



Class modelling (part1)

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(these slides are derived from the book “Object-oriented modeling and design with UML”)

UML and OO approaches

Unified Modeling Language (UML) is a standardized, general-purpose modeling language. UML includes a set of graphic notation techniques to create visual models of object-oriented (OO) software-intensive systems

- ▶ An OO approach includes 4 aspects:
 - ▶ Identity
 - ▶ Data organized into discrete distinguishable entities (**objects**)
 - ▶ Classification/Abstraction
 - ▶ Objects with the same attributes and operations are grouped into a **class**
 - ▶ Each object is said to be an **instance** of its class
 - ▶ Inheritance
 - ▶ Sharing of attributes and operations (**features**) among classes based on a hierarchical relationship
 - ▶ A superclass has general information that subclasses refine and elaborate
 - ▶ Polymorphism
 - ▶ The same operation may behave differently for different classes

UML and OO approaches



OO development

[Brooks-95]

The hard part of software development is the manipulation of his essence, owing the inherent complexity of the problem, rather than the *accidents* of its mapping into a particular language.

- ▶ A clean design in a precise notation
 - ▶ facilitates integration, maintenance, enhancement and the entire software lifecycle
 - ▶ provides useful documentation
- ▶ Design flaws that surface during implementation are more costly to fix than those that are found earlier
- ▶ A premature focus on implementation restricts design choices and leads to an inferior product

