Design Patterns and UML

Class and Object diagrams

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What are design patterns?

Definition 1

Patterns identify and specify abstractions that are above the level of single classes and instances, or of components.

Gamma et al (1995) [Gang of Four (GoF)]
(Erich Gamma, Richard Helm, Ralph Johnson and John Vlissides)

Definition 2

Design Patterns constitute a set of rules describing how to accomplish certain tasks in the realm of software development.

Pree (1995)

Definition 3

Design Patterns focus more on reuse of recurring architectural design themes, while frameworks focus on detail design and implementation.

Coplien and Schmidt (1995)

Definition 4

A pattern addresses a recurring design problem that arises in specific design situations and presents a solution to it.

Buschmann et al (1996)

Definition 5

Design Patterns are recurring solutions to design problems you see over and over.

The Smalltalk Companion (1998)

Definition 6

Experienced OO developers build up a repertoire of general principles and idiomatic solutions that guide them in the creation of software. These may be called patterns.

Craig Larman(2006)

Definition 7

Design Patterns are programming tools to improve code to be:

- easier to implement, and
- easier to maintain.
- are good answers to common and specialised problems.
- define a common (programming language independent) programming model that standardise common programming tasks into recognisable forms, giving your projects better cohesiveness.

CG Lasater (2007)

When design patterns are applied we achieve:

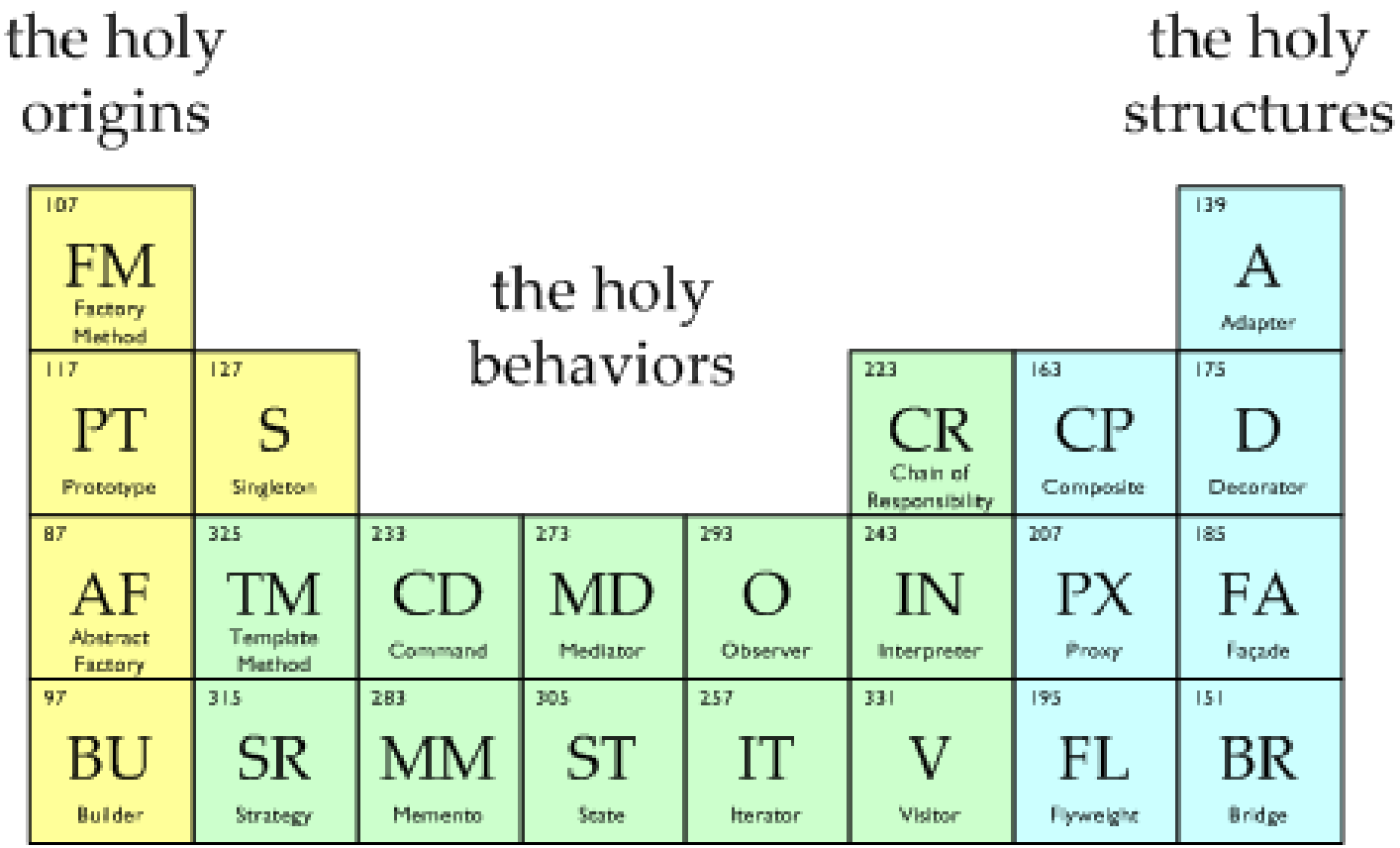
- Improved maintainability of code
- Improved adaptability of code
- Improved reliability of code
- Programmers who are more effective in their work.
- ...

