Entrepôts de Données et Big-Data

Intervenants

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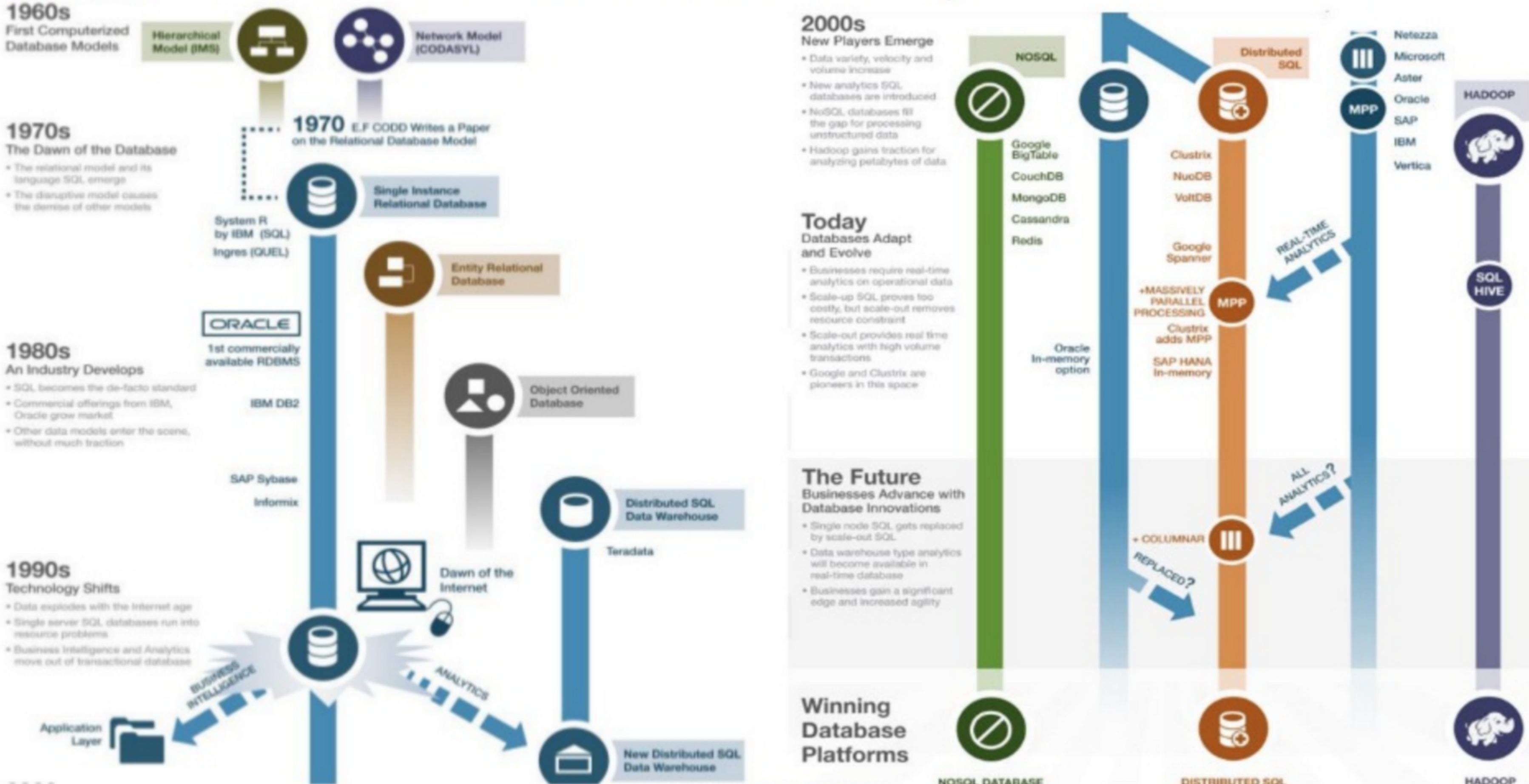
Database Evolution History



Source: Robin Purohit

Programme

1. Rappels et préliminaires (stocakge, optimisation)

2. Entrepôts de données

3. Technologies du Big-Data

Objectif : présenter les techniques de modélisation et les technologies conçues pour l'interrogation des données massives

MCC 100%CCI (2 sessions)

- Première session
  - Rappels (rendu facultatif)
  - Optimisation (TP à rendre)
  - Entrepôts de données (mini-projet + oral)
  - Hadoop Map/Reduce (mini-projet + oral)

TP et mini-projets en binômes - oraux individuels

- Deuxième session :
  - mini-projet individuel + oral sur tout le programme

- **Présence obligatoire** aux séminaires IBM

Divers

- Consultez la page Moodle dédiée à l'UE

- TP : éléments de correction dispensés en cours

- Access comptes Oracle *possible à distance* (SSH)
  - instructions sur Moodle

- Signaler les dysfonctionnements des serveurs Oracle
    - ENT --> Assistance --> Centre de Services --> Déclarer un Incident

- Nous écrire pour tout type de problème ou question
  - chifolleau@lirmm.fr , ulliana@lirmm.fr

Rappels

Readings

These slides should be considered simply as “pointers” to the references below.

[BD-G] Bases de données,
Georges Gardarin, 5ème edition 2005
http://georges.gardarin.free.fr/Livre_BD_Contenu/XX-TotalBD.pdf

[ORA] Oracle® Database SQL Language
Reference 11g Release 1 (11.1) - 2013
http://docs.oracle.com/cd/B28359_01/server.111/b28286.pdf

[UML] Prolegomenes_uml.pdf

[UML2] UML2 : de l’apprentissage à la pratique

Relational Databases & UML

NB : *Assumed to be well known from L2/L3, we just recall basic topics.*

1. UML

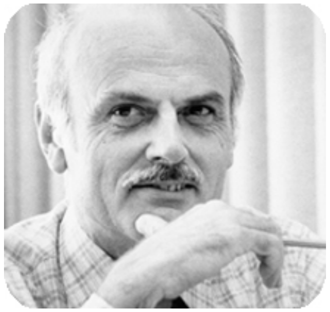
2. Relational Model

3. SQL

Levels of Modelling

- Conceptual Model (UML, EA, Merise)
  - defines what the system contains
- Logical Model (Relational Model, Object Model, Graph)
  - Defines data structures and rules of the system
- Physical Model (SQL, OQL, XML)
  - defines how the system has to be implemented

Peter Chang
EA – 1976



Ted Codd
RM – 1970

Don Chamberlin
SQL – 1974

BASIC RELATIONAL THEORY

The Relational Model

[BD-G] chapter VI section 2.1

Everything is a relation

- **Person**(`Bob,42,Paris`)

  (can model entities)

- **LiveTogether**(`Alice,Bob,Lyon,2010`)

  (can model associations)

Relational Schema

[BD-G] chapter VI section 2.2

- A set of relations built on a set of attributes, with well defined domains.

Person(Name,Age,City)

Name : String   Age: Integer   City : {Lyon,Paris}

The Model VS. The Content

- The idea of representing data using relations is clearly independent from the data to store.
- But, as this data is originated from real world interactions (eg., trading, social), all forms of weak and strong correlations are found in it.

Functional Dependency

[BD-G] chapter VI section 3

*A set of attributes **A** determining a set of attributes **B***

`(name, surname)` ------------> `birthday`

determine

`city` ------------> (population, state)

determine

Key(s)

[BD-G] chapter VI section 3.1

minimal set of attributes determining a whole tuple

LiveTogether(<u>Person1</u>, <u>Person2</u>, City, <u>Date</u>)

<u>Person1</u> , <u>Person2</u> , <u>Date</u> --------> City

key determines

(ex) **LiveTogether**(`Alice,Bob,Lyon,2010`)

Strongly recommended in systems (efficiency, coherence)

Data dependencies were undesirable

- Except for **keys** and referential **integrity constraints**
  - beside these cases, they just bring redundancy
- Database **normalization** eliminated dependencies

Normal Forms

Normal-Forms are guidelines for modeling.

Their definition is motivated by design mistakes.

So, let's find the right place for the attributes !

Normal Forms : 2NF

[BD-G] chapter VI section 6.2

- **2NF** : non-key attributes fully-dependent from the key

FournisseurPiece(<u>Name</u>, <u>Article</u>, Address, Price) **NO**

(Article --/--> Address)

↓ (decomposition)

FournisseurPiece(<u>Name</u>, <u>Article</u>, Price)

Fournisseur(<u>Name</u>, Address)

Normal Forms : 3NF

[BD-G] chapter VI section 6.3

- 3NF : no dependencies between non-key attributes

Person(<u>ID</u> , Name, City, *CityPopulation*) **NO**

<u>ID</u> -----> City -----> CityPopulation

↓ (decomposition)

Person(<u>ID</u> , Name, City) **Place**(City, *CityPopulation)*

Normal Forms : 3NF

[BD-G] chapter VI section 6.3

- This normal form is respected by **most***"transactional-database"* you will find in **any** real world company
  - it allows to fix common data redundancy problems
  - also, every schema can be normalized in 3NF

Normal Forms : Remarks

- 2NF & 3NF respected in practically any information system using a relational database

- Stronger normal forms (BCNF, 4NF, 5NF) are less employed (avoid rarer mistakes; not always achievable)

- Exceptions to normalizations are tolerated to save joins (at the price of redundancy)
  - **we will see this for datawarehouses**

SQL : SURVIVAL KIT

SQL

- Structured Query Language

- Declarative (logical) Language : tell what you want from relations, not what to do with them.
  - This is the main difference with C and Java, *not only* the fact that we deal with data.