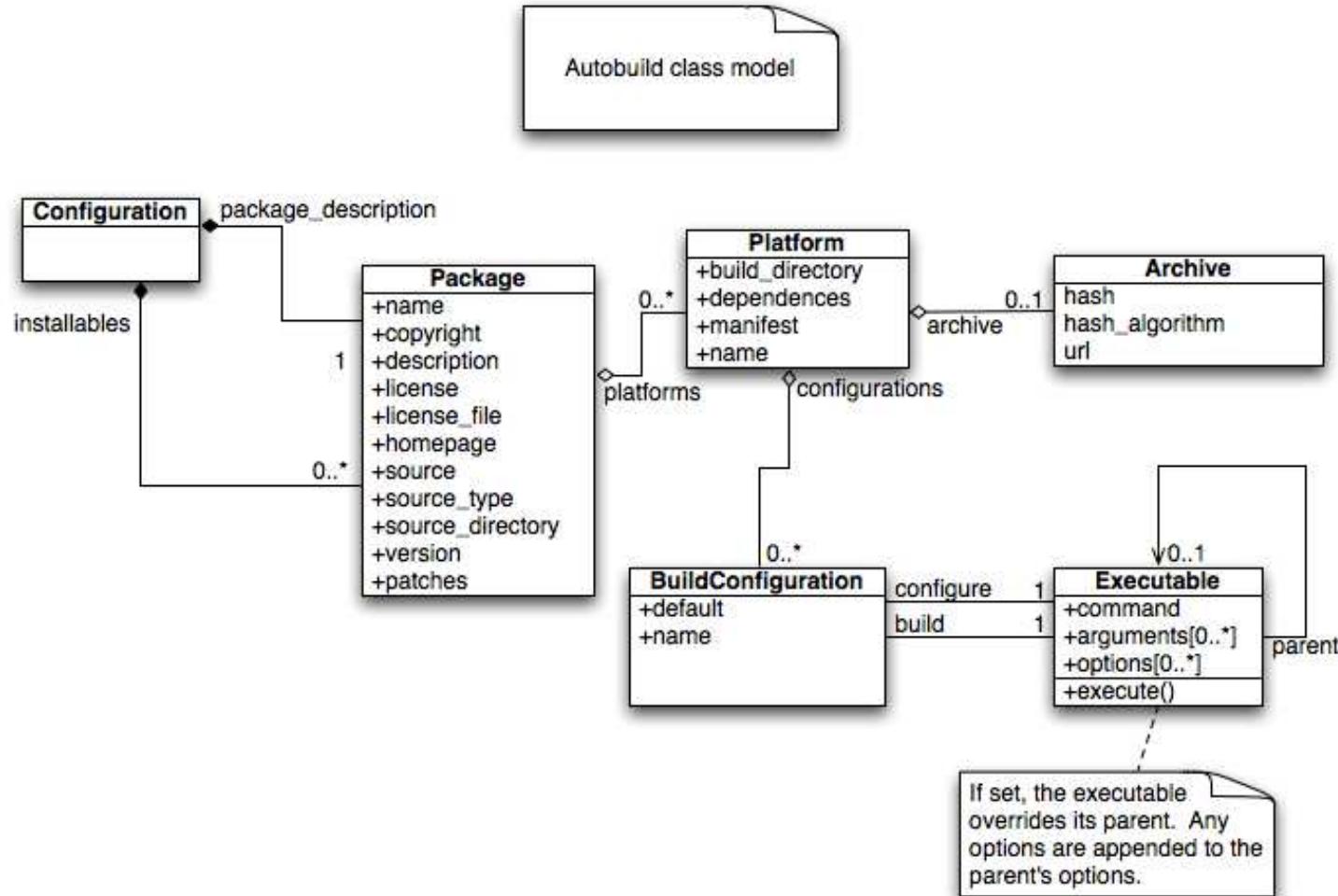
OO development



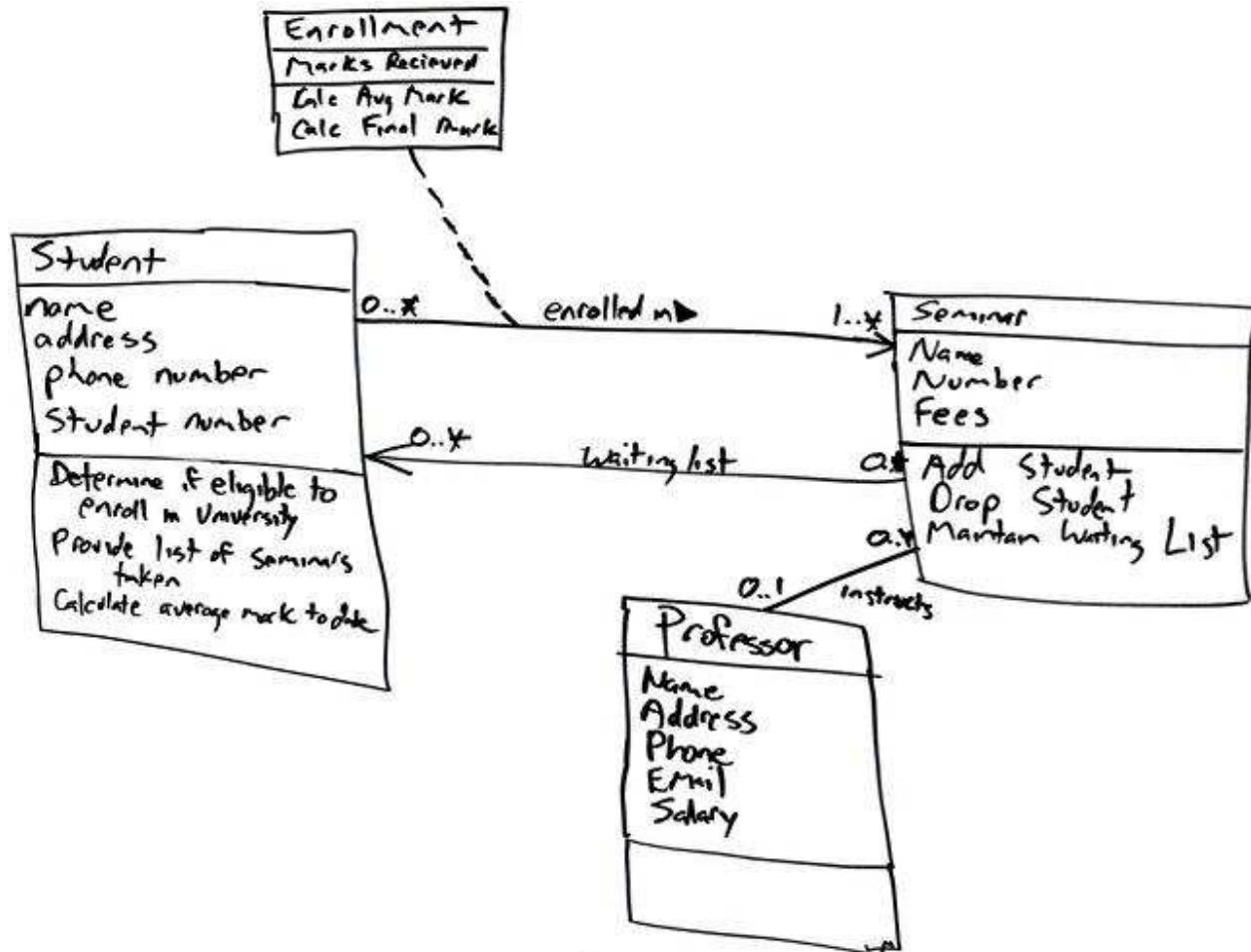
UML models

- ▶ Class model
 - ▶ Static structure of objects and their relationships
 - ▶ **Class diagrams**
 - ▶ Nodes are classes and arcs are relationships among classes
- ▶ Interaction model
 - ▶ How the objects in a system cooperate to achieve broader results
 - ▶ **Use cases**
 - ▶ Describe the functionalities of a system
 - ▶ Are elaborated with **sequence diagrams** (object interactions and time sequence of their interaction) and **activity diagrams** (processing steps)
- ▶ State model
 - ▶ Aspects of an object that change over time
 - ▶ **State diagrams**
 - ▶ Nodes are states and arcs are transitions between states caused by events

UML models



UML models



UML models



Class modelling

▶ Classes