There are 23 classic patterns, identified by the GoF, categorised as:

- **Creational** - creation of objects
- **Behavioural** - interaction between objects
- **Structural** - composition of objects

- **Creational** - Factory Method, Abstract Factory, Builder, Prototype, Singleton
- **Behavioural** - Interpreter, Template Method, Chain of Responsibility, Command, Iterator, Mediator, Memento, Observer, State, Strategy, Visitor
- **Structural** - Adapter, Bridge, Composite, Decorator, Façade, Flyweight, Proxy

The Sacred Elements of the Faith



Taken from `http://www.vincehuston.org/dp/`

Each design pattern is further categorised by the strategy used in the implementation.
The two implementation strategies are *Delegation* and *Inheritance*.
The relationships between objects are the main influencers of the delegation strategy, while the relationships between classes are the main focus of the inheritance strategy.

Category	Pattern	Strategy	
		Delegation	Inheritance
Creational	Factory Method		X
	Abstract Factory	X	
	Prototype	X	
	Builder	X	
	Singleton	X	
Behavioural	Memento	X	
	Template Method		X
	Strategy	X	
	State	X	
	Observer	X	
	Iterator	X	
	Mediator	X	
	Command	X	
	Chain of Responsibility	X	
	Interpreter		X
	Visitor	X	
Structural	Composite	X	
	Decorator	X	
	Adapter	X	X
	Bridge	X	
	Façade	X	
	Proxy	X	
	Flyweight	X	

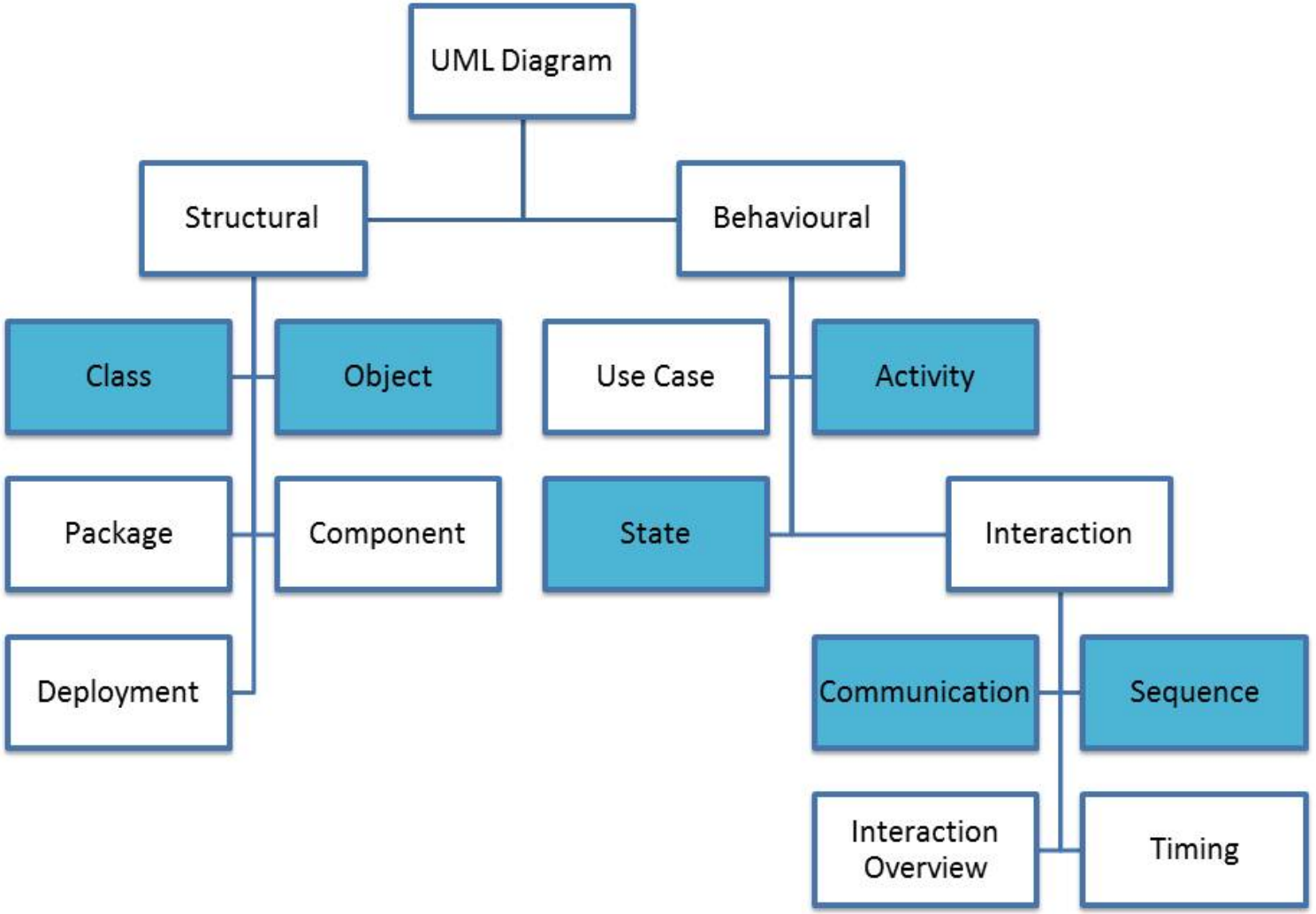
Unified Modelling Language (UML) is a standard notation for the modelling of real-world objects as a first step in developing an object-oriented design methodology.

`http://searchsoftwarequality.techtarget.com/definition/Unified-Modeling-Language`

UML *unifies* three OO methodologies:

- OMT - 1991 - James Rumbaugh
- OOA and OOD - early 1990's - while Grady Booch worked at Rationale
- OOSE - 1992 - Ivor Jacobson

The ideas of these "Three Amigos" and others, under the sponsorship of Rationale, lead to UML in 1995. UML 2 adapted by OMG in 2005. UML 2.5 released in June 2015.

