Software Tools & Methods
Class 5

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Summer Session 2009

ELH 110 9am-11:50am

Overview

- Reading for today was on UML, Larman
- Last Class: UML
- Up next
  - Quick Review
  - More UML
  - Class, Object, Package diagrams
  - Design Patterns

Software Tools and Methods

REVIEW

Iterative Development

- The development is carried out as a series of stages, each with its own design, implementation and testing phase.
- The output of each stage is a working, production-quality system but with reduced functionality.
- The customer is involved in evaluating each of the stages.
- Can accommodate changing requirements.

Iterative Development

- System is defined by use cases

Larman
p. 15

  - A “use case” is a major way of using the system, or a major type of functionality
- High level planning needs to
  - Define what are the major use cases
  - Determine in what order they will be done
  - Estimate development time for each use case (“timeboxing”)

Agile development

- A family of iterative development techniques that emphasise response to changing requirements (the opposite of the waterfall model)
- Makes heavy use of of UML for sketching.
  - Usually by a group of developers using white-boards.
  - The main purpose of using UML in this way is to understand the problems and solutions rather than to document them.

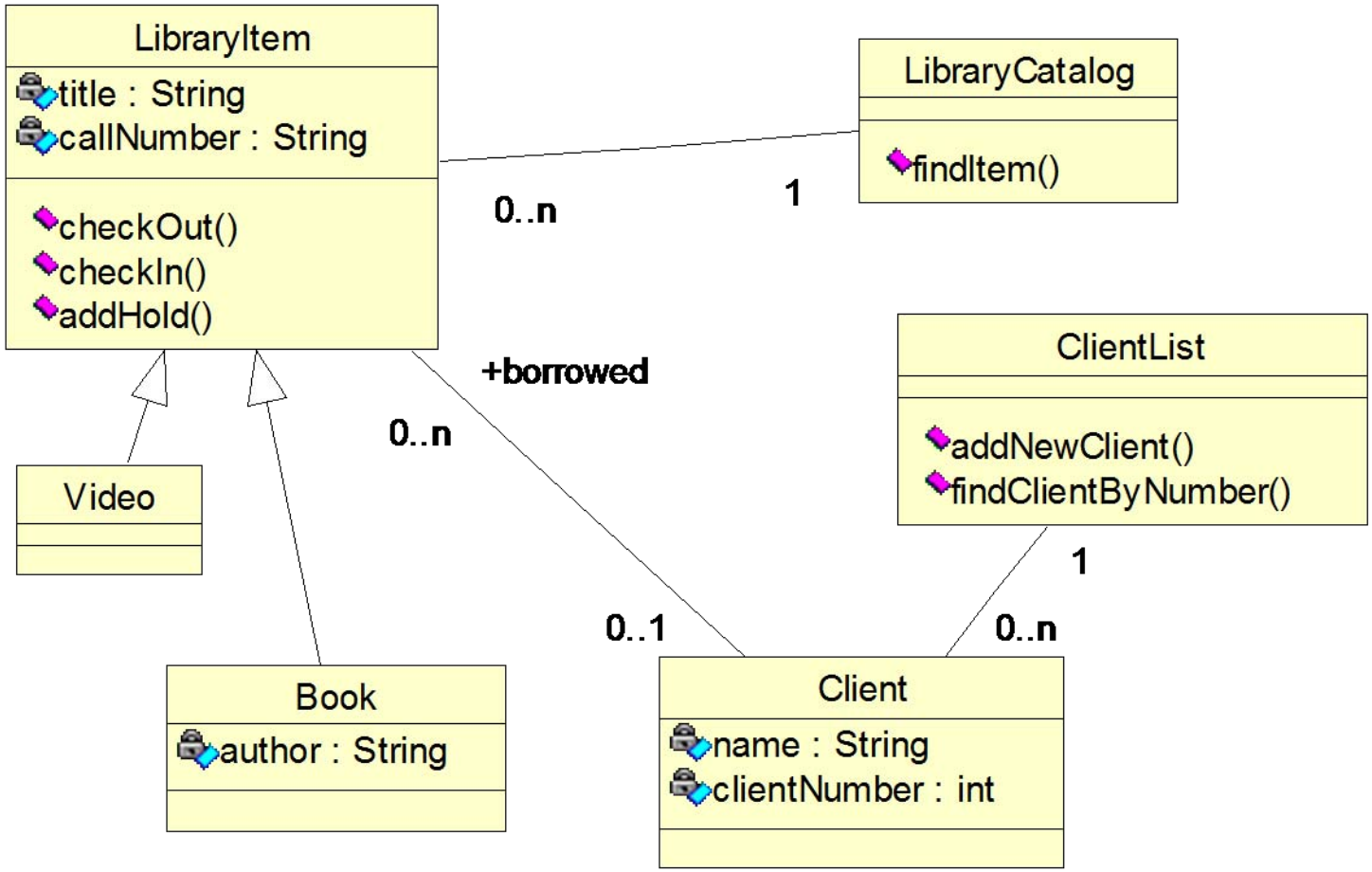
Software Methods & Tools

MORE UML

UML Goals

- The goals of UML are:
  - To model systems using OO concepts
  - To establish an explicit coupling between conceptual and software artifacts (objects)
  - To address the issues of scale inherent in complex mission critical systems
  - To create a modeling language usable by both humans and machines

Class Diagram



UML Method

- A method needs a language, and a process to describe how to use the language

  Method = Language + Process

- The Rational Unified Process (RUP or UP) was designed to be used with UML
  - UP is an iterative process
  - Provides a structure for system development

