SE 2AA4, CS 2ME3 (Introduction to Software Development)

Winter 2018

26 Specification Via UML (Ch. 5 and others)

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March 14, 2018

26 Specification Via UML (Ch. 5 and others)

- Administrative details
- Best specification technique?
- Designing spec of modules
- Interfaces in UML
  - Measurable interface
  - Multiple inheritance example
- Generic classes in UML
- Use cases with UML
- Sequence diagrams in UML

Administrative Details

- Who has skimmed the homework problem?
- Some delay likely in grading A2
- A3 deadlines
  - Part 1 - Specification: due 11:59 pm Mar 11
  - Part 2 - Code: due 11:59 pm Mar 20
- A4
  - Your own design and specification
  - Due April 3 at 11:59 pm
- Sources of slides
  - DataSet example based on Cay Horstmann, Big Java, John Wiley & Sons, 2002
  - Other UML examples from Stevens, Using UML, 2006
  - Ghezzi et al 2003

Best?

- What is the best software development tool?
- What is the most important software design principle?
- What is the best specification technique?

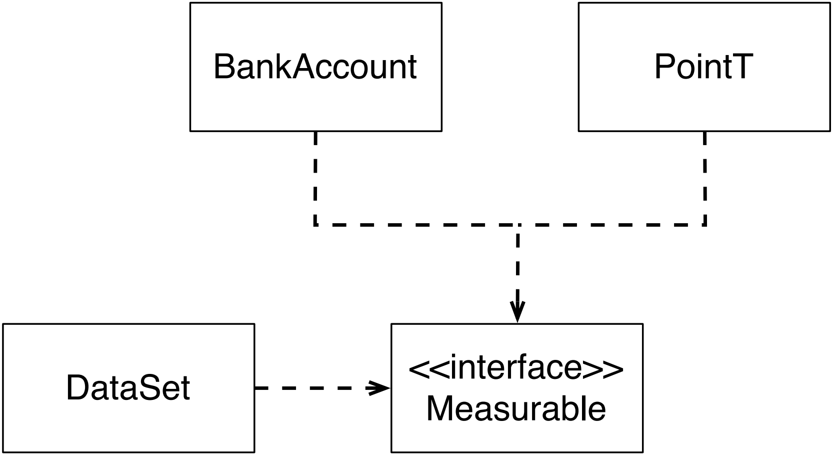
Best Continued

- What is the best programming language?
- What is the best engineering/scientific discipline?
- What is the best movie? video game?
- What is the best genre of music?
- What is the best food?

Deciding the Best Strategy For a Given Problem

- What is the approach at your company?
- Likely maintenance, so many decisions have likely been made.
- What tools/techniques/programming language etc. do you know?
- What can you afford in terms of cost/time?
- What tool is appropriate for the task at hand?
- What are the requirements?
  - Verifiability?
  - Maintainability?
  - Reusability?
  - etc.
- etc.

UML Diagram of Measurable Interface



- Realization arrow should have an outline triangle
- UML diagram can also show interface method names
- Realization arrow is like weak generalization (inheritance)

DataSet Without Interface I

```
public class DataSet
{
    private double sum;
    private double maximum;
    private int count;

    public DataSet()
    {
      sum = 0;
      count = 0;
      maximum = 0;
    }
    public void add(double x)
    {
```

DataSet Without Interface II

```
      sum = sum + x;
      if (count == 0 || maximum < x)
         maximum = x;
      count++;
    }
    public double getAverage()
    {
      if (count == 0) return 0;
      else return sum/count;
    }
    public double getMaximum()
    { return maximum;
    }
}
```

PointT I

```
import static java.lang.Math.*;
public class PointT {
    private double xc;
    private double yc;
    public PointT(double x, double y) {
      xc = x;
      yc = y;}
    // ..
    public double distToOrigin() {
      return sqrt(pow(xc,2.0) +
         pow(yc,2.0));
    }
}
```

DataSet for Points I

```
public class DataSetPoint
{
   private double sum;
   private PointT maximum;
   private int count;
   public DataSetPoint()
   { sum = 0;
     count = 0;
     maximum = null;
   }
   public void add(PointT x)
   {
     sum = sum + x.distToOrigin();
```

DataSet for Points II

```
      if (count == 0 ||
        maximum.distToOrigin() <
        x.distToOrigin()) maximum = x;
      count++;
    }
    public double getAverage()
    { if (count == 0) return 0;
      else return sum/count;
    }
    public PointT getMaximum()
    {
      return maximum;
    }
  }
```

