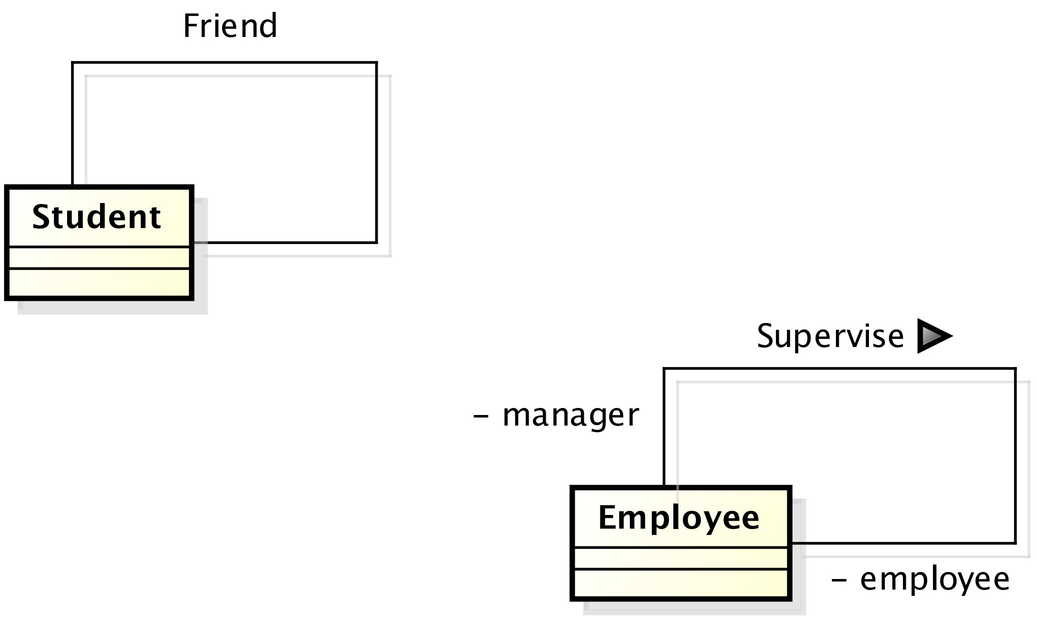
Association



Association – Examples

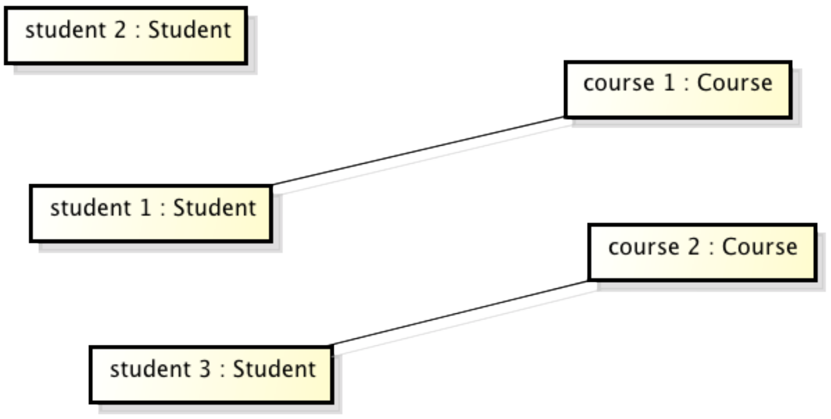


Recursive association–Samples



Link

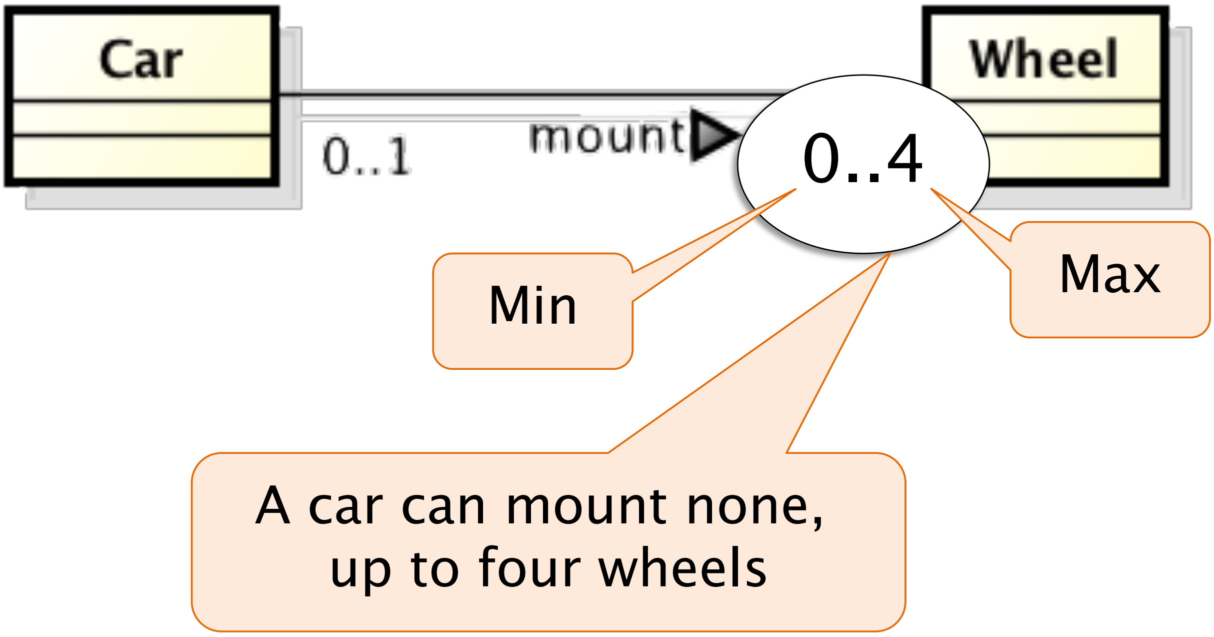
- Represents the instance of association between objects



Multiplicity

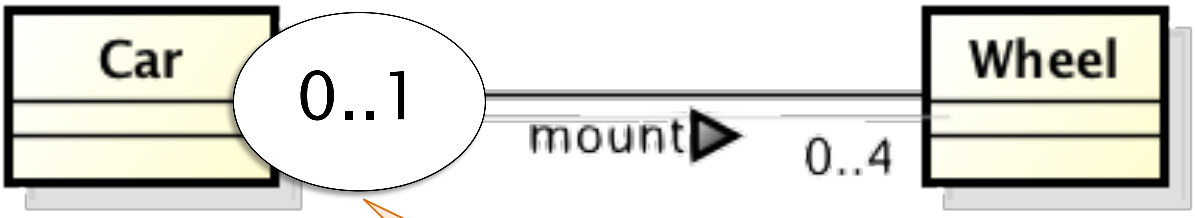
- Describes the maximum and minimum number of links in which a class occurrence can participate
  - Undefined maximum expressed as *
- Should be specified for each class participating in an association

Multiplicity – Example



A car can mount none, up to four wheels

Multiplicity – Example

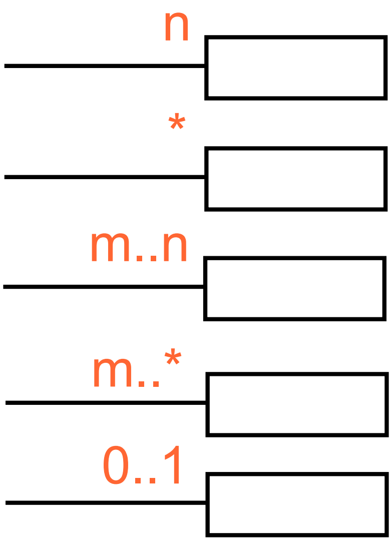


A wheel can be mounted on none or at most one car

Multiplicity

- Typically, only three values are used: 0, 1 and the symbol * (many)
- Minimum: 0 or 1
  - 0 means the participation is *optional,*
  - 1 means the participation is *mandatory;*
- Maximum: 1 or *
  - 1: each object is involved in at most one link
  - *: each object is involved in many links