UP Phases

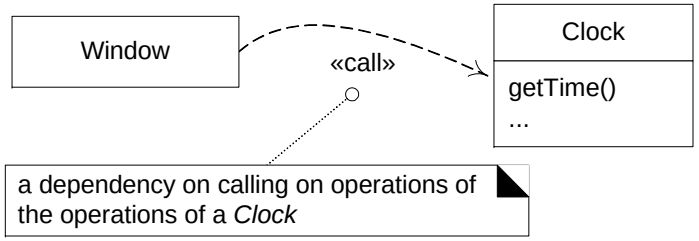
Larman
p. 19

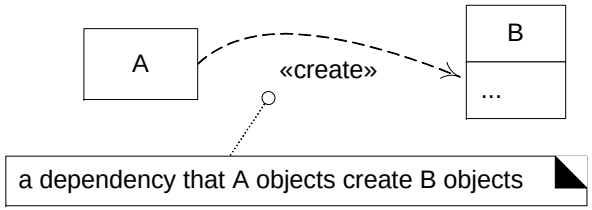
- Inception
- Elaboration
- Construction
- Transition

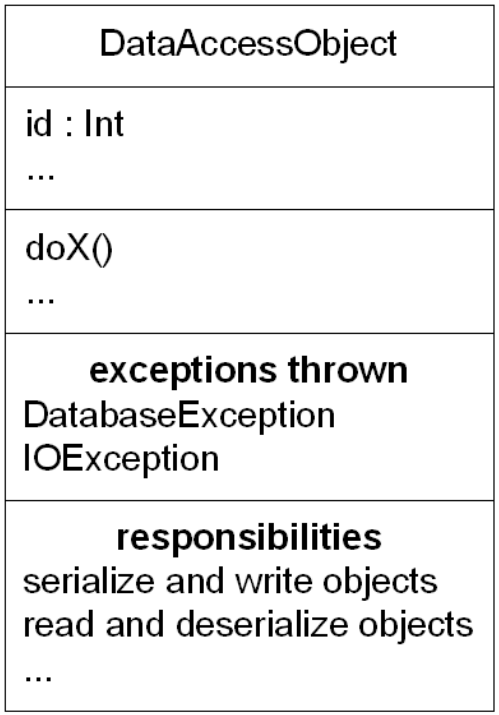
More in Larman

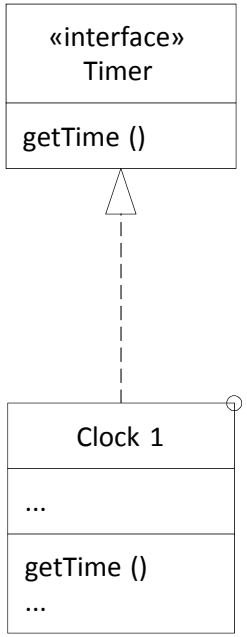
- Keywords («guillemets»)
  - Stereotypes
  - Examples: calls, interface, permit,…
- Responsibilities
  - Another compartment in class
  - Items prefixed by --
- Template classes

Examples


Window
«call»
Clock
getTime()
...
a dependency on calling on operations of the operations of a *Clock*


A
«create»
B
...
a dependency that A objects create B objects


DataAccessObject
id : Int
...
doX()
...
exceptions thrown
DatabaseException
IOException
responsibilities
serialize and write objects
read and deserialize objects
...


«interface»
Timer
getTime ()
Clock 1
...
getTime ()
...

Hints for Class Diagrams

- Remember: models are for communication
- Remember: include only important stuff
- How do I find classes, attributes and so on?
  - Classes often correspond to nouns
  - Associations often correspond to verbs
- A class should
  - Represent a coherent concept
    - Principle: Low Coupling, High Cohesion
  - Have a small, well-defined set of responsibilities
  - Be named with a singular noun that says what each instance of the class is
  - Have no more than 10-20 operations

Hints for Class Diagrams

- Class diagrams should
  - have a single purpose
  - have a title that expresses the purpose
  - show only things that are relevant for this purpose
- Avoid
  - cyclical dependencies, if possible
  - generalization hierarchies with more than 5 levels
  - crossing edges

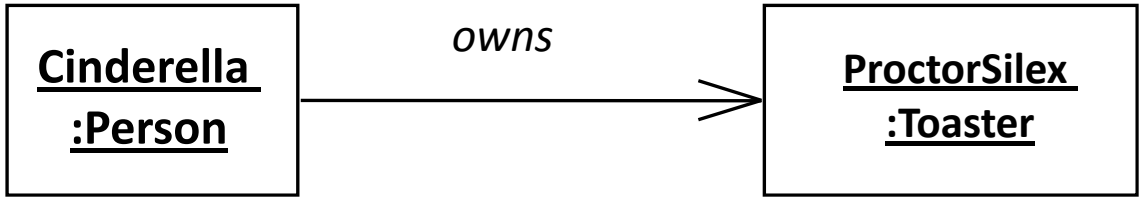
Hints for Class Diagrams

- Use colors judiciously
  - to highlight and group things
  - unless you have to print it in black-and-white!
- Lay out classes in a meaningful way
  - similar classes close to each other
  - top: closer to the user, bottom: closer to the data structures

Object Diagrams

- Show instantiation or specification of classes
- Associated with a particular use or instance of the model
- Differences between Classes and Objects
  - Name:class is underlined
  - Attributes and operations included as needed
  - Fields have data added
- Useful for showing interactions between interfaces, abstract classes, etc.
  - Where functionality is not clear until instantiation