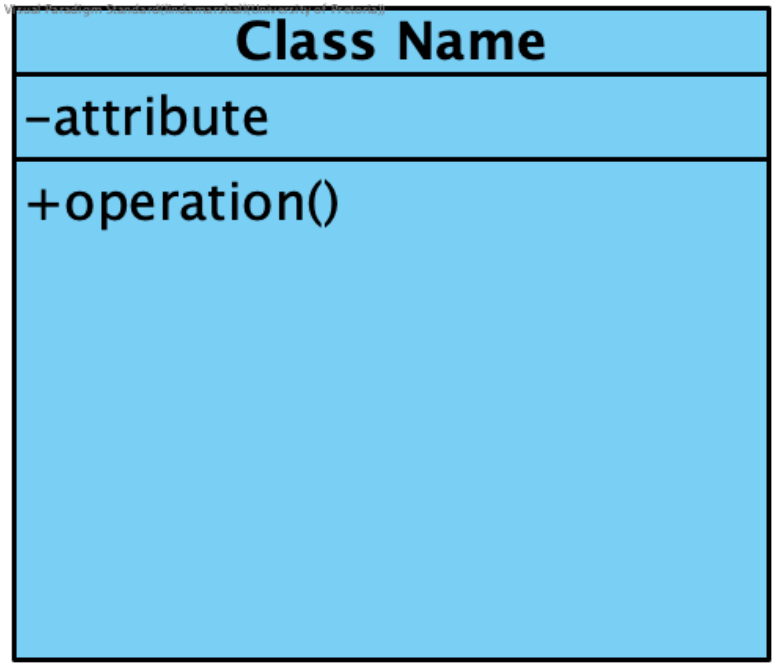

UML Diagram
Structural
Behavioural
Class
Object
Use Case
Activity
Package
Component
State
Interaction
Deployment
Communication
Sequence
Interaction Overview
Timing

A *Class diagram* is a UML structural diagram which shows the structure of the designed system at the level of classes and interfaces. Class diagrams show features, constraints and relationships – associations and generalisations etc. – of the classes and interfaces.

A class is a classifier which describes a set of objects that share the same:

- features
- constraints
- semantics (meaning)

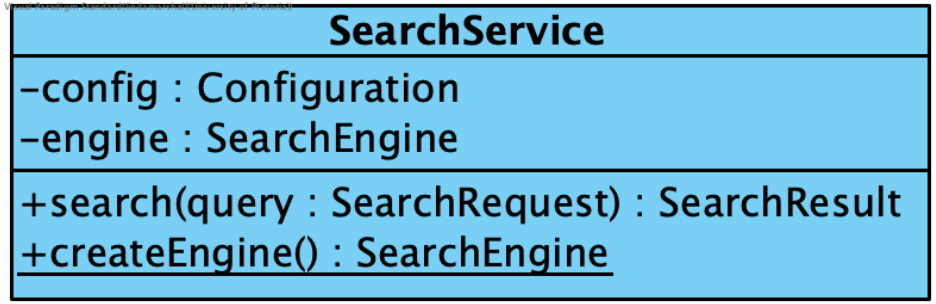
Features (or fields or members) of a class are **attributes** (fields) and **operations** (or functions or methods).



$+$ (public), $\#$ (protected) and $-$ (private) are used to specify the **visibility** of the respective features.

Always list features in order from public to private in each of the sections of the class.

Static members are underlined.

