UML

SOftEng
http://softeng.polito.it

UML

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

Conceptual modeling

Process modeling

Functional modeling

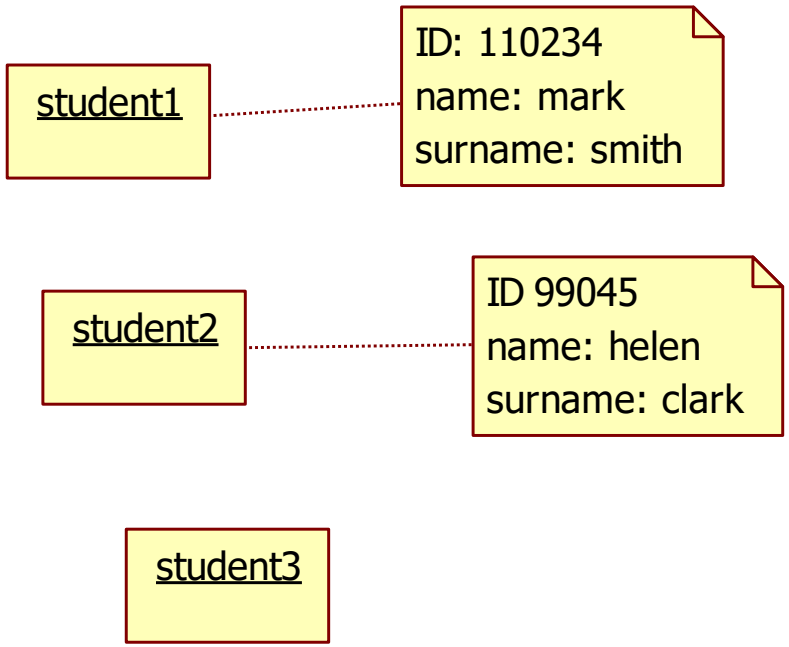
CLASS DIAGRAM

Language composed of

- Class
- Instance / object
- Attribute
- Operation
- Association

Object

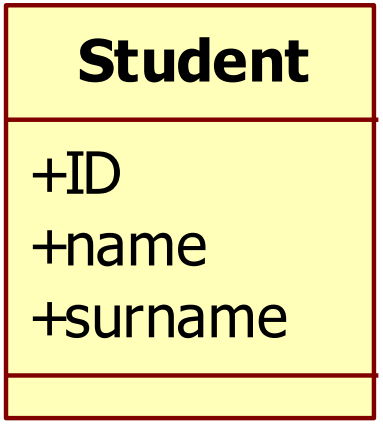
- Model of item (physical or within the software system)
  - ex.: a student, an exam, a window
- Characterized by
  - identity
  - attributes (or properties)
  - operations it can perform (behavior)
  - messages it can receive


student1
ID: 110234
name: mark
surname: smith
student2
ID 99045
name: helen
surname: clark
student3

Class

- They describe set of objects
  - Common properties (attributes, behaviours)
  - Autonomous existence
  - E.g. facts, things, people
- An instance of a class is an object of the type that the class represents.

Class – Examples



Attribute

- Elementary property of classes
  - Name
  - Type
- An attribute associates to each object a value of the corresponding type
  - Name: String
  - ID: Numeric
  - Salary: Currency

Usage of class diagram

- Model of concepts (glossary)
- Model of system (hw + sw) == system design
- Model of software classes (software design)

- Class in conceptual model (UML class diagram)
  - Ex Employee class
- Corresponding entities in software application
  - Data layer: Employee table in RDB
  - Business logic layer: Employee class in Java / C++, C#
  - Presentation layer: form to enter employee data, form to show employee data, and more

- Before doing a class diagram,

  DECIDE WHAT YOU WANT TO MODEL

Classes in conceptual diagram

- Where to look for
  - Physical entities: Person, Car,
  - Roles: Employee, Director, Doctor,
  - Social / legal / organizational entities: University, Company
  - Events: Sale, Order, Request, Claim, Call
  - Time intervals: Car rental, Booking, Course, Meeting
  - Geographical entities: City, Road, Nation
  - Reports, summaries: weather report, bank account statement

Classes in software design

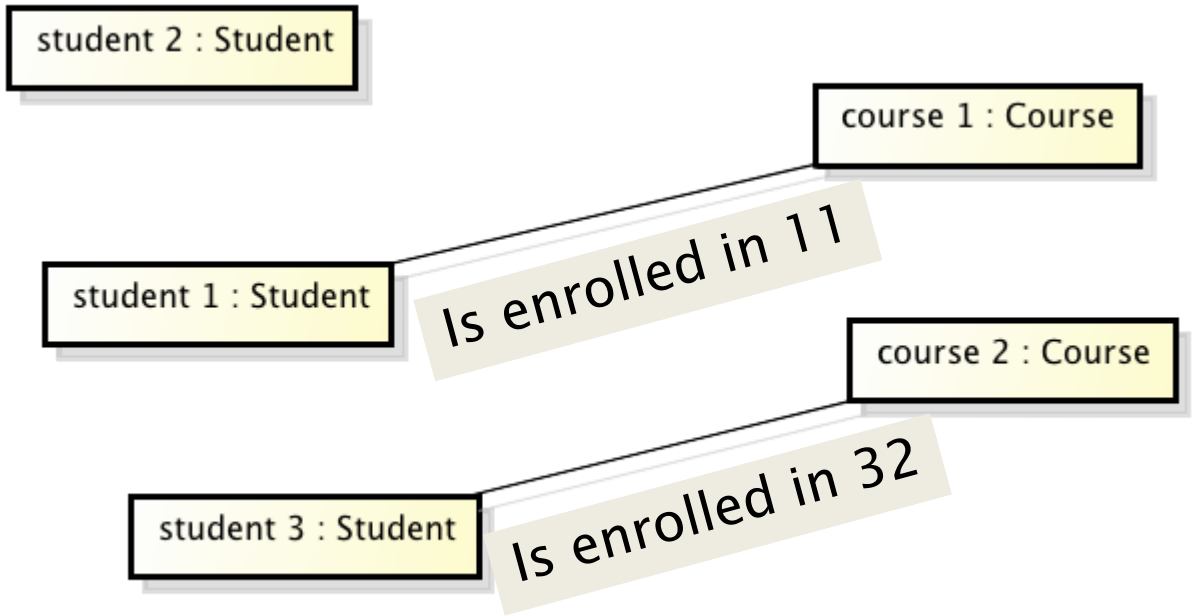
- Same as above,

  + software specific classes:

  - Collections
  - String, Integer, Float, ..
  - GUI classes (see AWT, Swing ..)
  - Beans
  - ...

Link

- Model of property between objects
  - A property that cannot be represented on one object only



Association

- Represent set of links between objects of different classes.

  {Is enrolled in 11,

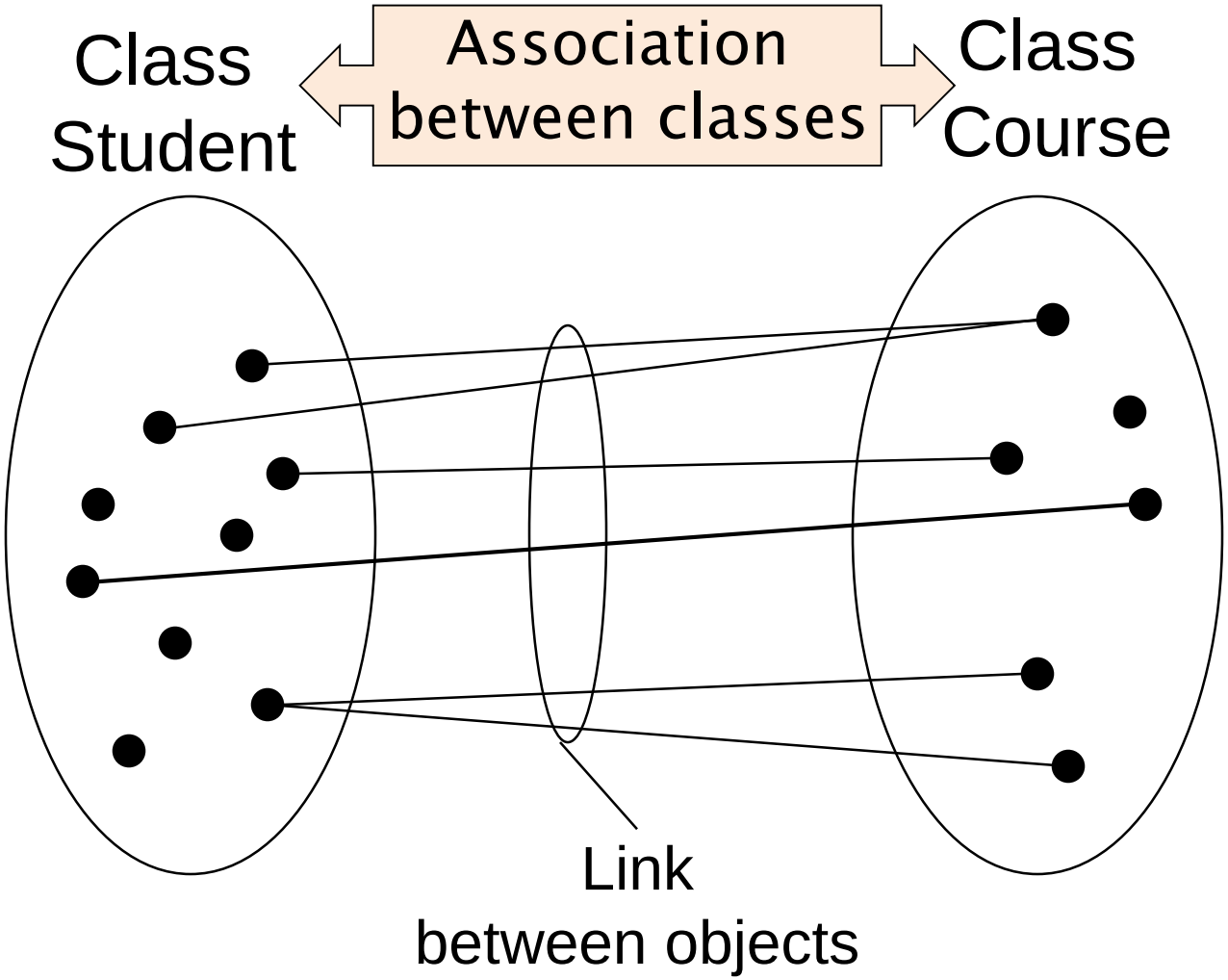
  Is enrolled in 32}

- Or pairs of objects (one per class):