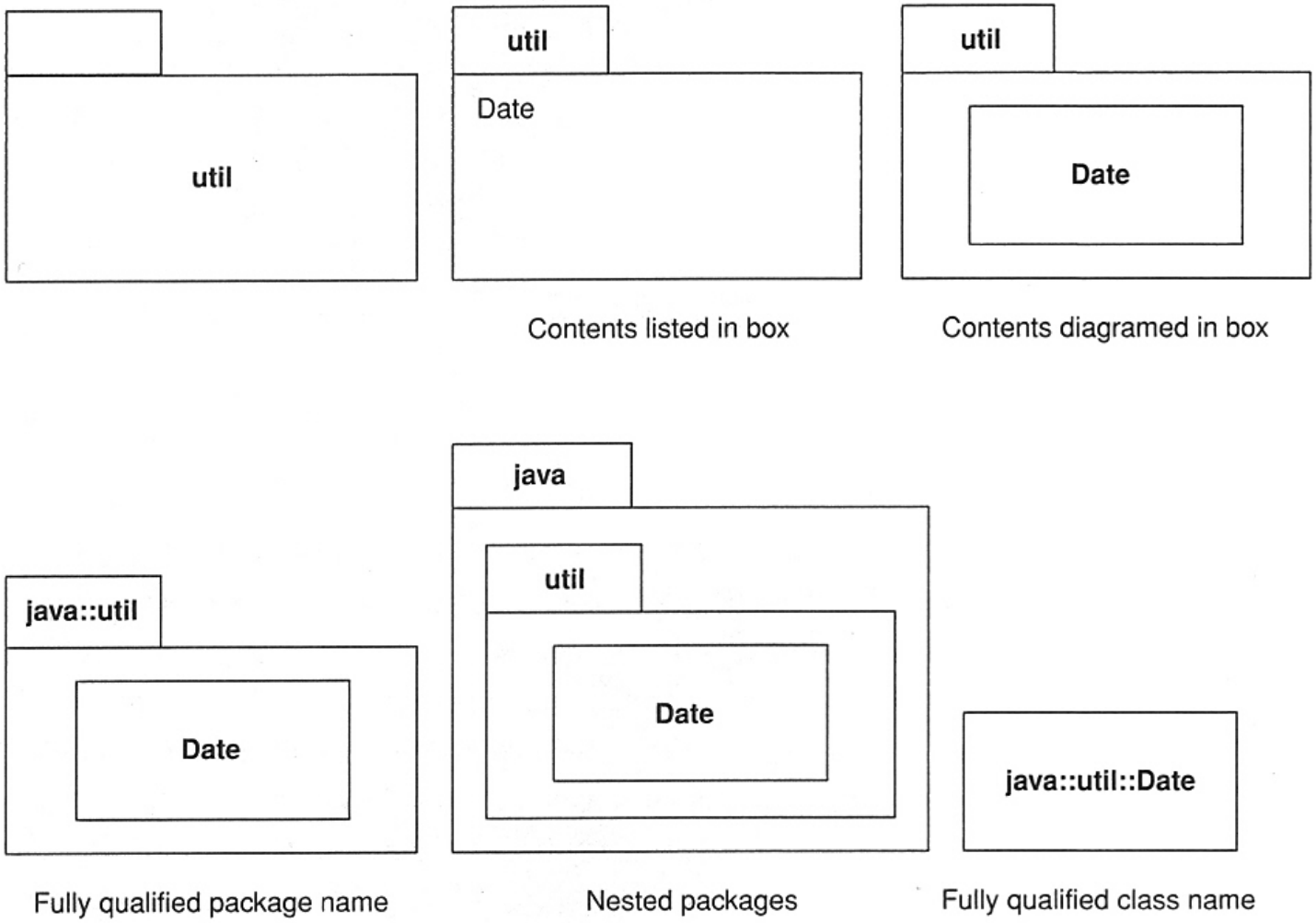
Example: Class to Object Diagrams



Package Diagrams

- Package is a grouping construct
  - Most commonly used for class diagrams, but can be used with any UML diagram or elements
  - Used to create a hierarchy or higher level of abstraction
  - Corresponds to package in Java
- Each package represents a namespace
  - Like Java, can have classes with same name in different packages