- In SQL terminology, a relation is called "table".

SQL

- DDL (Data Definition Language)
  – CREATE/ALTER structures (table, view, index)
- DML (Data Manipulation Language)
  – UPDATE/INSERT/DELETE content
- DQL (Data Query Language)
  – SELECT data

Create Table

[BD-G] chapter VII section 2.1 and [ORA] section 16-6

```
CREATE TABLE Employee (
 id   NUMBER,
 name VARCHAR2(50),
 birthday DATE
)
```

Oracle Built-in Datatypes

[ORA] section 2-6

Why do we need datatypes ?

- To associate fixed set of properties to attributes.
- This improves the database:
  - coherence : type-checking operations
    - cannot sum two strings
  - efficiency : a datatype has its own best storage
    - BLOB vs integers

Oracle Built-in Datatypes

- Character
- Numeric
- Date/Time
- Large Object

Complete list : see [ORA] table 2-1

Value Constraints

[ORA] section 8-4 and [BD-G] chapter VII section 2.1

- Why do we need constraints ?

- To restrict the values in a database and ensure the data integrity
  - ex : No employee without an ID

Not Null

[ORA] section 8-8

- Prohibits a database value from being null

```
CREATE TABLE Employee (

id          NUMBER NOT NULL,
name        VARCHAR2(50),
birthday    DATE

)
```

Unique

[ORA] section 8-9

- Prohibits multiple rows from having the same value (but allows them to be null)

```
CREATE TABLE Employee (

id          NUMBER UNIQUE,
name        VARCHAR2(50),
birthday    DATE

)
```

Primary Key

[ORA] section 8-9

- Combines a NOT NULL constraint and a UNIQUE constraint in a single declaration

```
CREATE TABLE Employee (

id          NUMBER PRIMARY KEY,
name        VARCHAR2(50),
birthday    DATE

)
```

Primary Key : Multiple Attributes

[ORA] section 8-20

- Combines a NOT NULL constraint and a unique constraint in a single declaration

```
CREATE TABLE Employee (
id          NUMBER,
name        VARCHAR2(50),
birthday    DATE,

PRIMARY KEY (name,birthday)
)
```

Foreign key

one (or more) ***attributes*** *which correspond to the* ***key*** *of another relation*

Employee(ID, Name, **Department_id**)

Departement(Dept_ID, Name)

Foreign Key

[ORA] section 8-10 and 8-21

Requires values in one table to match values in another table.

```
CREATE TABLE Employee (

    id             NUMBER,
    department NUMBER

    FOREIGN KEY department
                REFERENCES Dept(dept_id)
    )
```

Check

[ORA] section 8-10 and 8-22

Requires a value to satisfy with a specified condition

```
CREATE TABLE Employee (
      id              NUMBER,
      department      NUMBER,
      office          VARCHAR2(10)

      CHECK (
         office IN
            ('DALLAS','BOSTON', 'PARIS','TOKYO')
      )
)
```

Oracle does not verify mutually exclusive conditions (eg. AGE>1 AND AGE<0)

ALTER TABLE

[BD-G] chapter VII section 6.2.4 and [ORA] section 12-2

- Add a new column
  - `ALTER TABLE Employee ADD (office VARCHAR2(20));`
- Modify an existing column
  - `ALTER TABLE Employee MODIFY (office NUMBER);`
- Define a default value for the new column
  - `ALTER TABLE Employee MODIFY office DEFAULT ‘Corridor’;`
- Drop a column
  - `ALTER TABLE Employee DROP (office);`

DELETE TRUNCATE DROP

[ORA] section 17-25 and 19-62 and 18-5

	removes		
	rows	table	rollback
DELETE	✓	✗	✓
TRUNCATE	✓	✗	✗
DROP	✓	✓	✗

- TRUNCATE = DROP + CREATE TABLE

INSERT

[BD-G] chapter VII section 4.1 [ORA] section 18-66 and 18-54

```
INSERT
INTO Employee
VALUES
        ('Bob',
         TO_DATE(
         '03-OCT-1972','DD-MON-YYYY')
         )
```

TO_DATE converts a character/numeric to a date

[ORA] 2-49/50

SELECT FROM

[BD-G] chapter VII section 3.1 [ORA] section 18-66 and 18-54 and 2-49

```
SELECT
   TO_CHAR(birthday,'MM-DD-YYYY')

FROM
   Employee
```

TO_CHAR converts a numeric to a character
[ORA] 2-287/288 and 5-292

SELECT FROM WHERE

[BD-G] chapter VII section 3.2 [ORA] section 2-50

```
SELECT
   name

FROM
   Employee

WHERE
   birthday >
   TO_DATE('01-10-1970','DD-MM-YYYY')
```

JOINS

[BD-G] chapter VII section 3.3

```
SELECT
  Employee.name, Department.name
FROM
  Employee, Department
WHERE
  Employee.dept = Department.id
```

JOINS

Employee

name	**dept**
Alice	dep1
Bob	dep2
Eddy	dep1

Department

id	**name**
dep1	Sales
dep2	Production

Emp_Join_Dep

Employee.name	**Department.name**
Alice	Sales
Bob	Production
Eddy	Sales

Group By

[BD-G] chapter VII section 3.7

```
SELECT
  dept, count(*) as N
FROM
  Employee
GROUP By
  dept
```

Employee

name	**dept**
Alice	dep1
Bob	dep2
Eddy	dep1

Agg_Emp

dept	**N**
dep1	2
dep2	1

Summing Up

- Relations
  - Functional dependencies, Normal-forms

- SQL
  - CREATE, INSERT, DELETE, SELECT, GROUP-BY

MODELING WITH UML

UML (Unified Modeling Language)

- Universal graphical modeling language designed to model objects, associations, time events, system states
  - Main goal is to ease prototyping

- Good news : UML is a rich model and we can also use it to model data !

UML : Plan

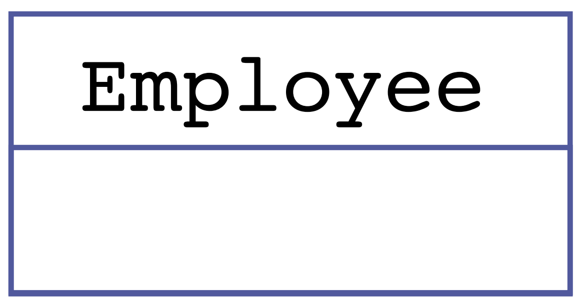
- UML Class Diagram
  - Basic constructs that can be used to model Relational Databases in UML
  - Real Object-oriented features

Class

[UML] section 3 [BD-G] chapter XVII section 2

- Set of elements sharing common properties
  - ex. peoples, animals, cars

- UML : draw a labelled box



Class : Attributes

[UML] section 3 [BD-G] chapter XVII section 2

- Attributes denote the properties of class objects
  - They are usually typed

- Write the attributes below the class name

Employee
name : string age : int

Operations can specify

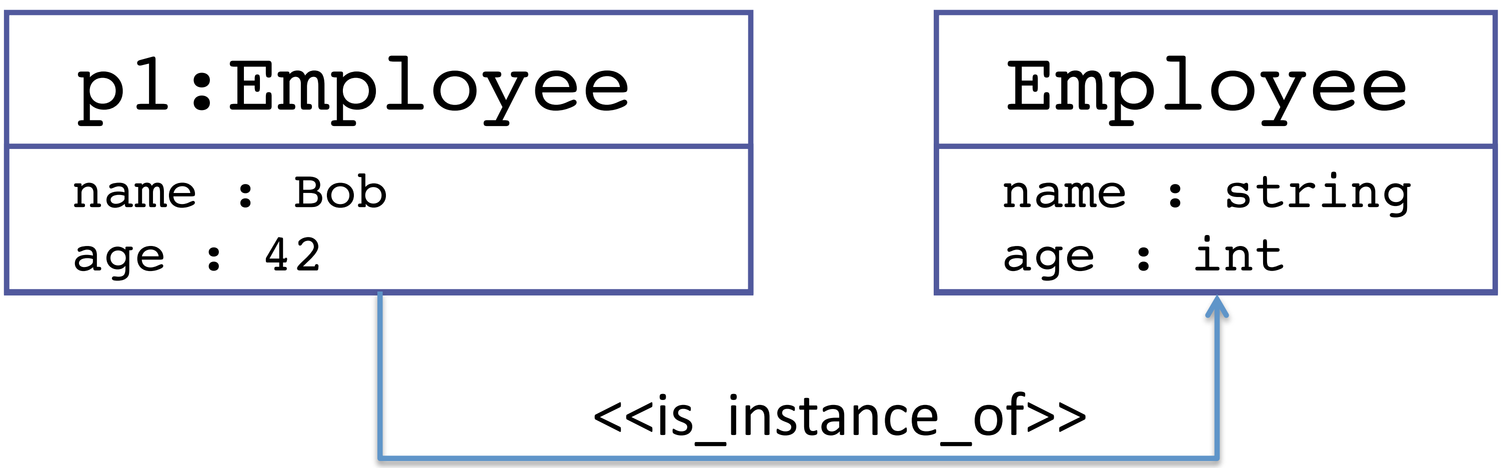
- Visibility (**+** public) (**-** private) (**#** protected)
- Return-type (*optional*; can be undefined)
- Multiplicity of parameter/return-type (*optional*)

```
Employee
-----------------------------
name : string
dept : int
-----------------------------
+setDepartment(
 int dept [1]) : bool [1]
```

