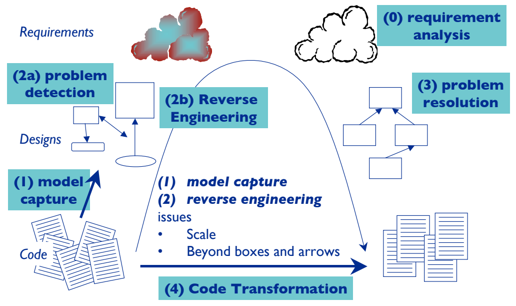
4. Design Extraction

- ***Why Extract Design? Why UML?***
- Interpreting UML
- Tracks For Extraction
- Extraction of Intention
- Extraction For The Reusers

The Reengineering Life-Cycle



Why is Design Extraction Needed?

- Documentation inexistent, obsolete, or too verbose
- Abstraction needed to understand applications
- Original programmers left
- Only the code available
- Why UML?
  - + *Standard*
  - + Communication based on a common language
  - + Can support documentation if we are precise about its interpretation
  - + *Extensible*

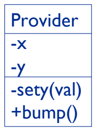
Design Extraction

Design is not code with boxes and arrows

- Design extraction is *not trivial*
  - + If you are serious about it, not a low level task!
- Design extraction should *scale up*
- Design extraction can be supported by computers but *not fully* automated
- A critical view on hype: *"we read your code and generate design documents"*
- Fertilize you with some basic techniques that may help you
- Show that UML is not that simple and clear but still *useful*

UML (Unified Modelling Language)

- Successor of OOAD&D methods of late 80 & early 90
- Unifies Booch, Rumbaugh (OMT) and Jacobson [Booc98a] [Rumb99a]. Currently standardized by OMG.
- UML is a modelling language and not a methodology (no process)
- UML defines
  - + a notation (the syntax of the modelling language)
  - + a meta-model (eMof in UML 2.0) — a model that defines the "semantics" of a model
  - + what is well-formed, defined in itself but weakly!



Roadmap

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Three Essential Questions

When we extract design we should be precise about:

- + *What* are we talking about? Design or implementation?
- + What are the *conventions* of interpretation that we are applying?
- + What is our *goal*: documentation for *programmers*, for *framework* users, high-level views, essence, contracts?

Interpreting UML

- UML purists do not propose different levels of interpretation, they refer to the UML semantics!
- Levels of interpretations are not part of UML but they are necessary!
- What is the sense of representing *subclassing* using *generalization*?

- So at a minimum we should have:
  - + Clear level of interpretation + Clear conventions + Clear goal + UML extensions: stereotypes

Levels of Interpretations: *Perspectives*

M. Fowler proposed 3 levels of interpretations called *perspectives* [Fowl97a]:

- + ***Conceptual***: we draw a diagram that represents the concepts that are somehow related to the classes but there is often no direct mapping.
- + ***Specification:*** we are looking at interfaces of object not implementation, types rather than classes. Types represent interfaces that may have many implementations
- + ***Implementation:*** implementation classes

Attributes in Perspectives

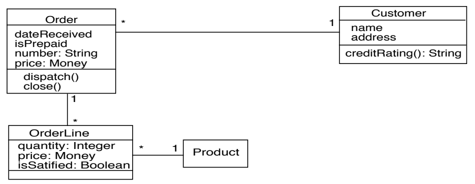
- Syntax:
  - + *visibility* attributeName: attributeType = defaultValue
  - + E.g.: +name: String
- Conceptual:
  - + Customer name ⇒ Customer has a name
- Specification:
  - + Customer class should provide a way to set and query the name
- Implementation:
  - + Customer has an attribute that represents its name
- Possible Refinements: Attribute Qualification
  - + Immutable: Value never change
  - + Read-only: Client cannot change it

Operations in Perspectives

- Syntax:
  - + visibility name (parameter-list):return-type
  - + E.g.: + public, # protected, - private
- Conceptual:
  - + principal functionality of the object. It is often described as a sentence
- Specification:
  - + public methods on a type
- Implementation: methods
  - + Operations approximate methods but are more like abstract methods
- Possible Refinements: Method qualification:
  - + Query (does not change the state of an object)
  - + Cache (does cache the result of a computation), Derived Value (depends on the value of other values), Getter, Setter

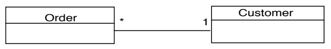
Associations: Conceptual Perspective

- Associations represent *conceptual* relationships between classes
  - + An Order has to come from a single Customer.
  - + A Customer may make several Orders.
  - + Each Order has several OrderLines that refers to a single Product.
  - + A single Product may be referred to by several OrderLines.