- ▶ A class describes a group of objects with the same properties (attributes), behavior (operations), kinds of relationships and semantics
- ▶ Classes often appears as nouns in problem descriptions with users

▶ Objects

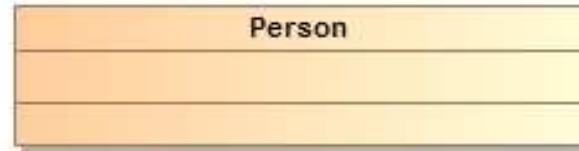
- ▶ An object is a concept, abstraction or thing with identity that has a meaning for an application
- ▶ An object is an instance of a class

How Many Classes? And Instances?

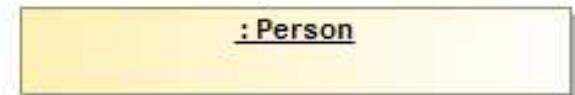
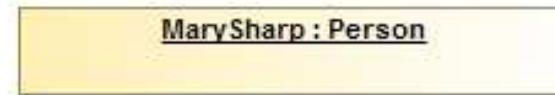
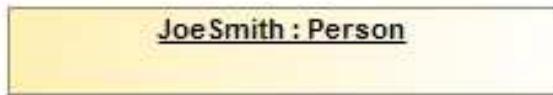


Class diagrams

- ▶ Class
 - ▶ UML notation: box with a class name



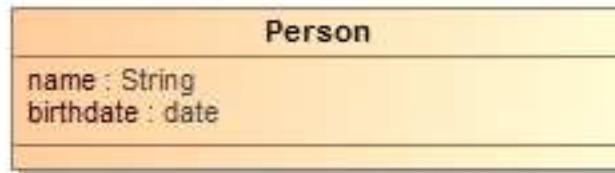
- ▶ Object
 - ▶ UML notation: box with an object name followed by a colon and a class name. The object name and the class name are both underlined



