CSE 331

Software Design & Implementation

Section: Sets; JUnit; AFs

Reminders

- HW4 is challenging for many students. Start early!

Upcoming Deadlines

- HW3 due 11pm tonight (7/07)
- Prep. Quiz: HW4 due 11pm Tuesday (7/11)

Last Time…

- Abstract Data Types (ADTs)
- Representation Invariants
- Abstraction Functions

Today's Agenda

- Review: AFs
- JUnit
- Sets and HW4

Abstract Data Types (ADTs)

- Abstraction representing some set of data
  - Meant to express the meaning/concept behind some Java class

- Different from implementation/Java fields!
  - Same ADT can have many different implementations

Abstract data types by example

Review ADT concepts through two examples:

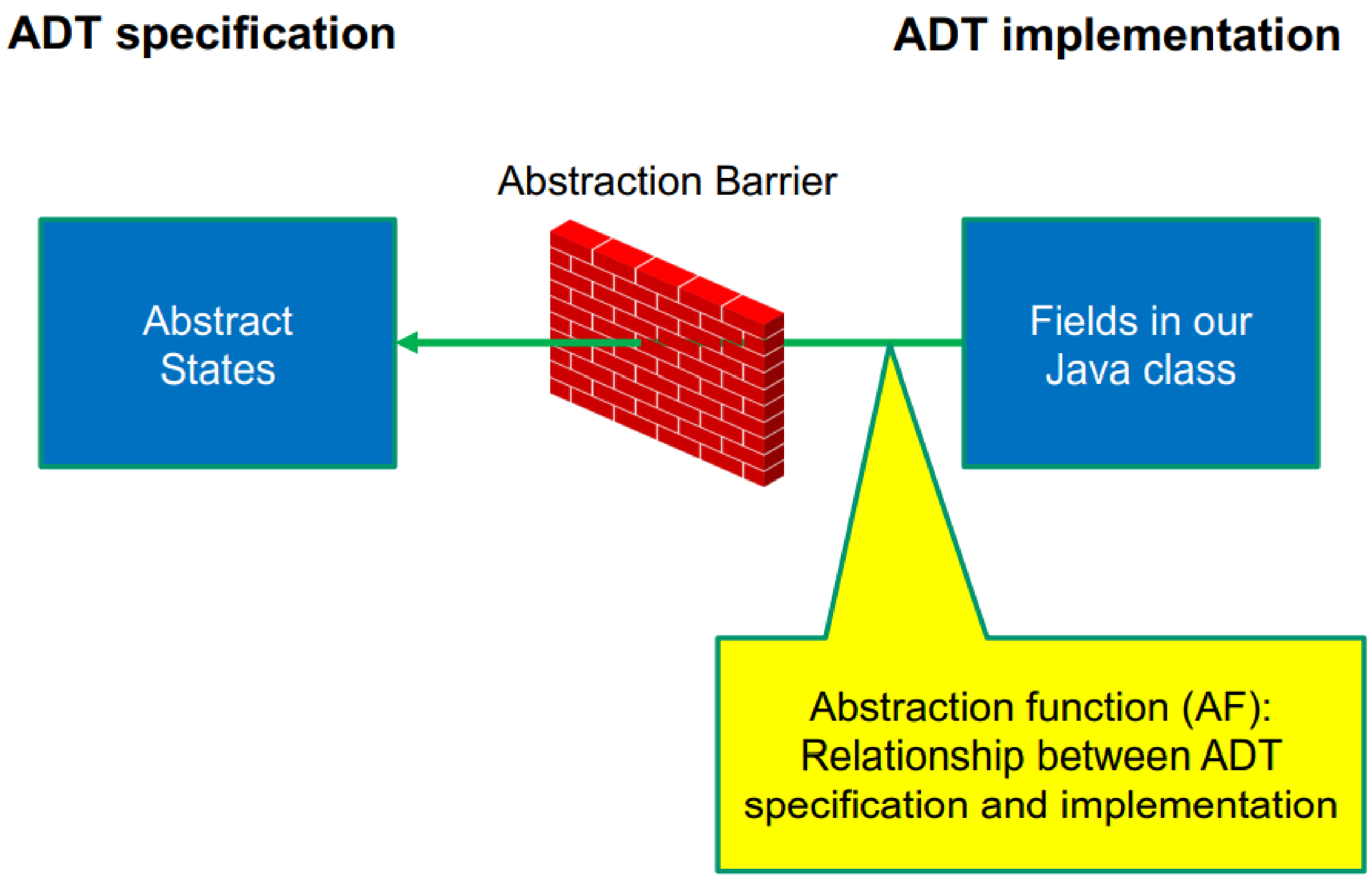
- A **`Line`** ADT
- A **`Rectangle`** ADT

On the course website, see "Resources" → "Class and Method Specifications" for a handy guide with full details.