Instances

- The elements of a class
  - ex. the employee Bob

- Related to their class by a directed edge

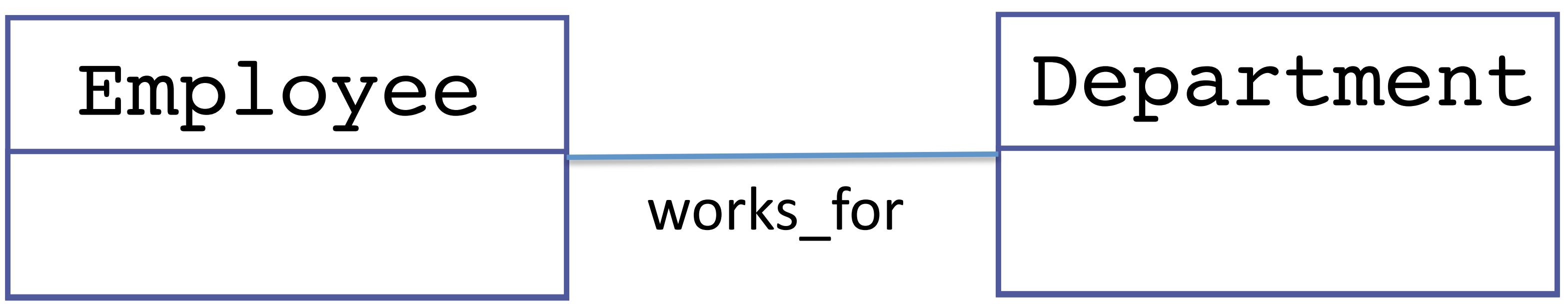


Binary Associations

[UML] section 4 [BD-G] chapter XVII section 2

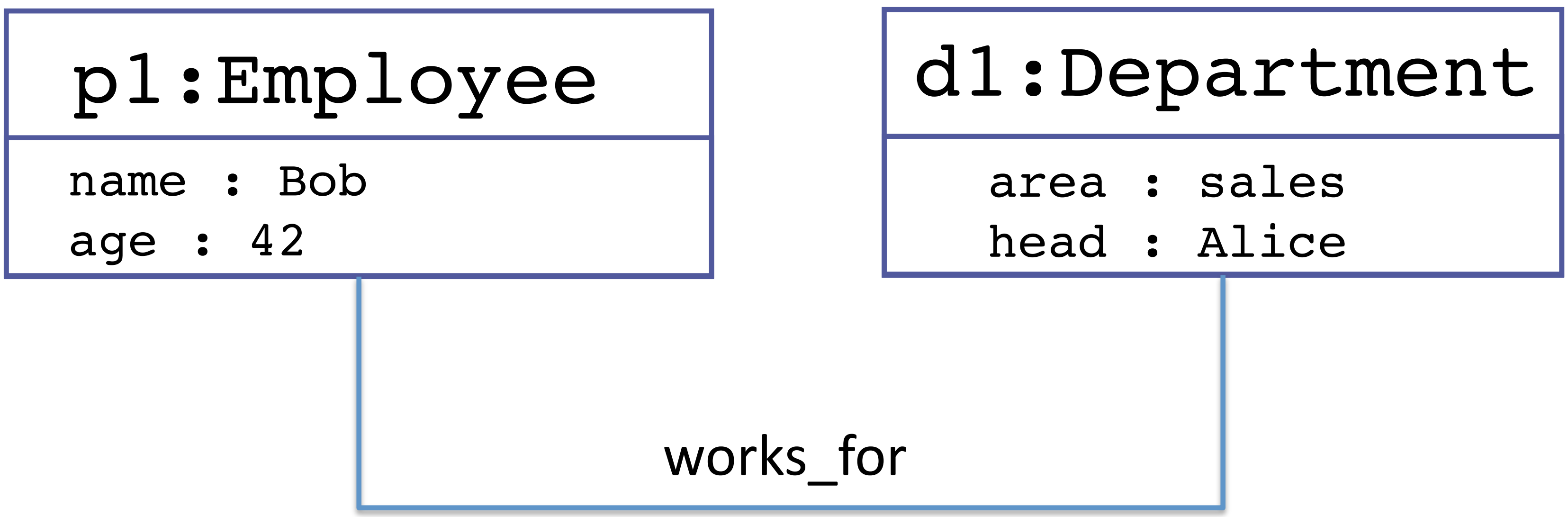
- General relationships between elements of two classes
  - ex. an employee works for a department
  - a concrete instance of association is called <u>link</u>

- Binary association : *undirected* edge between classes



Associations : Links

- Relationships between instances of classes

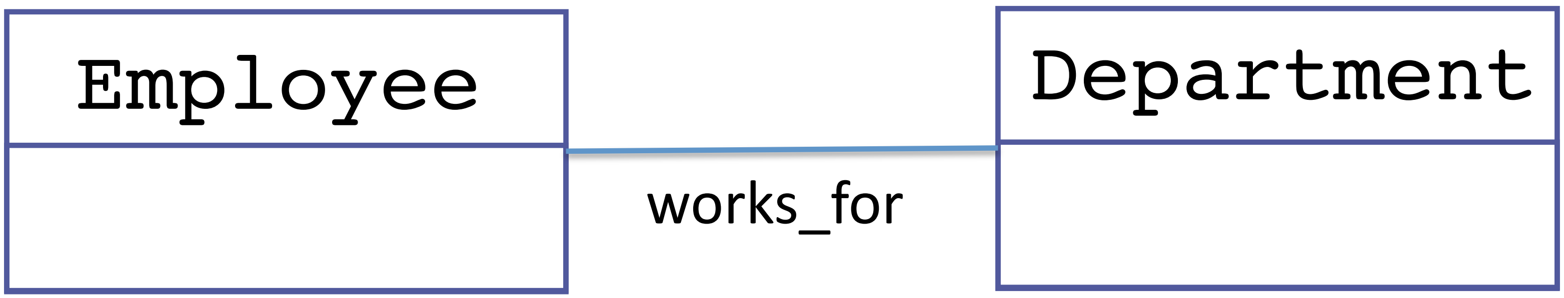


Associations : a tricky notation

- Any association is specified by three things

1. Its name
2. The cardinality constraints of the class elements
3. The role of the classes in the association (optional)

Associations : Name (1)

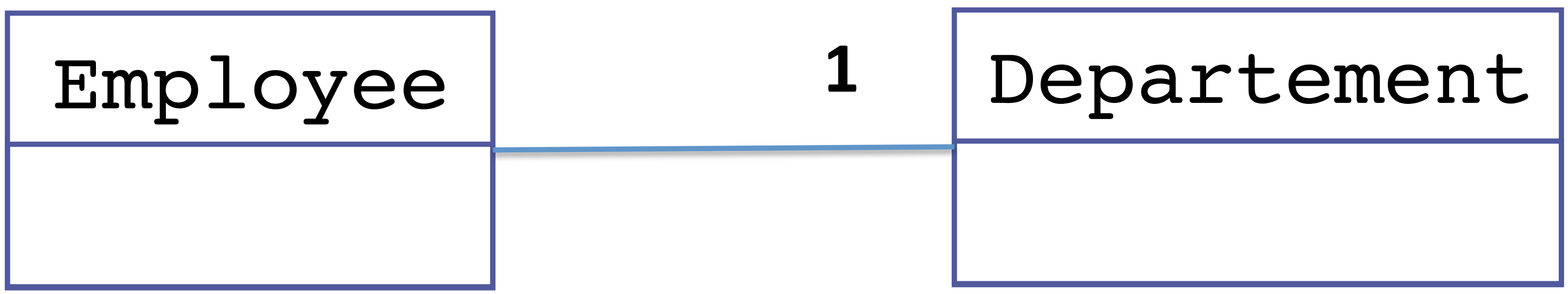


- The name is a label placed in the middle of the edge

Associations : Cardinality (2)

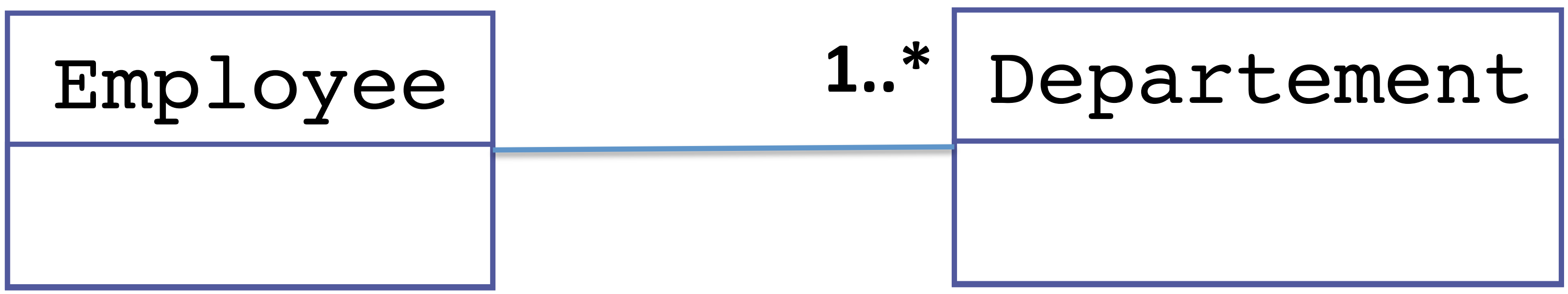
- This means that one instance of `A` participates in the association with **N** elements of the other class