Attributes and values

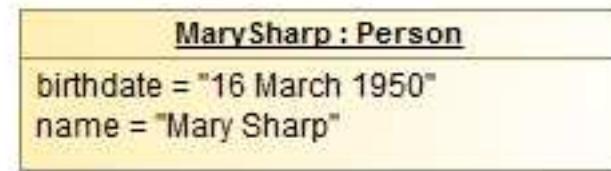
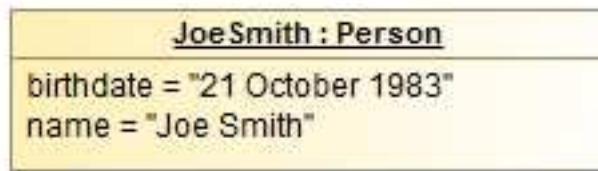
▶ Attribute

- ▶ An attribute is a named property of a class that describes a value held by each object of the class
- ▶ UML notation: attributes are listed in the second compartment of the class box. Optional details, such as type and default value, may follow each attribute



▶ Value

- ▶ A value is a piece of data
- ▶ UML notation: values are listed in the second compartment of the object box



Attributes and values



Attributes and values



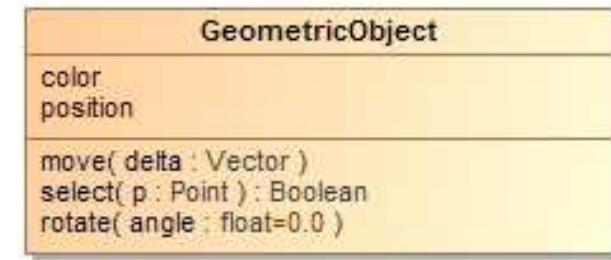
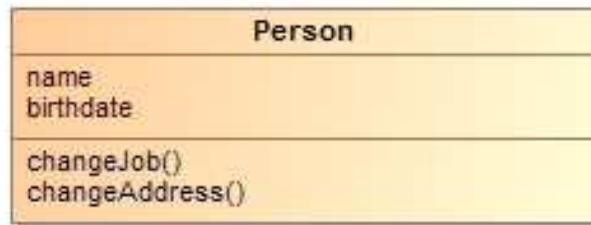
Attributes and values



Operations and methods

▶ Operation

- ▶ An operation is a function or procedure that may be applied by or to objects in a class
- ▶ UML notation: operations are listed in the third compartment of the class box



▶ Method

- ▶ A method is the implementation of an operation for a class

Operations and methods



Operations and methods



Visibility for attributes and operations

- + public
- # protected
- - private
- ~ package

Visibility for attributes and operations

Keyword	C#	C++	Java
private	class	class	class
protected	derived classes	derived classes	derived classes and/or within same package
package	-	-	within its package
public	everybody	everybody	everybody

(Binary) links and associations

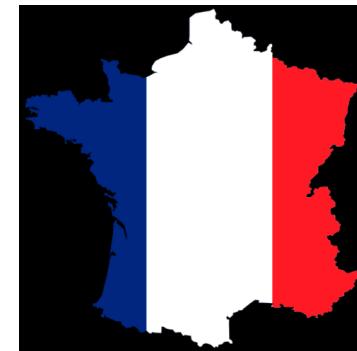
▶ Link

- ▶ A link is a physical or conceptual connection among objects
- ▶ UML notation: line between objects. A link can have a name (underlined)

▶ Association

- ▶ An association is a description of a group of links with common structure and common semantics
- ▶ UML notation: line between classes. An association can have a name (not underlined)

How many associations? Links?