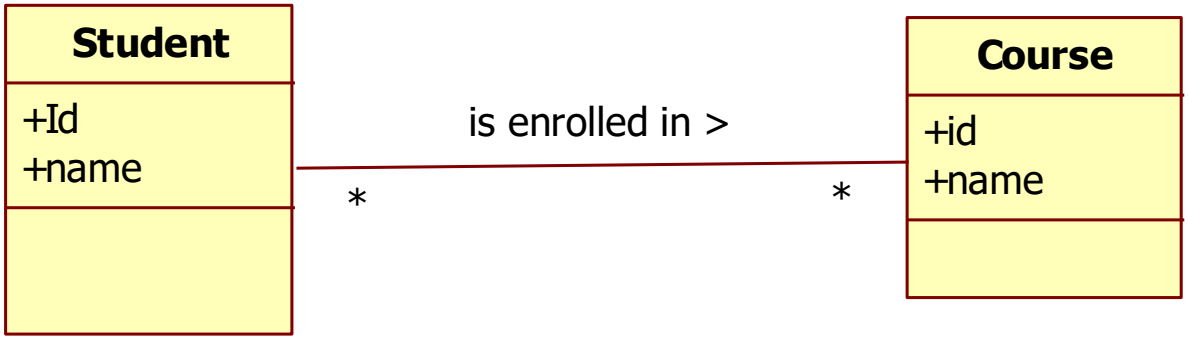
  {student1 – course1,

  student3 – course2 }

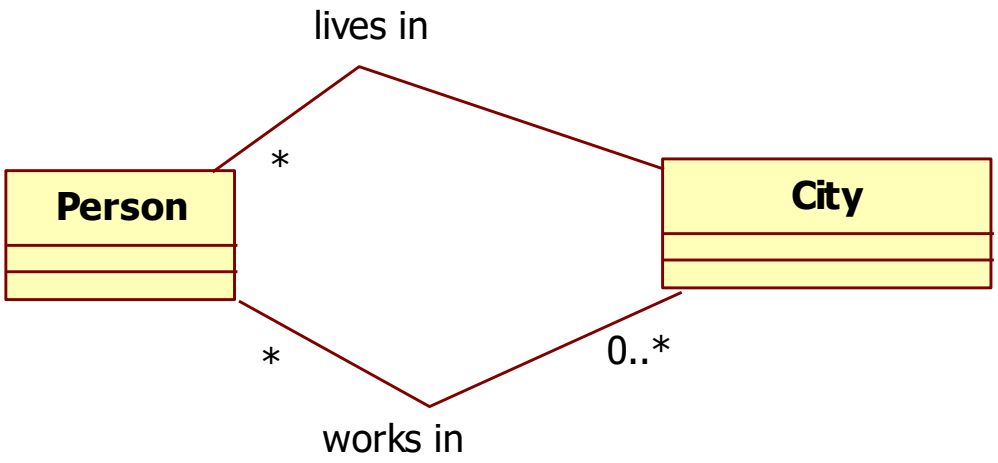
Associations



Association – Examples

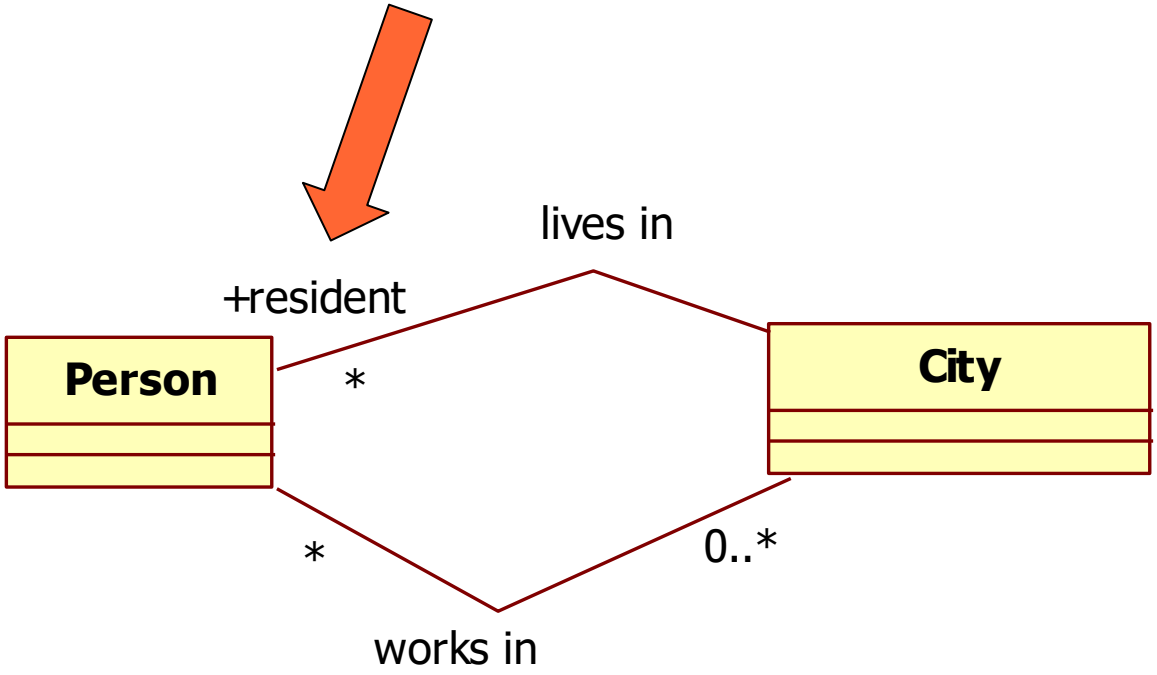


Association

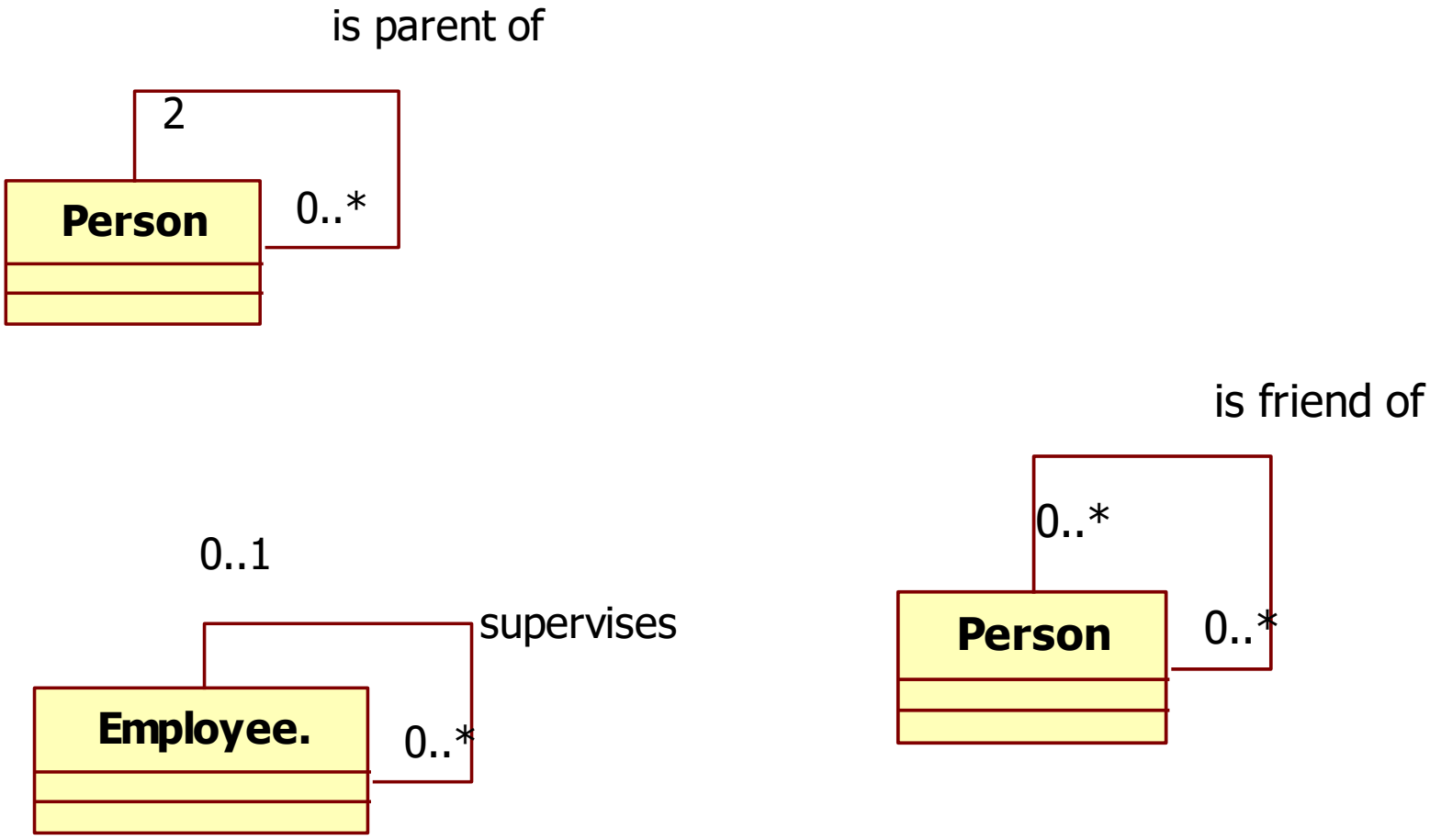


Role in association

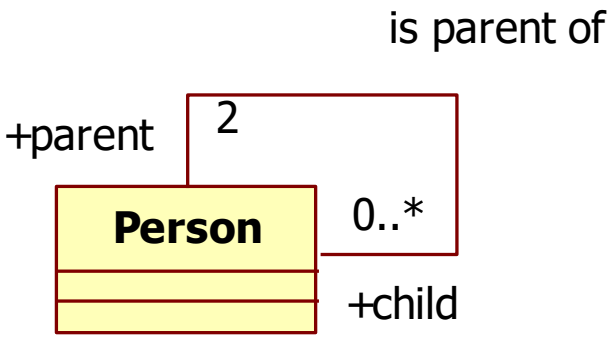
- Name of one end of association

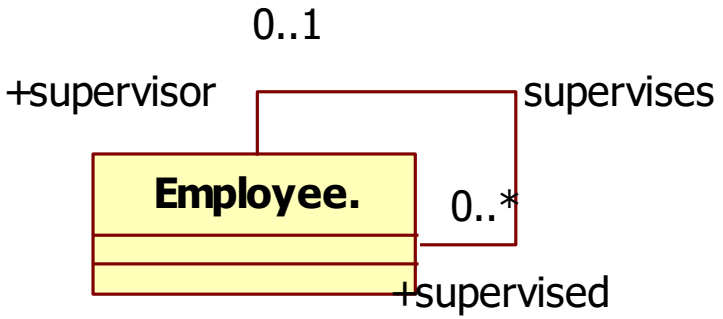


Recursive associations



Recursive associations + roles





Style suggestions

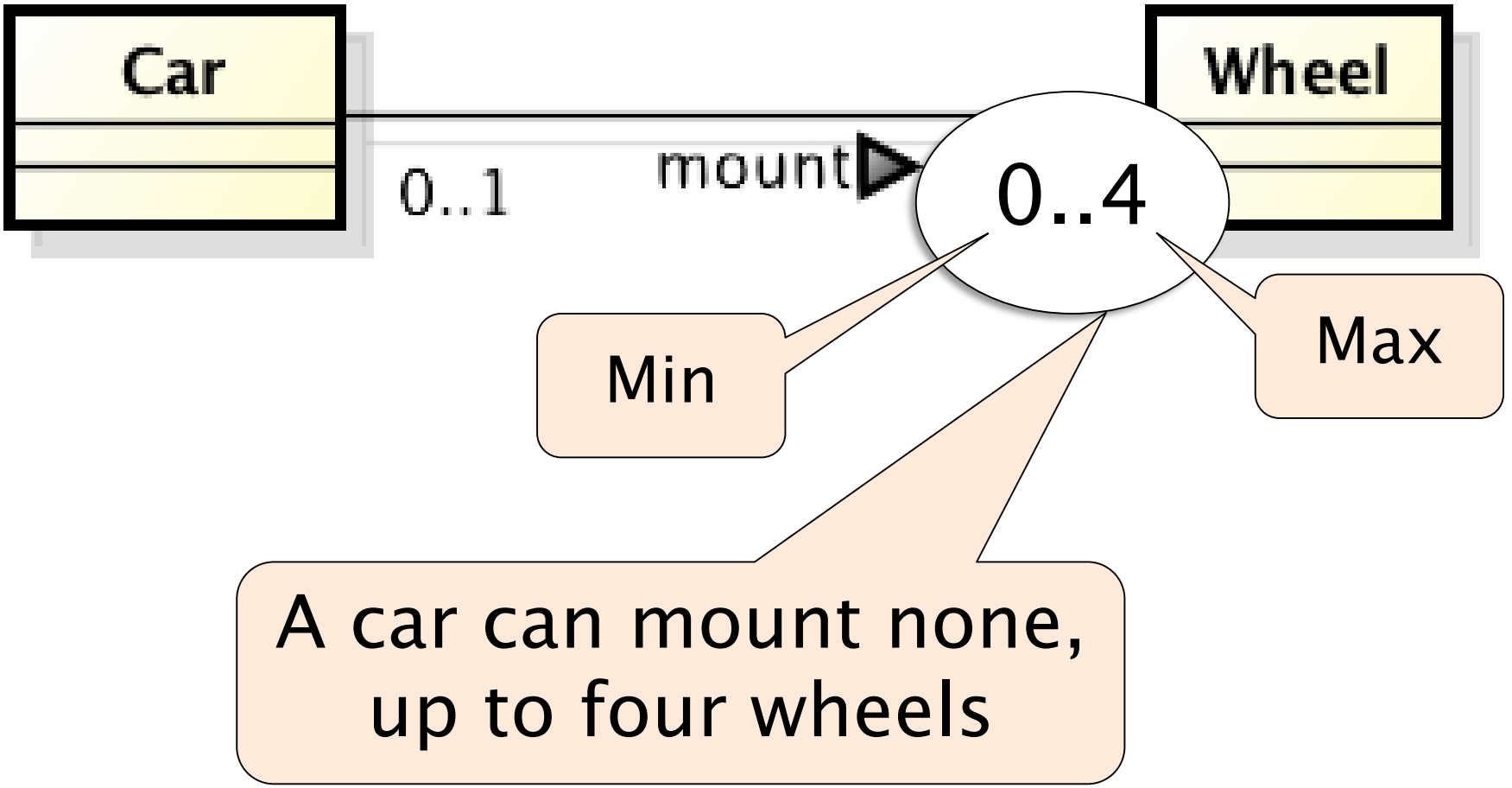
- Class names
  - Singular noun
- Association name
  - Verb
- Attributes
  - Type of attribute not needed in conceptual model