Multiplicity



Exactly n

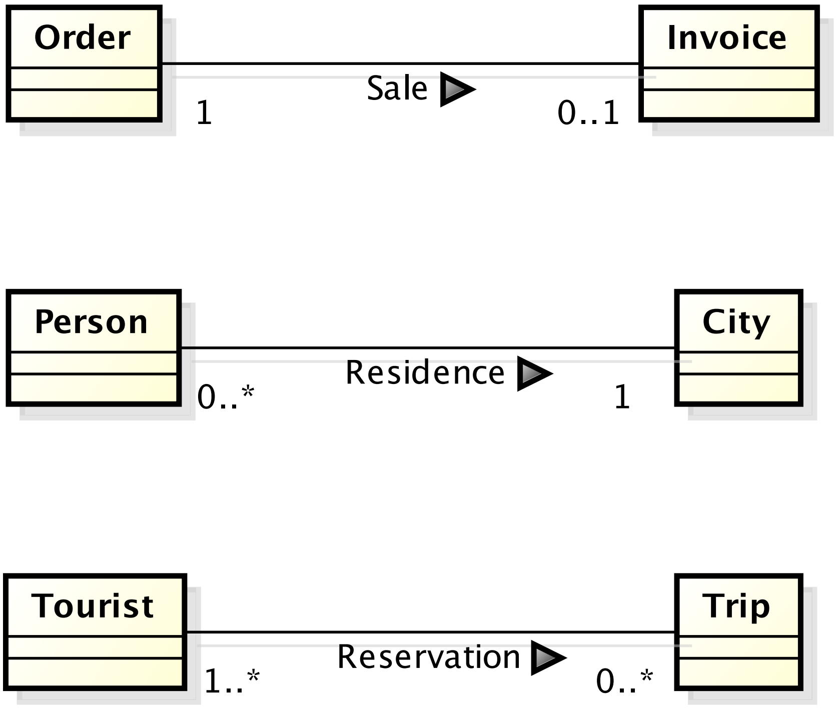
Zero or more

Between m and n (m,n included)

From m up

Zero or one (optional)

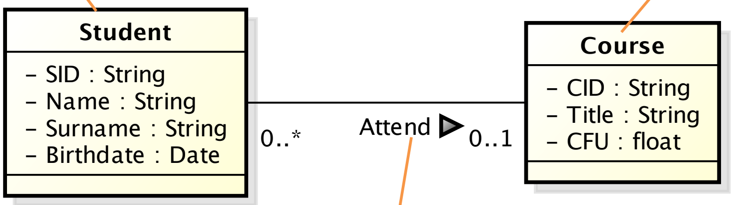
Multiplicity



Operational interpretation

SID	Name	Surname	Birthdate
S2345	John	Smith	1990-4-12
S1234	Jane	Brown	1991-7-11
S5678	Mario	Rossi	1991-11-5

CID	Title	CFU
C001	Information Systems	8
C002	Advanced Programming	10
C003	Calculus	10

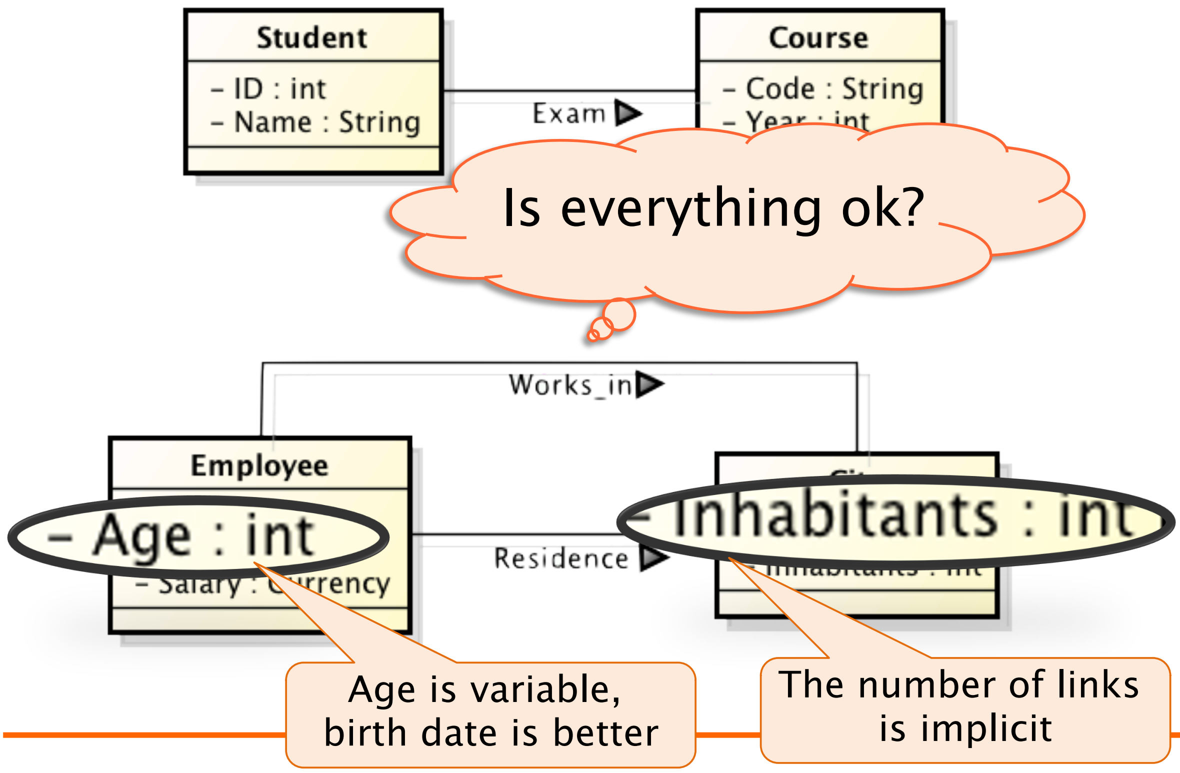


	C001	C002	C003
S2345			X
S1234	X		
S5678	X		

Practical limitations

- The theoretical model of the association is that of a set relationship
  - i.e. a subset of the cartesian product
- An association can represent the presence (or absence) of a link between two objects
  - Not the presence of several links between the same two objects
    - E.g. a student either attend or does not, a given course

Derived attributes

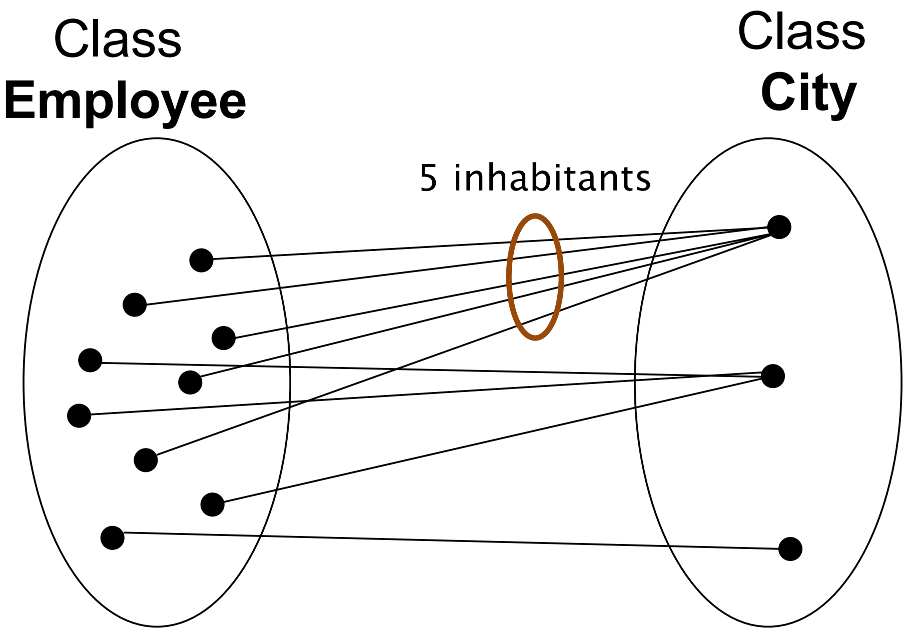


Is everything ok?