Associations : Cardinality (2)



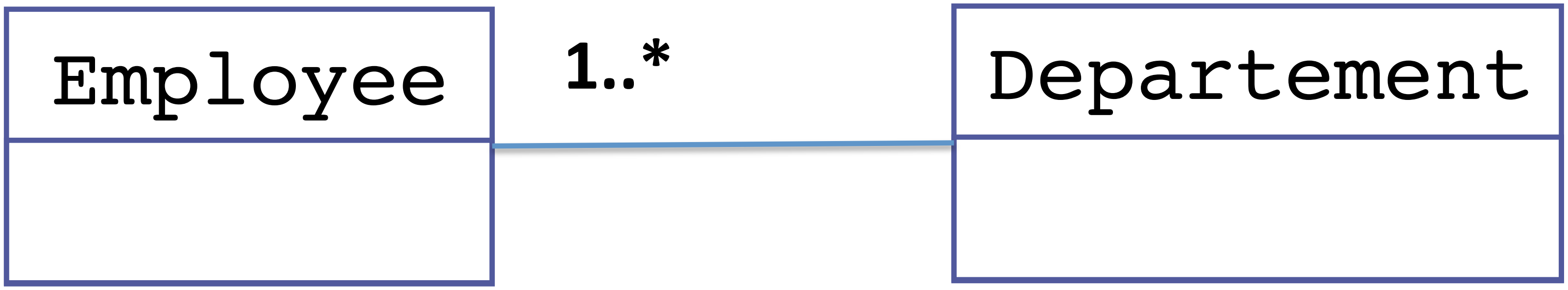
This means that an employee works for exactly **1** department

Associations : Cardinality (2)



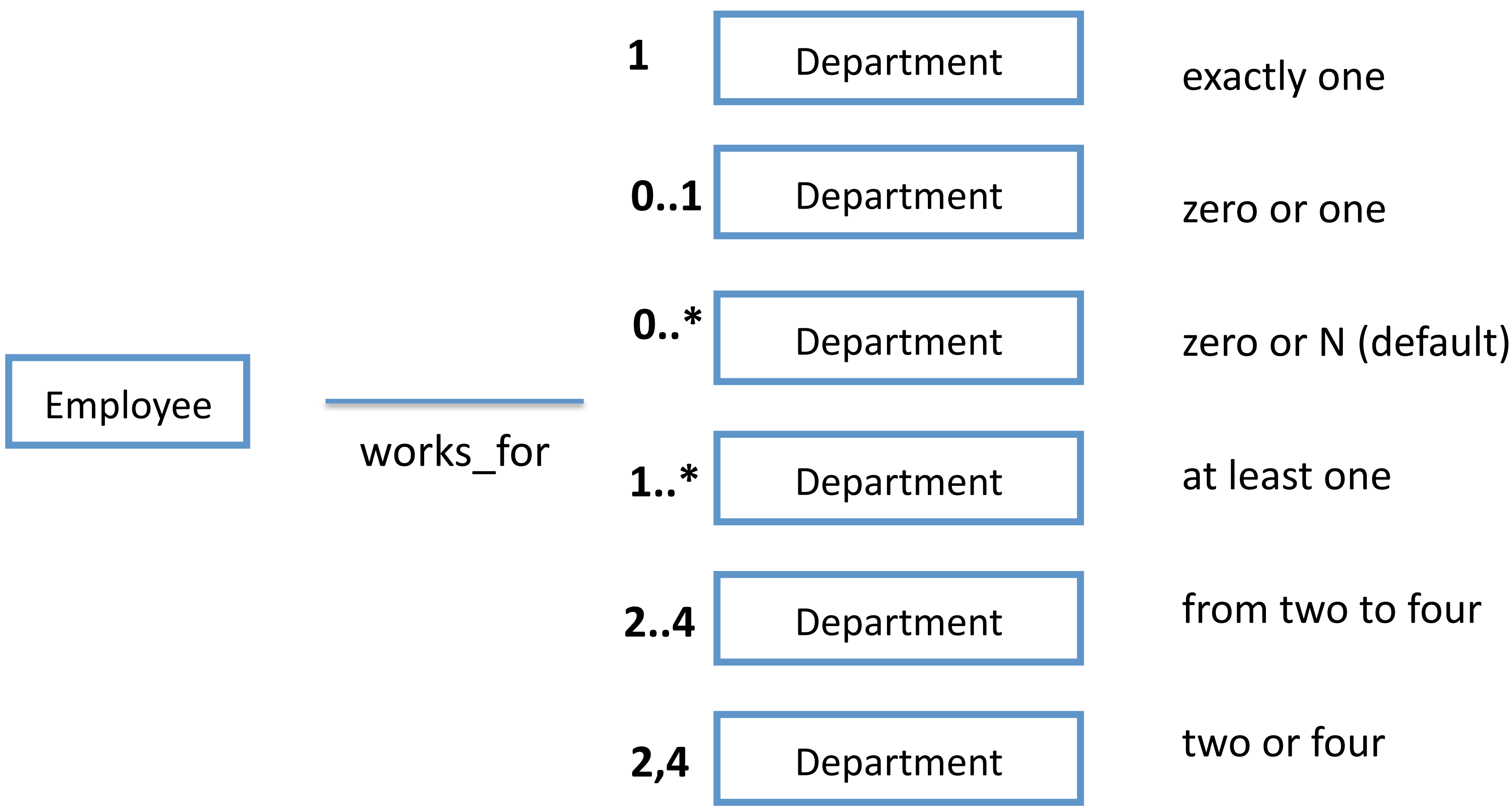
This means that an employee can work for more than **1** department (but at least one)

Associations : Cardinality (2)



This means that a department has at least one employee, with no upper-limit.

Cardinality Specification



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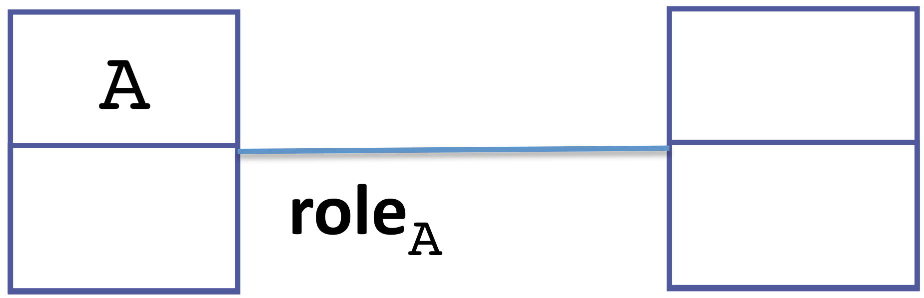
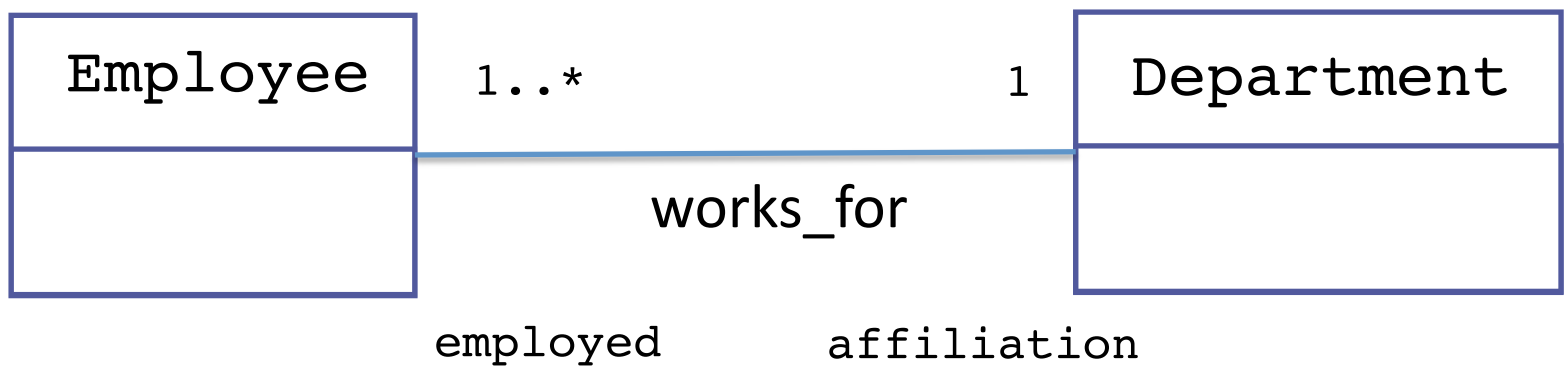
Associations : Roles (2)