Multiplicity

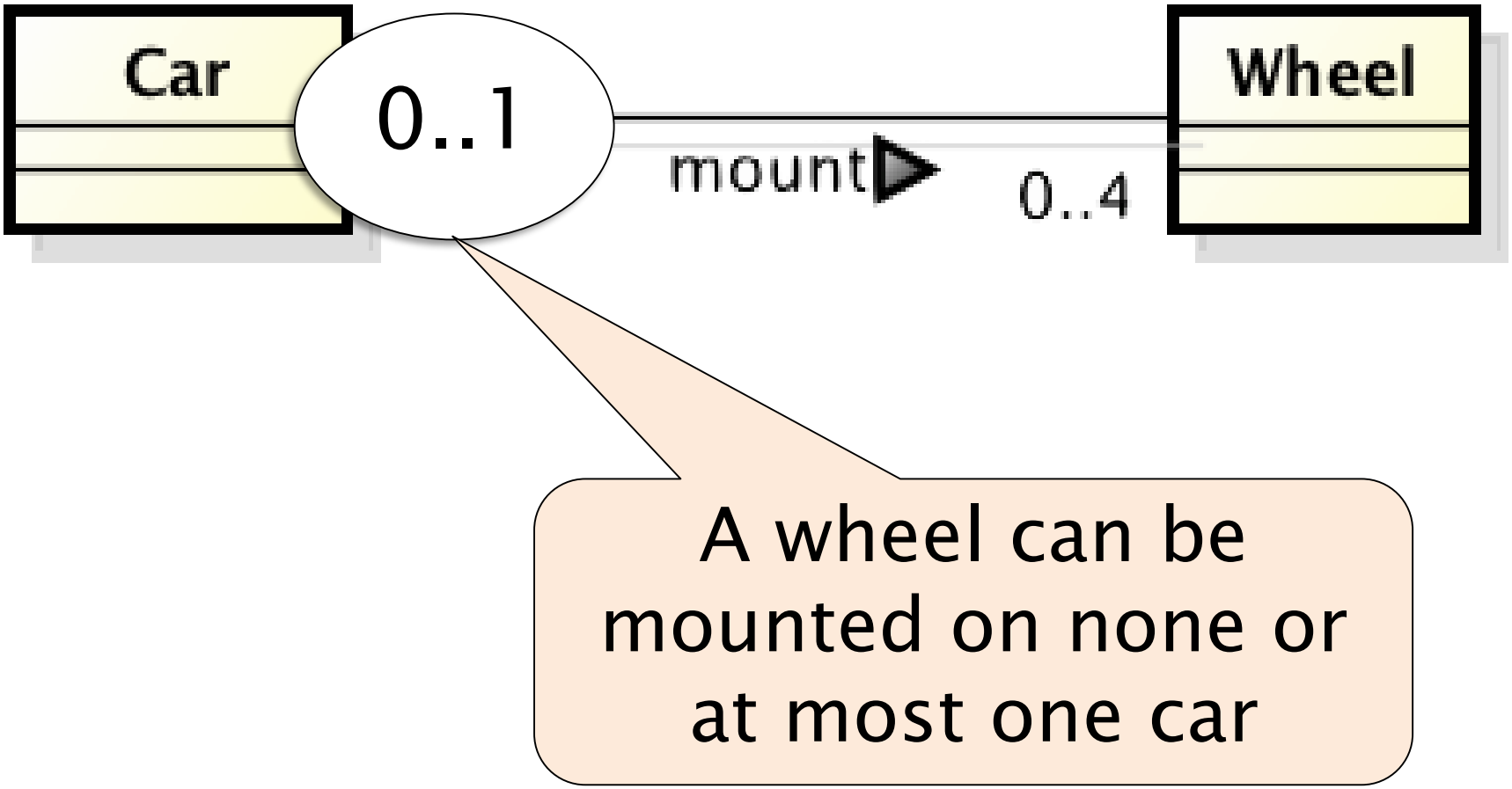
- Describe the maximum and minimum number of links in which an object of a class can participate

- Should be specified for each class participating in an association

Multiplicity – Example



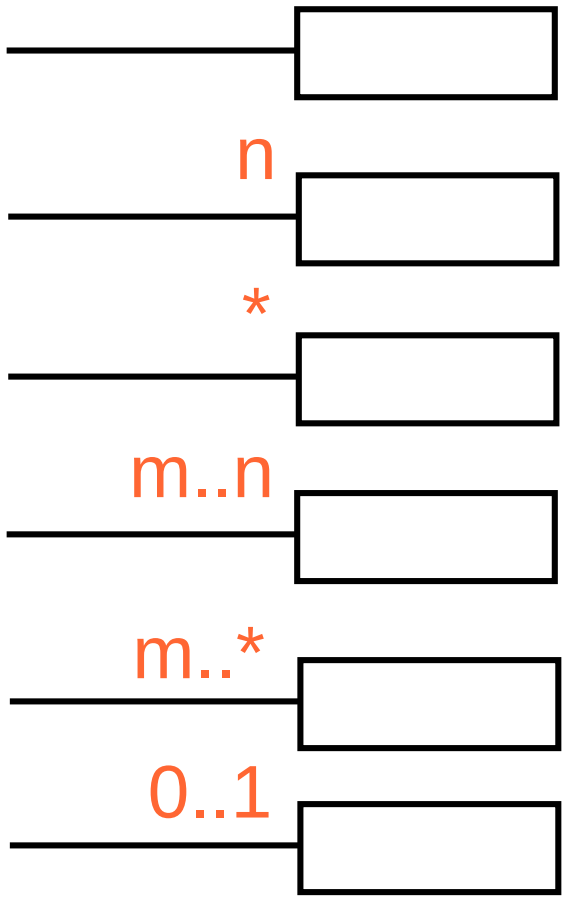
Multiplicity – Example



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 1

Exactly n

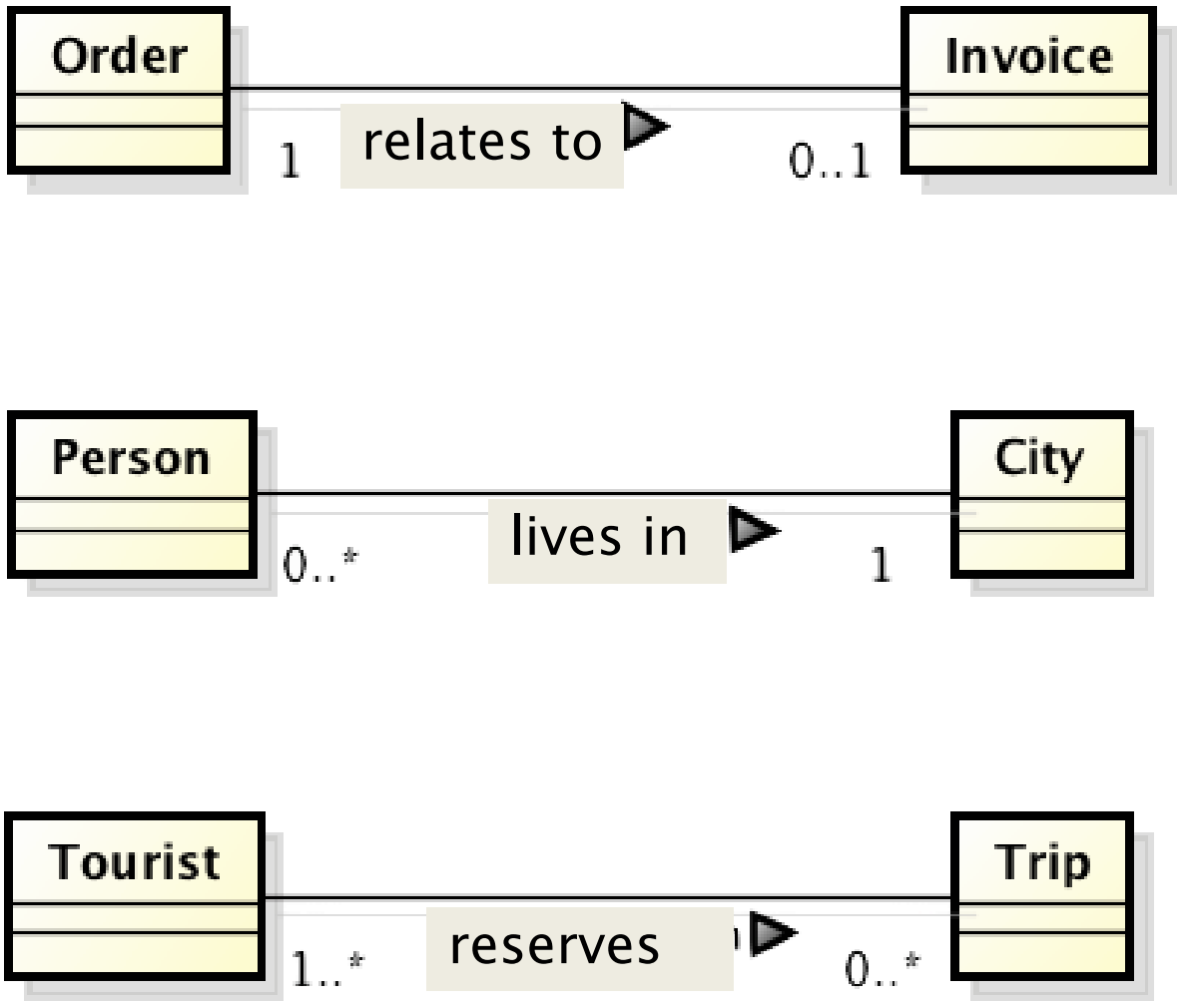
Zero or more

Between m and n (m,n included)

From m up

Zero or one (optional)