Bank Account Class I

```java
public class BankAccount
{
    private double balance;

    public BankAccount()
    { balance = 0;}
    public void deposit(double amount)
    { balance = balance + amount;}
    public void withdraw(double amount)
    { balance = balance − amount;}
    public double getBalance()
    { return balance;}
}
```

DataSet for Bank Accounts I

```
public class DataSetBankAccount
{
   private double sum;
   private BankAccount maximum;
   private int count;

   public DataSetBankAccount()
   {
     sum = 0;
     count = 0;
     maximum = null;
   }
   public void add(BankAccount x)
   {
```

DataSet for Bank Accounts II

```
      sum = sum + x.getBalance();
      if (count == 0 ||
          maximum.getBalance() <
          x.getBalance()) maximum = x;
      count++;
    }
    public double getAverage()
    { if (count == 0) return 0;
      else return sum/count;
    }
    public BankAccount getMaximum()
    { return maximum;
    }
}
```

Measurable Interface I

```
public interface Measurable
{
  double getMeasure();
}
```

Data Set with Measurable Interface I

```
public class DataSetInterface
{
    private double sum;
    private Measurable* maximum;
    private int count;

    public DataSetInterface()
    {
      sum = 0;
      count = 0;
      maximum = null;
    }
    public void add(Measurable x)
    {
```

Data Set with Measurable Interface II

```
      sum = sum + x.getMeasure();
      if (count == 0 ||
         maximum.getMeasure() <
         x.getMeasure()) maximum = x;
      count++;
    }
    public double getAverage()
    { if (count == 0) return 0;
      else return sum/count;
    }
    public Measurable getMaximum()
    { return maximum;
    }
 }
```

PointT with Measurable Interface I

```
import static java.lang.Math.*;
public class PointTInterface implements
   Measurable
{
   private double xc;
   private double yc;
   public PointTInterface(double x, double
       y) {
     xc = x;
     yc = y;
   }
   //..
   public double distToOrigin() {
```

PointT with Measurable Interface II

```
      return sqrt(pow(xc,2.0) +
         pow(yc,2.0));
    }
    public double getMeasure(){
      return distToOrigin();
    }
  }
```

Bank Account with Measurable Interface I

```
public class BankAccountInterface
   implements Measurable
{   private double balance;
    public BankAccountInterface()
    { balance = 0;
    }
    //..
    public double getBalance()
    { return balance;
    }
    public double getMeasure()
    { return balance;}
}
```

Using DataSet I

```
public class DataSetTest
{  public static void main(String[] args)
   { DataSetInterface bankData = new
      DataSetInterface();
     bankData.add(new
        BankAccountInterface());
     BankAccountInterface b = new
        BankAccountInterface();
     b.deposit(134.56);
     bankData.add(b);
     System.out.println(”Average balance =
        ” + bankData.getAverage());
     Measurable max =
        bankData.getMaximum();
```

Using DataSet II

```
System.out.println("Highest balance =
   " + max.getMeasure());
DataSetInterface pointData = new
   DataSetInterface();
pointData.add(new
   PointTInterface(1.0, 1.0));
pointData.add(new
   PointTInterface(2.0, 2.0));
pointData.add(new
   PointTInterface(3.0, 3.0));
System.out.println("Average distance
   to origin = " +
   pointData.getAverage());
max = pointData.getMaximum();
```

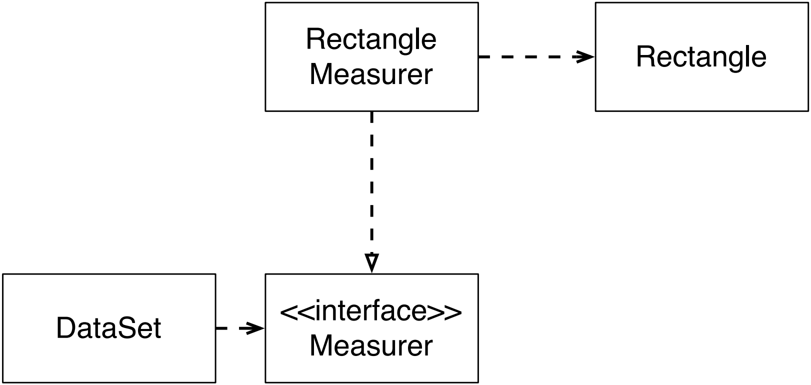
Using DataSet III

```
        System.out.println("Greatest distance
           to origin = " + max.getMeasure());
    }
}
```