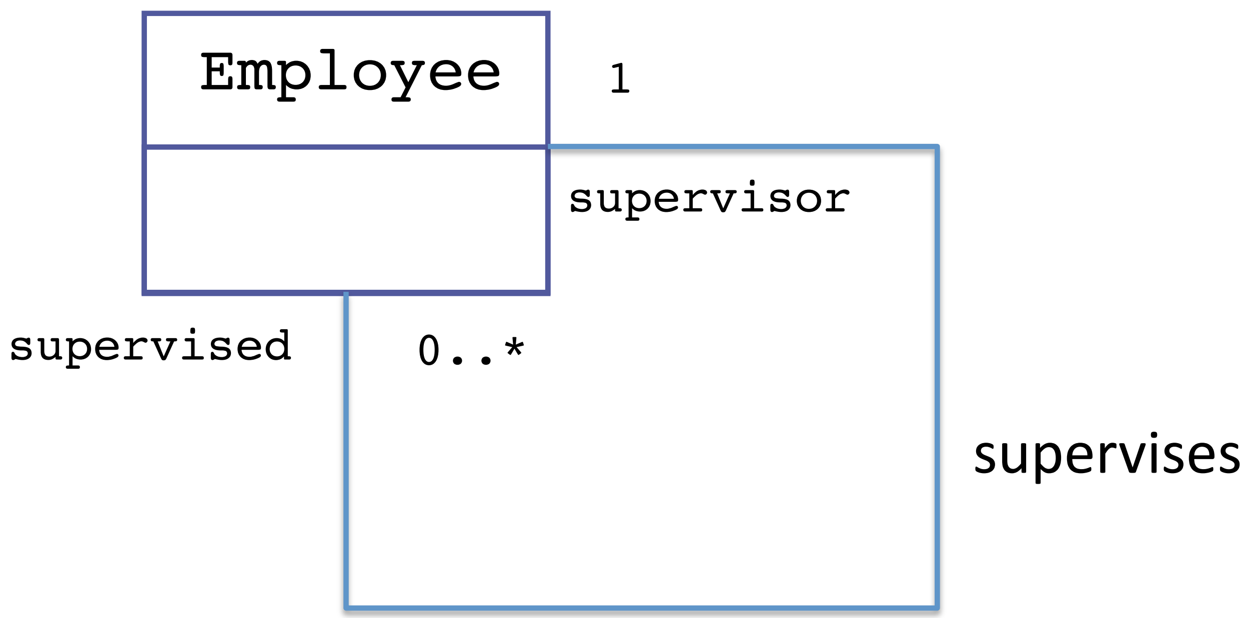


- This means that in the association an instance of `A` plays **role**$_{\mathtt{A}}$