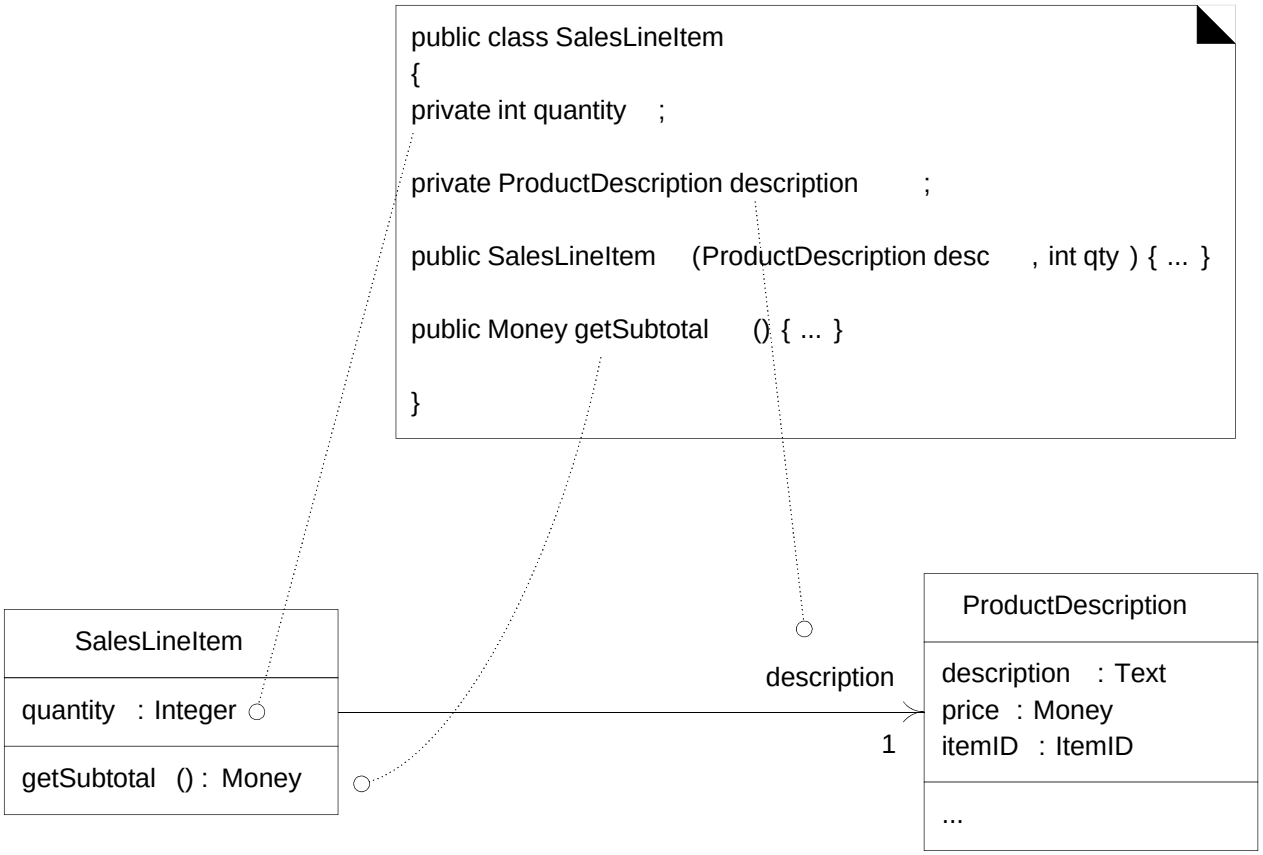
Representing Packages



Code to UML

```
public class SalesLineItem
{
private int quantity    ;

private ProductDescription description        ;

public SalesLineItem    (ProductDescription desc     , int qty ) { ... }

public Money getSubtotal     () { ... }

}
```

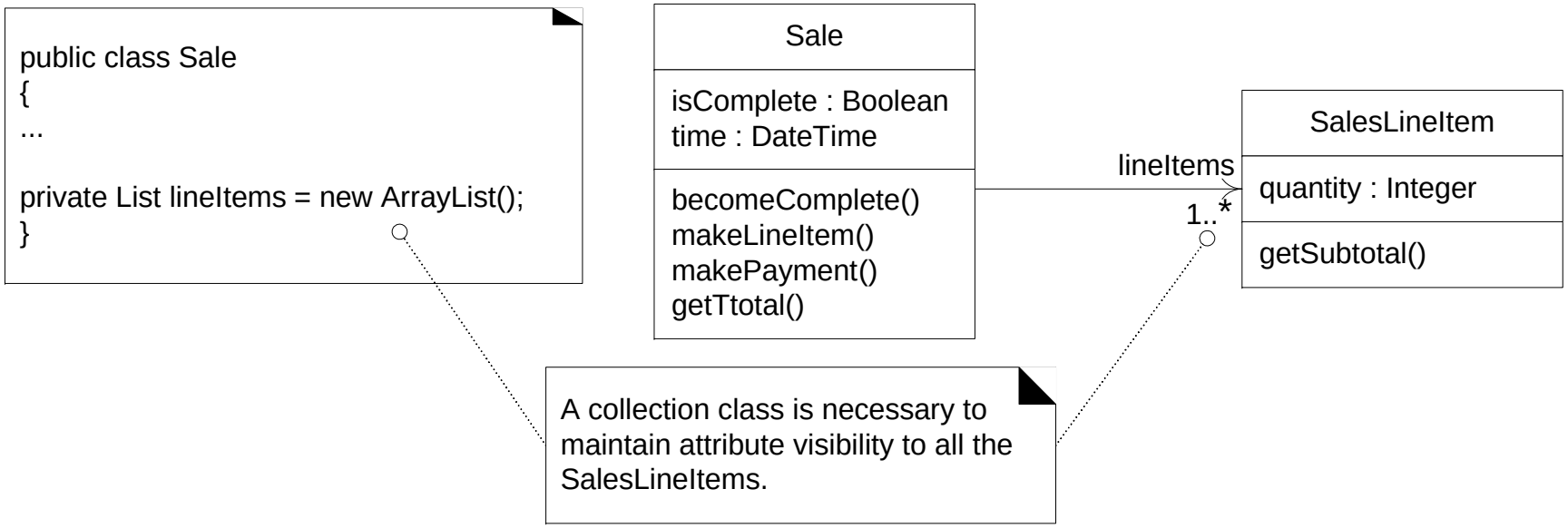
Code to UML


public class SalesLineItem
{
private int quantity ;
private ProductDescription description ;
public SalesLineItem (ProductDescription desc , int qty) { ... }
public Money getSubtotal () { ... }
}
SalesLineItem
quantity : Integer
getSubtotal () : Money
description
1
ProductDescription
description : Text
price : Money
itemID : ItemID
...