Interface Strategy

- There are limitations to the Measurable interface
  - You can only add a Measurable interface to classes that you control
  - You can measure an object in only one way
- Move responsibility for measuring outside of objects themselves
- Have another object carry out the comparison
- Introduce a Measurer interface

UML Diagram of Measurer Interface



- Rectangle is part of Class java.awt
- You cannot change it

Measurer Interface I

```
public interface Measurer
{
  double measure(Object anObject);
}
```

Data Set with New Strategy I

```
public class DataSetStrategy
{   private double sum;
    private Object maximum;
    private int count;
    private Measurer measurer;
    public DataSetStrategy(Measurer
        aMeasurer)
    { sum = 0;
      count = 0;
      maximum = null;
      measurer = aMeasurer;
    }
    public void add(Object x)
    {
```

Data Set with New Strategy II

```
        sum = sum + measurer.measure(x);
        if (count == 0 ||
            measurer.measure(maximum) <
            measurer.measure(x)) maximum = x;
        count++;
    }
    public double getAverage()
    { if (count == 0) return 0;
        else return sum/count;
    }
    public Object getMaximum()
    { return maximum;
    }
}
```

Rectangle Measurer I

```java
import java.awt.Rectangle;
class RectangleMeasurer implements Measurer
{
   public double measure(Object anObject)
   {
      Rectangle aRectangle = (Rectangle)
         anObject;
      double area = aRectangle.getWidth() *
         aRectangle.getHeight();
      return area;
   }
}
```

Using Rectangle Measurer I

```
import java.awt.Rectangle;
public class DataSetStrategyTest
{
   public static void main(String[] args)
   {
      class RectangleMeasurer implements
         Measurer
      {
         public double measure(Object
            anObject)
         {
            Rectangle aRectangle =
               (Rectangle) anObject;
```

Using Rectangle Measurer II

```
    double area =
       aRectangle.getWidth() *
       aRectangle.getHeight();
    return area;
  }
}
Measurer m = new RectangleMeasurer();
DataSetStrategy data = new
   DataSetStrategy(m);
data.add(new Rectangle(5, 10, 20,
   30));
data.add(new Rectangle(10, 20, 30,
   40));
System.out.println("Average area = "
   + data.getAverage());
```

Using Rectangle Measurer III

```
        Rectangle max = (Rectangle)
           data.getMaximum();
        System.out.println("Maximum area = "
           + m.measure(max));
    }
}
```

Comparable Versus Comparator

- Comparable similar UML diagram to Measurable
- Comparator similar UML diagram to Measurer

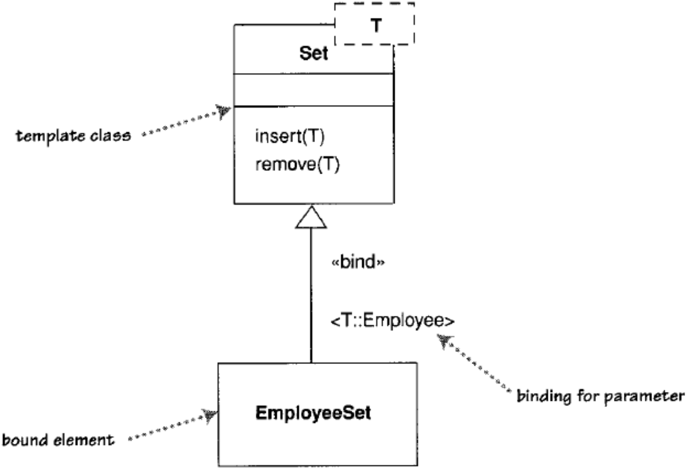
```
public interface Comparable<T>
{
    int compareTo(T obj);
}

public interface Comparator<T>
{
    public int compare(T obj1, T obj2);
}
```