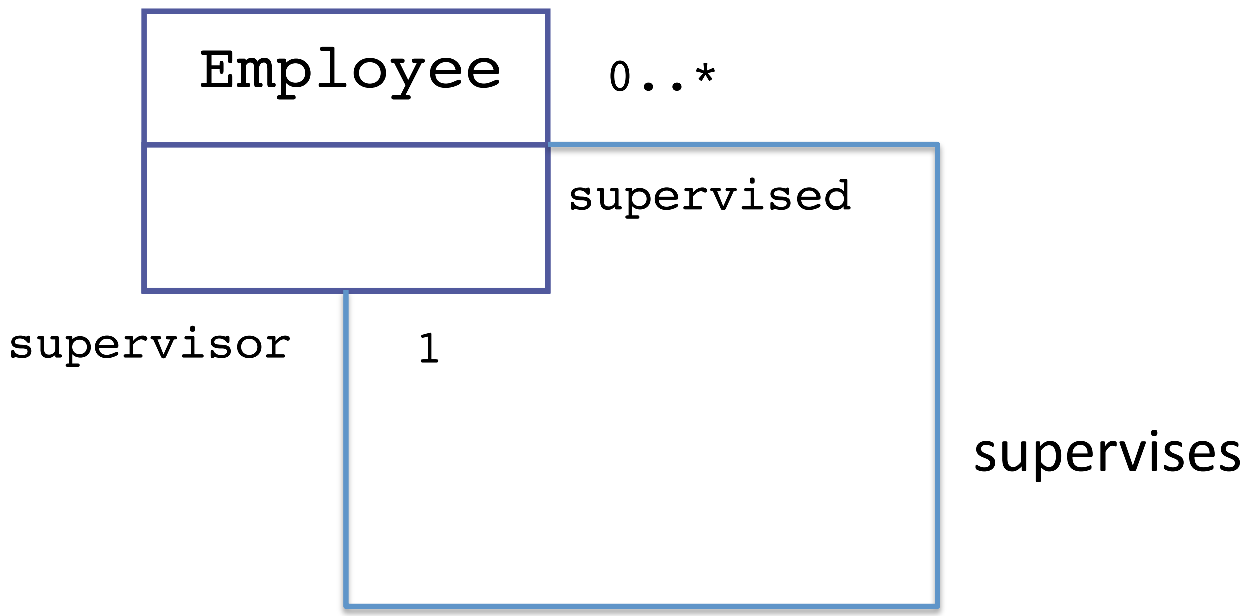
Putting everything together



Reflexive Associations

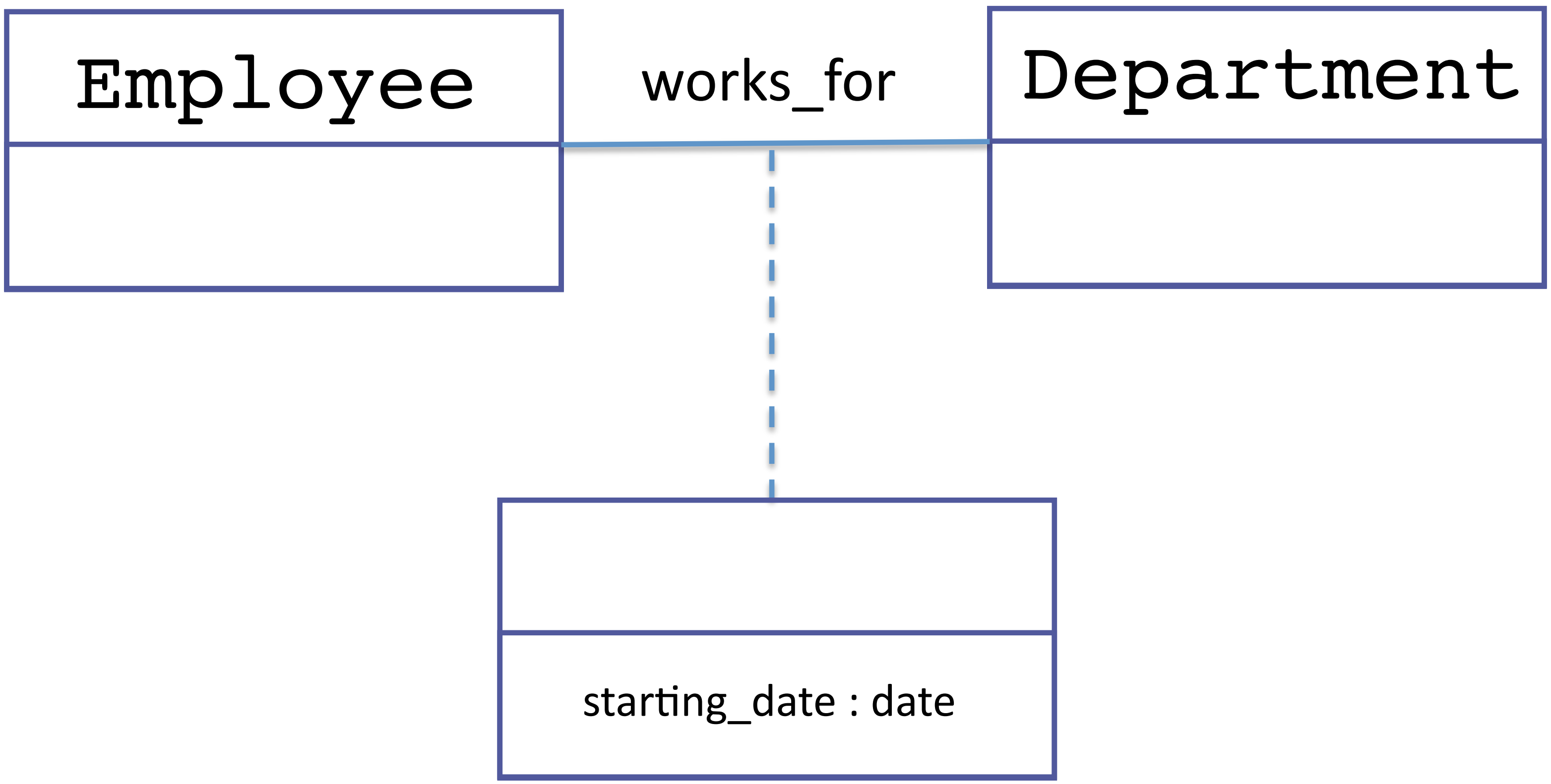


Equivalent Formulation



Notation for Attributes in Associations

[UML] section 4 [BD-G] chapter XVII section 2



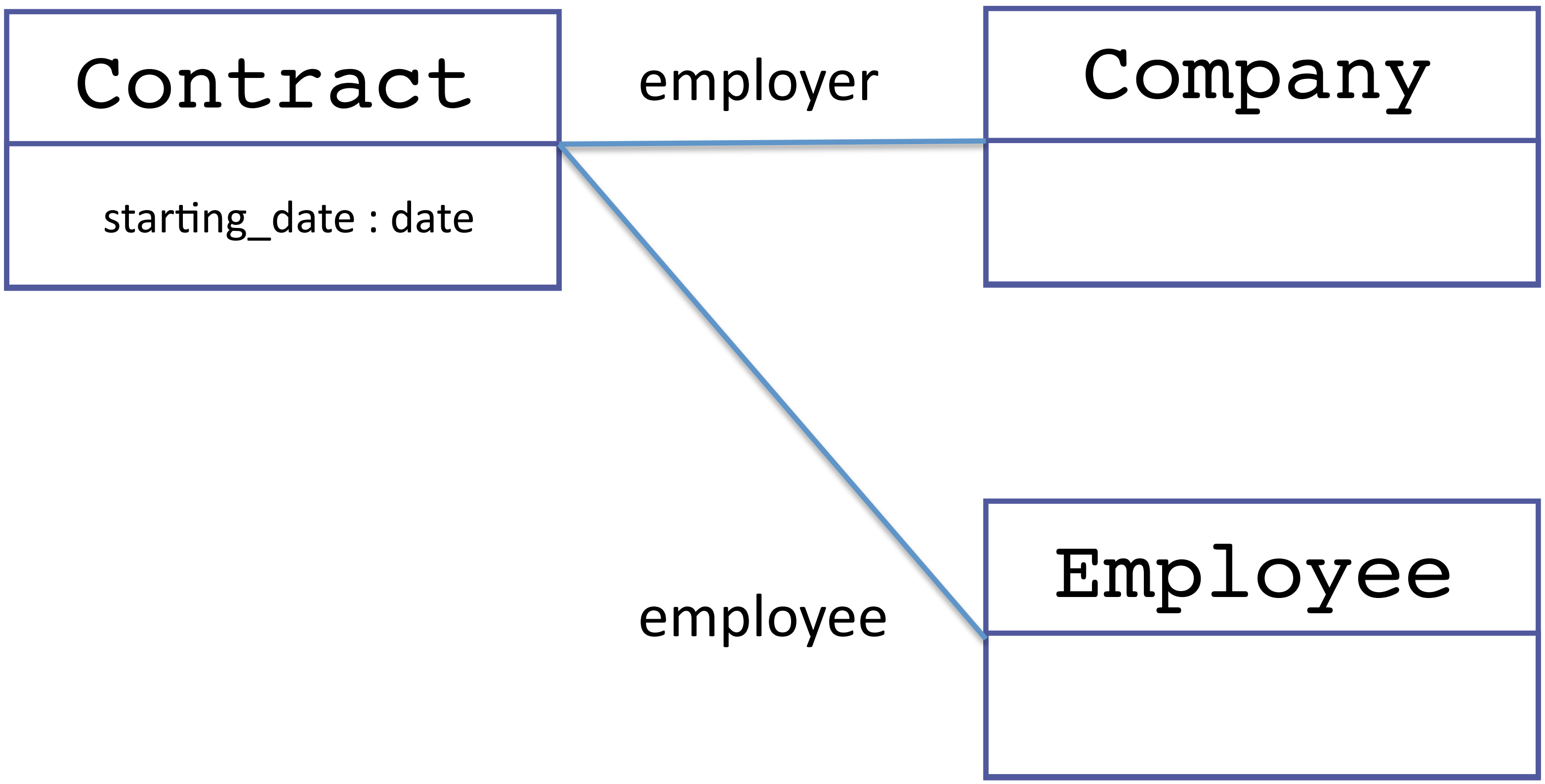
Why Associations can be tricky

Often, a relatioship between two entities combines:

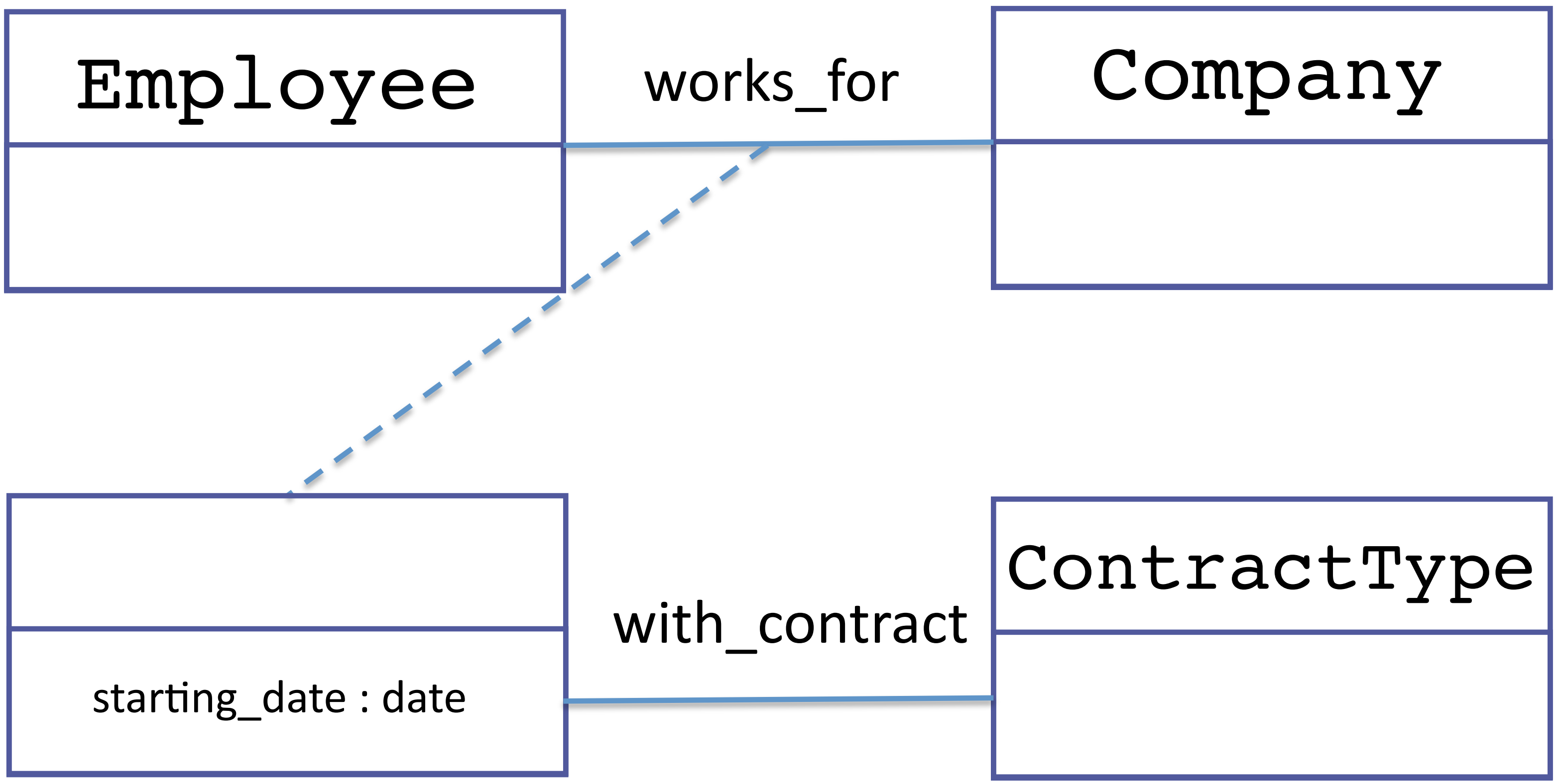
- ***association*** features
  – the fact that two or more things are linked
- **representation** features
  – the details about this association

- Ex: a working contract can be seen as a relationship (an association between an employee and a company) or as an entity (representation of a legal concept)
  – This duality is the source of most design problems !
    - Recognize your own modelling choices !