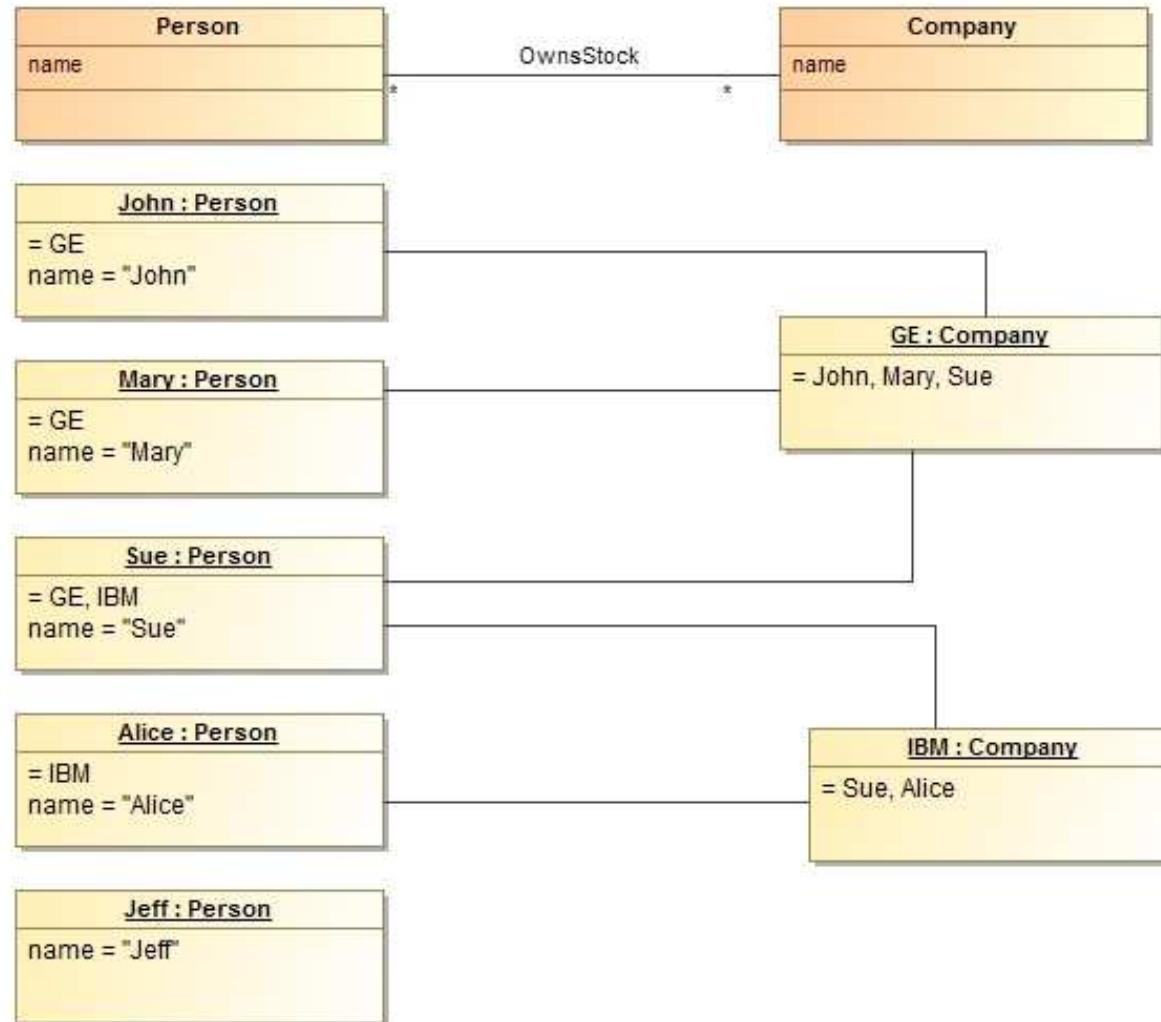
Multiplicity

- ▶ Specifies the number of instances of one class that may relate to a single instance of an associated class
- ▶ UML notation: specified at the end of the association lines
 - ▶ Examples: “1” (exactly one); “3..5” (three to five, inclusive); “*” (many, zero or more)

Multiplicities?