Abstraction Functions (AFs)

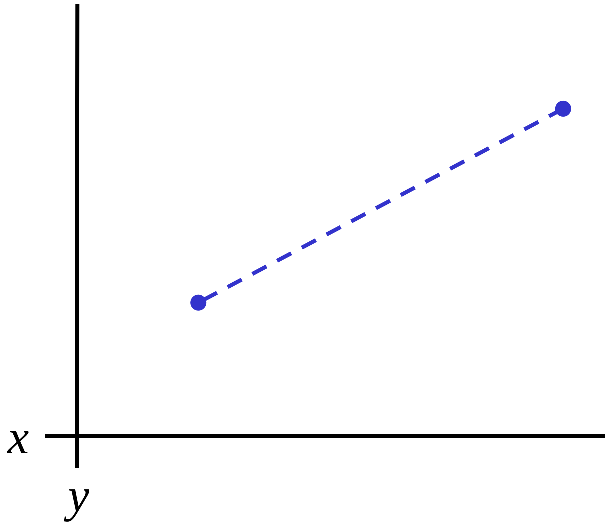
- Let's say we have an ADT
  - And we choose some way to implement it
- How does the concrete implementation relate to our ADT?
- This is an **abstraction function**
  - Maps object implementation (our Java fields) to the abstract state
  - Ex: "How does a Triangle object from Triangle.java represent a Triangle ADT?"
  - Note: specific to implementation

Diagram


ADT specification
ADT implementation
Abstraction Barrier
Abstract States
Fields in our Java class
Abstraction function (AF): Relationship between ADT specification and implementation

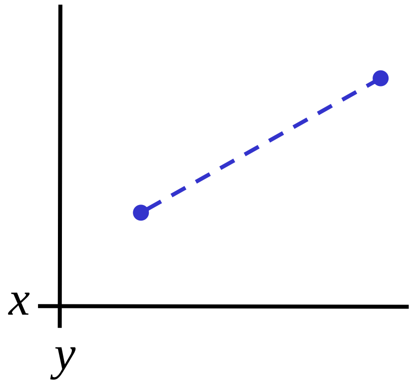
Line ADT

Concept: A line segment in the Cartesian co-ordinate plane



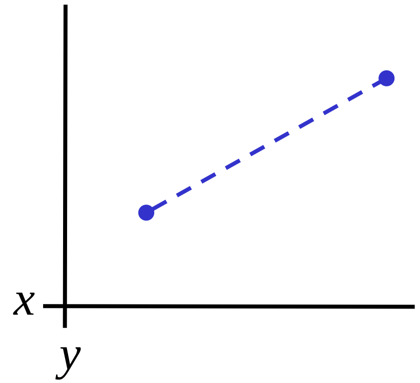
Line ADT: Class specification

```
/**
 * A Line is a mutable 2D line segment with endpoints
 * p1 and p2.
 */
public class Line {
  ... // rep invariant, fields, methods, etc.
}
```



Line ADT: Representation #1

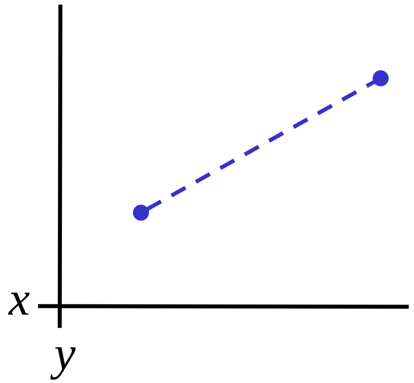
```
/**
 * A Line is a mutable 2D line segment with endpoints
 * p1 and p2.
 */
public class Line {
  // Abstract state is ______
  private Point p1, p2;
}
```



What is our abstraction function?