Code to UML

```
public class SalesLineItem extend BasicLineItem implements Item
{
private int quantity    ;

private ProductDescription description        ;

public SalesLineItem    (ProductDescription desc     , int qty ) { ... }

public Money getSubtotal     () { ... }

}
```

Code to UML


public class Sale
{
...
private List lineItems = new ArrayList();
}
Sale
isComplete : Boolean
time : DateTime
becomeComplete()
makeLineItem()
makePayment()
getTtotal()
lineItems
1..*
SalesLineItem
quantity : Integer
getSubtotal()
A collection class is necessary to maintain attribute visibility to all the SalesLineItems.

Software Tools & Methods

DESIGN PATTERNS

Design Patterns

- Reusable design component
- First codified by the Gang of Four in 1995
  - Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides
- Concept taken from architecture
  - "A Pattern Language" by Christopher Alexander
  - "…a three-part rule, which expresses a relation between a certain context, a problem, and a solution."
- Original Gang of Four book described 23 patterns
  - More have been added
  - Other authors have written books

Design Patterns Template

- Context
  - General situation in which the pattern applies
- Problem
  - The main difficulty being tackled
- Forces
  - Issues or concerns that need to be considered. Includes criteria for evaluating a good solution.
- Solution
  - Recommended way to solve the problem in the context. The solution “balances the forces”

- The following are optional
- Antipatterns
  - Common mistakes to avoid
- Related Patterns
  - Similar patterns; could be alternated solutions or work with the pattern
- References
  - Source of pattern
  - Who developed or inspired the pattern

Gang of Four Design Patterns

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

Patterns in Java

- Chain of Responsibility
  - Exception handling
  - Try/catch/throw blocks
- Iterator
  - Container classes
- Observer
  - Listeners in GUIs

Gang of Four Design Patterns

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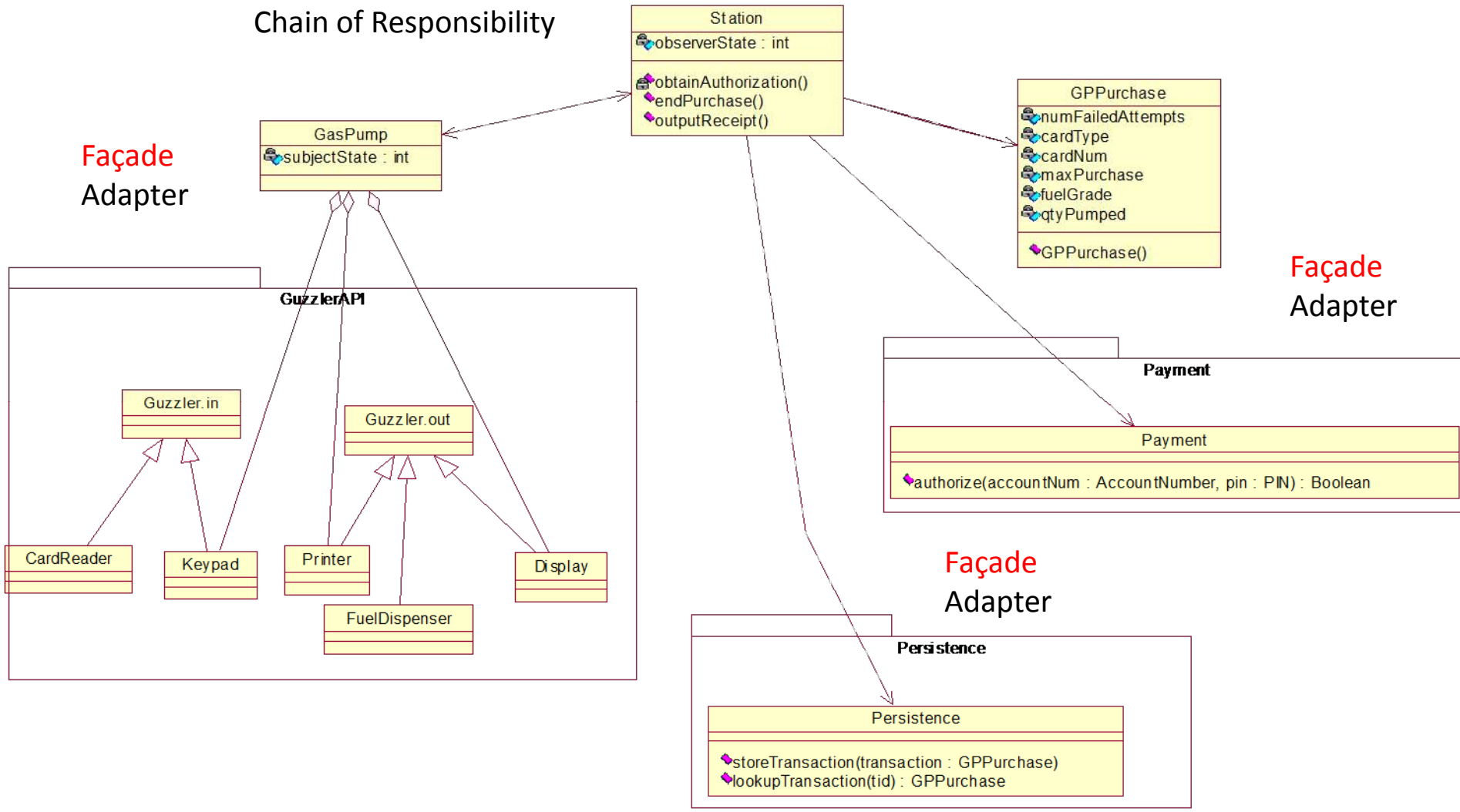
Façade
Singleton