Age is variable, birth date is better

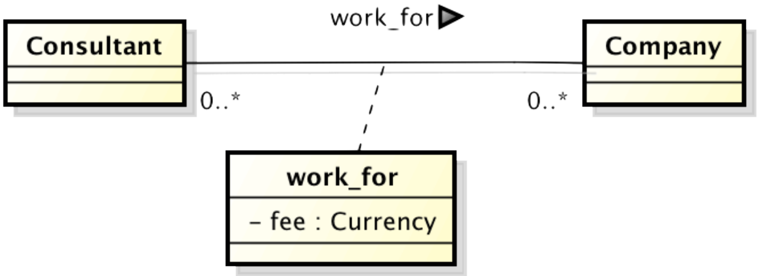
The number of links is implicit

Derived attributes

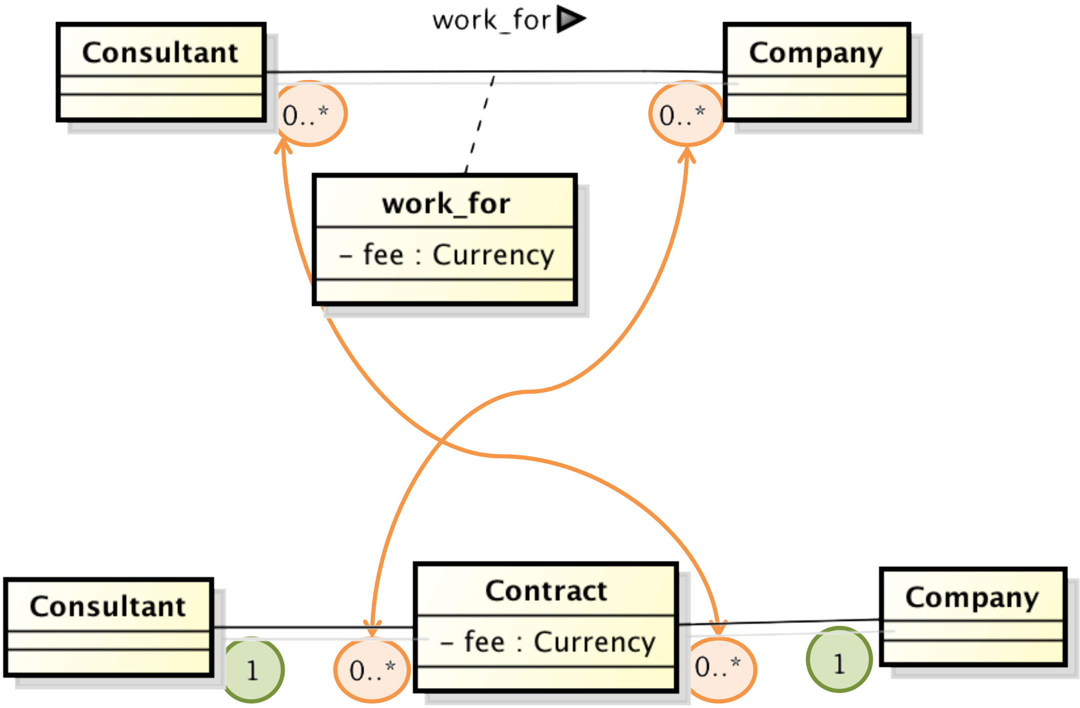


Association Class

- The association class define the attributes related to the association
- A link between two object includes
  - The two linked objects
  - The attributes defined by the association class



Association class – Equivalence



Association Class Limitations

- Association class
  - Fee is a function of consultant and company

    fee (Consultant , Company)

- Intermediate class
  - Fee is a function of the contract

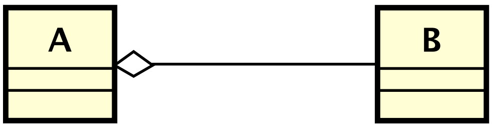
    fee (Contract)

Association class limitation

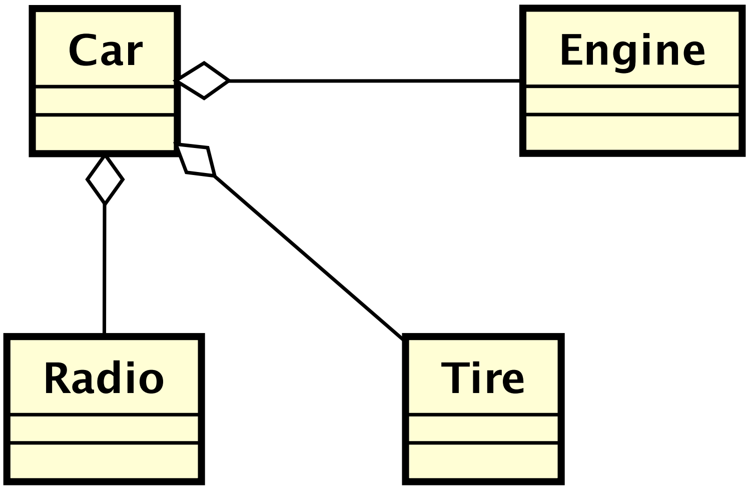
- Specific case:
  - A *Consultant* can work several times for the same *Company*
- This configuration cannot be represented by an association class
- It can only be represented through intermediate class

Aggregation

- B *is-part-of* A means that objects described by class B can be seen as attributes of objects described by A
  - Typically objects of type B exist as long as the aggregate (container) object of type A exists

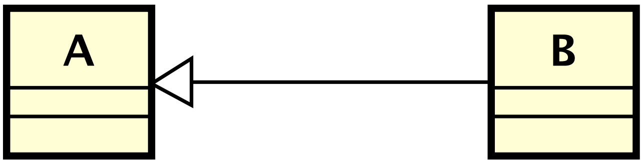


Aggregation Example

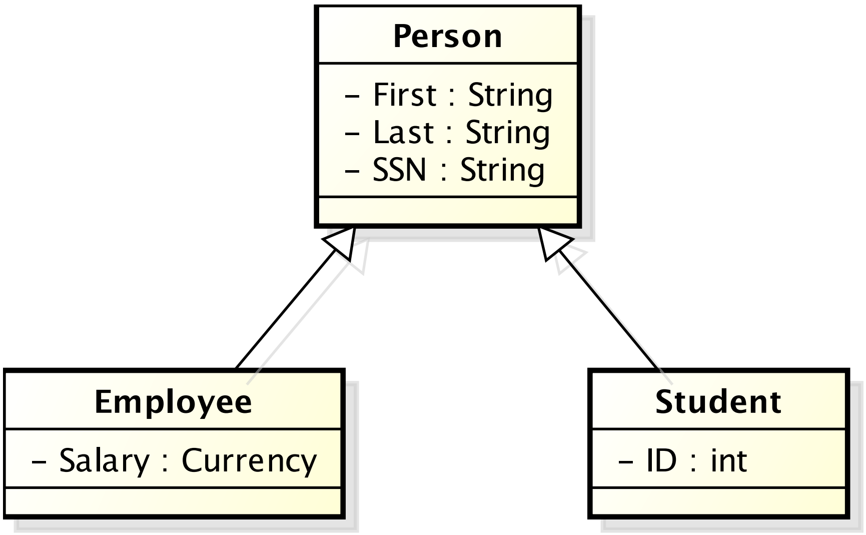


Specialization / Generalization

- B *specializes* A means that
  - B has the same characteristics as A
    - Attributes
    - Participation in associations
  - B may have additional characteristics
  - B is a special case of A
  - A is a generalization of B