Multiplicity many-to-many

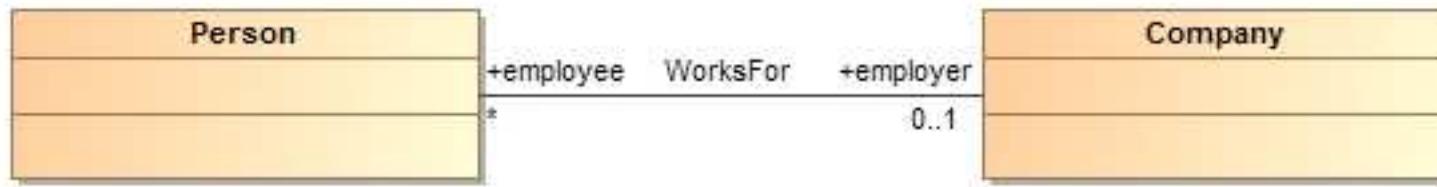


Multiplicity one-to-one



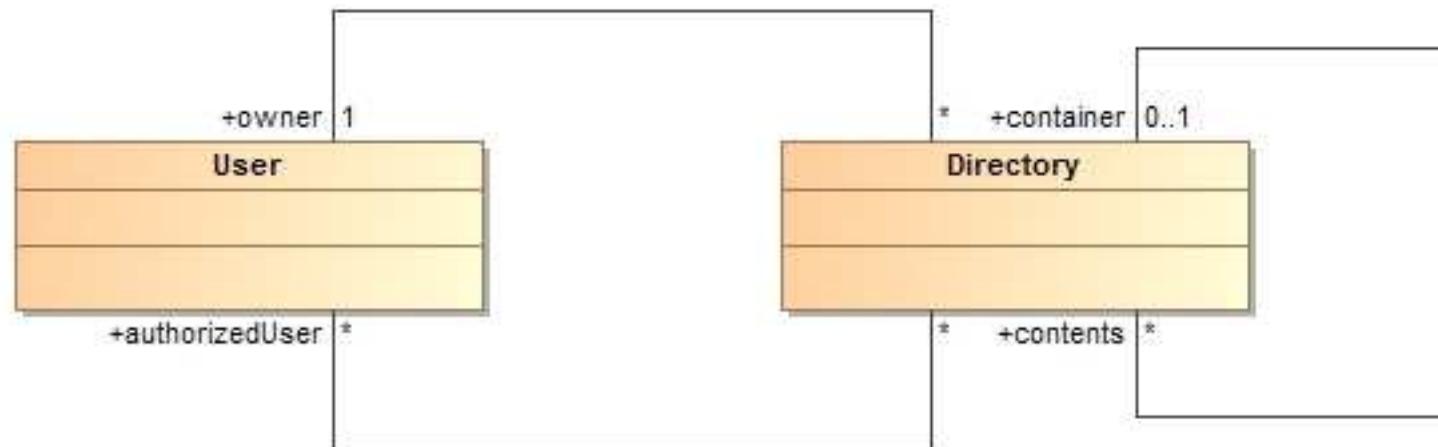
Association end names

- ▶ Association ends can be provided with a name as well as with a multiplicity

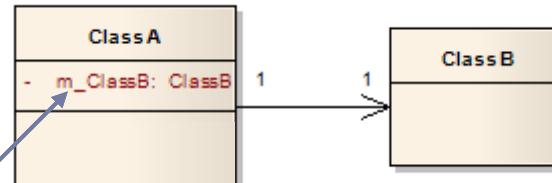


Association end names

- ▶ Association end names are necessary for associations between two objects of the same class. They can also distinguish multiple associations between a pair of classes
- ▶ Association end names as pseudo attributes