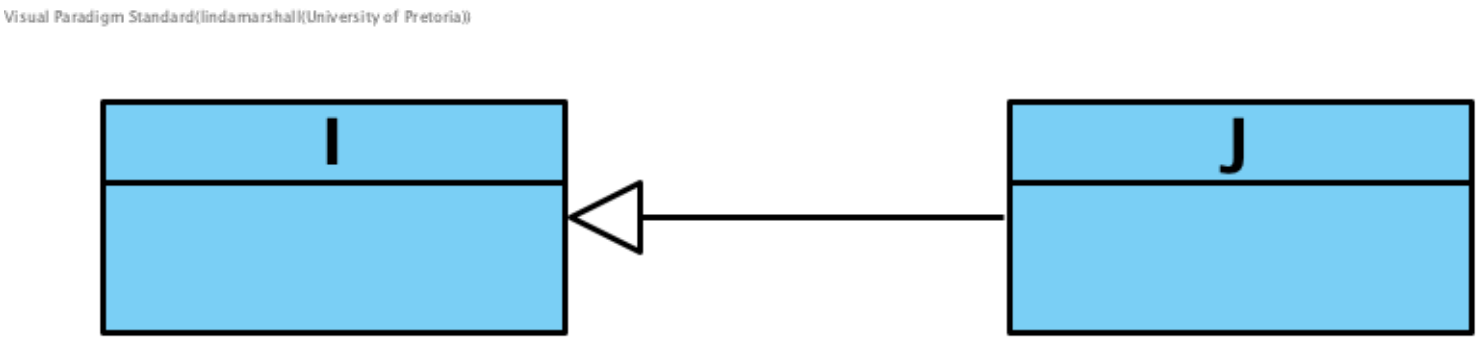


Set the Scope to "classifier" in Visual Paradigm

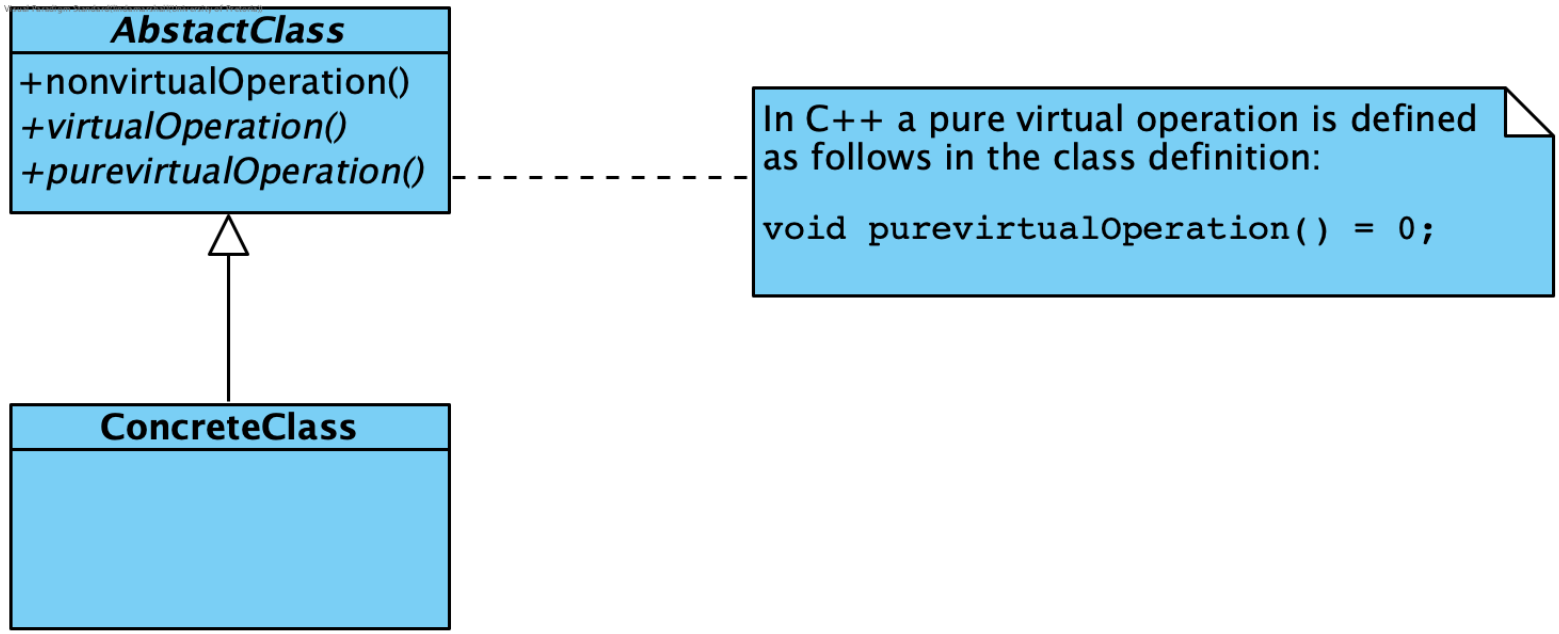
Relationships between classes are classified as either

- **generalisations** or
- **associations**.

Generalisation is a relationship for modelling **inheritance** and specifically *public* inheritance. It is the manifestation of the *is-a* relationship.



Operations in a class are defined as non-virtual, virtual or pure virtual.



Associations are a type of relationship between objects of classes that model **delegation**. An object of a class makes use of an object of another class. These associations are modelled in a class diagram to show how objects of the classes will interact with one another.

There is an association between class A and class B.

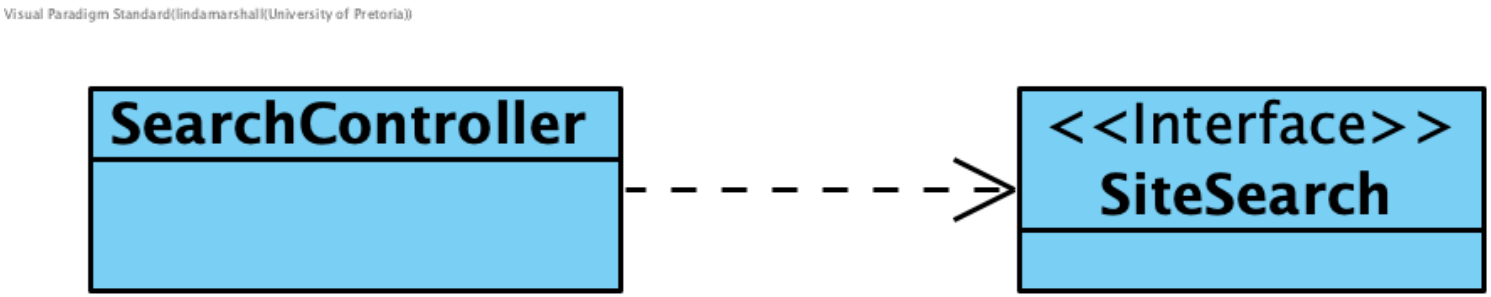
An association exists when an object:

- accepts an object of another class as a parameter in one of its operations.
- instantiates an object of another class in one of its operations, or
- holds an attribute of an object of another class.

Different levels of coupling can be represented by associations. These include:

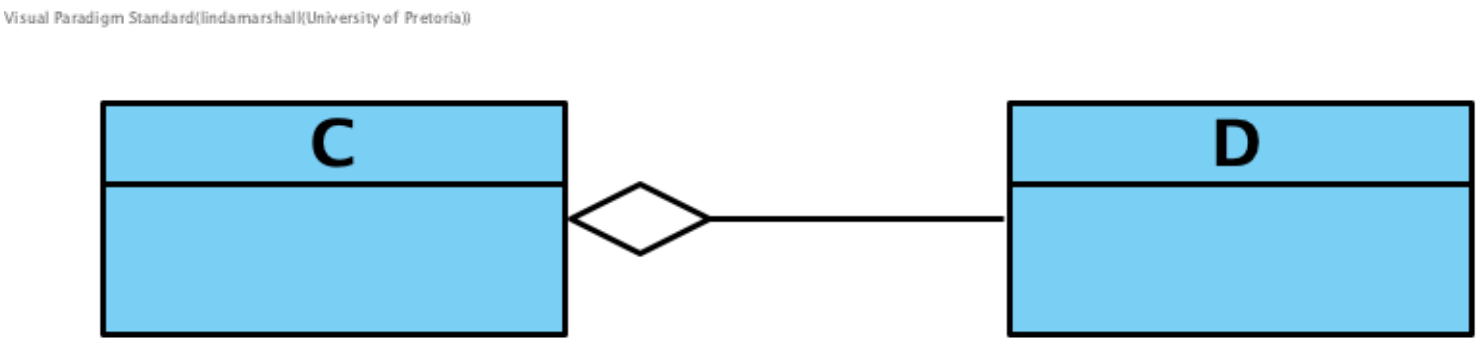
- Dependency (*uses-a* relationship)
- Aggregation (*has-a* relationship)
- Composition (*owns-a* relationship)

