CMSC 433 – Programming Language Technologies and Paradigms
Spring 2007

Documentation

Feb. 20, 2007

Software Specifications

- A specification defines the *behavior* of an abstraction
- This is the *contract* between user and provider
  - Provider's code must implement the specification
  - Providers are free to change the implementation
    - So long as the new code meets the specification
  - Users who depend only on specification won't have trouble
    - Don't rely on implementation
- Black box testing essentially checks compliance of an implementation with its specification

Good Specifications are Hard to Write

- Very difficult to get people to write specifications
  - Even harder to keep them up to date
- Having specifications in a separate document from code almost guarantees failure
  - Rationale for **Javadoc**: extract a standalone specification from the code and embedded comments
- Hard to accurately and formally capture all properties of interest
  - Always finding important details not specified

Specifications Help You Write Code

- Lots of subtle algorithms and data structures
  - Internal specs/invariants vital to correct implementation
- Example: Binary Search Tree
  - All nodes reachable from left child have smaller key than current node
  - All nodes reachable from right child have larger key than current node

Specifications Help You Maintain Code

- In the real world, much coding effort goes into modifying previously written code
  - Often originally written by somebody else
  - Perhaps many different people have modified this code
- Documenting and respecting key internal specifications are the way to avoid a mess
- Documenting and respecting key external specifications are the way to avoid having your customers storm the office with torches and pitchforks

Formal vs. Informal Specifications

```
static int find(int[] d,int x)
```

- An informal specification
  - If the array **d** is sorted, and some element of the array **d** is equal to **x,** then find() returns the index of **x** ……
- A formal specification
  - (for all i, 0 < i < **d**.length, **d**[i-1] < **d**[i]
    and there exists j, 0 <= j < **d**.length, such that **d**[j] == **x**)
    implies find(d,x) = j ……
- Note: These specs assume array has no duplicates

Advantages and Disadvantages

- Formal specifications
  - Forces you to be very clear
  - Automated tools can check some specifications
    - Either at compile-time (static checking) or run-time (dynamic checking)
- Informal specifications
  - Some important properties are hard to express formally
    - Sometimes just difficult
    - Sometimes don't have the necessary formal notation
  - Some people are intimidated by formal specs

Types of External Specifications

- Specifications on methods
  - Pre-conditions/requires: What must be true before call
  - Post-conditions/effects: What is must be true after call
    - Often relates final values to initial values

```
// precondition: the array d is sorted
// postcondition:
//    returnValue >= 0 && d[returnValue] == x
//    or (returnValue == -1 && x does not occur in d)
static int find(int d[], int x);
```

Types of Internal Specifications

- Specifications appearing within code itself
  - i.e., comments
- Loop invariants: condition that must hold at the beginning of each iteration of a loop
  - d[0..i] is sorted
- Data structure or field invariants
  - elementCount <= elementData.length

Specifications and Subtyping

- Liskov substitution principle (original? formal stmt)
  - If for each object *o1 of type* ***S*** *there is an object o2 of type* ***T*** *such that for all programs* ***P*** *defined in terms of* ***T****, the behavior of* ***P*** *is unchanged when o1 is substituted for o2 then* ***S*** *is a subtype of* ***T****.*
  - I.e, if anyone expecting a **T** can be given an **S**, then **S** is a subtype of **T**.
- If we *override* a method, how do the specifications of the original and new method relate?

Specifications and Subtyping (cont'd)

```
// precondition: the array d is sorted
// postcondition:
//    returnValue >= 0 && d[returnValue] == x
//    or (returnValue == -1 && x does not occur in d)
static int find(int d[], int x);
```

- If we override this method, can the new method
  - Have true as a precondition?
  - Have precond "**d** is sorted and exists **i** s.t. **d[i] == x**"?
  - Have postcond "**returnValue**==-1 or **returnValue** is first index such that **d[returnValue] == x**"?
  - Throw **NoSuchElementException** rather than returning -1 when **x** does not occur in **d**?

What Makes a Good Specification?

- Sufficiently restrictive
  - Forbids unacceptable implementations
- Sufficiently general
  - Allows all acceptable implementations
- Clear
  - Easy to understand
  - A little redundancy may help (some people disagree)

Javadoc

- Integrates documentation into source code as comments
- Will generate an external specification

```
/** Javadoc Comment for this class */
public class MyClass {
  /** Javadoc Comment for field text */
  String text;
  /** Javadoc Comment for method setText
      @param t Javadoc comment for parameter t
  */
  public void setText(String t) {...}
}
```


Javadoc example

```
/** Given a sorted array, returns the index
  into the array of the given element,
  otherwise returning -1.

  @param d array to search in, assumed sorted
  @param x the element to search for
  @returns i >= 0 when d[i] == x, and -1 when
    x does not occur in d
*/
public static int find(int d[], int x) {
  …
}
```


Javadoc example: HTML

Method Detail

find

```
public static int find(int[] d,
                       int x)
```

Given a sorted array returns the index into the array of the given element, otherwise returning -1.

Parameters:
d - array to search in, assumed sorted
x - the element to search for

Returns:
i >= 0 when d[i] == x, and -1 when x does not occur in d

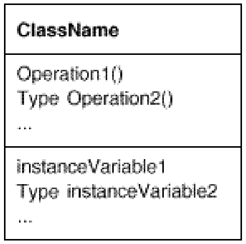
A Few Javadoc Tags

- Special tags for classes
  - @author
  - @version
- Special tags for methods
  - @param
  - @return
  - @exception
- Reference to another element
  - @see

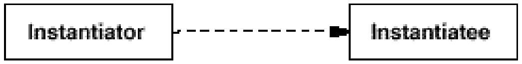
Object Modeling Technique (OMT)

- Graphical representation of OO relationships
  - **Class diagrams** show the static relationship between classes
  - **Object diagrams** represent the state of a program as series of related objects
  - **Interaction diagrams** illustrate execution of the program as an interaction among related objects

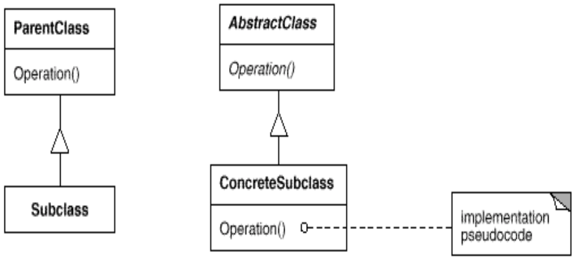
Classes



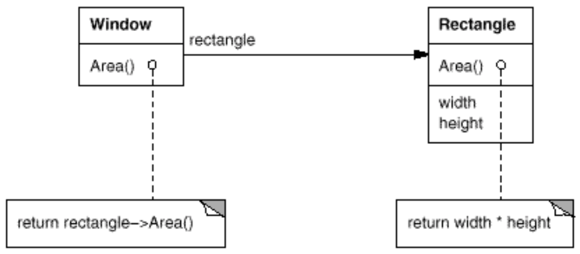
Object instantiation



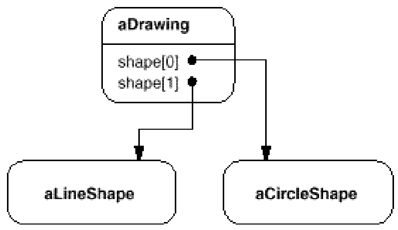
Subclassing and Abstract Classes



Pseudo-code and Containment



Object diagrams



Interaction diagrams