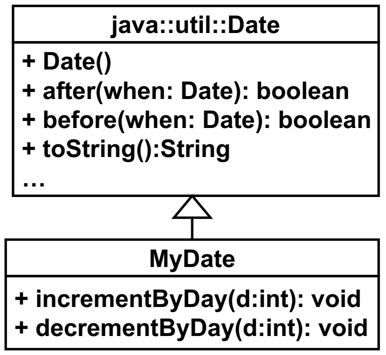
## Your Email Address

- Send your (preferred) email address to umasscs680@gmail.com ASAP.
  - I will use that address to email you lecture notes, announcements, etc.

## Inheritance (Generalization)

## Inheritance

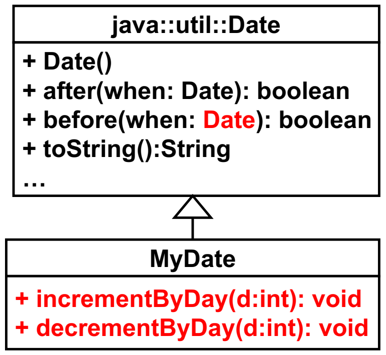

java::util::Date
+ Date()
+ after(when: Date): boolean
+ before(when: Date): boolean
+ toString():String
…
MyDate
+ incrementByDay(d:int): void
+ decrementByDay(d:int): void

```
Date d = new Date();
d.after( new Date() );

MyDate md = new MyDate();
md.after( d );
// after() is inherited to MyDate
```

- Generalization-specialization relationship
  - a.k.a. "is-a" relationship; MyDate is a (kind of) Date.
- A subclass can *inherit* all public/protected data fields and methods from its base/super class.
  - Exception: Constructors are not inherited.

## Inheritance (cont'd)


java::util::Date
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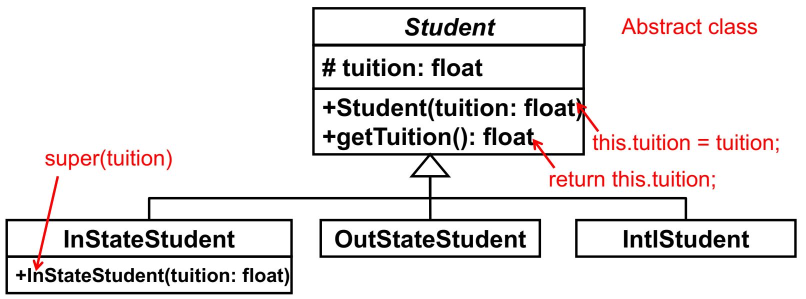
…
MyDate
+ incrementByDay(d:int): void
+ decrementByDay(d:int): void

```
Date d = new Date();
d.after( new Date() );

MyDate md = new MyDate();
md.after( new Date() );

d.incrementByDay(1);
// Compilation error
md.incrementByDay(2); // OK

d.before(md); // OK
```

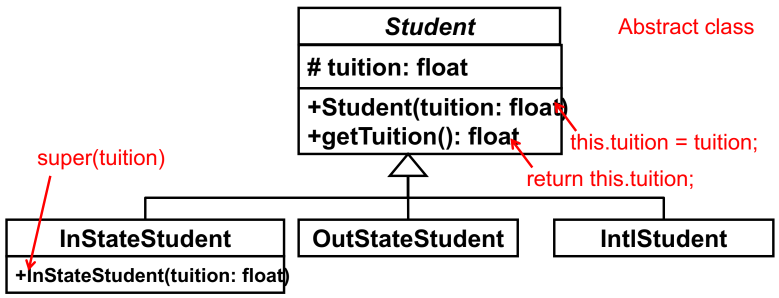
- A subclass can *extend* a base/super class by adding extra data fields and methods.
- An instance of a subclass can be assigned to a variable typed as the class's superclass.