Dependency (uses-a)

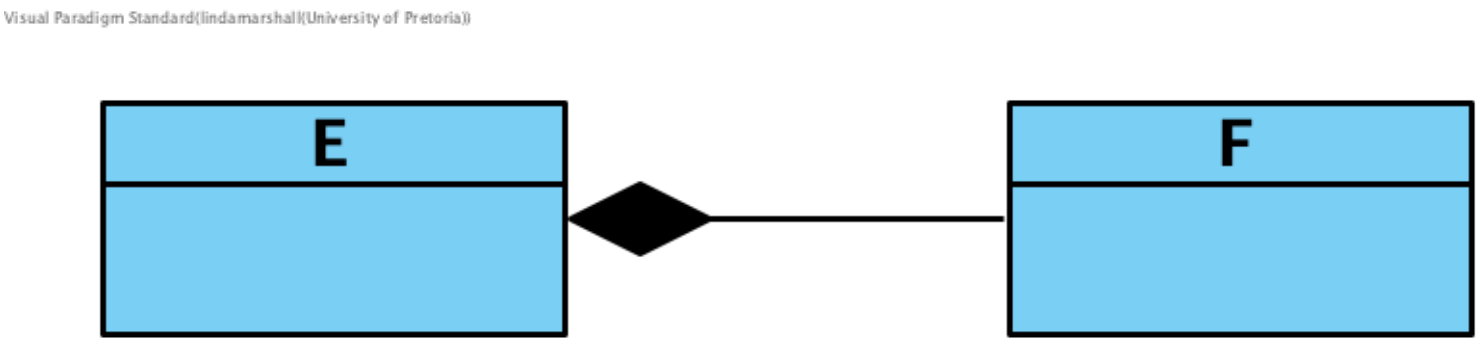


Interface SiteSearch is used (required) by SearchController

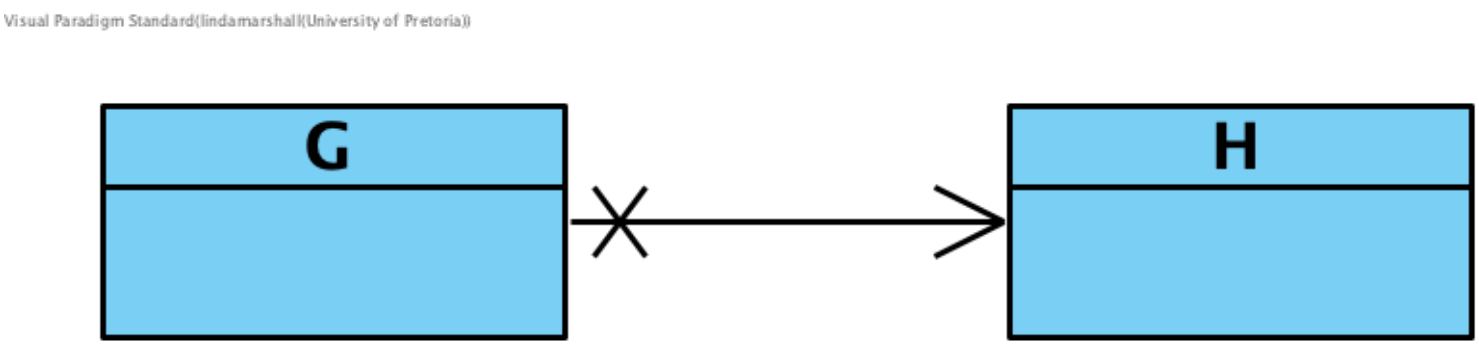
Aggregation (has-a)



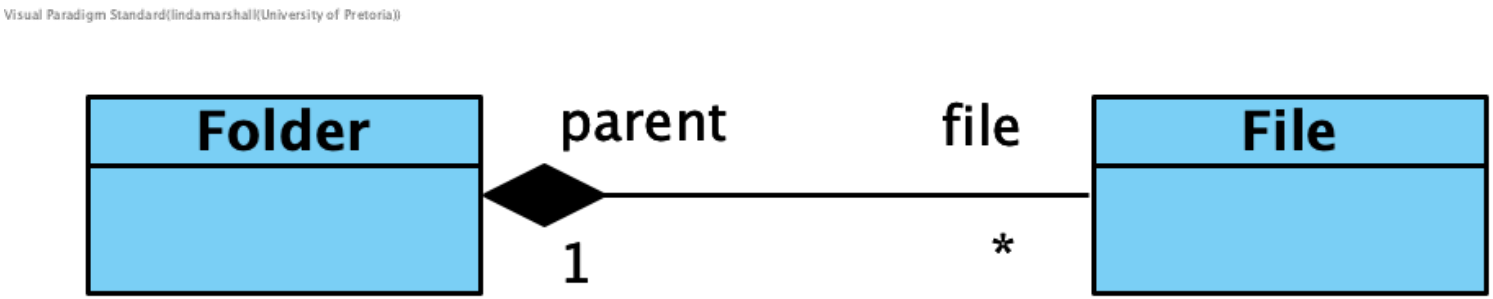
Composition (owns-a)