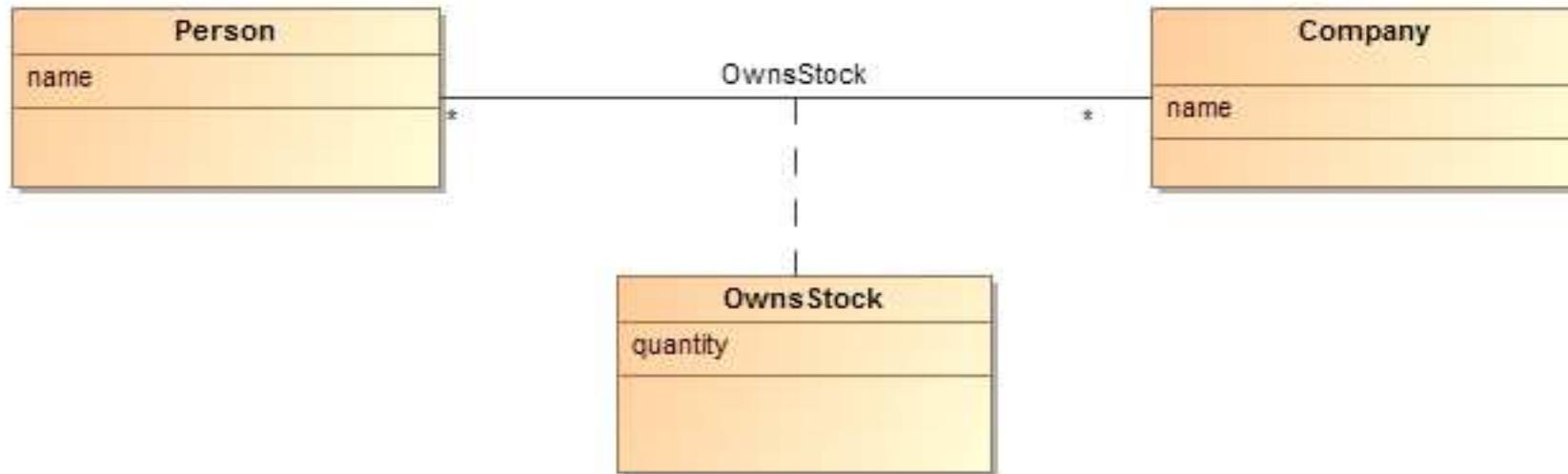
Directed associations



Association end name

Association classes

- ▶ An association class is an association that is also a class
- ▶ Like a class, an association class can have attributes and operations and participate in associations
- ▶ UML notation: class box attached to the association by a dashed line