Multiplicity

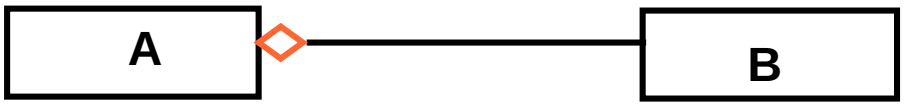


Associations

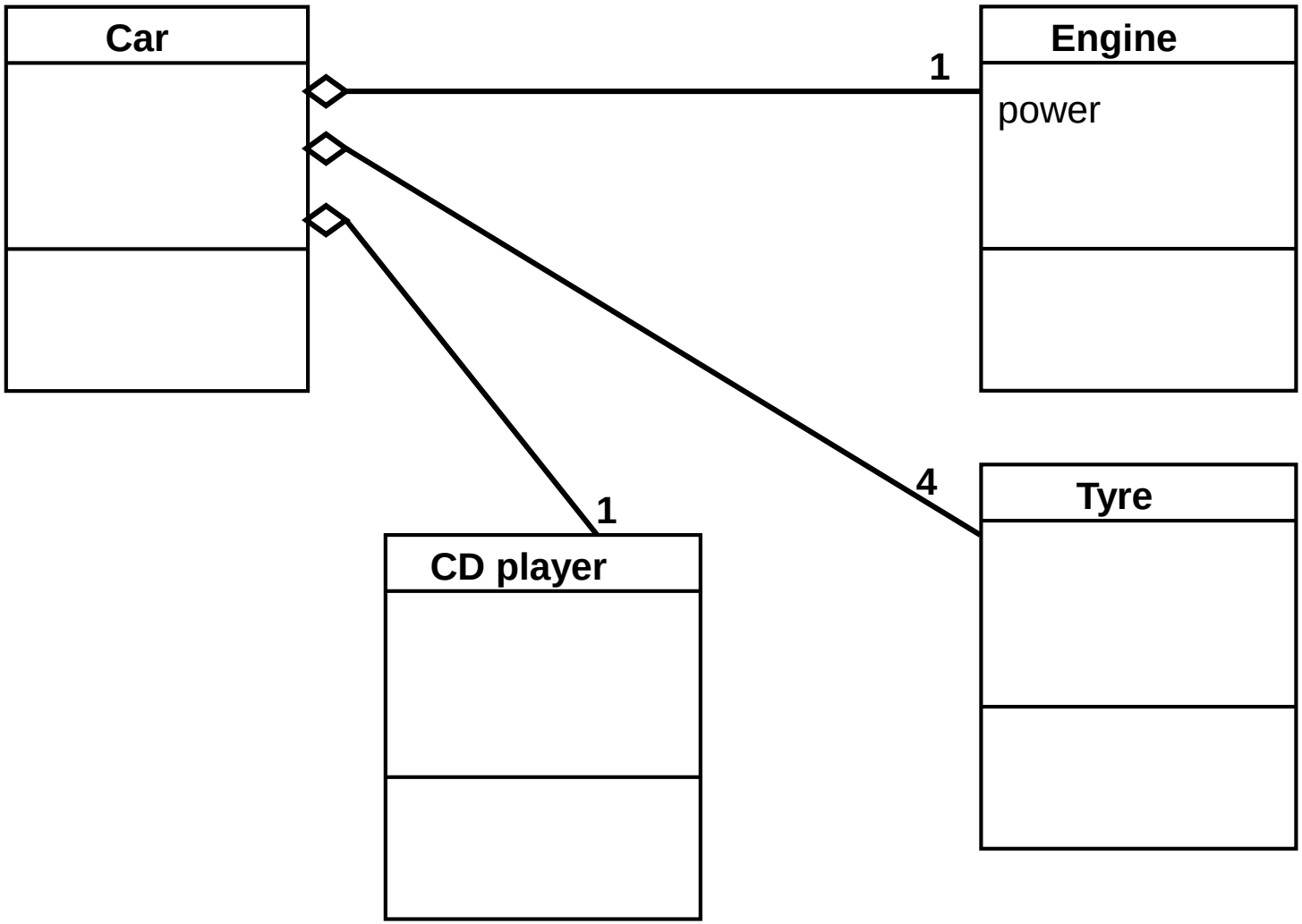
- There are three special cases of associations
  - Aggregation
  - Composition
  - Specialization

Aggregation

- B *is-part-of* A or
- A *has* B

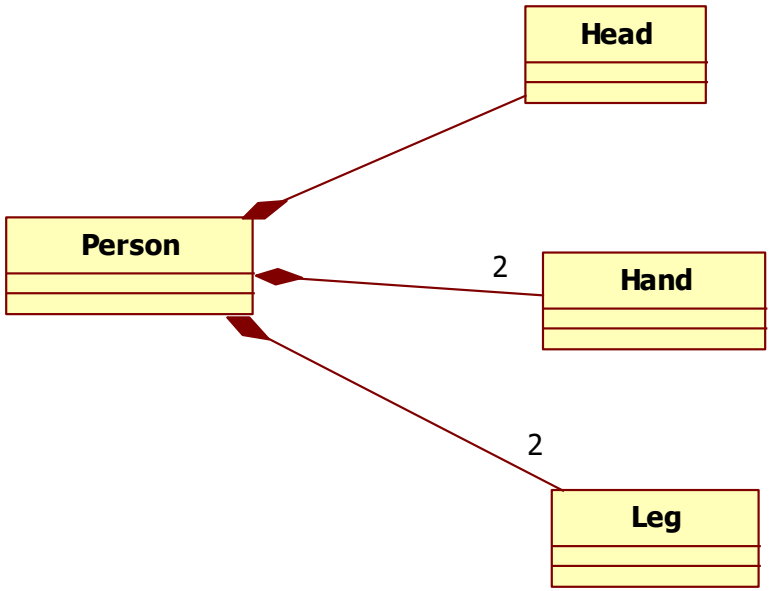


Example



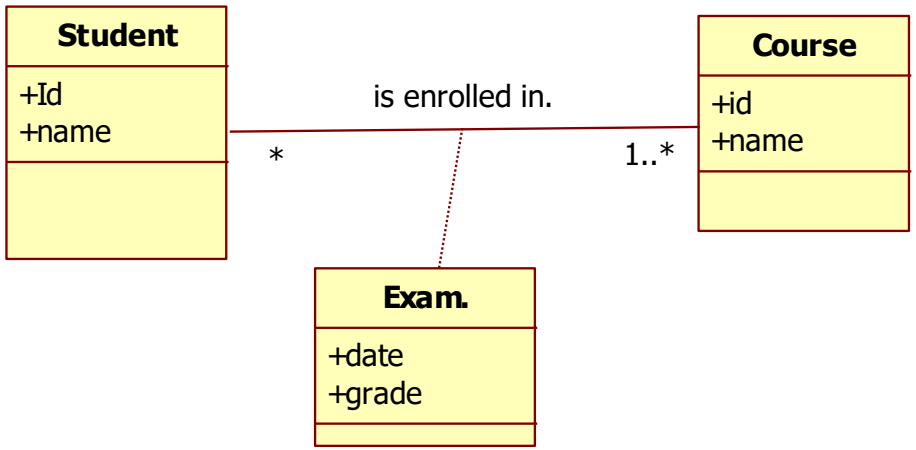
Composition

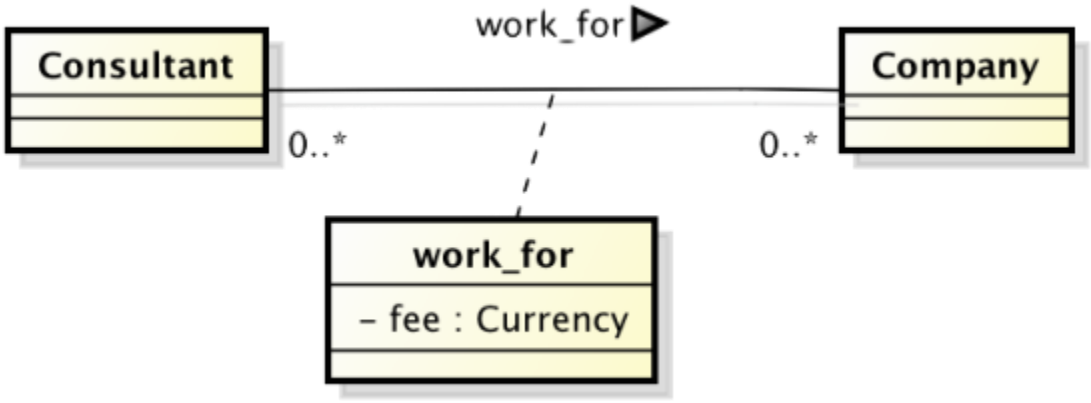
- An aggregation where the link part / whole is more strict: lifecycle of both classes is the same
  - if object Person disappears, so the corresponding 2 objects Leg, Hand



Association Class

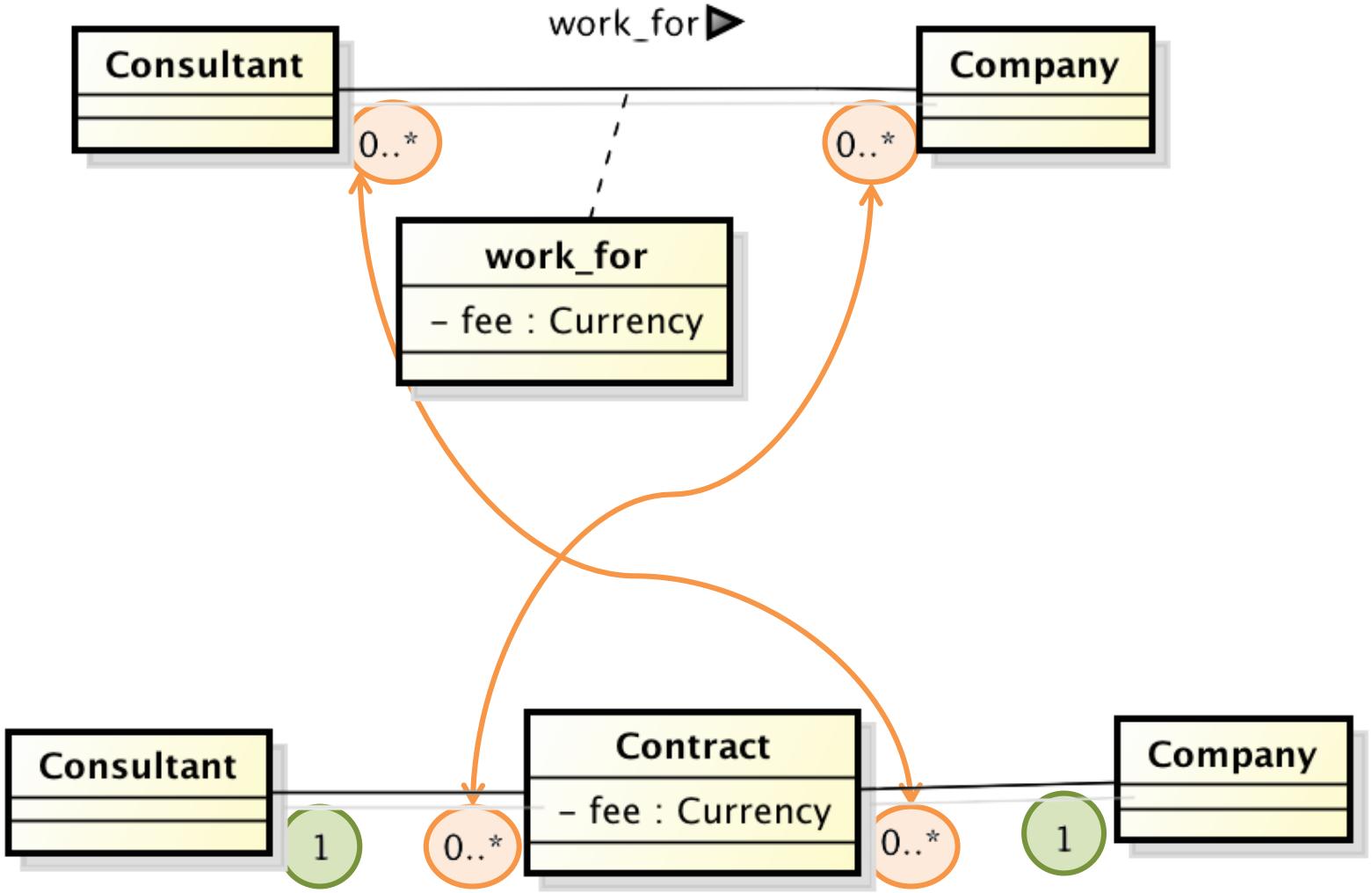
- The association class allows to attach attributes to the association
- A link between two object includes
  - The two linked objects
  - The attributes of the link




work_for
Consultant
Company
0..*
0..*
work_for
- fee : Currency

Consultant	Company	fee
consultant1	company2	300
consultant1	company3	200
~~consultant1~~	~~company3~~	~~250~~
consultant2	company2	100
consultant3	company2	300

Instead of Association class

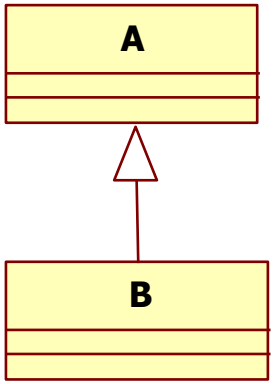


Consultant	Company	Contract
consultant1	company2	300
consultant1	company3	200
consultant1	company3	250
consultant2	company2	100
consultant3	company2	300