## Quiz



-
  ```
  ArrayList<Student> students = new ArrayList<Student>();
  students.add( new OutStateStudent(2000) );
  students.add( new InStateStudent(1000) );
  students.add( new IntlStudent(3000) );
  Iterator<Student> it = students.iterator();
  while( it.hasNext() )
    System.out.println( it.next().getTuition() );
  ```

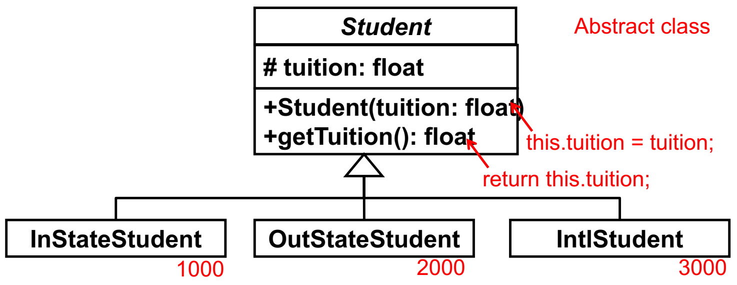
- What are printed out in the standard output?



-
  ```
  ArrayList<Student> students = new ArrayList<Student>();
  students.add( new OutStateStudent(2000) );
  students.add( new InStateStudent(1000) );
  students.add( new IntlStudent(3000) );
  Iterator<Student> it = students.iterator();
  while( it.hasNext() )
    System.out.println( it.next().getTuition() );
  ```

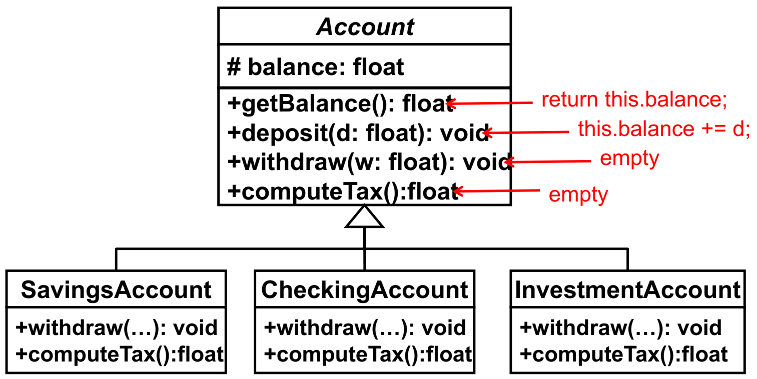
- 2000
  1000
  3000

## Polymorphism

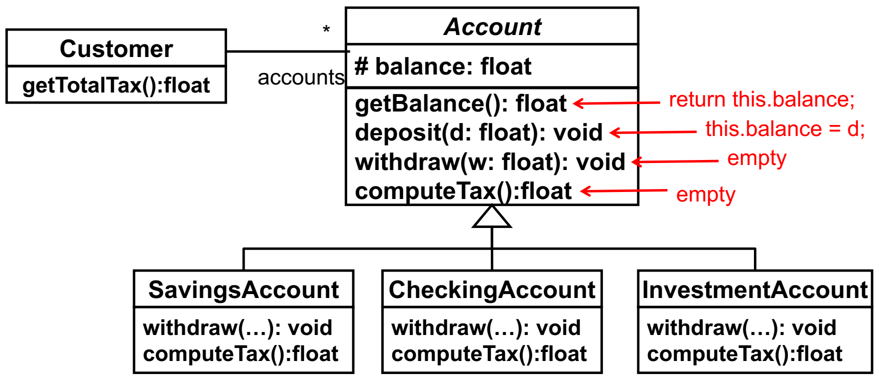


-
  ```
  ArrayList<Student> students = new ArrayList<Student>();
  students.add( new OutStateStudent(2000) );
  students.add( new InStateStudent(1000) );
  students.add( new IntlStateStudent(3000) );
  Iterator<Student> it = students.iterator();
  while( it.hasNext() )
    System.out.println( it.next().getTuition() );
  ```

- All slots in “students” (an array list) are typed as Student, which is an abstract class.
- Actual elements in “students” are instances of Student’s subclasses.



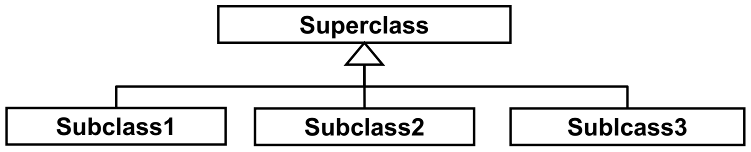
- Subclasses can redefine (or override) inherited methods.
  - A savings account may allow a negative balance with some penalty charge.
  - A checking account may allow a negative balance if the customer’s savings account maintains enough balance.
  - An investment account may not allow a negative balance.



```
• public float getTotalTax(){
      Iterator<Account> it = accounts.iterator();
      while( it.hasNext() )
             System.out.println( it.next().computeTax() ); }
```

- Polymorphism can effectively eliminate conditional statements.
  - Conditional statements are VERY typical sources of bugs.