Why Associations can be Tricky

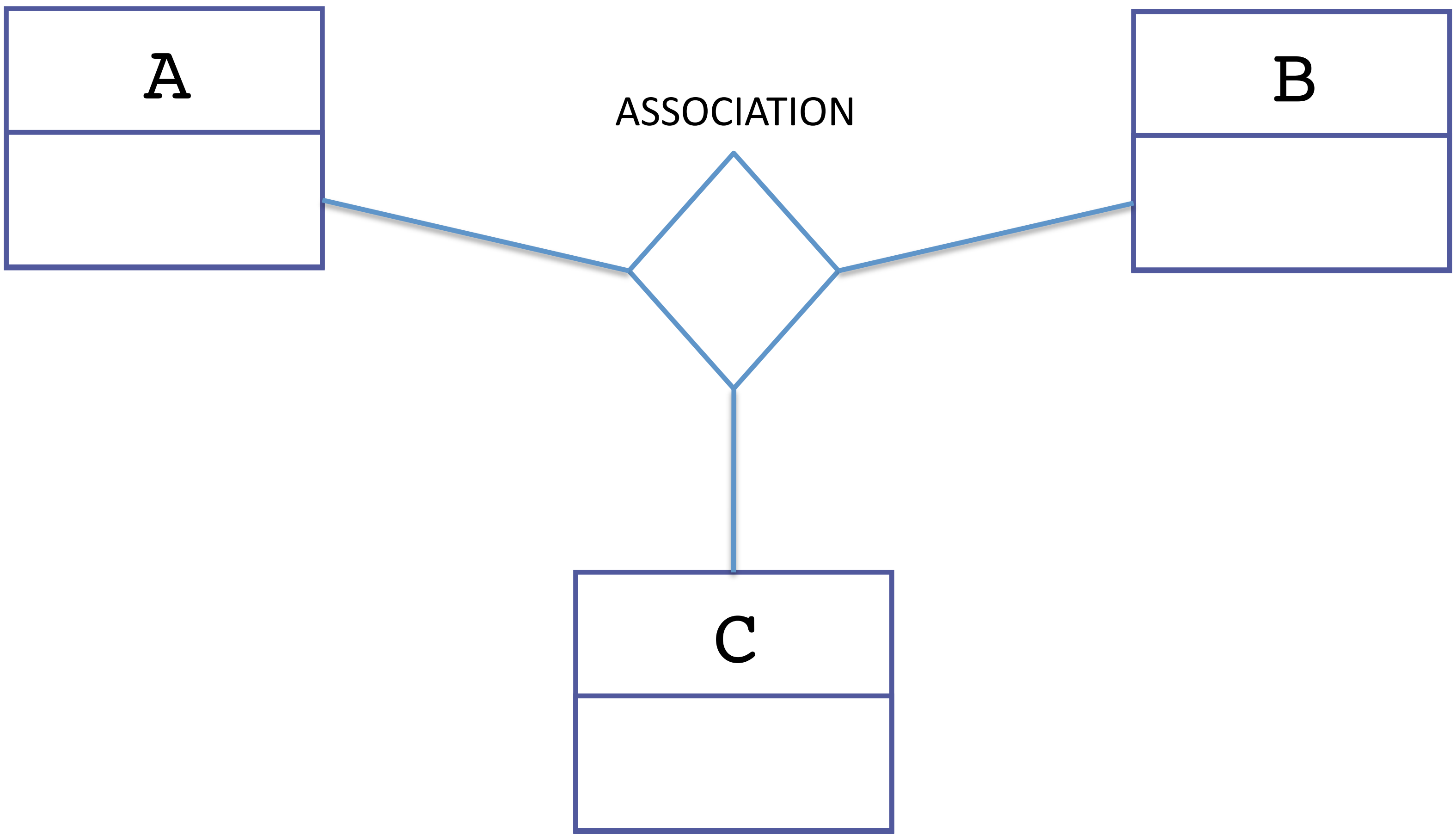


Associations Participating in Other Associations



Notation for 3-ary Associations

[UML] section 4.1 [UML2] section [3.3.4]



Summing Up

UML for Relational Databases

[UML] section 4 [BD-G] chapter XVII section 2

- Basic UML
  - Classes, binary associations, n-ary associations
  - Can model relational databases

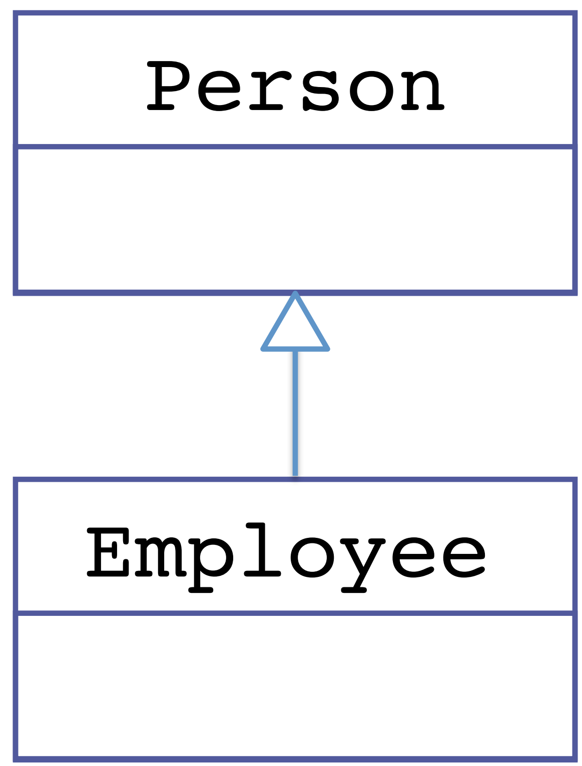
- The construct of the language we have seen so far are enough to model relational databases

SubClass

[UML] section 5 [BD-G] chapter XVII section 2.2

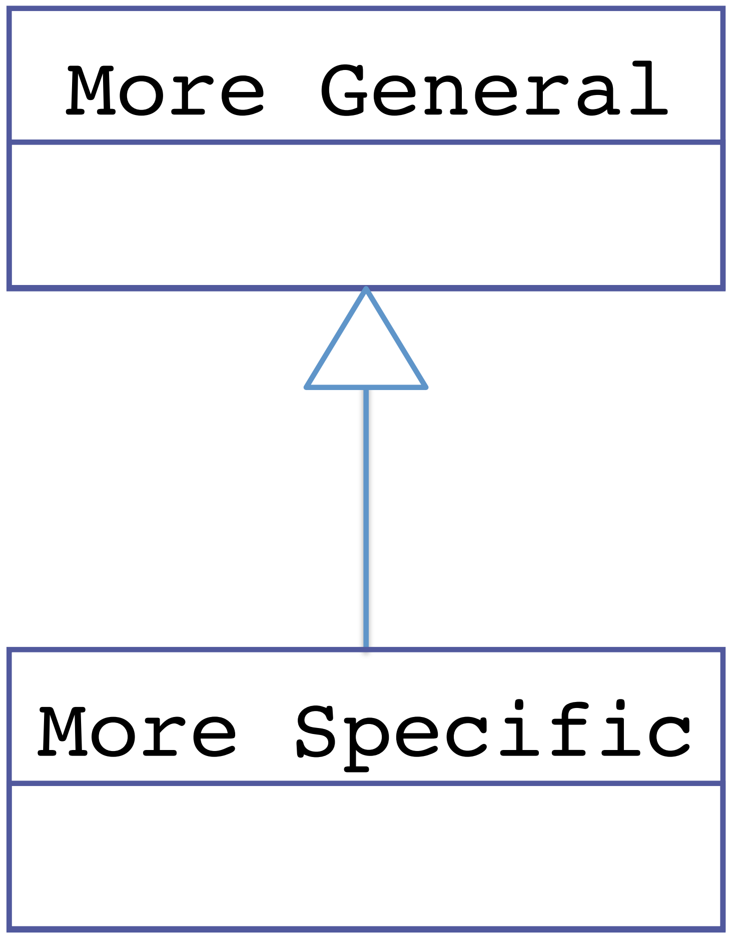
- A subset of the instances of a Class
  - ex. every employee is a person

- A subclass <u>inherits</u> all superclass properties or <u>redefines</u> them.



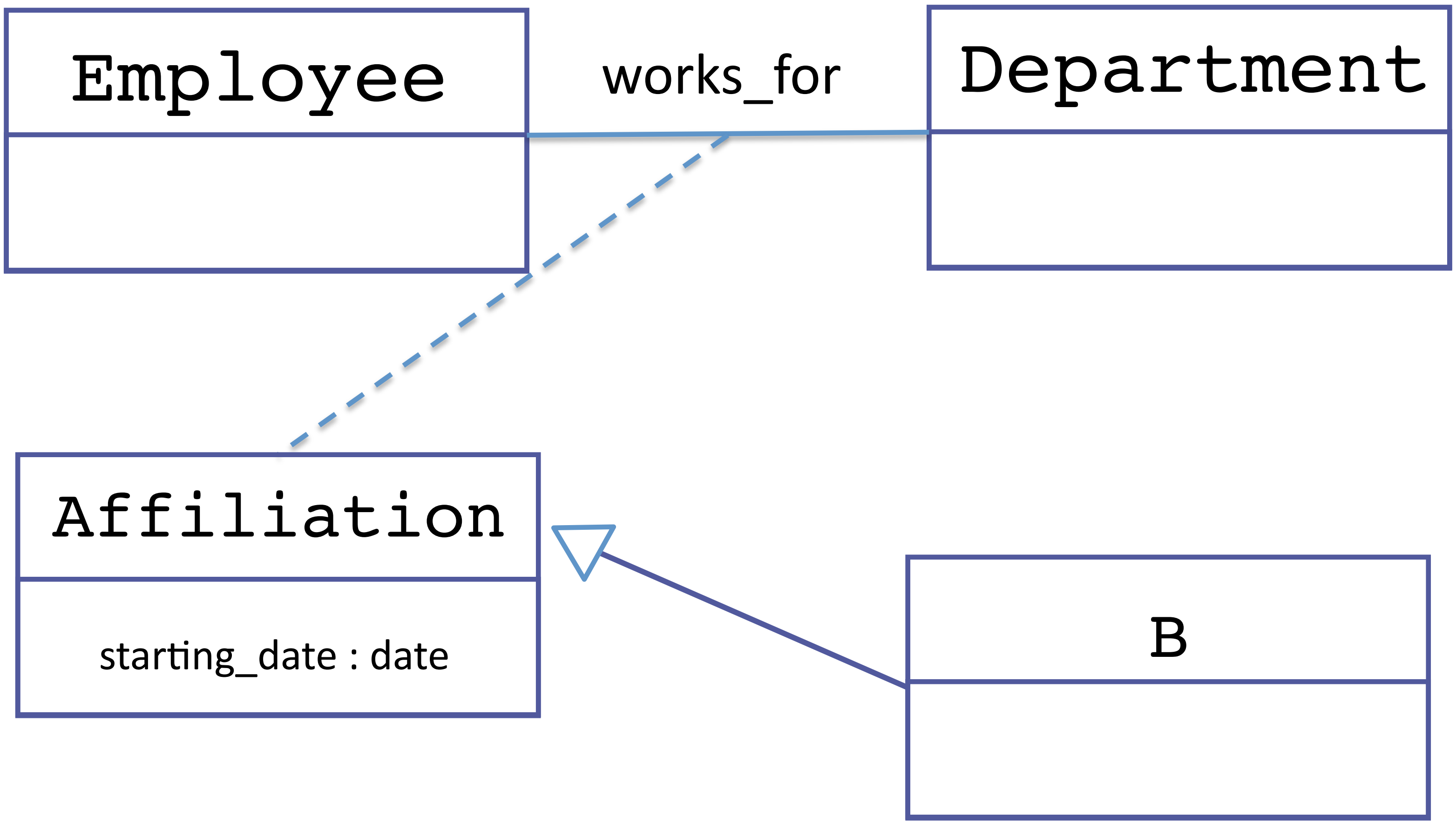
SubClass = Generalization/Specialization