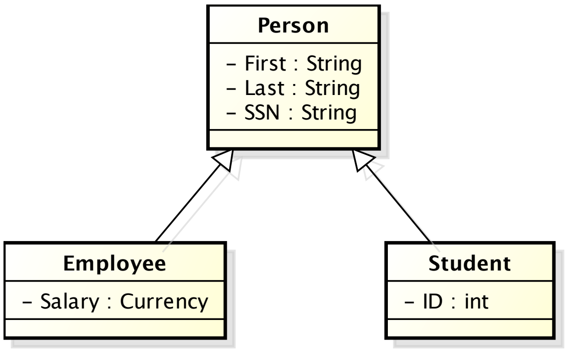
Specialization example

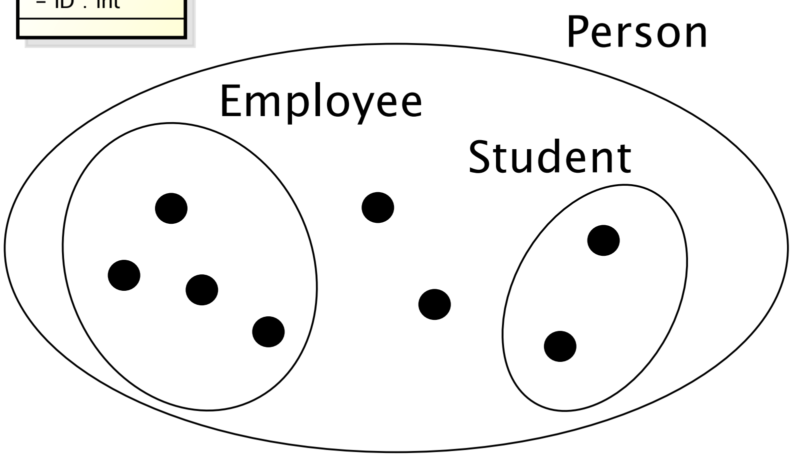


Inheritance terminology

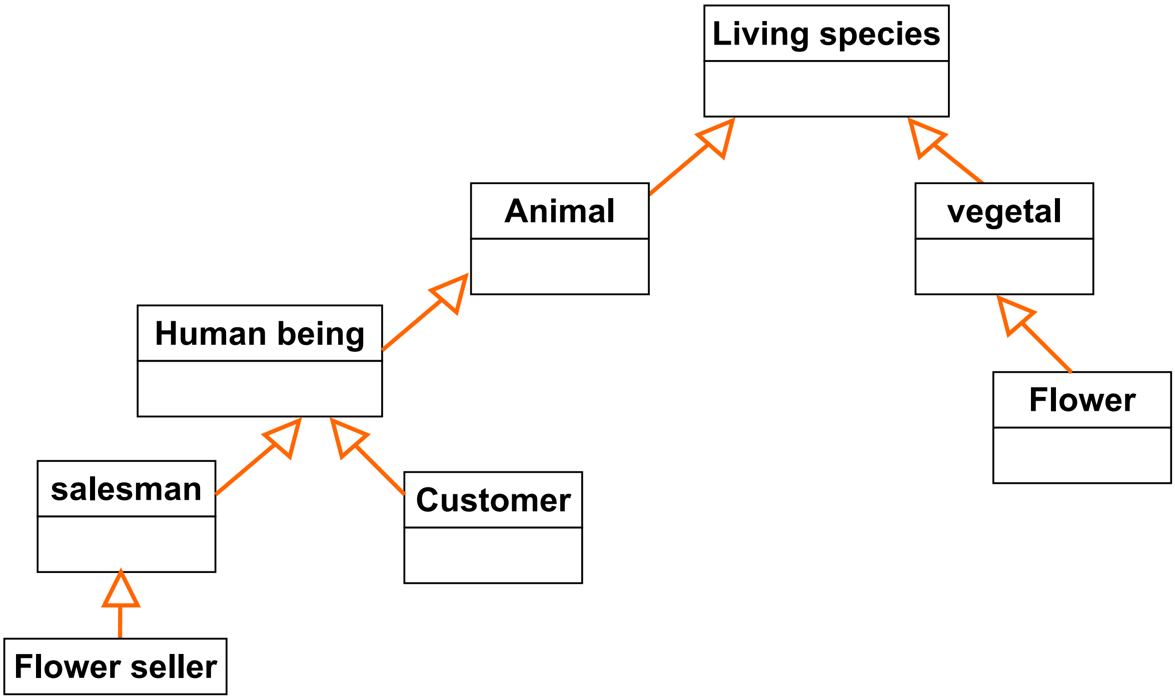
- Class one above
  - Parent class
- Class one below
  - Child class
- Class one or more above
  - Superclass, Ancestor class, Base class
- Class one or more below
  - Subclass, Descendent class, Derived class

Set theory and Specialization





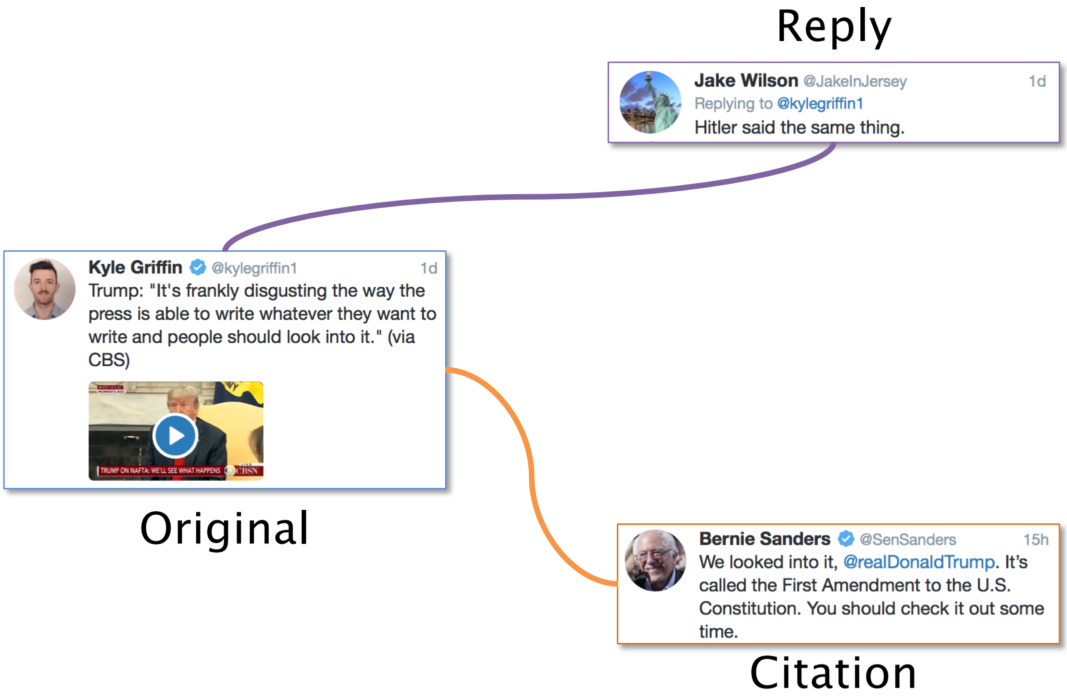
Example of inheritance tree



Specialization types

- Totality
  - Total: the union of the derived classes covers all the base class
  - Partial: some object does not belong to any of the derived classes
- Exclusion
  - Mutual exclusive: an object can belong to at most one derived class
  - Inclusive: an object can belong to more than one derived class

Example



Reply

Jake Wilson @JakeInJersey 1d
Replying to @kylegriffin1
Hitler said the same thing.