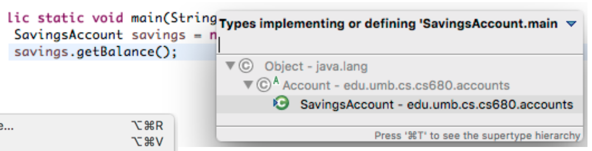
## Why Inheritance?



- Reusability
  - You can define common data fields and methods in a superclass and make them reusable in subclasses.
- Customizability and extensibility
  - You can customize method behaviors in different subclasses by overriding (re-defining) inherited methods.
  - You can add new data fields and methods in subclasses.

## An Eclipse Tip

- Ctrl+T to browse a class hierarchy.

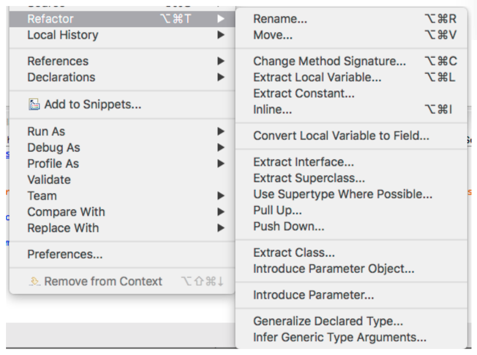


```
lic static void main(String
 SavingsAccount savings = n
 savings.getBalance();
```

Types implementing or defining 'SavingsAccount.main

```
▼ Object - java.lang
  ▼ Account - edu.umb.cs.cs680.accounts
      SavingsAccount - edu.umb.cs.cs680.accounts
```

Press '⌘T' to see the supertype hierarchy



- “refactor” menu

## Excercise

- Learn generics in Java (e.g., ArrayList) and understand how to use it.
- Learn how to use java.util.Iterator.
- This code runs.

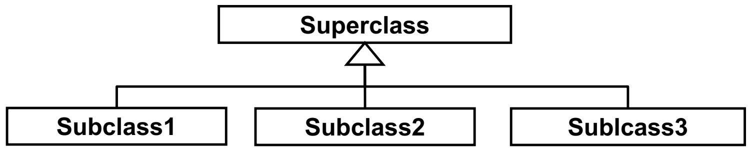
```
– ArrayList<Student> al = new ArrayList<Student>();
  al.add( new OutStateStudent(2000) );
  System.out.println( al.get(0).getTuition() ); → 2000
```

- This one doesn’t due to a compilation error.

```
– ArrayList al = new ArrayList();
  al.add( new OutStateStudent(2000) );
  System.out.println( al.get(0).getTuition() );
```

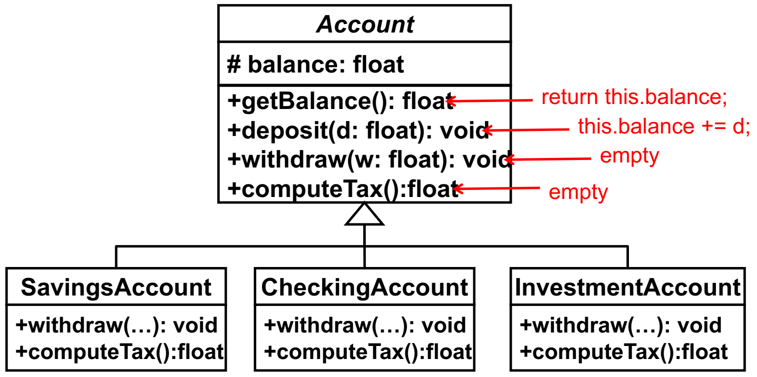
- Describe what the error is and why you encounter the error.

## Why Inheritance?



- Reusability
  - You can define common data fields and methods in a superclass and make them reusable in subclasses.
- Customizability and extensibility
  - You can customize method behaviors in different subclasses by overriding (re-defining) inherited methods.
  - You can add new data fields and methods in subclasses.

