cs2220: Engineering Software

Class 4: Specifying Procedures

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Menu

Specifications

Return PS1

Managing Complexity

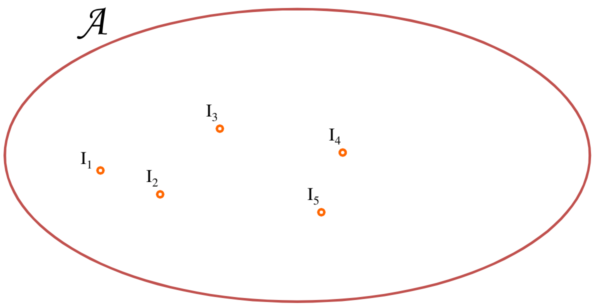
Divide problem into subproblems that

- Can be solved independently
- Can be combined to solve the original problem

How do we know they can be solved **independently**?

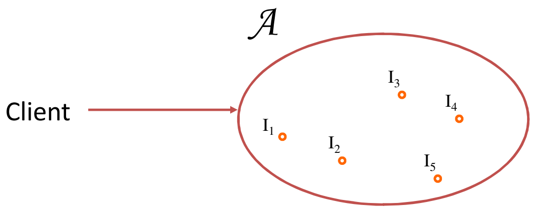
How do we know they can be combined to solve the original problem?

Abstraction



An abstraction is a ***many-to-one*** map.

Using Abstractions



When a client uses an abstraction, it *should work as the client expects it to* no matter which implementation is provided.

How should client know what to expect?

Specification

- Tells the **client** of an abstraction what the client can **expect it to do**
- Tells the **implementer** of an abstraction what the implementation **must do to satisfy the client**
- **Contract** between client and implementer:
  - Client will only rely on behavior described by specification
  - Implementer will provide an implementation that satisfies the specification

Formality of Specifications

Informal: written in a natural language (e.g., English)

- People can disagree on what it means
- Degrees of informality

Specifications in cs2220

Formal: written in a specification language

- Meaning is defined by specification language (whose meaning is defined precisely, but eventually informally)
- May be analyzed by machines

Note: people (e.g., Wes Weimer) also attempt to develop programs to analyze informal specifications, but its much harder!

Good Specifications

- **Clear**, **precise** and **unambiguous**
  - Clients and implementers will agree on what they mean
- **Complete**
  - Describe the behavior of the abstraction in all situations
- **Declarative**
  - Describe ***what*** the abstraction should do, not ***how*** it should do it

All specifications in cs2220 should strive for all of these

Is it ***even possible*** for an **informal** specification to achieve all these?

What do you call people who decide what informal specifications mean?

Example Informal Specification

Excessive bail shall not be required, nor excessive fines imposed, nor cruel and unusual punishments inflicted.

8th Amendment

Correct Implementation?

```
public static boolean
  violatesEigthAmendment (Punishment p) {
     // EFFECTS: Returns true if p violates the 8th
     //     amendment (cruel and unusual
     //     punishments).
     return (p.isCruel () && p.isUnusual ());
}
```

Or did they mean **p.isCruel () || p.isUnusual ()** ?

Procedural Specifications

Specification for a procedure describes:

What its **inputs** are including their **types** and **meanings**

The **mapping between inputs and outputs**

What it **can do to the state** of the world

Parts of a Procedure Specification

Header: name of procedure, types of parameters and return value

- Java declaration (this is formal)

Clauses: (comments in English)

REQUIRES

precondition the client must satisfy before calling

EFFECTS

postcondition the implementation satisfy at return

Specifications are **Contracts**

Client promise:

satisfy the precondition in REQUIRES clause

Implementer promise:

if client satisfies the precondition,

when the function returns, the return value and state will satisfy the **postcondition**.

Specification Contract

f ()

REQUIRES: *precondition*

EFFECTS: *postcondition*

precondition
{ f (); }
postcondition

If the precondition is true, after we call *f*() the postcondition is true.

Specification Example

```
public String bestStock ()
    // REQUIRES: false
   // EFFECTS: Returns the name of the
    //        best stock to buy on the NASDAQ
    //        tomorrow.
```

Can we implement a procedure that satisfies this specification?

Yes, any implementation will satisfy this specification! If the precondition in the requires clause is not satisfied, the procedure can do **anything** and still satisfy its specification!

Specification Example

```
public String bestStock ()
    // REQUIRES: true
   // EFFECTS: Returns the name of the
    //        best stock to buy on the NASDAQ
    //        tomorrow.
```

Can we implement a procedure that satisfies this specification?

Preconditions

The *weaker* (more easy to make true) the requires clause:

- The **more useful** a procedure is **for clients**
- The **more difficult** it is **to implement correctly**

Avoid preconditions unless there is a really good reason to have one

- Default requires clause is: **REQUIRES true**
- Client doesn't need to satisfy anything before calling

Specification Example

public static int biggest (int [ ] a)

  // REQUIRES: true

  // EFFECTS: Returns the value of the mathematically greatest

  //   ~~biggest~~ element of a.

Is this a good specification?

Clear, **precise** and **unambiguous**

✗ **Complete**

Declarative

Specification Example

```
public static int biggest (int [ ] a)
  // REQUIRES: a has at least one element.
  // EFFECTS: Returns the value of the
  //     biggest element of a.
```

Is this a good specification?