Line ADT: Representation #1

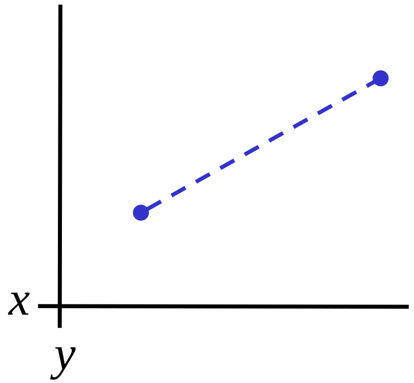
```
/**
 * A Line is a mutable 2D line segment with endpoints
 * p1 and p2.
 */
public class Line {
  // Abstract state is line with endpoints p1 and p2
  private Point p1, p2;
}
```



Line ADT: Representation #2

```
/**
 * A Line is a mutable 2D line segment with endpoints
 * p1 and p2.
 */
public class Line {
  // Abstract state is _____
  private int x1, x2;
  private int y1, y2;
}
```

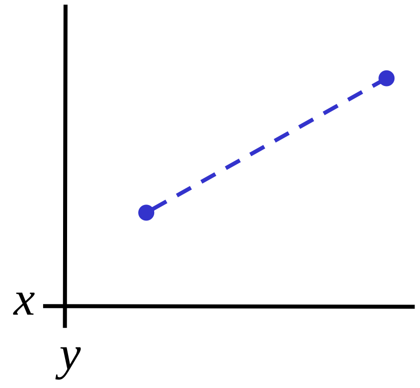
What is our abstraction function?



Line ADT: Representation #2

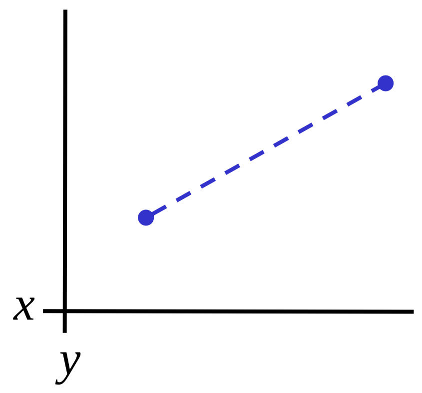
```
/**
 * A Line is a mutable 2D line segment with endpoints
 * p1 and p2.
 */
public class Line {
  // Abstract state is line with endpoints (x1, y1) and
  //                                       (x2, y2)
  private int x1, x2;
  private int y1, y2;
}
```

Does this representation have any advantages over #1?



Line ADT: Representation #3

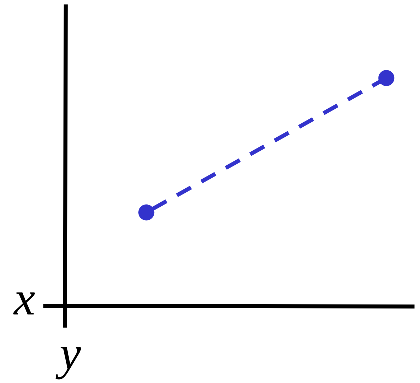
```
/**
 * A Line is a mutable 2D line segment with endpoints
 * p1 and p2.
 */
public class Line {
  // Abstract state is _____
  private int x1, y1;
  private double angle;
  private double len;
}
```



What is our abstraction function?

Line ADT: Representation #3

```java
/**
 * A Line is a mutable 2D line segment with endpoints
 * p1 and p2.
 */
public class Line {
  // Abstract state is line with endpoints (x1, y1) and
  //   (x1 + len * cos(angle), y1 + len * sin(angle))
  private int x1, y1;
  private double angle;
  private double len;
}
```



Does this representation have any advantages over #1?

Try it yourself!

Write your own specification of a Rectangle ADT on the handout.

Then give two different possible representations for your Rectangle ADT and write abstraction functions for them.

Testing: A quick introduction

- In past assignments, you have run the test suite.
- But now you must start writing your own tests!