- The two options are equivalent, except

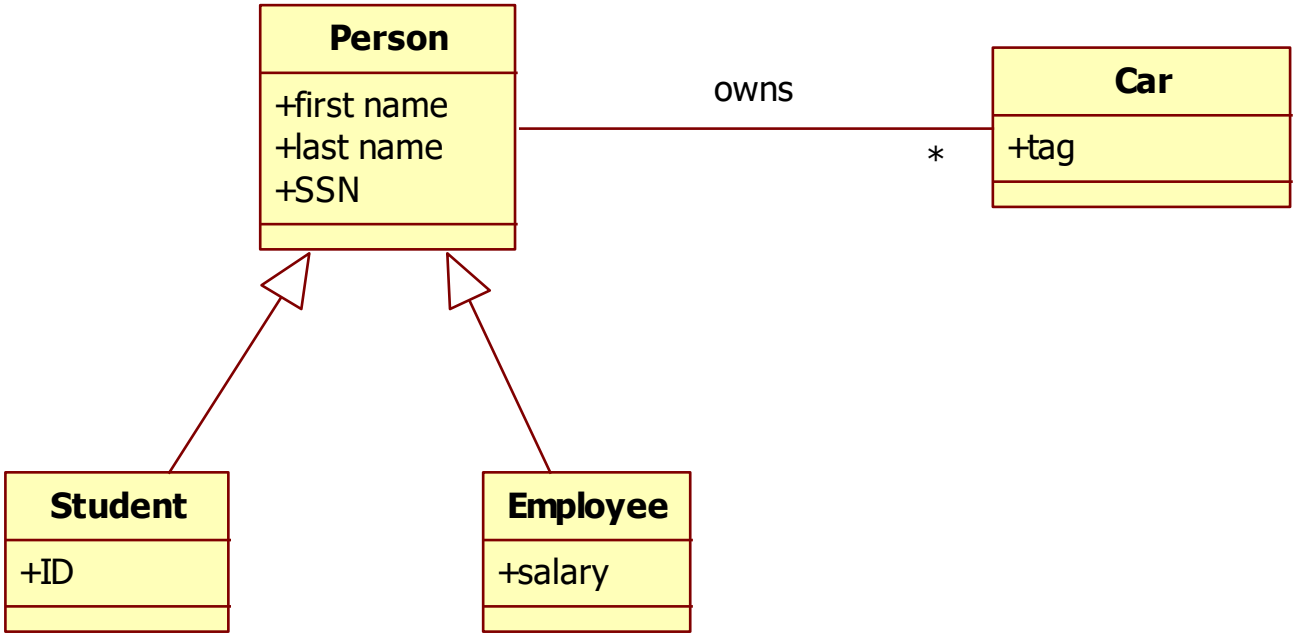
- Intermediate class:
  - More than one value for a link
- Association class:
  - Only one value for a link

Specialization / Generalization



- B *specializes* A means that objects described by B have the same properties of objects described by A
- Objects described by B may have additional properties
- B is a special case of A
- A is a generalization of B (and possibly of other classes)

Generalization



- Specialization can be used only if it is possible to state
  - B is-a A
- Employee is-a Person – yes
- Student is-a Person – yes
- Head is-a Person – no
- Person has-a Head – yes

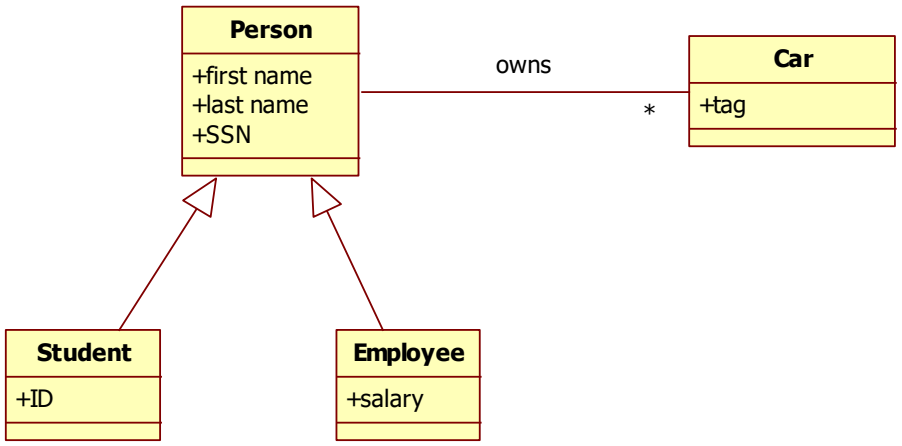
Inheritance terminology

- 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

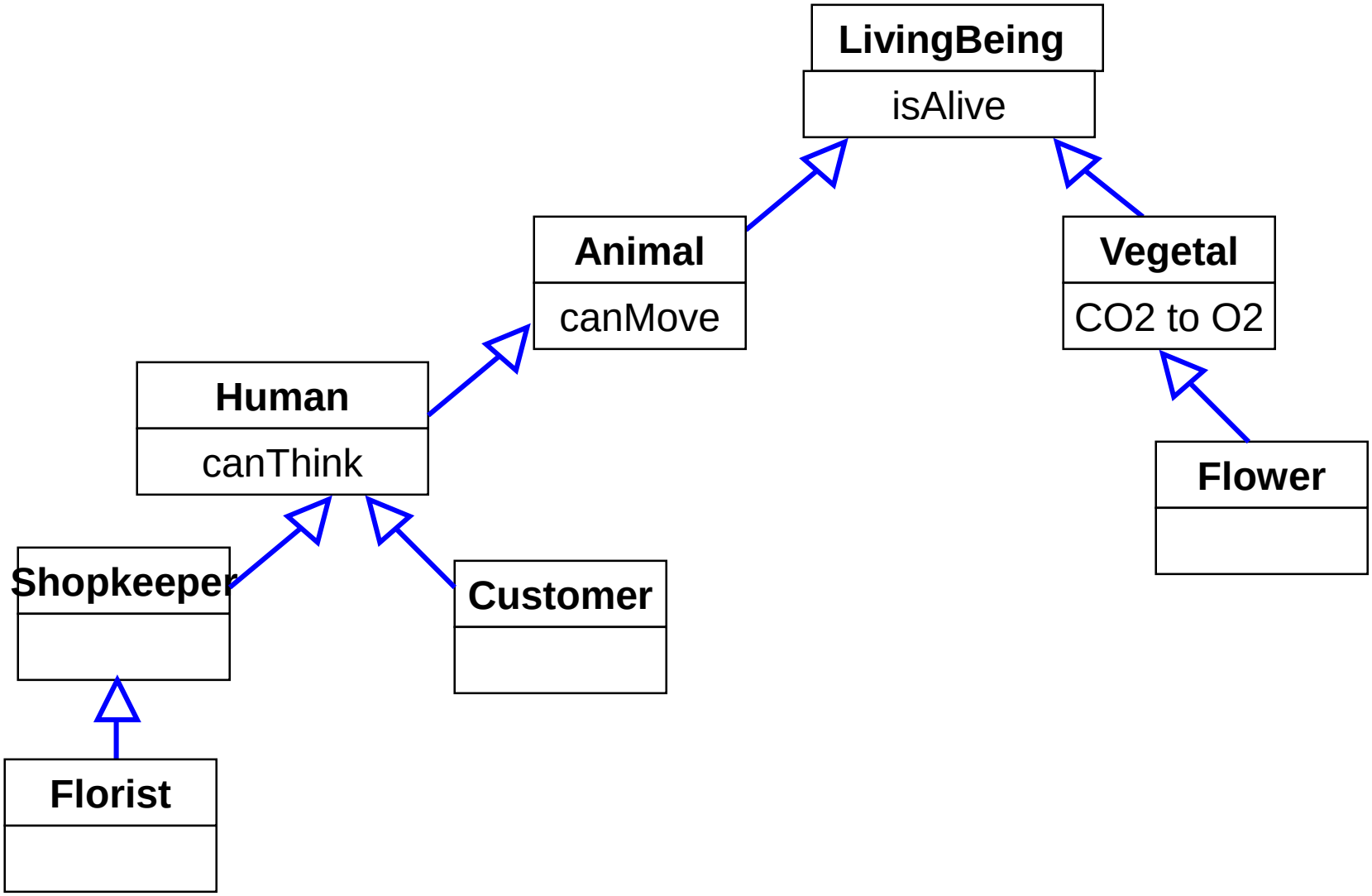
Effects of inheritance

- The subclass inherits
  - All attributes
  - All associations
- Of all ancestors

- Employee has properties
  - First name (inherited)
  - Last name (inherited)
  - SSN (inherited)
  - Salary
- Employee
  - Owns Car (inherited)



Example of inheritance tree



DOs in Class Diagram

- Decide goal of model
  - Conceptual model?
  - Design model?

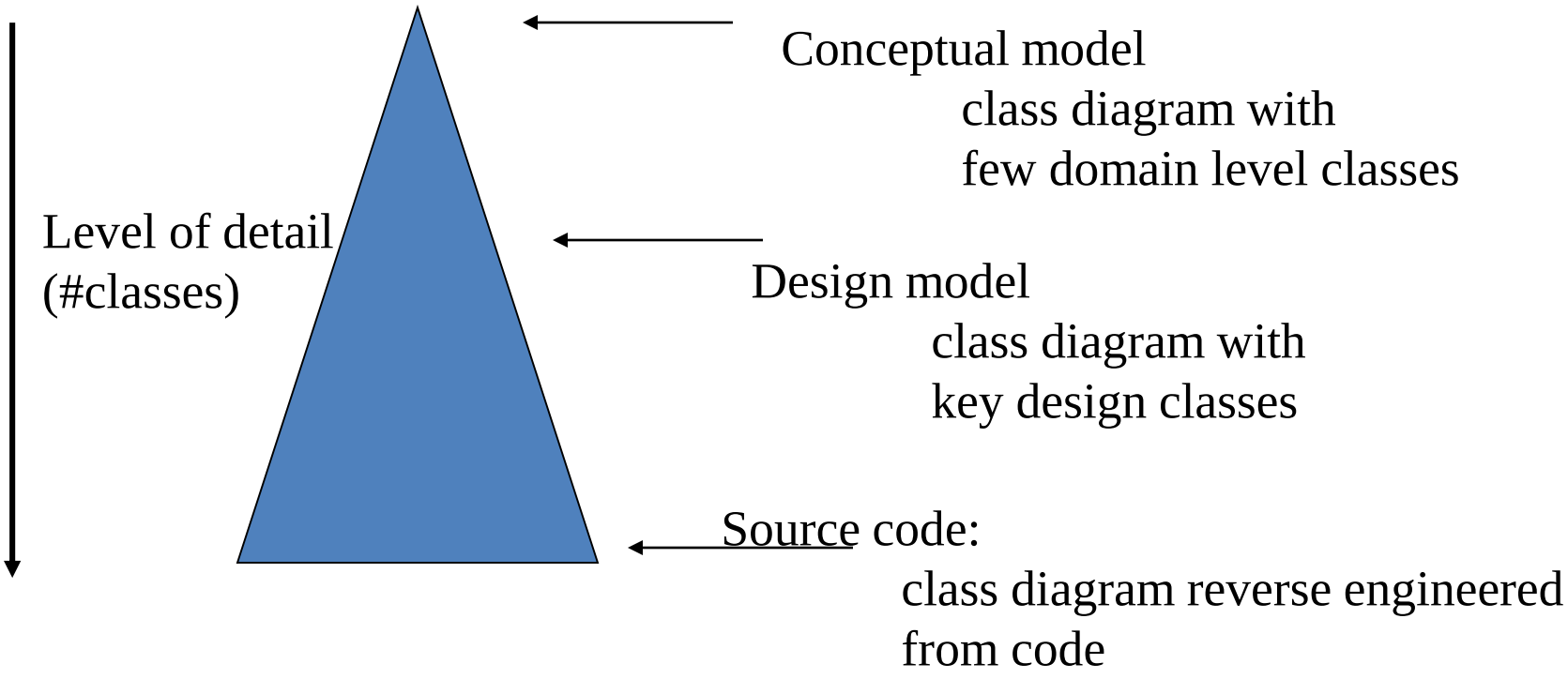
Dos – consider:

- Physical entities: Person, Car,
- Roles: Employee, Director, Doctor,
- Social / legal / organizational entities: University, Company, Department
- Events: Sale, Order, Request, Claim, Call
- Time intervals: Car rental, Booking, Course, Meeting
- Geographical entities: City, Road, Nation
- Reports, summaries, paper documents: weather report, bank account statement, travel request