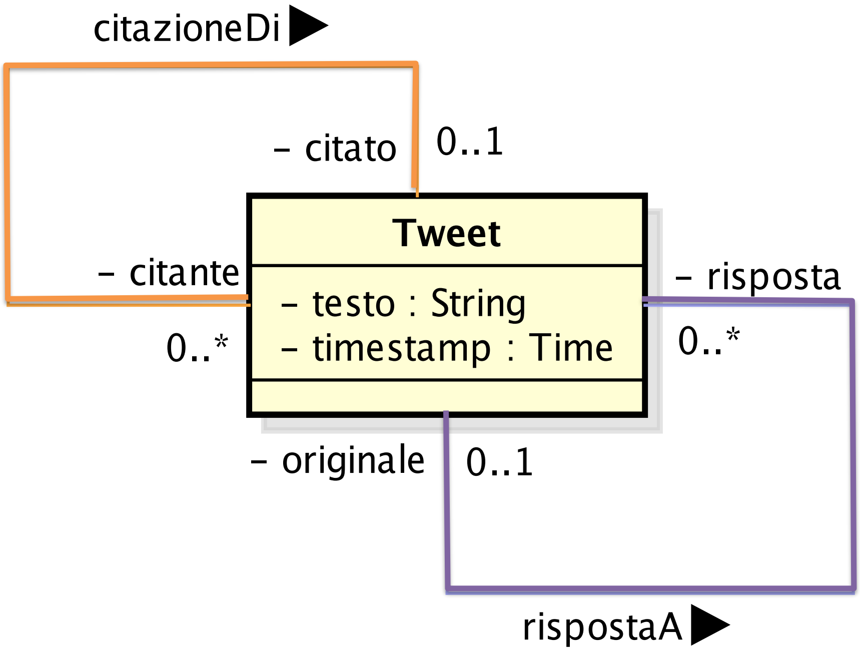
Kyle Griffin @kylegriffin1 1d
Trump: "It's frankly disgusting the way the press is able to write whatever they want to write and people should look into it." (via CBS)

Original

Bernie Sanders @SenSanders 15h
We looked into it, @realDonaldTrump. It's called the First Amendment to the U.S. Constitution. You should check it out some time.