JUnit

- Industry-standard Java toolkit for unit testing
  - We're using JUnit **4.12**
  - Check out the javadocs

- A unit test is a test for one "component" by itself
  - "Component" typically a class or a method

- Each unit test written as a method
  - We'll see the particulars in a moment…

- Closely related unit tests should be grouped into a class
  - For example, all unit tests for the same ADT implementation

Writing tests with JUnit

A method annotated with **`@Test`** is flagged as a JUnit test

```
import org.junit.*;
import static org.junit.Assert.*;

/** Unit tests for my Foo ADT implementation */
public class FooTests {
  @Test
  public void testBar() {
    ... /* use JUnit assertions in here */
  }
}
```

Using JUnit assertions

- JUnit assertions establish success or failure of the test method
  - *Note*: JUnit assertions are *different* from Java's **`assert`** statement
- Use to check that an actual result matches the expected value
  - Example: **`assertEquals(42, meaningOfLife());`**
  - Example: **`assertTrue(list.isEmpty());`**
- A test method stops immediately after the first assertion failure
  - If no assertion fails, then the test method passes
  - Other test methods still run either way
- JUnit results show details of any test failures

Common JUnit assertions

JUnit's [documentation] has a full list, but these are the most common assertions.

Assertion	Failure condition
`assertTrue(`*`test`*`)`	***`test`*** **`== false`**
`assertFalse(`*`test`*`)`	***`test`*** **`== true`**
`assertEquals(`*`expected, actual`*`)`	***`expected`*** and ***`actual`*** are not equal
`assertSame(`*`expected, actual`*`)`	***`expected != actual`***
`assertNotSame(`*`expected, actual`*`)`	***`expected == actual`***
`assertNull(`*`value`*`)`	***`value`*** **`!= null`**
`assertNotNull(`*`value`*`)`	***`value`*** **`== null`**

Any JUnit assertion can also take a string to show in case of failure, *e.g.*, **`assertEquals("helpful message", expected, actual)`**.

Always* use >= 1 JUnit Assertion

- If you don’t use any JUnit assertions, you are only checking that no exception/error occurs

- That’s a pretty weak notion of passing a test; rarely the best test you could write

- Having more than one JUnit assertion in a test may make sense, but one is the most common scenario

* Special case coming in a couple slides

JUnit assertions vs Java's assert

- Use JUnit assertions **only in JUnit test code**
  - JUnit assertions have names like **`assertEquals`**, **`assertNotNull`**, **`assertTrue`**
  - Part of JUnit framework used to report test results
    - Accessed via **`import org.junit`**....
  - **Don't** use in ordinary Java code (***never*** **`import org.junit.`**... in non-JUnit code)

- Use Java's **`assert`** statement in ordinary Java code
  - Use liberally to annotate/check "must be true" / "must not happen" / etc. conditions
  - Use in **`checkRep()`** to detect failure if problem(s) found
  - **Do not** use in JUnit tests to check test result – does not interact properly with JUnit framework to report results

Checking for a thrown exception

- Should test that your code throws exceptions as specified
- This kind of test method fails if its body does *not* throw an exception of the named class
  - May not need any JUnit assertions inside the test method unlike our previous guideline

```
@Test(expected=IndexOutOfBoundsException.class)
public void testGetEmptyList() {
  List<String> list = new ArrayList<String>();
  list.get(0);
}
```

- **Do not** use `assertThrows()` (that comes in JUnit 4.13, and we are using JUnit 4.12)

Test ordering, setup, clean-up

JUnit does not promise to run tests in any particular order.

However, JUnit can run helper methods for common setup/cleanup

- Run before/after ***each*** test method in the class:

```
@Before
public void m() { ... }
@After
public void m() { ... }
```

- Run once before/after running ***all*** test methods in the class:

```
@BeforeClass
public static void m() { ... }
@AfterClass
public static void m() { ... }
```

Demo: JUnit Tests Example

Now let's look at some example JUnit tests…

Tips for effective testing

- Use constants instead of hard-coded values
  - Makes easier to change later on
- Take advantage of assertion messages
- Give a descriptive name to each unit test (method)
  - Verbose but clear is better than short and inscrutable
  - Don’t go overboard, though :-)
- Write tests with a simple structure
  - Isolate bugs one at a time with successive assertions
  - Helps avoid bugs in your tests too!
- Aim for thorough test coverage
  - Big/small inputs, common/edge cases, exceptions, …

Worksheet: Test Design

- Work in small groups
- Give logic of the tests, not actual code
- Only test the operations provided on the worksheet
- More details in lecture if additional information/review needed