Associations: Specification Perspective

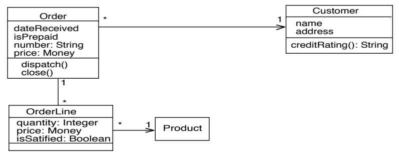
- Associations represent *responsibilities*



- Implications:
  - + One or more methods of Customer should tell what Orders a given Customer has made.
  - + Methods within Order will let me know which Customer placed a given Order and what Line Items compose an Order
- Associations also imply responsibilities for updating the relationship, such as:
  - + specifying the Customer in the constructor for the Order
  - + add/removeOrder methods associated with Customer

Arrows: Navigability

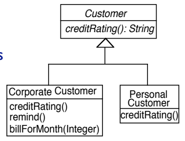
- No arrow = navigability in both directions or unknown



- Conceptual perspective: Orders know Customers but not inverse
- Specification perspective: responsibility
  - + an Order has the responsibility to identify their Customer but Customer don't have to identify their orders
- Implementation perspective:
  - + an Order points to a Customer, but a Customer doesn't point to its Orders

Generalization

UML semantics only supports generalization and not inheritance.



- Conceptual:
  - + What is true for an instance of a superclass is true for a subclass (associations, attributes, operations).
  - + Corporate Customer is a Customer
- Specifications:
  - + Interface of a subtype must include all elements from the interface of a superclass.
- Implementation:
  - + Generalization semantics is not inheritance. But we should interpret it this way for representing extracted code.

Need for a Clear Mapping

- UML
  - + language independent even if influenced by C++
  - + fuzzy (navigability, package...)
    - We should define how we interpret it
    - Define some conventions
- Some C++ examples:

Board board() Board& operator =(const Board& other) throw (const char*);	board(): Board
Piece* myMap;	myMap: Piece
class Gomoku: public Boardgame { ...	«public inherits»
static int width();	width:Integer

Private you said?! Which one?

Is it *class-based* (C++) or *instance-based* (Smalltalk)?

- in C++:
  - + any public member is visible anywhere in the program
  - + a private member may be used only by the class that defines it
  - + a protected member may be used by the class that defines it or its subclasses
  - + Class-based private
- in Smalltalk:
  - + instance variables C++ protected, methods are public
- In Java:
  - + a protected member may be accessed by subclasses but also by any other classes in the same package as the owing class
  - ⇒ *protected* is more public than *package*

Language Impact on Extraction

Attribute interpretation

- In C++ ⇒

Piece* myPiece	→ aggregation or association
Piece& my Piece	→ aggregation or association
Piece myPiece	→ composition (copied so not shared)

- In Smalltalk and Java

Aggregation and composition are not easy to extract

Piece myPiece	→ attribute or association or aggregation

Stereotypes: To Represent Conventions!

- Mechanism to specialize the semantics of the UML elements
- New properties are added to an element
- When a concept is missing or does not fit your needs select a close element and extend it

- *40 predefined stereotypes* (c = class, r = relation, o = operation, a = attribute, d = dependency, g = generalization): metaclass (c), instance (r), implementation class (c) constructor (o), destructor(o), friend (d), inherits (g), interface (c), private (g), query (o), subclass (g), subtype (g),

- *Do not push stereotypes to the limit or you will lose standards*

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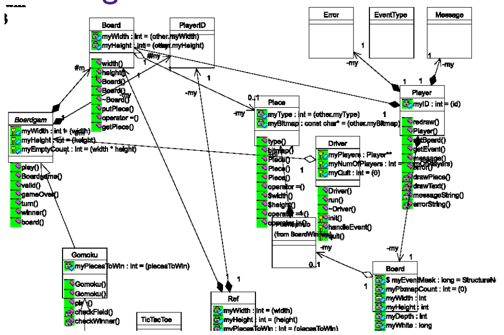


Association Extractions (i)

Goal: Explicit references to domain classes

- Domain Objects
  - + Qualify as attributes only implementation attributes that are not related to domain objects.
  - + Value objects ⇒ attributes and not associations,
  - + Object by references ⇒ associations

    E.g.: `String name` ⇒ an attribute

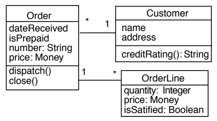
    `Order order` ⇒ an association

    `Piece myPiece` (in C++) ⇒ composition
- Define your own conventions
  - + E.g.: `integer x integer` ⇒ point attribute
- Two classes possessing attributes on each other
  - + an association with navigability at both ends

Convention Based Association Extraction

- Filtering based coding conventions or visibility
- In Java, C++ filter out private attributes
  - + _*
- In Smalltalk depending on coding practices you may filter out
  - + attributes
  - + that have accessors and are not accessed into subclasses.
  - + with name: *Cache.
  - + attributes that are only used by private methods.
- If there are some coding conventions

```
class Order {
    public Customer customer();
    // single value
    public Enumerator orderLines();
    // multi-values
}
```