Navigatibility and direction



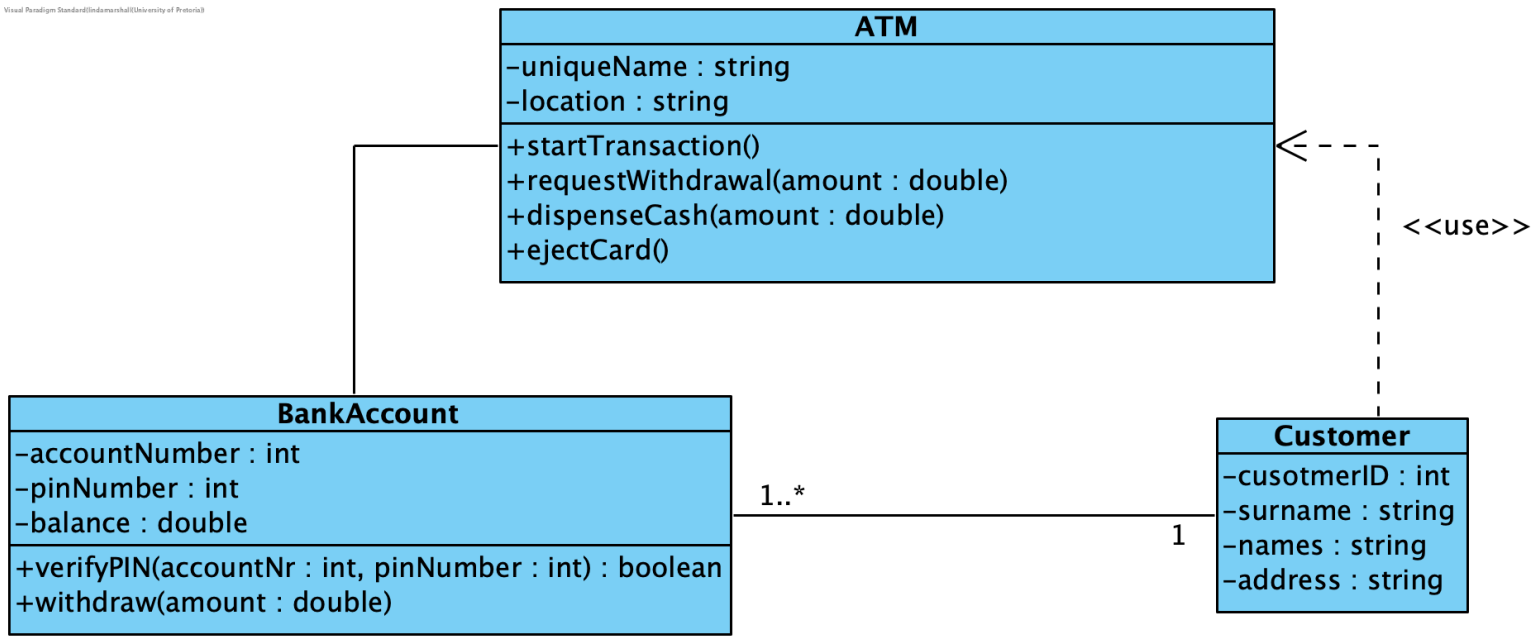
Multiplicity and Roles



Multiplicity cont.

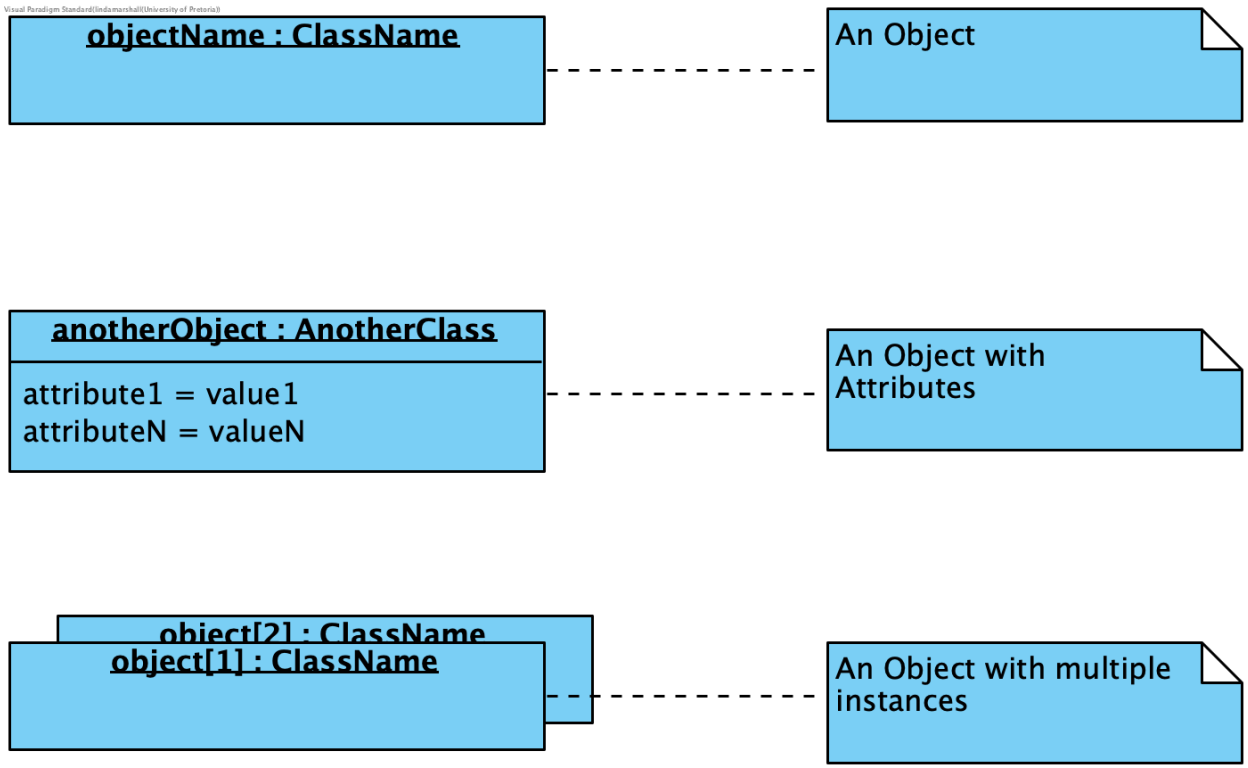
Multiplicity	**Meaning**
n	Exactly n
$*$	0 or more
$0..n$	0 to n
$0..*$	0 or more
$m..n$	At least m and at most n