Before next lecture…

1. Do HW3 tonight! (reminder: deadline is 11pm)
   - Written portion (submit PDF on Gradescope)
   - Coding portion (push and tag on GitLab)

2. Start HW4 Written early – many find it challenging!

3. Review JUnit testing slides discussed in this section.

4. Review Sets slides for HW4.

HW4 Background: Floats

- Floats vs. Doubles
  - Both represent floating point numbers, but doubles are twice the size (think **int** vs **long**)
  - But we will be using [floats]()
- Special cases:
  - **`Float.POSITIVE_INFINITY`** and **`Float.NEGATIVE_INFINITY`**
  - **`Float.NaN`** – means not a number
- Operations where either one of the operands is **`NaN`**
  - **<u>All operations</u>** will return **`NaN`**
  - e.g. **`NaN * 1.23456f = NaN`**
- Including **`==`**
  - **`Float.NaN == Float.NaN -> false`**
  - Use **`Float.isNaN()`** or **`Float.isFinite()`** instead

Finite Sets

- In HW4, we will be working in the **`FiniteSet`** class, which represents a set of points along a number line, where each point is a **float**.

- Let's say we choose to represent this as an array of floats, i.e. **`float[]`**
- We need to make some choices:
  - Should we allow duplicates? Why or why not?
  - Should we sort our array? Why or why not?

- We will not allow duplicates and keep the array sorted.
- We will also store a **`Float.NEGATIVE_INFINITY`** as the first element in the array and a **`Float.POSTIVE_INFINITY`** as the last element…
  - This will make reasoning about it easier. For instance, we can guarantee that there is an index **`i`** such that **`D[i] < x < D[i+1]`**

`FiniteSet` Field

```
private final float[] vals;
```

The set **`{ -5.3, 1.48, 7.1234, 463.8 }`** will be represented as:
`[Float.NEGATIVE_INFINITY, -5.3, 1.48, 7.1234, 463.8, Float.POSITIVE_INFINITY]`

What is our representation invariant and abstraction function?

```
// Points are stored in an array, in sorted order, with an
// extra -infinity at the front and +infinity at the end
// to simplify union etc.
//
// RI: -infinity = vals[0] < vals[1] < ... <
//                            vals[vals.length-1] = +infinity
// AF(this) = { vals[1], vals[2], ..., vals[vals.length-2] }
```

`FiniteSet` Methods

Some common set operations:

- Finding the **union** (∪) of set A and set B. This is a **new** set of points that are **either** in A, B, or **both** A and B:
  - `union([-inf, 1, 4, 5, 7, inf], [-inf, 1, 6, 7, 11, inf])`
    `= [-inf, 1, 4, 5, 6, 7, 11, inf] => { 1, 4, 5, 6, 7, 11 }`

- Finding the **intersection** (∩) of set A and set B. This is a **new** set of points that are in **both** A and B:
  - `intersection([-inf, 1, 4, 5, 7, inf], [-inf, 1, 6, 7, 11, inf])`
    `= [-inf, 1, 7, inf] => { 1, 7 }`

- Finding the **difference** (- or \) of set A and set B. This is a **new** set of points that are **in** A but **not** B:
  - `difference([-inf, 1, 4, 5, 7, inf], [-inf, 1, 6, 7, 11, inf])`
    `= [-inf, 4, 5, inf] => { 4, 5 }`

`SimpleSet`

For much of the assignment, you will be working in **`SimpleSet.java`**

- A SimpleSet is defined as either a finite set of points **or** the complement of a finite set of points (meaning everything but).
  - e.g. given the set of points **`{ 1, 7, 9 }`**:
    - we can have a simple set that contains **`1`, `7`,** and **9 or**
    - one that contains all real numbers **except `1`, `7`,** and **`9`**

```
/**
 * Represents an immutable set of points on the real line that is easy to
 * describe, either because it is a finite set, e.g., {p1, p2, ..., pN},
 * or because it excludes only a finite set, e.g., R \ {p1, p2, ..., pN}.
 * As with FiniteSet, each point is represented by a Java float with a
 * non-infinite, non-NaN value.
 */
public class SimpleSet {
```

`FiniteSet` starter code

Let's now skim the starter code…