Citation

Optional Recursive Associations



citazioneDi ▶

– citato 0..1

– citante 0..*

Tweet

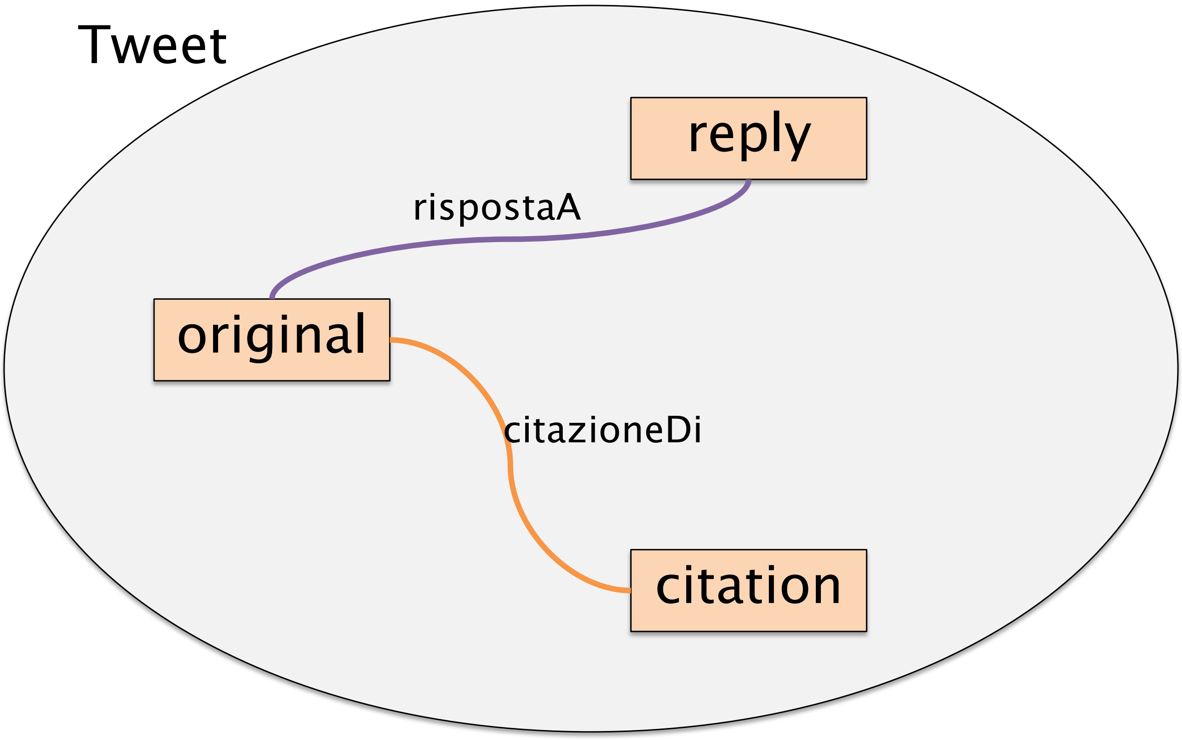
– testo : String
– timestamp : Time

– risposta 0..*

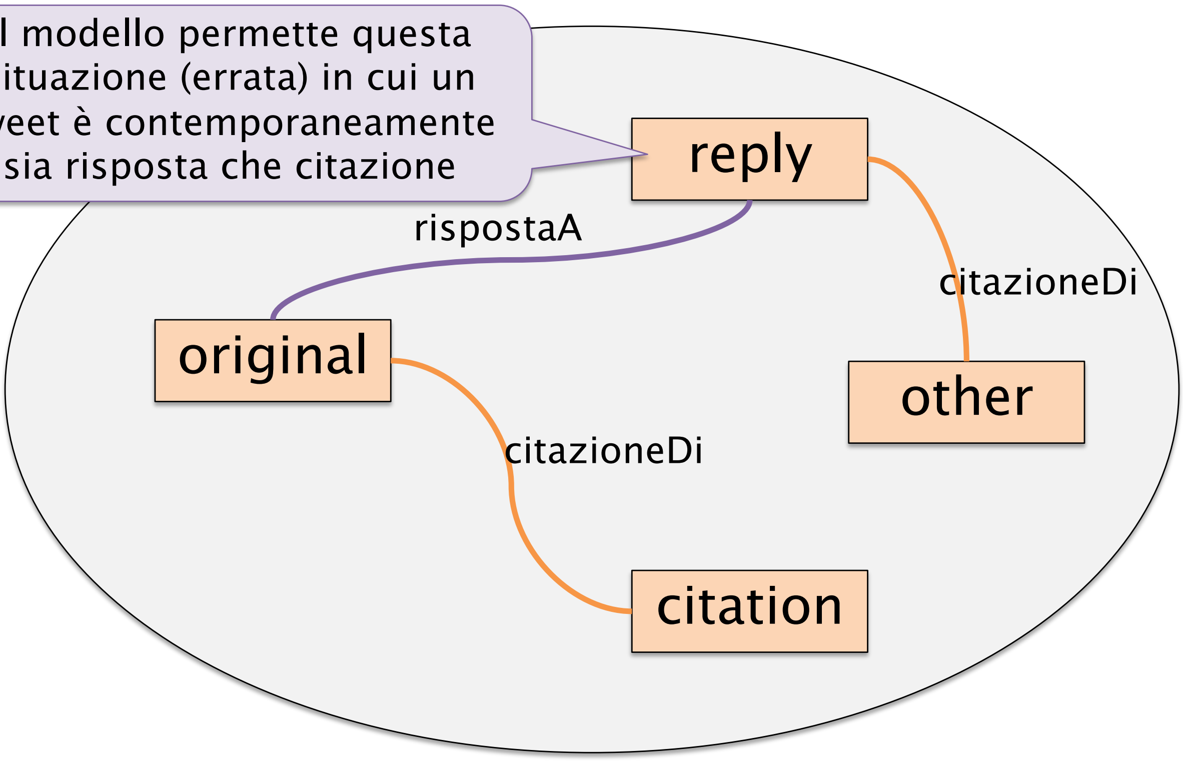
– originale 0..1

rispostaA ▶

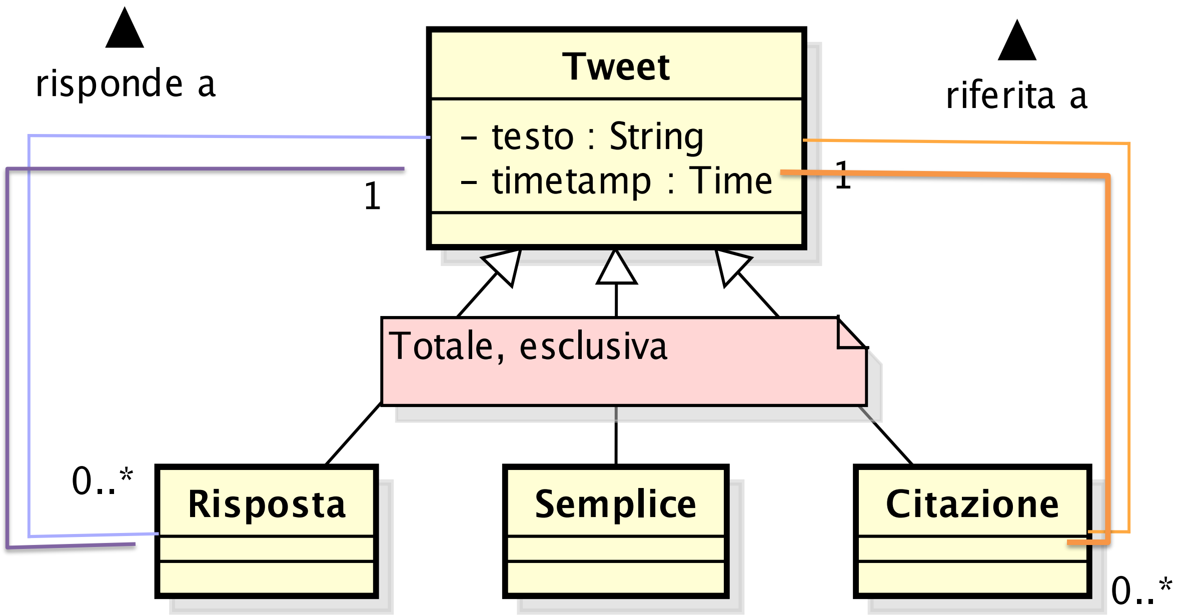
Optional Recursive Associations



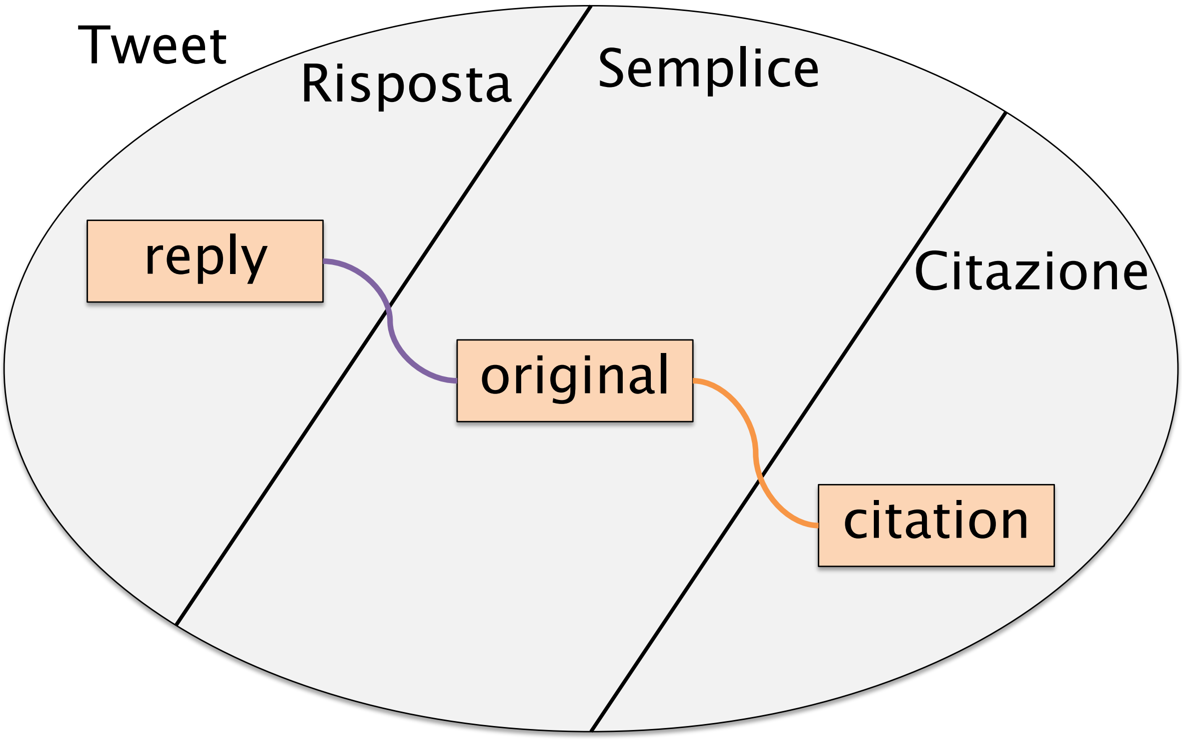
Optional Recursive Associations


Il modello permette questa situazione (errata) in cui un tweet è contemporaneamente sia risposta che citazione