[UML] section 5

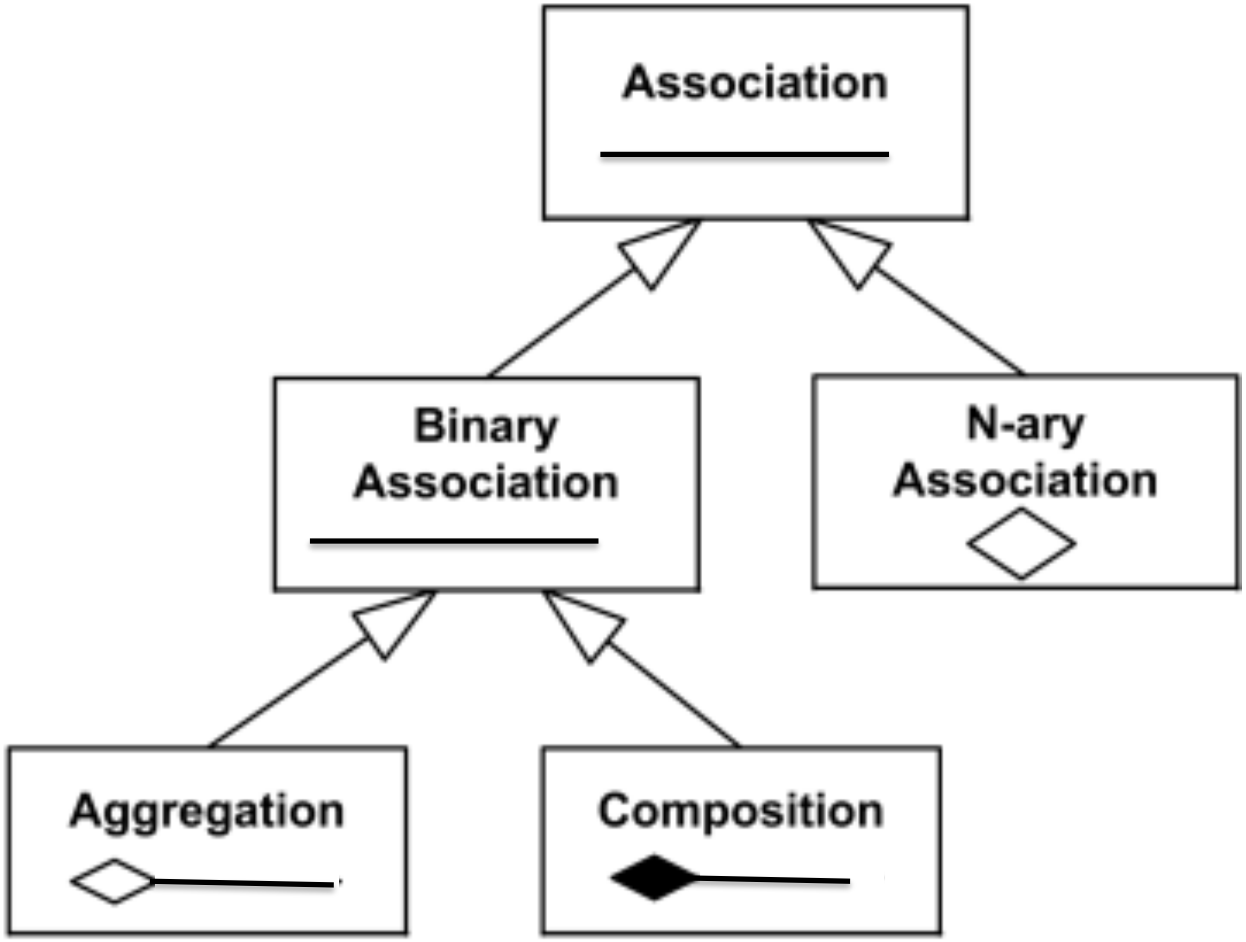


Association modeled by a Class

[UML] section 4.3



- Consequence : such class can have proper attributes, operations and also other associations


Association
Binary Association
N-ary Association
Aggregation
Composition

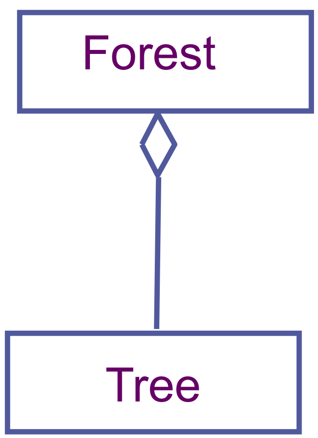
Part-Of (binary) Association

- “A forest is made of trees”

Aggregation

[BD-G] chapter XVII section 2.2

- Consequence 1 : a tree can exist even without a forest



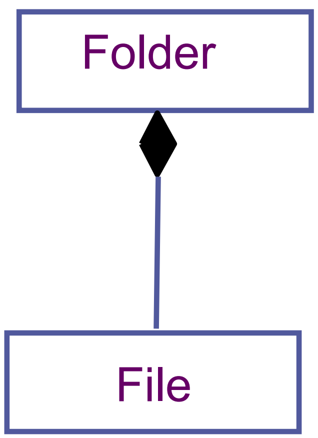
Part-Of (binary) Association

- “A folder is made of files”

Composition

[BD-G] chapter XVII section 2.2

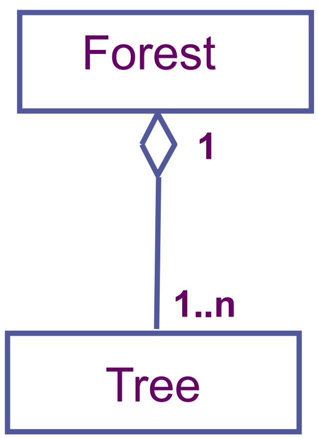
- Consequence 1 : a file <u>cannot</u> exists without a folder

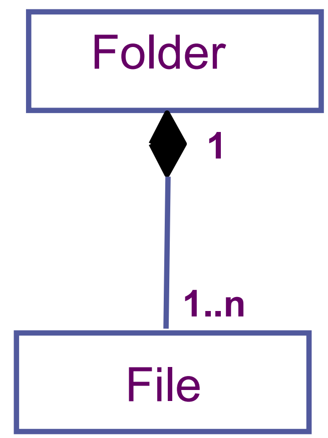


Aggregation Composition

[BD-G] chapter XVII section 2.2

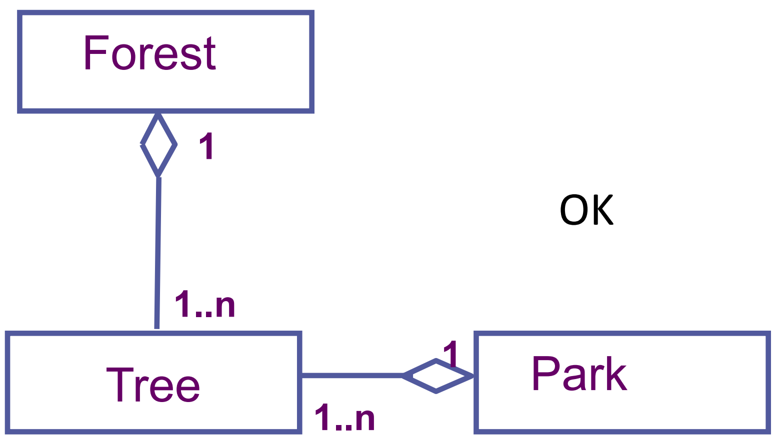
- Consequence 1 : a tree can exist even without a forest
- Consequence 1 : a file cannot exists without a folder





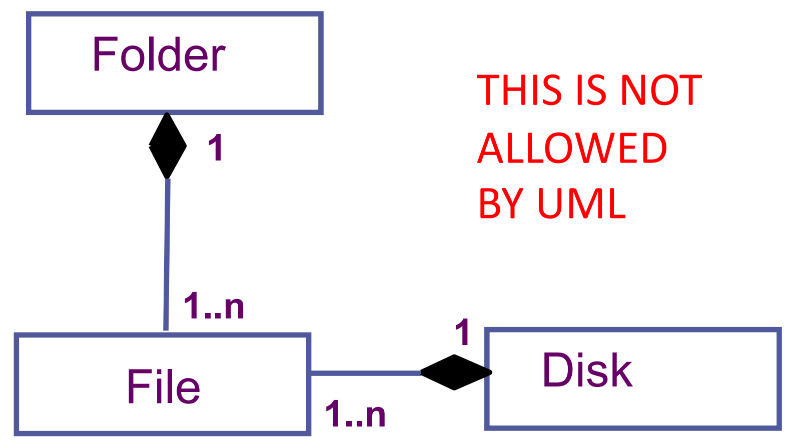
Aggregation

- Consequence 2 : a tree can be part of both a forest and a park



Composition

- Consequence 1 : a file <u>cannot</u> exists without a folder



Summing Up

- Instances/Links/Operations
- Subclasses
- Aggregation and Composition