Maybe, depends on the client. Its risky…

Bad Use of Preconditions

Bug discovered in Microsoft Outlook that treats messages that start with “begin ” as empty attachments (can be exploited by viruses)

http://support.microsoft.com/kb/260822

To workaround this problem:
- Do not start messages with the word "begin" followed by two spaces.
- Use only one space between the word "begin" and the following data.
- Capitalize the word "begin" so that it is reads "Begin."
- Use a different word such as "start" or "commence".

Specification Example

```
public static int biggest (int [ ] a)
  // REQUIRES: true
  // EFFECTS: If a has at least one
  //     element, returns the value biggest
  //     element of a.  Otherwise, returns
  //     Integer.MIN_VALUE (smallest int value).
```

Better, but client has to deal with special case now.
Best would probably be to use an exception…

Specification Example

```
public static int biggest (int [ ] a) thows NoElementException
  // REQUIRES: true
  // EFFECTS: Scans through each element in a, checking
  //     if the value is bigger than the biggest previous value.
  //     Returns the value of the biggest element.  If the array
  //     is empty, throws NoElementException.
```

Is this a good specification?

Clear, **precise** and **unambiguous**

Complete

Declarative

Modifies

How does a client know **a** is the same after **biggest** returns?

```
public static int biggest (int [ ] a) thows NoElementException
  // REQUIRES: true
  // EFFECTS: If a has at least one element,
  //     returns the value biggest element of a.
  //     Otherwise, throws NoElementException.
```

Reading the effects clause should be enough – if biggest modifies anything, it should describe it. But, that’s a lot of work.

Modifies

MODIFIES clause: any state ***not*** listed in the modifies clause **may not be changed** by the procedure.

```
public static int biggest (int [ ] a)
  // REQUIRES: true
  // MODIFIES: nothing
  // EFFECTS: If a has at least one element,
  //     returns the value biggest element of a.
  //     Otherwise, returns Integer.MIN_VALUE
  //     (smallest int value).
```

Modifies Example

```
public static ~~int~~ void replaceBiggest (int [ ] a, int [] b)
  // REQUIRES: a and b both have at least one
  //    element
  // MODIFIES: a
  // EFFECTS: Replaces the value of the biggest
  //      element in a with the value of the biggest
  //      element in b.
```

Defaults

What should it mean when there is no REQUIRES?

REQUIRES: true

What should it mean when there is no MODIFIES?

MODIFIES: nothing

What should it mean when there is no EFFECTS?

Meaningless.

Returning PS1 / PS2 Partners

Blanton, James jb7bq; Smith, David dcs9z; Wallace, Alexander aww8rj
Borja, Joseph jjb4wa; Noh, Brian bkn3yh
Brown, Jeremy jpb4s; Marion, John jjm6p
Chen, Jiamin jc2kk; Kalish, Michael mk8af
Dewey-Vogt, Michael mkd5m; Sparkman, Elisabeth egs5u
Dilorenzo, Jonathan jd9hz; Hearn, Charles cmh3eg
Dollhopf, Niklaus nmd3ey; Oh, Uyn uho6r
Featherston, Joseph jef5ez; Sun, Yixin ys3kz
Hearn, Charles cmh3eg; Dilorenzo, Jonathan jd9hz
Herder, Samuel srh5ne; Lopez, Erik ejl3tf
Kalish, Michael mk8af; Chen, Jiamin jc2kk
Lopez, Erik ejl3tf; Herder, Samuel srh5ne
Marion, John jjm6p; Brown, Jeremy jpb4s
Noh, Brian bkn3yh; Borja, Joseph jjb4wa
Oh, Uyn uho6r; Dollhopf, Niklaus nmd3ey
Smith, David dcs9z; Blanton, James jb7bq; Wallace, Alexander aww8rj
Sparkman, Elisabeth egs5u; Dewey-Vogt, Michael mkd5m
Sun, Yixin ys3kz; Featherston, Joseph jef5ez
Wallace, Alexander aww8rj; Smith, David dcs9z; Blanton, James jb7bq

Which is better?

```
/**
  * EFFECTS: Plays the old song forever.
  */
public static void playOldSong() {
   Player player new Player();
   player.play(tune);
   playOldSong();
}
```

```
/**
  * EFFECTS: Plays the old song forever.
  */
public static void playOldSong() {
   Player player = new Player();
   while (true) {
       player.play(tune);
   }
}
```

Where's the base case?

if (true) {

Which is better?

```
public static void accelerateSong(String tune, int repeats, int tempo, double rate) {
    double currenttempo = tempo;
  for (int i = 0; i < repeats; i++) {
  playOldSongTempo(Integer.round(currenttempo));
      currenttempo = currenttempo * rate;
  }
}
```

```
public static void accelerateSong(String tune, int repeats, int tempo, double rate) {
  double currenttempo = tempo;
  for (int i = 0; i < repeats; i++) {
     playOldSongTempo(Integer.round(currenttempo));
     currenttempo = currenttempo * rate;
  }
}
```

Unlike Python, the Java compiler doesn't care how you indent your code. But, you should!
In Eclipse: use **`ctrl-I`** to indent your code structurally.

Finding Java Documentation

Bing/Google: **java se 1.6 ArrayList**

There are many old specs you will find first without this; some things have changed, so be careful to use the current specs.

Java compiler error messages:

cannot be resolved to a variable

Java "cannot be resolved to a variable"

Charge

- Find your PS2 partner now
  - If you haven’t already finished part I, finish it soon so you can get started together on part II
- PS2 question 6: a lot for you to figure out on your own (but help will be available, and I’ll provide hints when you ask)
  - Keep things simple
  - Design for testability: check your code as you go