Observer
Chain of Responsibility



Façade
Adapter

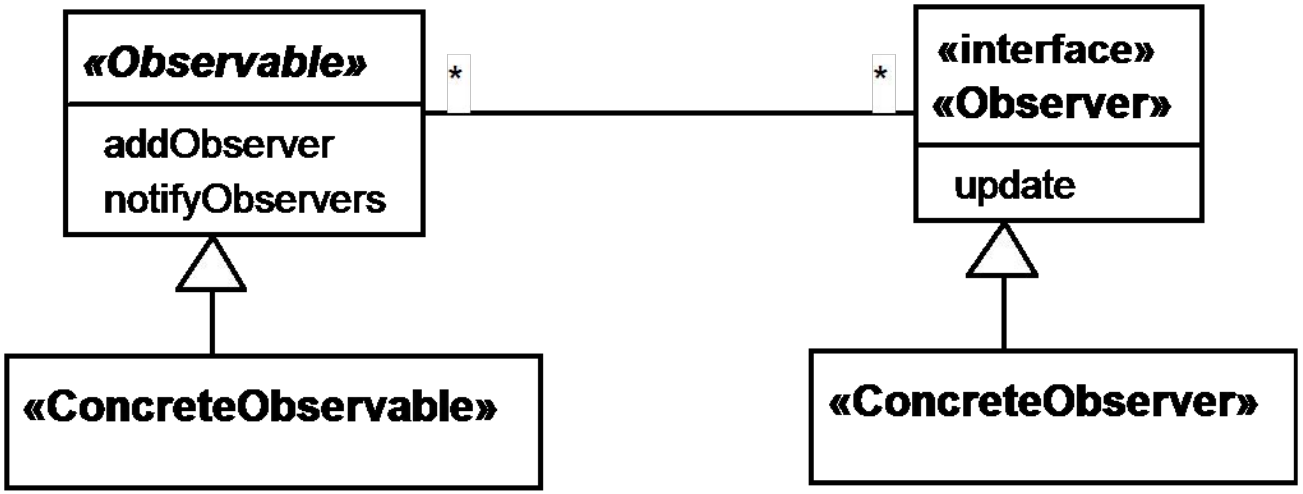
Façade
Adapter

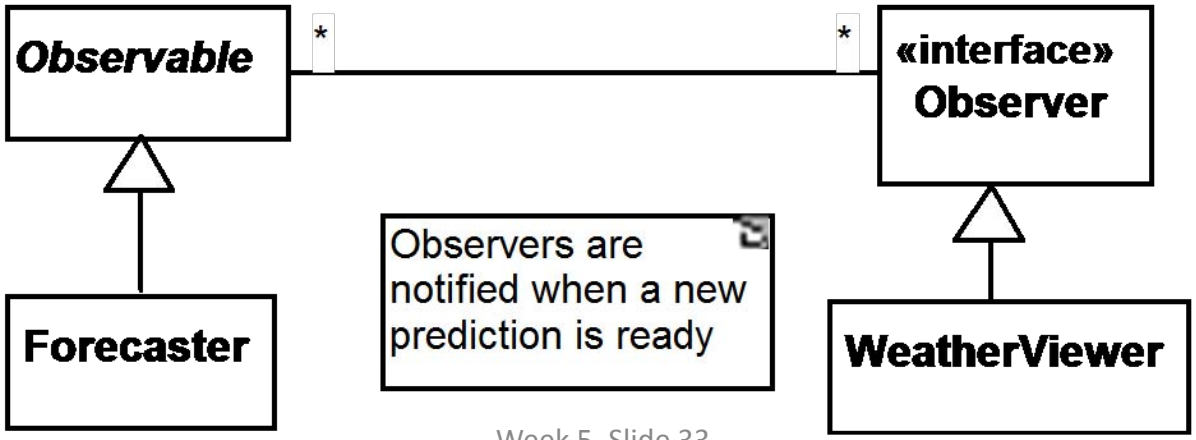
Façade
Adapter

The Observer Pattern

- Context
  - When an association is created between two classes, the code for the classes becomes inseparable.
  - If you want to reuse one class, then you also have to reuse the other.
- Problem
  - How do you reduce the interconnection between classes, especially between classes that belong to different modules or subsystems?
- Forces
  - You want to maximize the flexibility of the system to the greatest extent possible

The Observer Pattern





Observer

- Antipatterns (Don't do this)
  - Connect an observer directly to an observable so that they both have references to each other.
  - Make the observers *subclasses* of the observable.
- Reference
  - Gang of Four