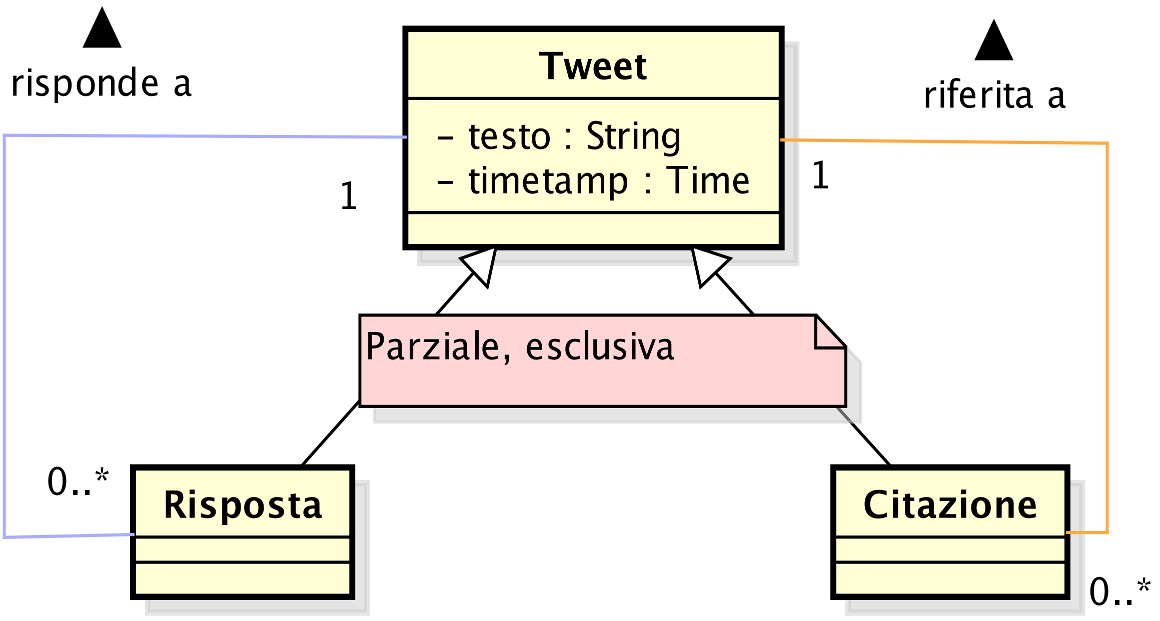
Specialization



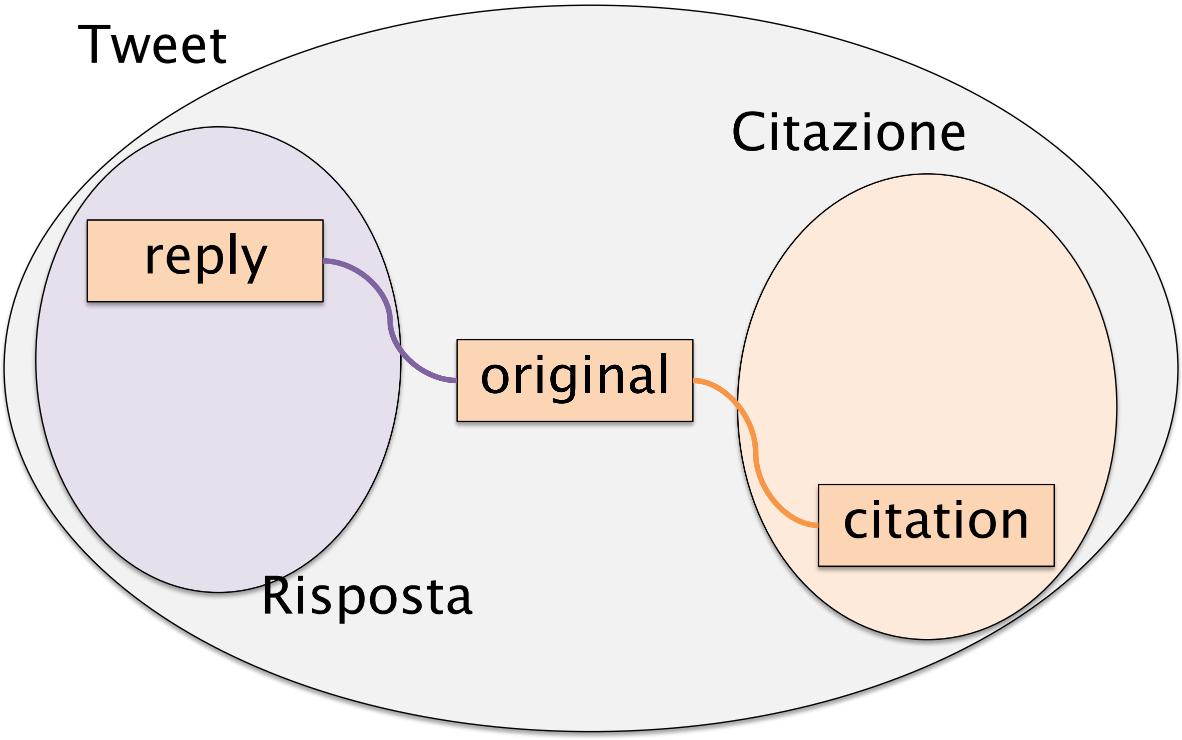
Specialization



Partial Specialization



Patial Specialization



NL Requirements Specification

- Requirements specifications are often written in natural language (NL)
  - At least in the first draft.
- NL is, by nature, subject to ambiguity and misinterpretation.
- Inaccuracies and ambiguous terms must be removed
  - Necessary an in-depth analysis of the specification document

Essential guidelines

- If a concept has significant properties and/or describes types of objects with an autonomous existence, it can be represented by a class.
- If a concept has a simple structure and has no relevant properties associated with it, e.g. a simple value, it is likely an attribute of a class.
- If a concept provides a logical link between two (or more) entities, it is convenient to represent it by means of an association.
- If one or more concepts are special cases of another concept, it is convenient to represent them by means of a generalization.

Modeling strategies

- Top-down
  - Start with abstract concepts and perform successive refinements
- Bottom-up
  - Start with detailed concepts and proceed with integrating different pieces together
- Inside-out
  - Like bottom-up but beginning with most important concepts first
- Hybrid

Conceptual model quality

- Correctness
  - No requirement is misrepresented
- Completeness
  - All requirements are represented
- Readability
  - It is easy to read and understand
- Minimality
  - There are no avoidable elements