DO NOT in class diagrams

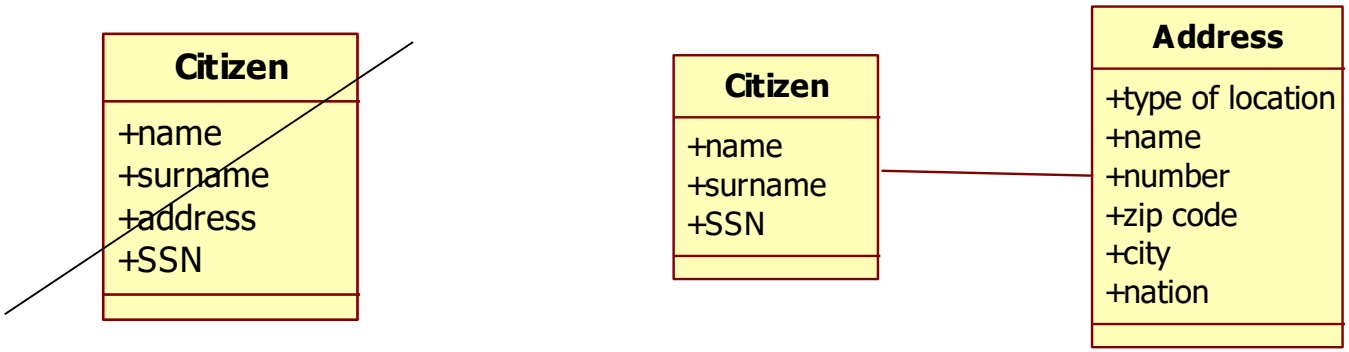
- Use plurals for classes
  - Person yes, PersonS no
- Forget multiplicities
- Forget roles / association classes, when needed

Use of class diagrams



DO NOT in class diagrams

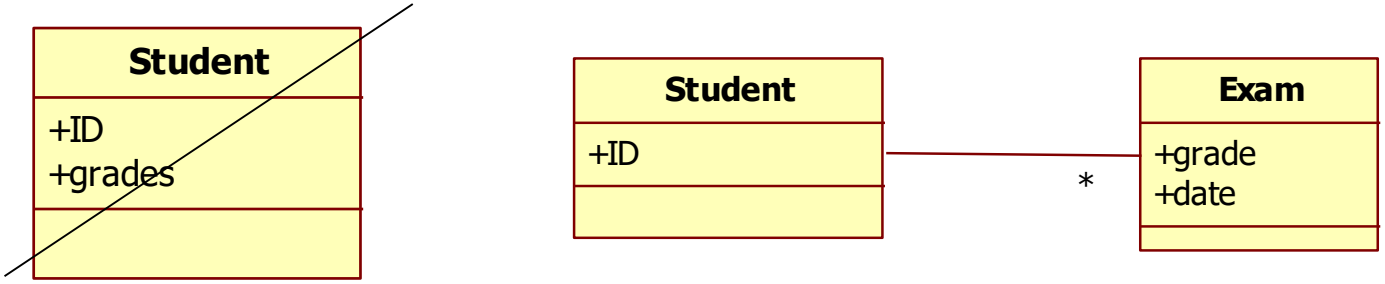
- Use class as an attribute



If address has many attributes it should be modelled as a class, not as an attribute

DO NOT in class diagrams

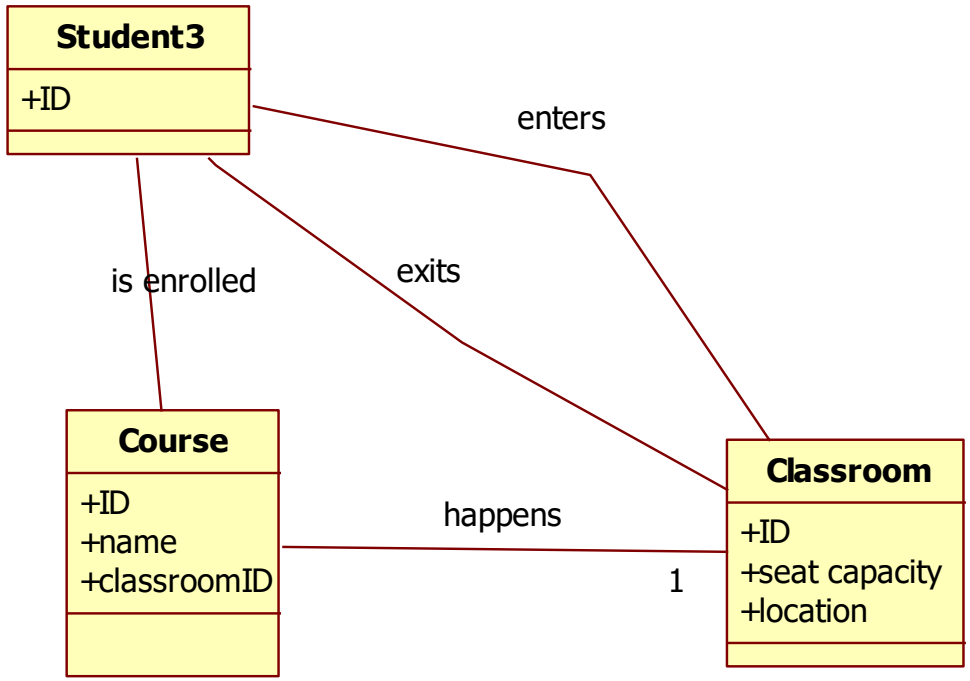
- Use attribute that represents many objects



'grades' is not an attribute, but an association with multiplicity *

DO NOT in class diagrams

- Use transient (dynamic) relationships that represent events

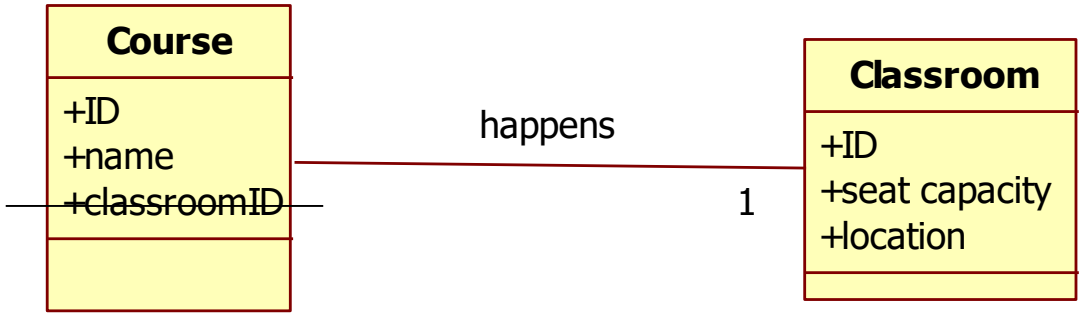


‘Enters’, ‘exits’

- Correspond to events (student enters a classroom)
- Avoid them
  - They clutter the diagrams
  - They are better represented in scenarios, or activity diagrams, or BPMN (all dynamic models)
  - even if the information is needed (ex application to trace Covid19 contacts), the association may not be enough
    - Only one link possible student-x classroom-y
    - Then use class ‘Entrance log’

DO NOT in class diagrams

- Repeat as an attribute of a class a relationship starting from the class

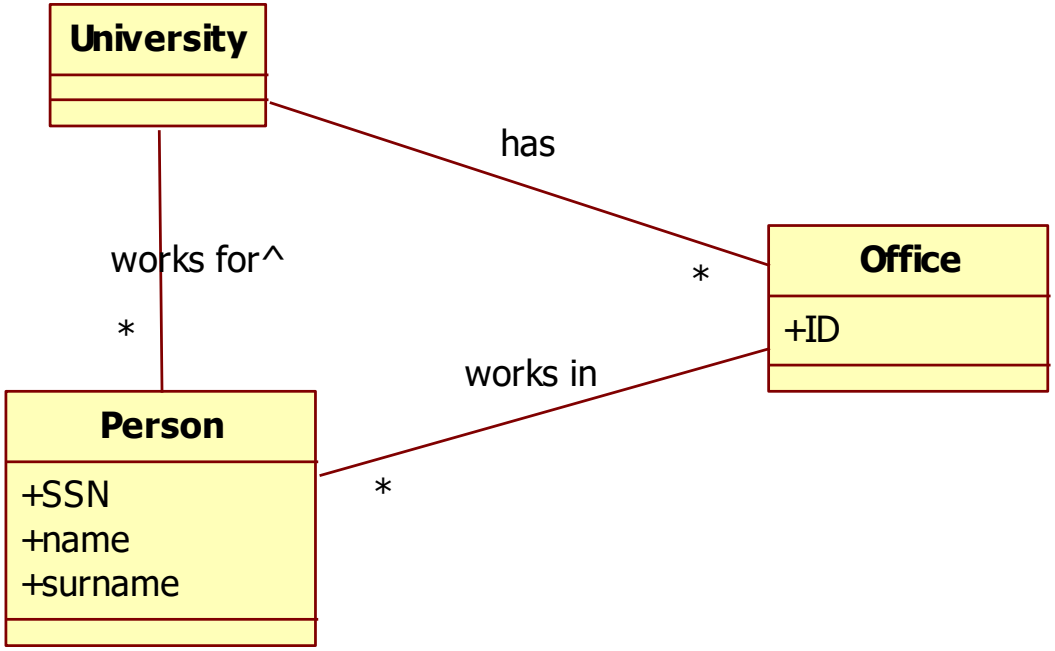


classroomID in Course is redundant (and part of sw design), the association ‘happens’ already conveys the information

DO NOT in class diagrams

- Use loops in relationships (normally avoid them unless the information they represent is different over different paths)

Loops



Loop university – office – person

Ok, because ‘works in’ identifies the specific office where a person is, while ‘has’ identifies a larger set of offices

DO NOT in class diagrams

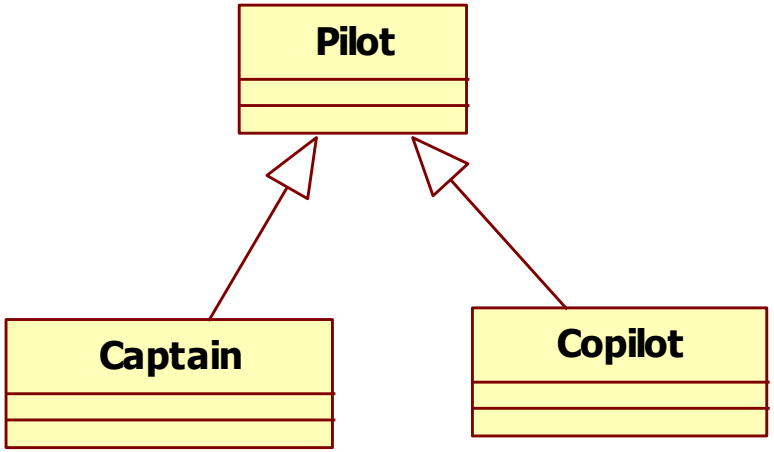
- Confound system design, software design, glossary /conceptual model
  - DO decide goal of diagram

DO NOT in conceptual model

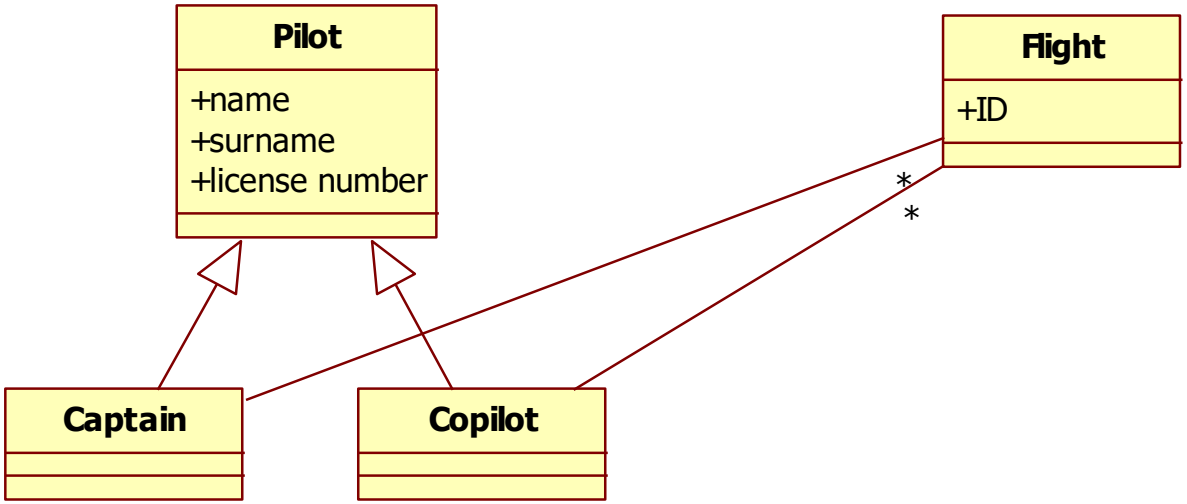
- Dont model classes that belong to software design
- Collections
  - Linkedlist
  - Array
- GUI classes
  - Window
  - Button