Association classes



PA

Association classes



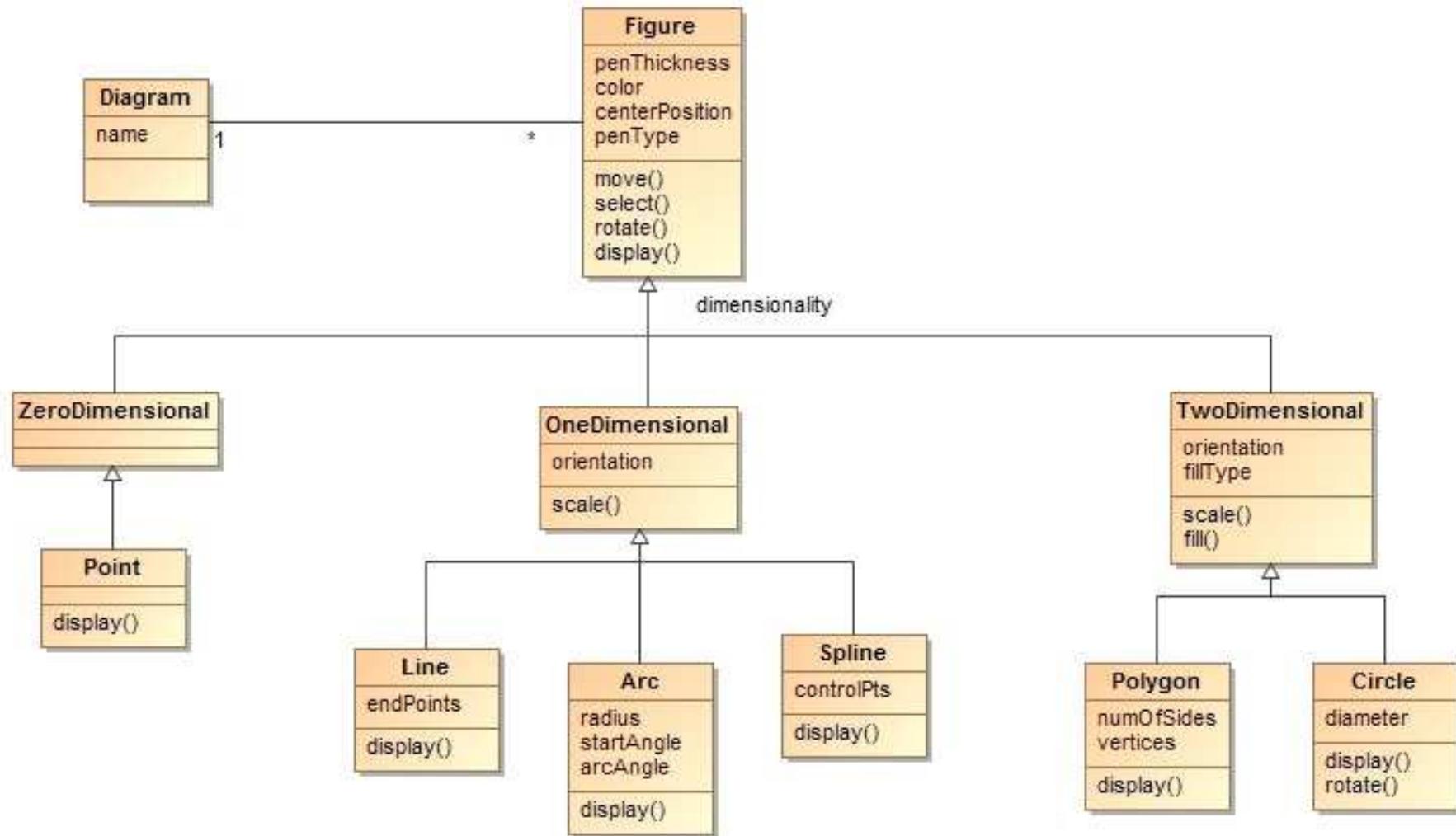
Generalization and Inheritance

- ▶ **Generalization** is the relationship between a class (superclass) and one or more variations of the class (subclasses)
 - ▶ The superclass holds common attributes, operations and associations. The subclasses add specific attributes, operations and associations (each subclass is said to inherit the features of its superclass)
 - ▶ Simple generalization organizes classes into a hierarchy
 - ▶ There can be multiple levels of generalizations
 - ▶ A large arrowhead denotes generalization. The arrowhead points to the superclass
- ▶ A **generalization set name** is an enumerated attribute that indicates which aspect of an object is being abstracted by a particular generalization

Ancestors and Descendants

- ▶ Generalization is transitive across an arbitrary number of levels:
 - ▶ An instance of a subclass is also instance of all its ancestor classes
 - ▶ An instance includes a value for every attribute of every ancestor class
 - ▶ An instance can invoke any operation of any ancestor class
 - ▶ Each subclass not only inherits all the features of its ancestors but add its own specific features as well

Generalization and Inheritance



Use of Generalization

- ▶ **Polymorphism**
 - ▶ Increases the flexibility of software. You can add a new subclass to inherit the superclass behavior without disrupting existing code
 - ▶ Overriding features
- ▶ **Objects taxonomy**
 - ▶ Organizes objects on the basis of their similarities and differences
- ▶ **Reuse of code**
 - ▶ You can inherit code within your application as well as from past work