Operation Extraction

- You may not extract
  - + accessors
  - + operators, non-public methods,
  - + simple instance creation methods (new in Smalltalk, constructor with no parameters in Java)
  - + methods already defined in superclass,
  - + methods already defined in superclass that are not abstract
  - + methods that are responsible for the initialization, printing of the objects
- Use company conventions to filter
  - + Access to database, Calls for the UI, Naming patterns

Operation Extraction (ii)

If there are several methods with more or less the same intent

- + if you want to know that the functionality exists not all the details
- + select the method with the *smallest prefix*

If you want to know all the possibilities but not all the ways you can invoke them

- + select the method with the most parameters

If you want to focus on important methods

- + categorize methods according to the number of times they are referenced by clients
- + a hook method is not often called but is still important

- What is important to show: the creation interface
  - + Smalltalk class methods in 'instance creation' category,
  - + Non default constructors in Java or C++

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Design Patterns

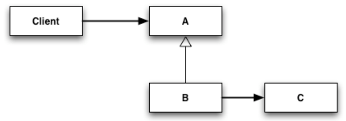
Design Patterns *reveal the intent* so they are definitely appealing for supporting documentation [John92a] [Oden97a]

But

- + *Difficult* to identify design patterns from the code [Brow96c, Wuyt98a, Prec98a]
- + What is the difference between a State and a Strategy from the code point of view?
- + Need somebody *who knows*
- + *Read the Code in one Hour*
- + Lack of support for code annotation so difficult to keep the use of patterns and the code evolution [Flor97a]

DPs are NOT about Structure

- Adapter Intent: Convert the interface of a class into another interface clients expect. Adapter lets classes work together that couldn't otherwise because of incompatible interfaces.
- This code structure IS NOT an Adapter: it may if the relationship between B and C is about protocol adaptation!



DPs are about Intent and Pros/Cons

- DPs are not carved in stone
- They are *vocabulary* and *intention*
- They are tradeoffs
- Read the class names
- Read the comments
- Watch out for "DPs Magic Extracting tools"

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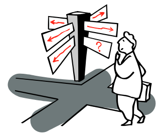
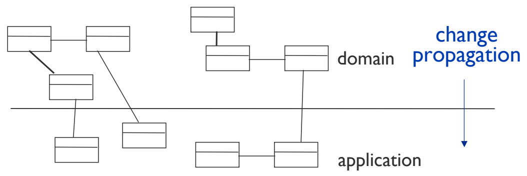
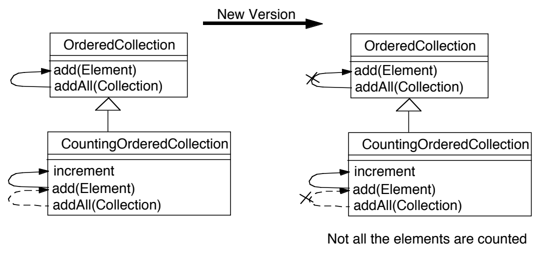


Evolution Impact Analysis: Reuse Contract

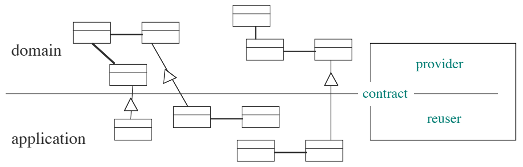
- ***How to identify the impact of changes?***
- ***How to document for reusers/extenders?***
- ***How to document framework?***



Example

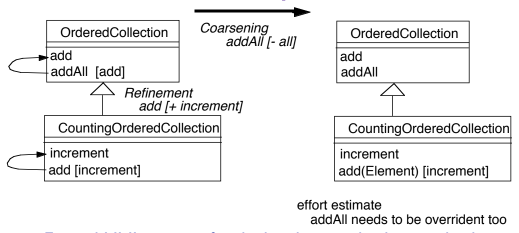


Reuse Contracts: General Idea



Reuse Contracts [Stey96a] propose a methodology to:
- + specify and qualify extensions
- + specify evolution
- + detect conflicts

Example



- Extend UML to specify which other methods a method invokes (reuse contracts)
- In class Set
  - + + addAll: (c Collection): Collection {invokes add}

Lessons Learned

- You should be clear about:
  - + Your goal (detailed or architectural design)
  - + *Conventions*, like navigability,
  - + Language *mapping* based on *stereotypes*
  - + Level of *interpretations*
- For *Future* Development
  - + Emphasize literate programming approach
  - + *Xunit*-like approaches
  - + Extract design to keep it *synchronized*
- UML as Support for Design Extraction
  - + Often fuzzy
  - + Do not support well dynamic/reflective languages
  - + But UML is extensible, so define your own stereotype!