Be careful

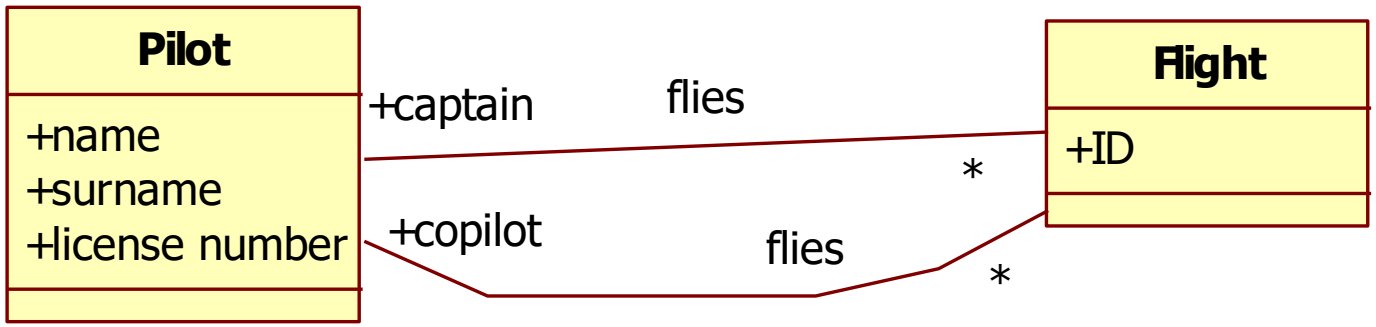
- Instance of a subclass cannot become instance of another subclass
  - Ex: captain cannot be copilot and copilot cannot be captain



- Flights must have a captain, and a copilot



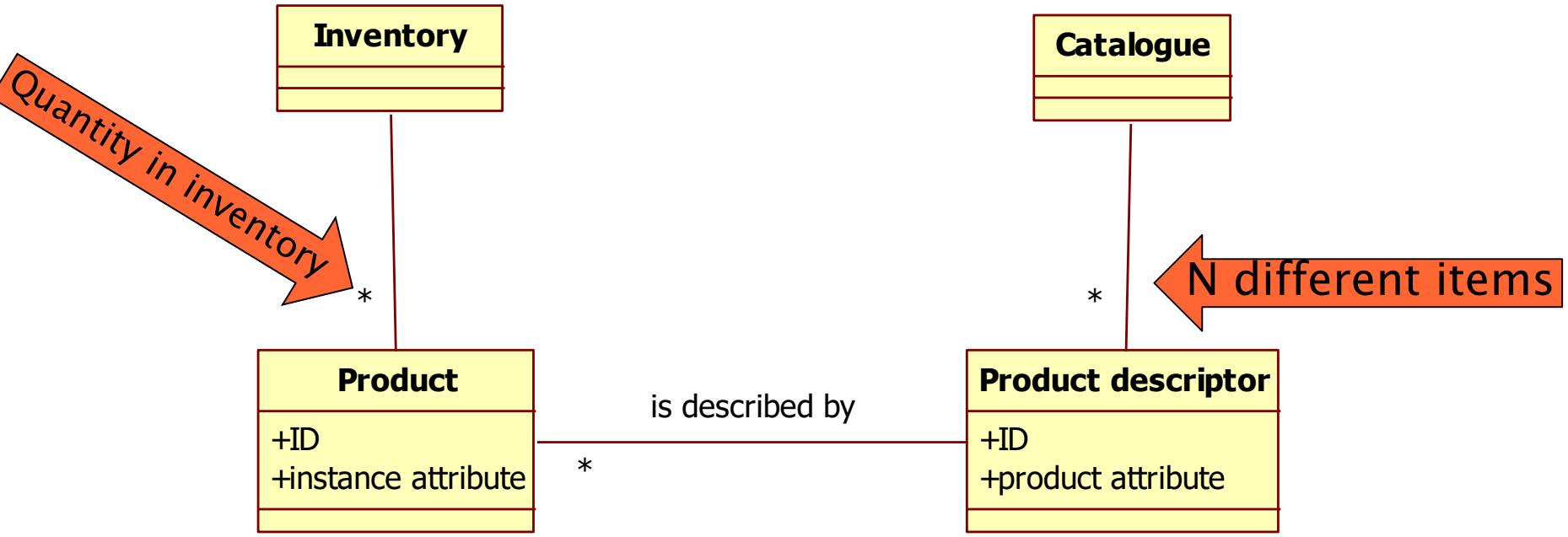
- Captain John Smith is always captain, cannot be copilot (copilot X Y is always copilot)



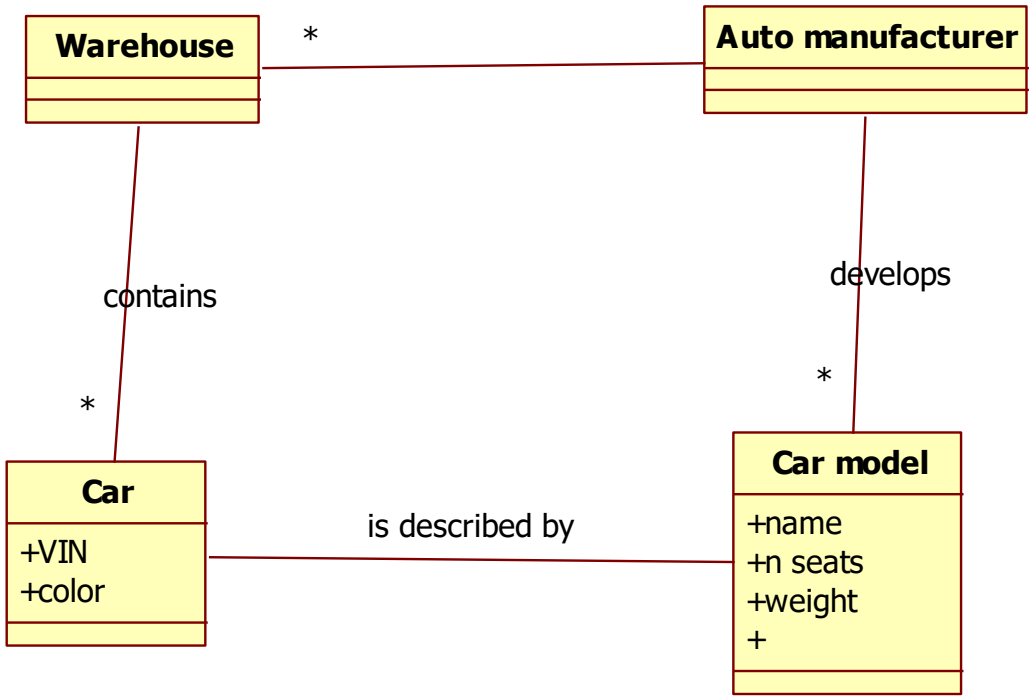
- Captain and copilot as roles. Pilot john smith can be captain on one flight and copilot on another