Observer in Java

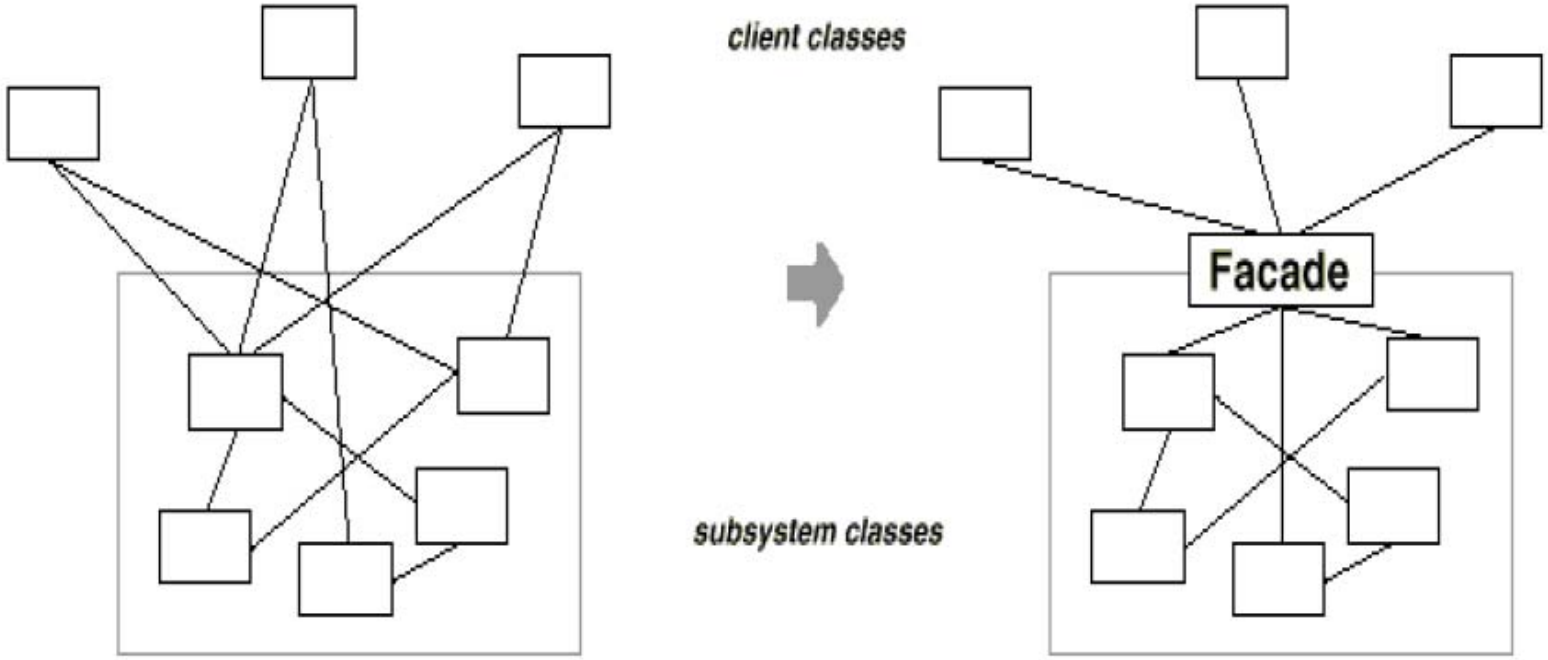
- Observer interface and Observable class exist
  - java.util.Observer and java.util.Observable
- But people usually implement their own
  - Usually can't or don't want to sub-class from Observable
  - Can't have your own class hierarchy and multiple inheritance is not available
  - Has been replaced by the Java Delegation Event Model (DEM)
    - Passes event objects instead of update/notify
- Listener is specific to GUI classes

The Façade Pattern

- Context
  - Often, an application contains several complex packages.
  - A programmer working with such packages has to manipulate many different classes
- Problem
  - How do you simplify the view that programmers have of a complex package?
- Forces
  - It is hard for a programmer to understand and use an entire subsystem
  - If several different application classes call methods of the complex package, then any modifications made to the package will necessitate a complete review of all these classes.

The Façade Pattern

-



The Façade Pattern

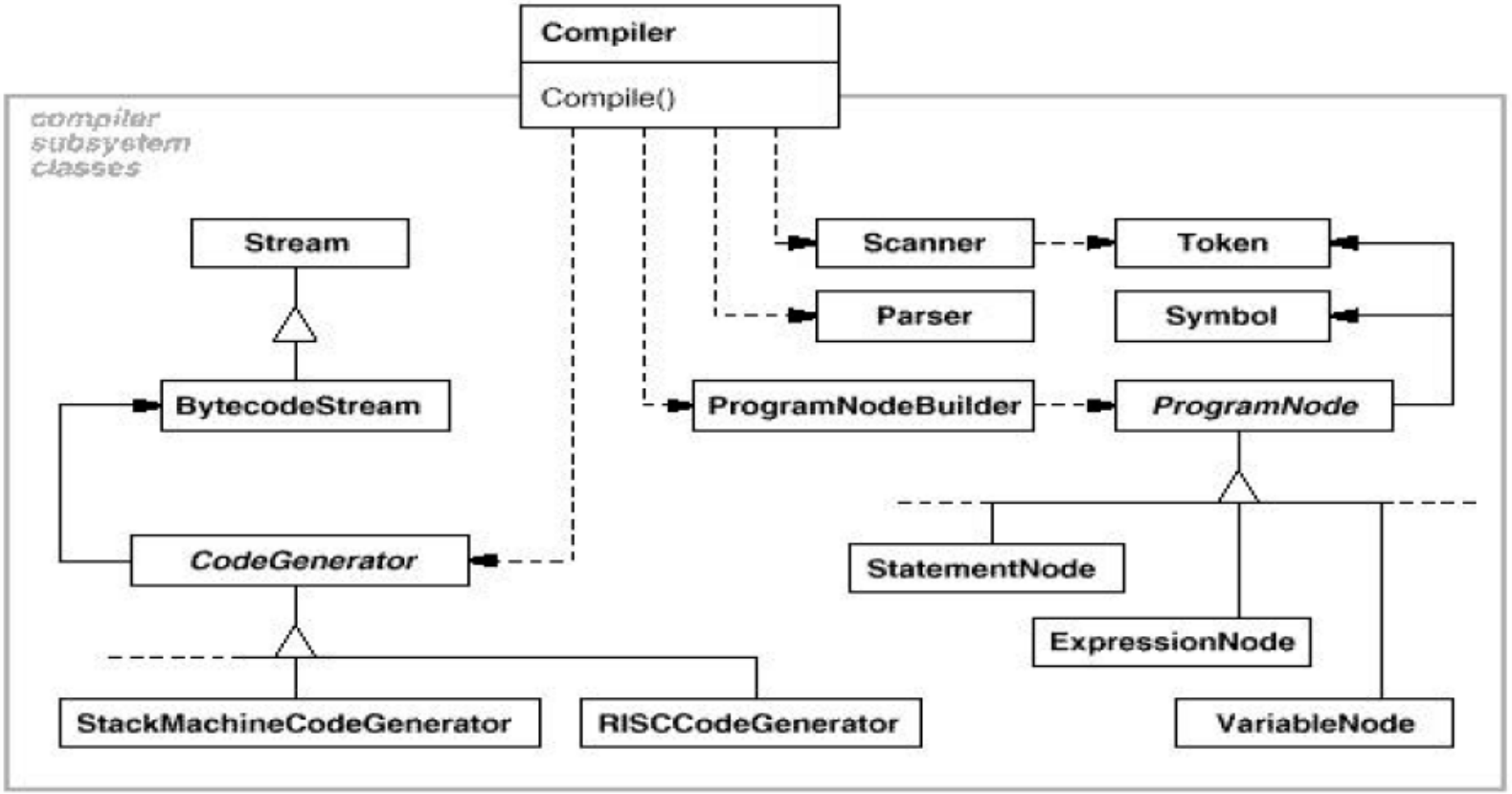
- Solution
  - Provide a simple interface to a complex subsystem.
  - Decouple the classes of the subsystem from its clients and other subsystems, thereby promoting subsystem independence and portability