## An Example



- Subclasses can redefine (or override) inherited methods.
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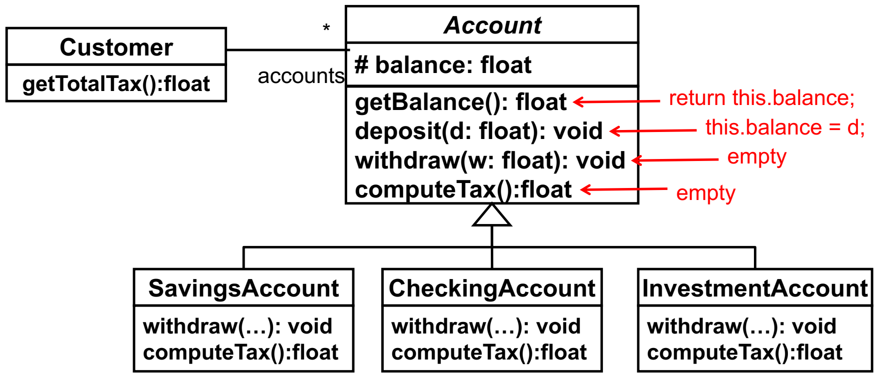
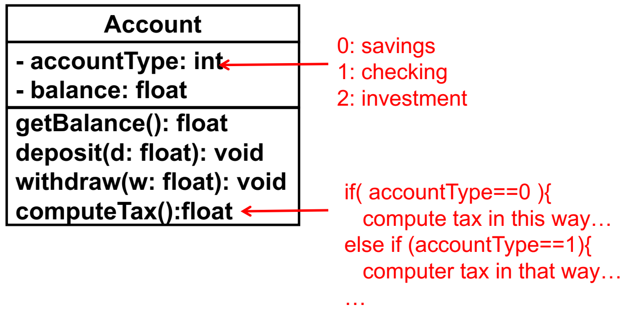
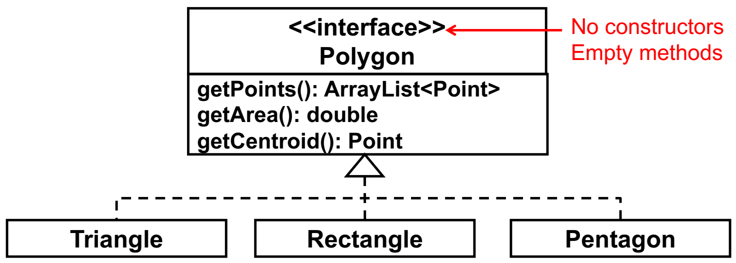


-
  ```
  public float getTotalTax(){
      Iterator<Account> it = accounts.iterator();
      while( it.hasNext() )
            System.out.println( it.next().computeTax() ); }
  ```

- Polymorphism can effectively eliminate conditional statements.
  - Conditional statements are VERY typical sources of bugs.

## If Polymorphism is not available…





```
• ArrayList<Polygon> p = new ArrayList<Polygon>();
  p.add( new Triangle( new Point(0,0),
                       new Point(2,2),
                       new Point(1,3) ));
  p.add( new Rectangle ( new Point(0,0)... ));
  Iterator<Polygon> it = p.iterator();
  while( it.hasNext() ){
    Polygon nextP = it.next();
    System.out.println( nextP.getPoints() );
    System.out.println( nextP.getArea() );
    System.out.println( nextP.getCentroid() ); }
```

## Excercise

- Write the Polygon interface and two classes: Triangle and Rectangle.
  - You can reuse Point in Java API or define your own.
- Implement getPoints() and getArea() in the two subclasses.
  - Use Heron's formula to compute a triangle's area.
    - The area of a triangle = Sqrt(s(s-a)(s-b)(s-c))
      - where s=(a+b+c)/2
      - a, b and c are the lengths of the triangle's sides.
- Write test code that
  - Makes two different triangles and two different rectangles,
  - Contains those 4 polygons in a collection (e.g. ArrayList),
    - Use generics and an iterator
  - Print outs each polygon's area.
- Keep the encapsulation principle in mind.
  - All data fields must be "private."
  - No setter methods are required.

## Note

- If you are not very familiar with class inheritance and polymorphism, you may want to implement Student and Account examples as well.