Patterns in IS – descriptor

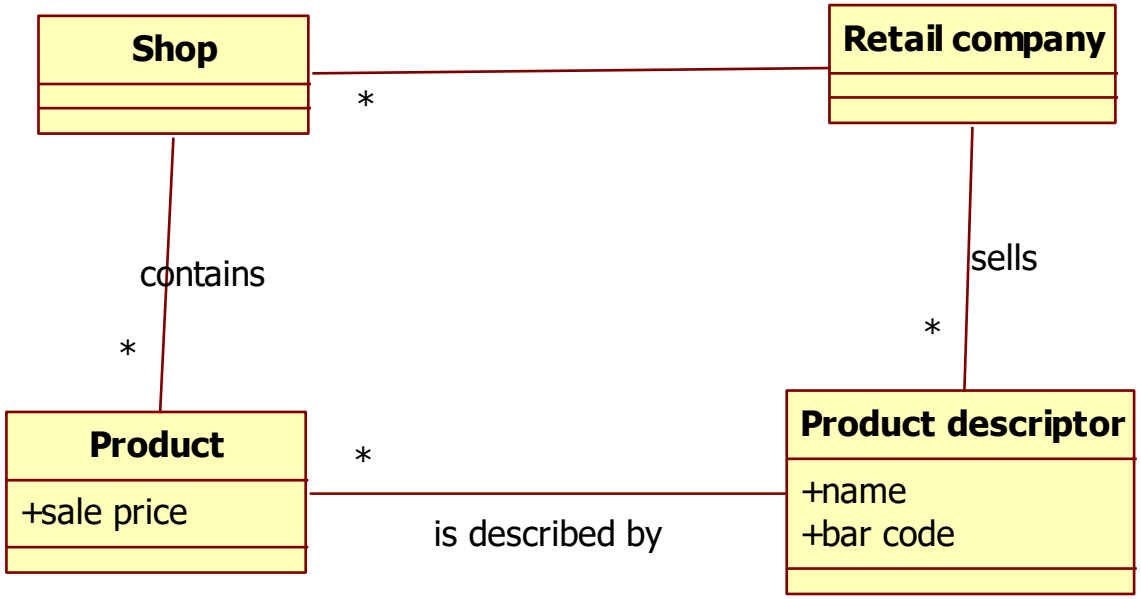
- Catalogue vs inventory



Ex automotive

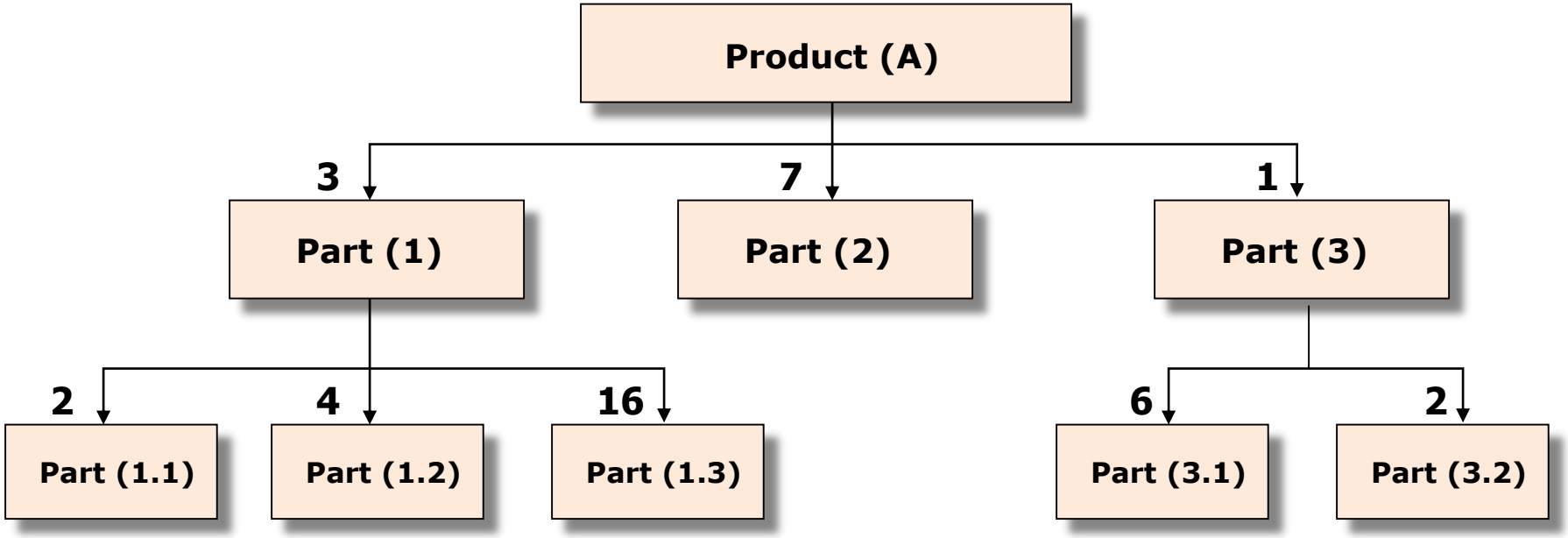


Ex retail

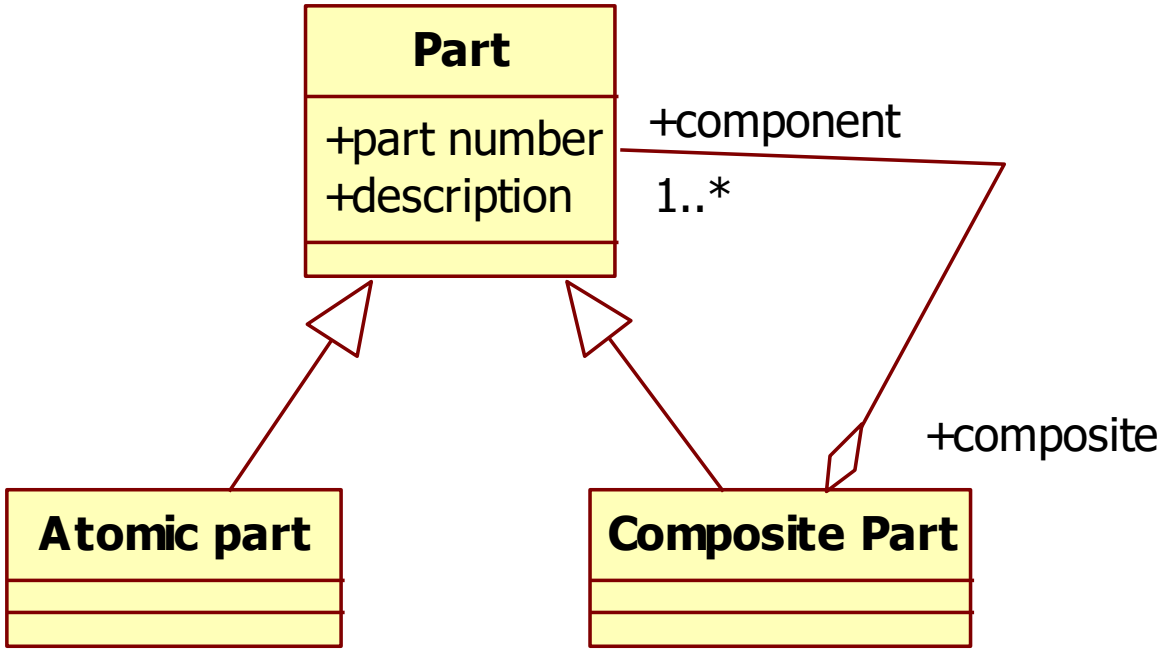

Shop
Retail company
*
contains
*
sells
*
Product
+sale price
*
is described by
Product descriptor
+name
+bar code

Patterns in IS – composite (BOM)

Bill of materials (BOM)



Composite pattern – BOM



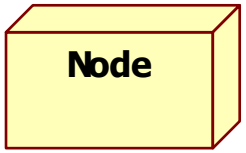
UML Deployment diagram

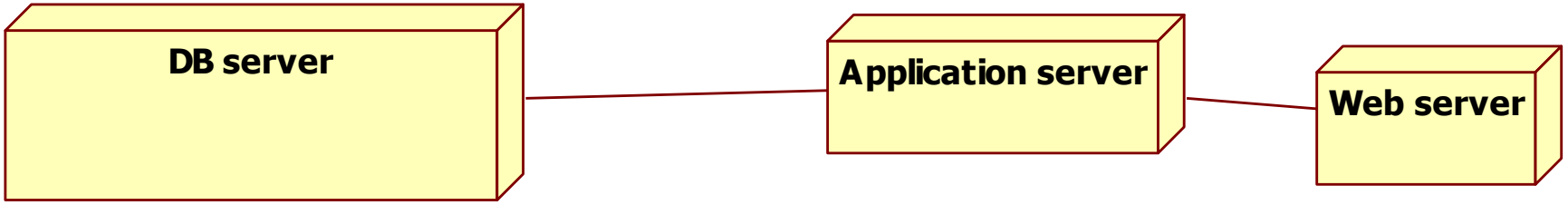
SOftEng
http://softeng.polito.it

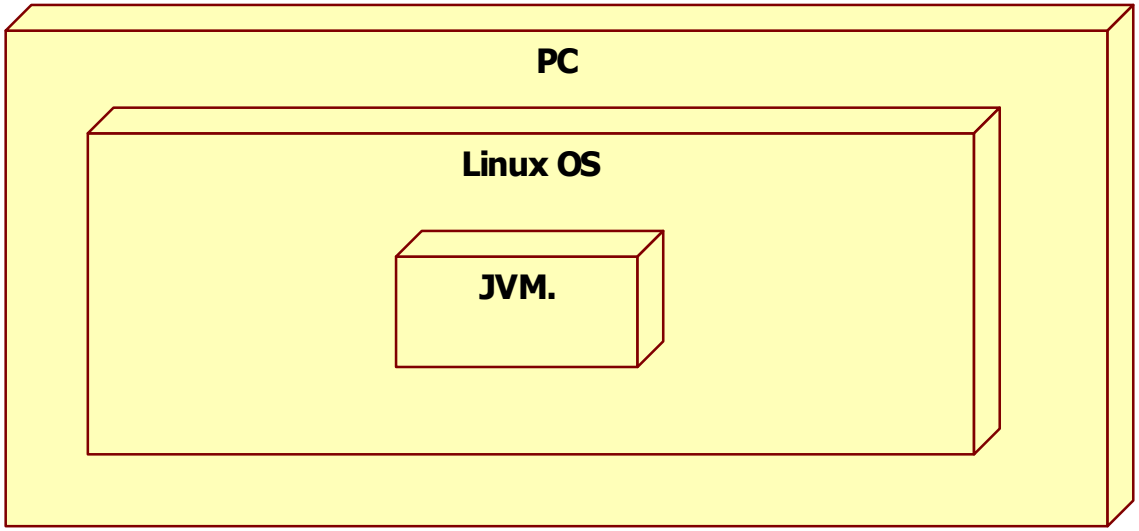
- Goal: design / show the hardware / software configuration of (one, many) applications

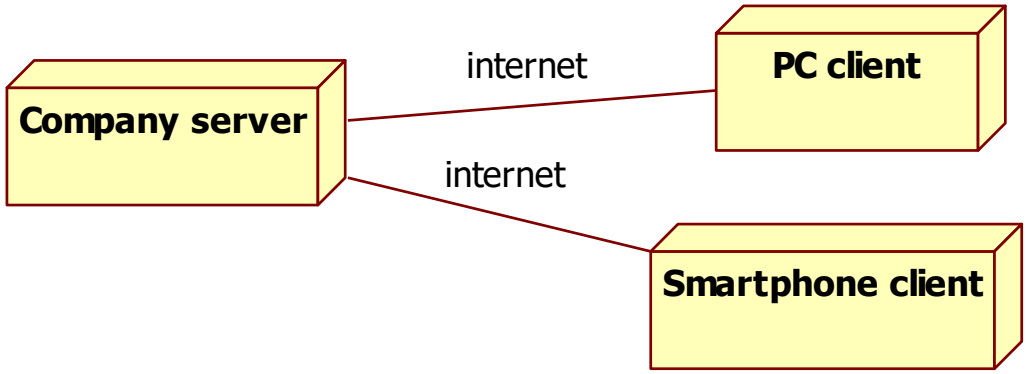
Node, association

- Node: Physical entity or software entity capable of processing
- Association: physical link
- Can be nested



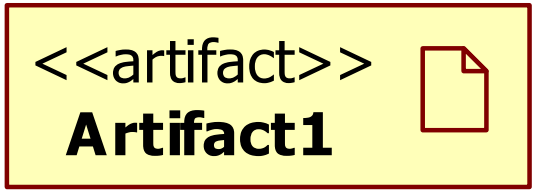

DB server
Application server
Web server


PC
Linux OS
JVM.

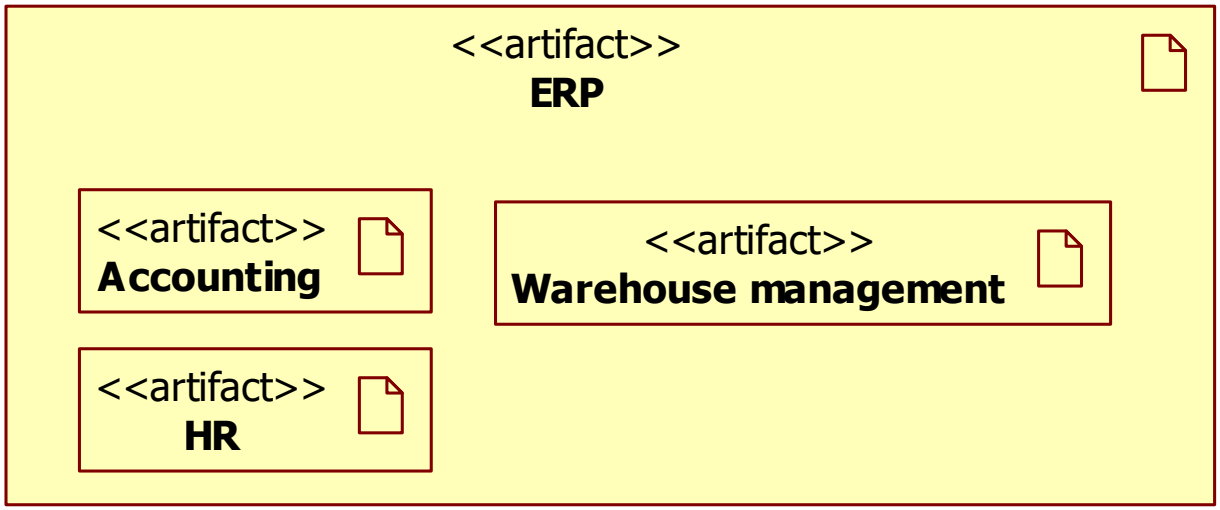

Company server
internet
PC client
internet
Smartphone client

Artifact

- Source file, executable file, library, db table, ..
  - In our case, mostly artifact == application
- Can be nested

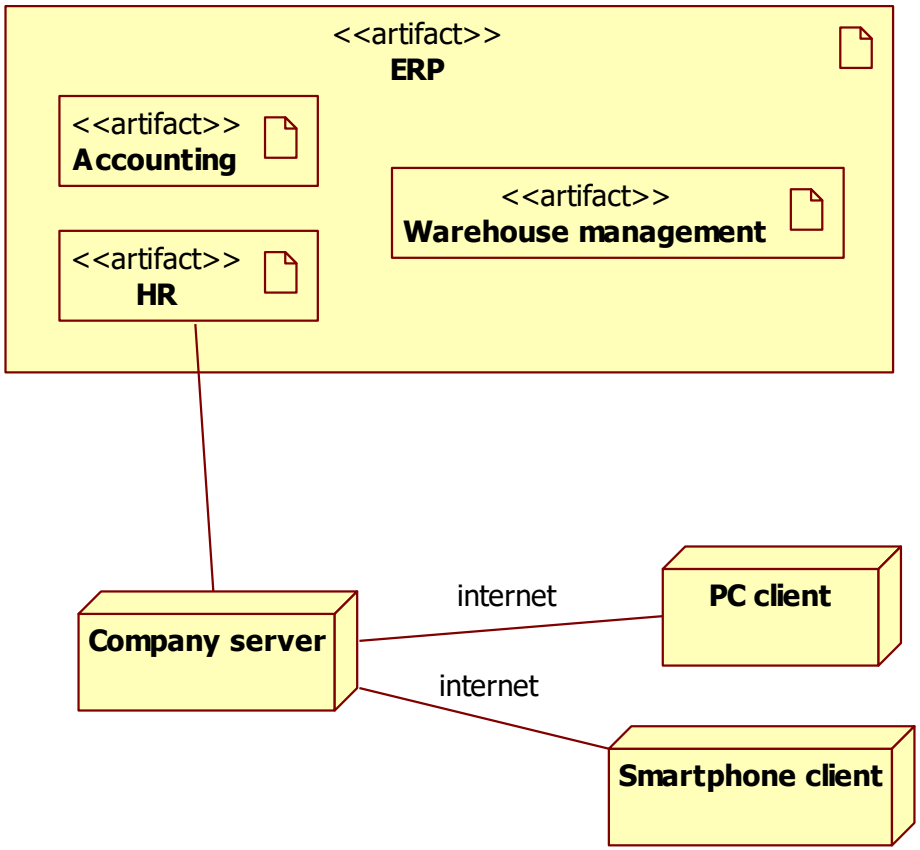


Artifact


<<artifact>>
ERP
<<artifact>>
Accounting
<<artifact>>
Warehouse management
<<artifact>>
HR

Deployment diagram

- Which artifact on which node



- Using nesting