Using the Façade Pattern

- Hides implementation details
- Promotes weak coupling between the subsystem and its clients.
- Reduces compilation dependencies in large software systems

- Does not add any functionality, it just simplifies interfaces
- Does not prevent clients from accessing the underlying classes.

Façade Example

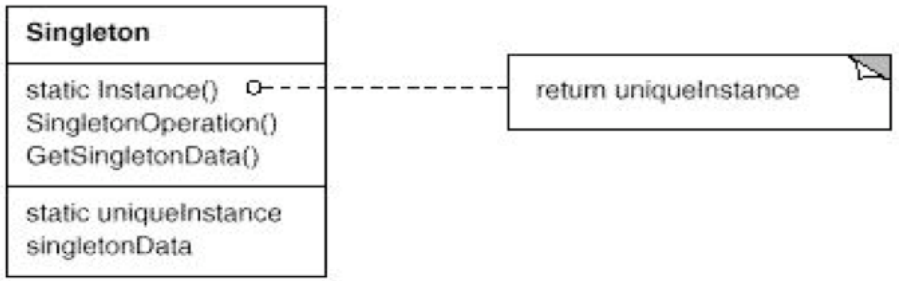


The Singleton Pattern

- Context
  - It is very common to find classes for which only one instance should exist (singleton)
- Problem
  - How do you ensure that it is never possible to create more than one instance of a singleton class?
- Forces
  - The use of a public constructor cannot guarantee that no more than one instance will be created.
  - The singleton instance must also be accessible to all classes that require it

The Singleton Pattern

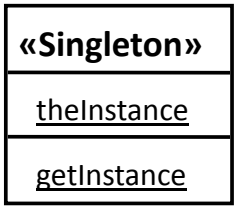
- Solution



Singleton

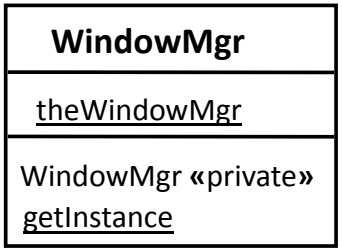
- Example

Pattern



This is the code for getInstance

Instantiation of Pattern




```
if (theWindowMgr==null)
  theWindowMgr= new WindowMgr();

return theWindowMgr;
```

Constructor for WindowMgr is private
getInstance is public and static
theWindowMgr is private and static

Singleton Design Pattern

```
public class WindowMgr {
    private static WindowMgr theWindowMgr;
    private String windowLabel;

    private WindowMgr (){
   }

    // Lazy instantiation
    public static synchronized WindowMgr getInstance(){
        if (theWindowMgr == null){
            theWindowMgr = new WindowMgr();
        }
        return theWindowMgr;
    }

...
}
```

Singleton Design Pattern

```
public class WindowMgr {
    // Eager instantiation
    private static WindowMgr theWindowMgr = new WindowMgr();
    private String windowLabel;

    private WindowMgr (){
   }

    public static synchronized WindowMgr getInstance(){
        return theWindowMgr;
    }

...
}
```

Questions

- Why do you need the getInstance method? Why isn't it enough to just make theWindowMgr static (i.e. one per class)?
  - This results in extra instances of WindowMgr, but still only one underlying theWindowMgr
- Why do you need an instance of WindowMgr at all? Why not just make all the methods static?
  - May need an instance, e.g. as an observer, for callbacks
  - More flexible when you discover later that you don't want WindowMgr to be a singleton any more

Drawbacks

- Need to add synchronization to getInstance
  - Race condition could occur in if block
- Sub-classing becomes complicated
  - Private constructor violates normal Java design principles
  - Could change constructor to protected, but that would violate the security provided
    - Make a sub-class that is identical to parent
    - Can have lots of pseudo-WindowMgrs running around
  - Alternatively, each sub-class has own getInstance method
- Also need to prevent cloning by overriding Cloneable interface
- Erich Gamma doesn't like Singleton any more

Singleton Design Pattern

- Related Patterns
  - Factory and Façade
- Reference
  - Gang of Four