EXAMPLE

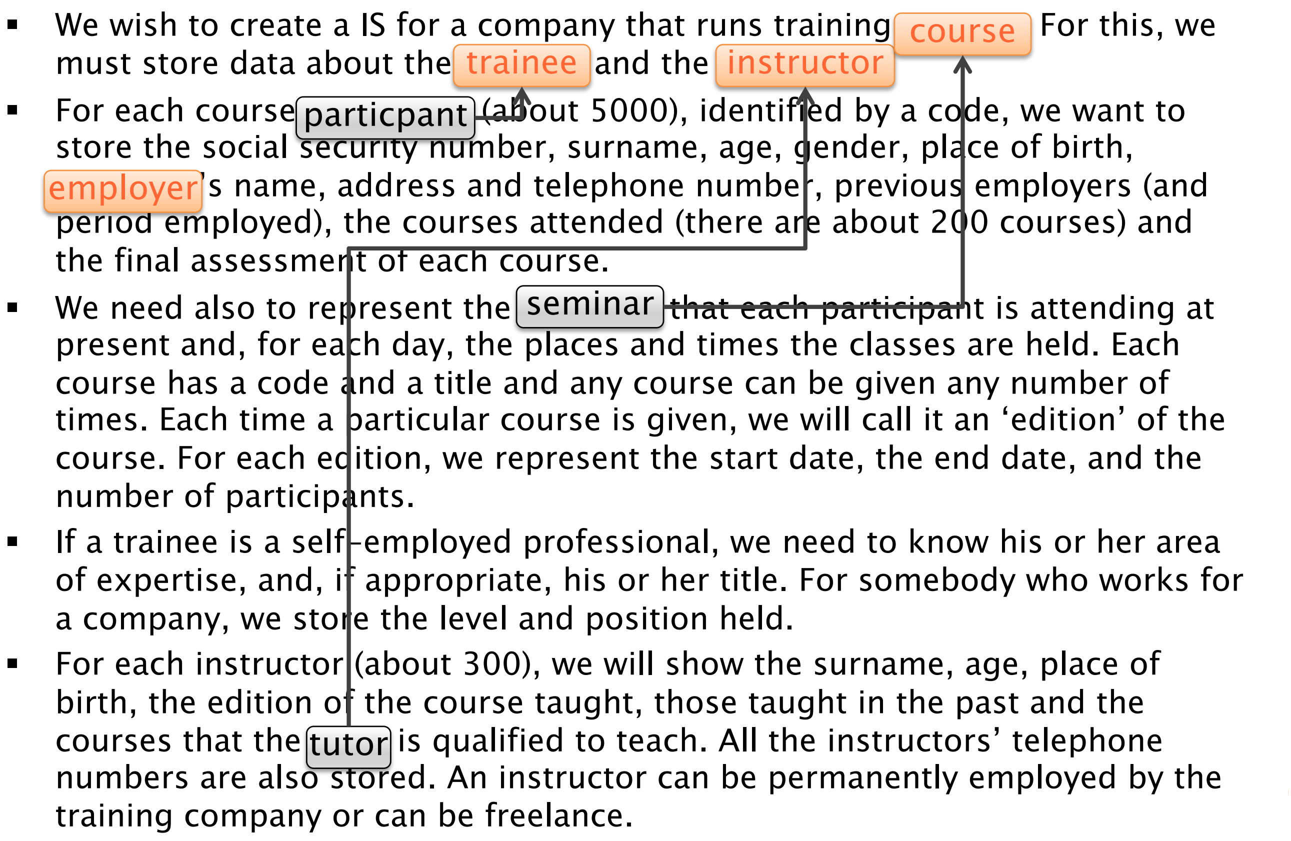
Example

- We wish to create a IS for a company that runs training courses. For this, we must store data about the trainees and the instructors.
- For each course participant (about 5000), identified by a code, we want to store the social security number, surname, age, gender, place of birth, employer's name, address and telephone number, previous employers (and period employed), the courses attended (there are about 200 courses) and the final assessment of each course.
- We need also to represent the seminars that each participant is attending at present and, for each day, the places and times the classes are held. Each course has a code and a title and any course can be given any number of times. Each time a particular course is given, we will call it an 'edition' of the course. For each edition, we represent the start date, the end date, and the number of participants.
- If a trainee is a self-employed professional, we need to know his or her area of expertise, and, if appropriate, his or her title. For somebody who works for a company, we store the level and position held.
- For each instructor (about 300), we will show the surname, age, place of birth, the edition of the course taught, those taught in the past and the courses that the tutor is qualified to teach. All the instructors' telephone numbers are also stored. An instructor can be permanently employed by the training company or can be freelance.

Requirement analysis

- Choose the appropriate level of abstraction
  - Identify the main concepts
- Construct a glossary of terms
- Identify synonyms and homonyms, and standardize terms
- Make cross-references explicit
- Standardize sentence structure
- Avoid complex phrases

Main concepts



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Glossary

Term	Description	Synonym	Links
Course	Course offered. Can have various editions.	Seminar	Instructor, Trainee
Trainee	Participant in a course. Can be an employee or self- employed.	Participant	Course, Employer
Instructor	Course tutor. Can be freelance.	Tutor	Course
Employer	Company by which a trainee is employed or has been employed.		Trainee

Standardize and simplify

- We wish to create a IS for a company that runs training courses. For this, we must store data about the trainees and the instructors.
- For each ~~course participant~~ trainee (about 5000), identified by a code, we want to store the social security number, surname, age, gender, place of birth, ~~employer's name, address and telephone number~~ current employer, previous employers (and start date and the end date of period employed), the courses editions attended (there are about 200 courses) and the final assessment of each course. For each employer we store the name address and phone number.
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- For each employer we store the name, address, and phone number
- Each course has a code and a title and any course can be given any number of times. Each time a particular course is given, we will call it an 'edition' of the course. We need also to record for each day, the places and times the classes are held. For each edition, we represent the start date, the end date, and the number of participants.
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Example

Generic statements

We wish to create a IS for a company that runs training courses. For this, we must store data about the trainees and the instructors.

of each cou

- For each employer we store the name, address, and phone number

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Example

Statements about Trainees

For each trainee (about 5000), identified by a code, we want to store the social security number, surname, age, gender, place of birth, current employer's, previous employers (and start date and end date of the period employed), the courses editions attended (there are about 200 courses) and the final assessment of each course edition.

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Statements about employers

For each employer we store the name, address, and phone number

n

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and the number of pa

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Example

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Statements about Courses

Each course has a code and a title and any course can be given any number of times. Each time a particular course is given, we will call it an ‘edition’ of the course. We need also to record for each day, the places and times the classes are held. For each edition, we represent the start date, the end date, and the number of participants.

An instructor can ployed by the training com freelance.

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Statements about types of employers

If a trainee is a self-employed professional, we need to know his or her area of expertise, and, if appropriate, his or her title. For somebody who works for a company, we store the level and position held.

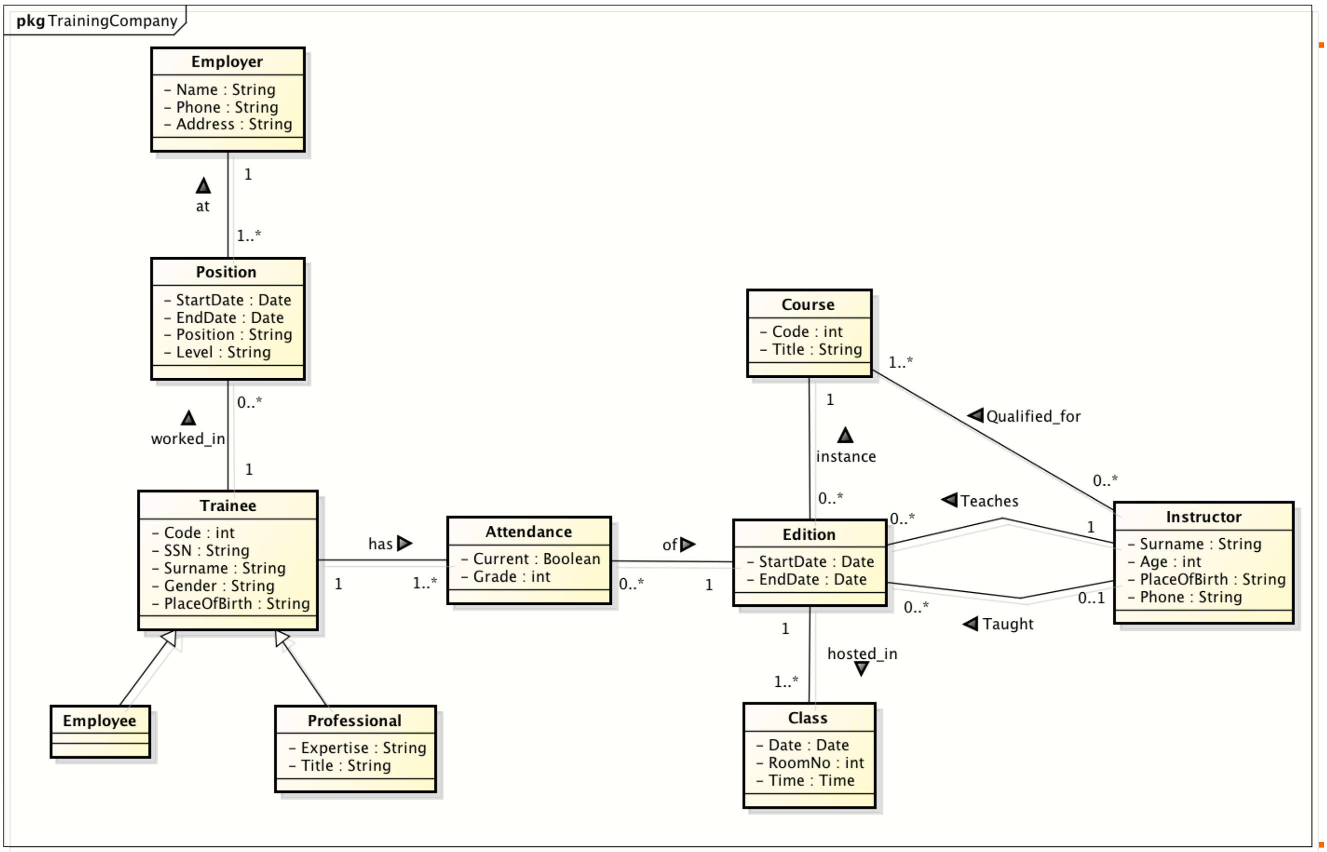
tutor is qualified to teach. instructors’ telephone numbers are also stored. An instructor can be permanently employed by the training company or can be freelance.

Example

- We wish to create a IS for a company that runs training courses. For this, we must store data about the trainees and the instructors.
- For each trainee (about 5000), identified by a code, we want to store the social security number, surname, age, gender, place of birth, current employer's, previous employers (and start date and end date of the period employed), the

Statements about types of instructors

For each instructor (about 300), we will show the surname, age, place of birth, the edition of the course taught, those taught in the past and the courses that the tutor is qualified to teach. All the instructors' telephone numbers are also stored. An instructor can be permanently employed by the training company or can be freelance.



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