Example

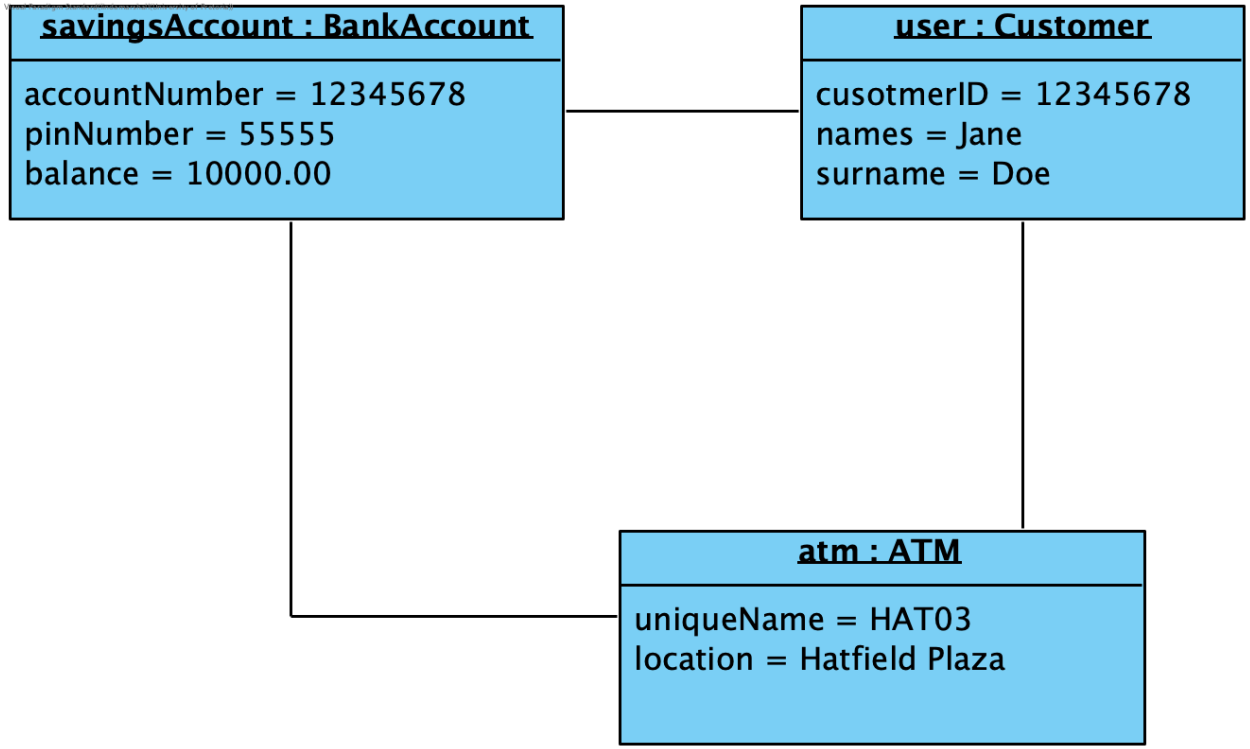

Visual Paradigm Standard(lindamarshall(University of Pretoria))
ATM
-uniqueName : string
-location : string
+startTransaction()
+requestWithdrawal(amount : double)
+dispenseCash(amount : double)
+ejectCard()
<<use>>
BankAccount
-accountNumber : int
-pinNumber : int
-balance : double
+verifyPIN(accountNr : int, pinNumber : int) : boolean
+withdraw(amount : double)
1..*
1
Customer
-cusotmerID : int
-surname : string
-names : string
-address : string

Object diagrams are derived from class diagrams:

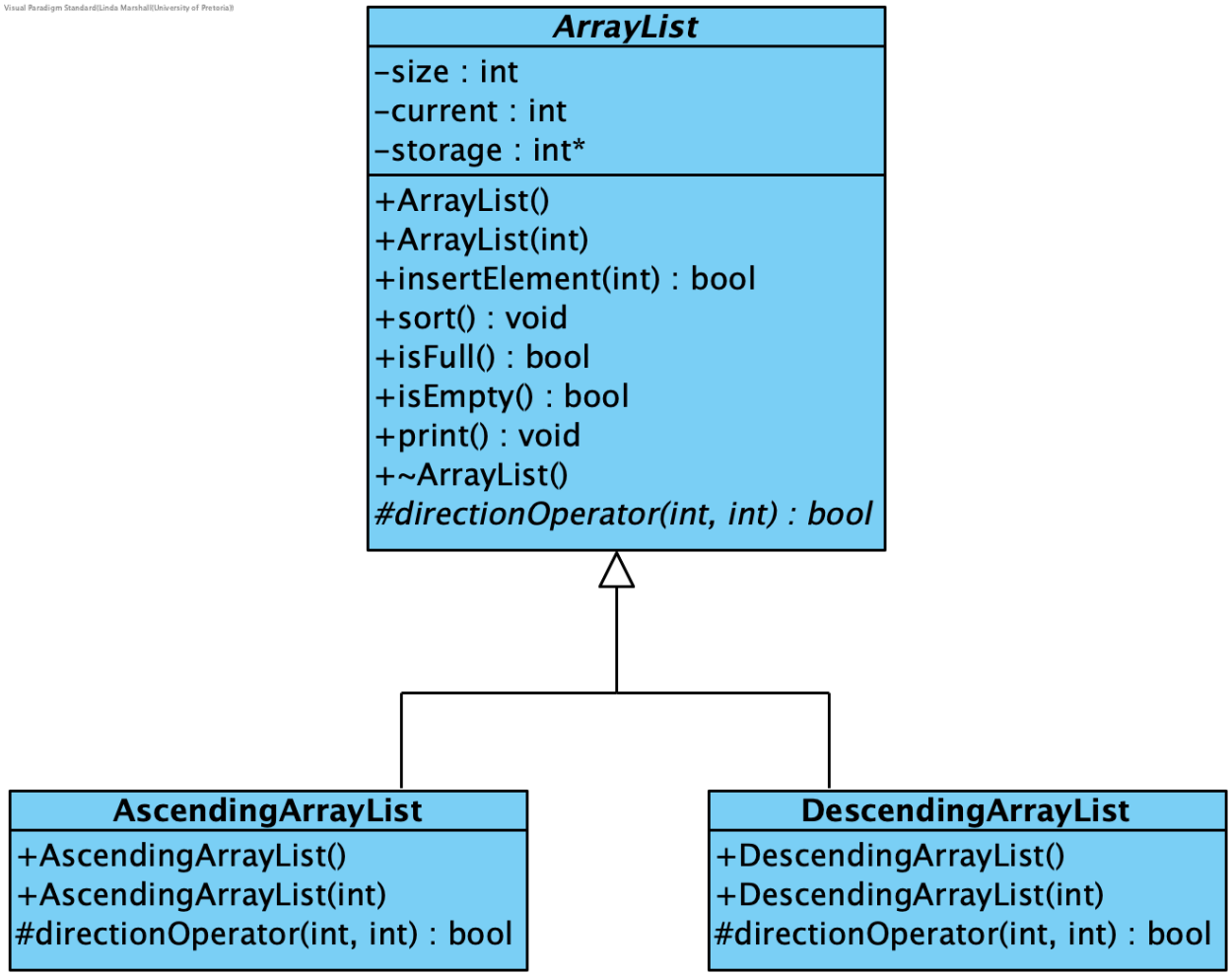
- and are therefore dependent on class diagrams
- represent an instance of a class or classes - static view or snapshot of the system at the current moment
- therefore, concrete in nature - represent the real-world versus class diagrams which are abstract and represent the blueprint

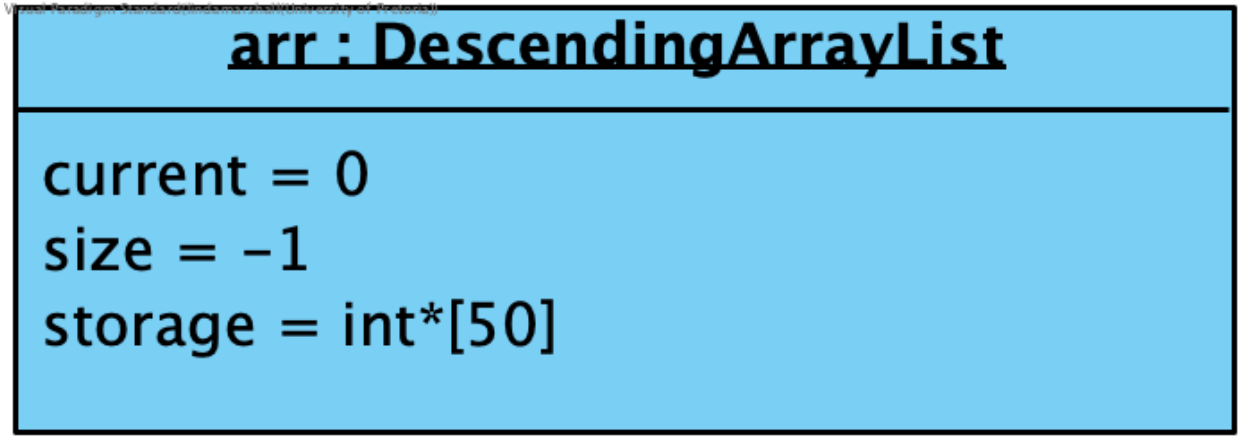


"Name" section is underlined



Use the same basic association relationships as class diagrams


Visual Paradigm Standard(Linda Marshall(University of Pretoria))
ArrayList
-size : int
-current : int
-storage : int*
+ArrayList()
+ArrayList(int)
+insertElement(int) : bool
+sort() : void
+isFull() : bool
+isEmpty() : bool
+print() : void
+~ArrayList()
#directionOperator(int, int) : bool
AscendingArrayList
+AscendingArrayList()
+AscendingArrayList(int)
#directionOperator(int, int) : bool
DescendingArrayList
+DescendingArrayList()
+DescendingArrayList(int)
#directionOperator(int, int) : bool




```
DescendingArrayList arr(50)
 // OR
ArrayList* arr = new DescendingArrayList(50);
```

- Tackling Design patterns, Chapters 1, 2 and 6.
  https://www.cs.up.ac.za/cs/lmarshall/TDP/TDP.html
- http://www.uml-diagrams.org
- https://www.youtube.com/watch?v=UI6lqHOVHic&t=338s