## Automatic Build

- Use Ant (http://ant.apache.org/) to compile/build all of your Java programs in every coding HW.
  - Learn how to use it, if you don't know that.
  - Turn in *.java and a build script (e.g. build.xml).
    - Turn in a ***single*** build script (build.xml) that
      - configures all settings (e.g., class paths, a directory of source code, a directory to generate binary code),
      - compiles all source code from scratch,
      - generates binary code (*.class files), and
      - runs compiled code
    - DO NOT include absolute paths in a build script.
      - You can assume my OS configures a right Java API (JDK/JRE) Jar file (in its env setting).
    - DO NOT turn in byte code (class files).
    - DO NOT use any other ways for configurations and compilation.
      - Setting paths manually with a GUI (e.g., Eclipse)
      - Setting an output directory manually with a GUI
      - Clicking the "compile" button manually

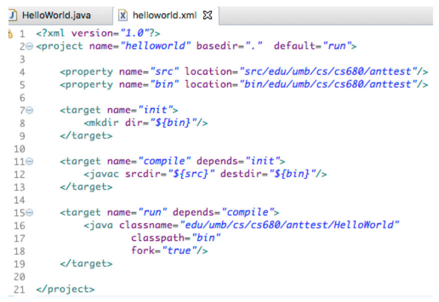
- I will simply type “ant” (on my shell) in the directory where your build.xml is located and see how your code works.
  - You can name your build script as you like.
    - No need to name it build.xml.
    - I will type: ant -f abc.xml
  - If the “ant” command fails, I will NOT grade your HW code.
- Fully automate configuration and compilation process to
  - speed up your configuration/compilation process.
  - remove potential human-made errors in your configuration/compilation process.
  - Make it easier for other people (e.g., code reviewers, team mates) to understand your code/project.

## Using Ant on a Shell.

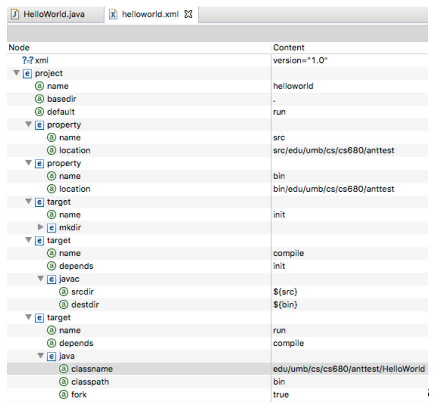
- If you download Ant from http://ant.apache.org/ and use it on a shell,
  - Use the ANT_HOME and PATH environment variables to specify the location of the “ant” command (e.g., ant.sh and ant.bat)
    - ANT_HOME
      - Reference the top directory of an Ant distribution
        - » e.g. Set ~/code/ant/apache-ant-1.9.7 to ANT_HOME
        - » e.g., Set ${ANT_HOME}/bin to PATH
    - c.f. http://ant.apache.org/manual/

## Ant in Eclipse

- You can use Ant that is available in your IDE (e.g. Eclipse).
  - However, I will run your build script on a shell.



```xml
<?xml version="1.0"?>
<project name="helloworld" basedir="."  default="run">

    <property name="src" location="src/edu/umb/cs/cs680/anttest"/>
    <property name="bin" location="bin/edu/umb/cs/cs680/anttest"/>

    <target name="init">
        <mkdir dir="${bin}"/>
    </target>

    <target name="compile" depends="init">
        <javac srcdir="${src}" destdir="${bin}"/>
    </target>

    <target name="run" depends="compile">
        <java classname="edu/umb/cs/cs680/anttest/HelloWorld"
                classpath="bin"
                fork="true"/>
    </target>

</project>
```



| Node | Content |
|---|---|
| ?-? xml | version="1.0" |
| project | |
| name | helloworld |
| basedir | . |
| default | run |
| property | |
| name | src |
| location | src/edu/umb/cs/cs680/anttest |
| property | |
| name | bin |
| location | bin/edu/umb/cs/cs680/anttest |
| target | |
| name | init |
| mkdir | |
| target | |
| name | compile |
| depends | init |
| javac | |
| srcdir | ${src} |
| destdir | ${bin} |
| target | |
| name | run |
| depends | compile |
| java | |
| classname | edu/umb/cs/cs680/anttest/HelloWorld |
| classpath | bin |
| fork | true |

## Expected Directory Structure

- Make “src” subdirectory under the top directory for a HW.
- Have build.xml generate “bin” subdirectory under the top directory, generate all binary files in there, and run your code by calling main()
- Place build.xml in the top directory.
- An example:
  - <top directory for a HW>

```
build.xml
src
    edu/umb/cs680/HelloWorld.java
    edu/umb/cs680/Umass.java
bin
    edu/umb/cs680/HelloWorld.class
    edu/umb/cs680/Umass.class
```

- Submit me an archive file (in .zip, .rar, .tar.gz, .7z, etc.) that contains build.xml and the “src” sub directory.
  - Email it to me at umasscs680@gmail.com, OR
  - Place it somewhere online (e.g. at G Drive) and email me a link to it.