Interface Versus Abstract

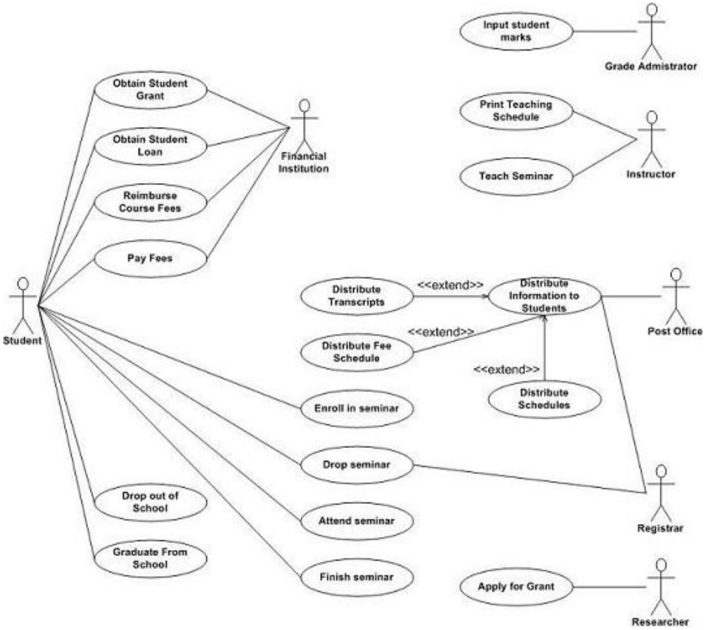
- What is the difference between an interface and an abstract class?

- Interface
  - Methods are implicitly abstract and public
  - Methods can have default implementation (JDK 8)
  - Cannot have constructors
  - Variables are final
  - Can only extend interfaces
  - Classes can extend multiple instances
  - Appropriate for unrelated classes
- Abstract class
  - At least one method is declared as abstract
  - Some methods can implement a default behaviour
  - Cannot instantiate them, but can have constructors
  - Variables are not necessarily final
  - Can extend other class
  - Can implement multiple interfaces
  - Classes can extend only one abstract class
  - Sharing code between closely related classes

UML Diagram for Generic Classes



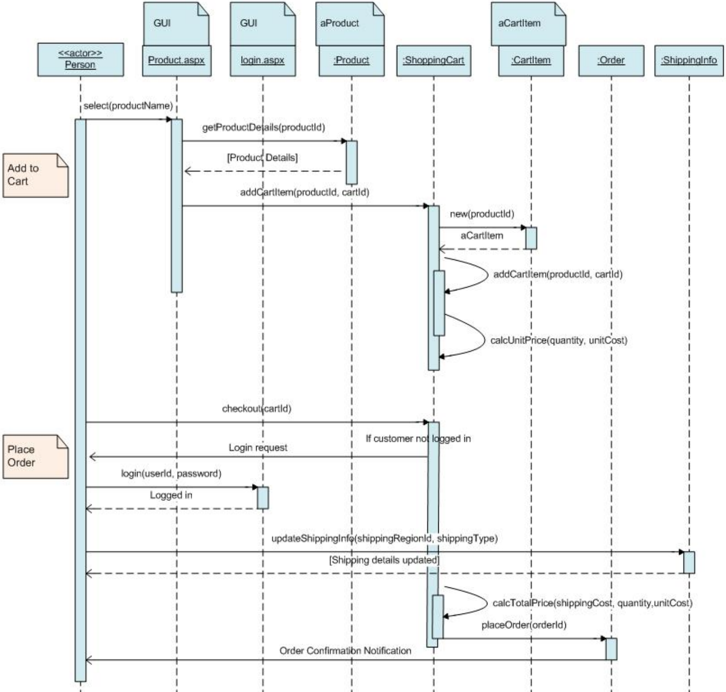
UML Class Diagram Template



UML 2 Use Case Diagrams: An Agile Introduction

Use Cases

- Often used for capturing requirements
- From user's (actor's) viewpoint
  - Person
  - Other system
  - Hardware
  - etc. (anything external
- Each circle is a use case
- Lines represent possible interactions
- An actor represents a role, individuals can take on different roles


GUI
GUI
aProduct
aCartItem
<<actor>>
Person
Product.aspx
login.aspx
:Product
:ShoppingCart
:CartItem
:Order
:ShippingInfo
select(productName)
getProductDetails(productId)
Add to Cart
[Product Details]
addCartItem(productId, cartId)
new(productId)
aCartItem
addCartItem(productId, cartId)
calcUnitPrice(quantity, unitCost)
checkout(cartId)
If customer not logged in
Place Order
Login request
login(userId, password)
Logged in
updateShippingInfo(shippingRegionId, shippingType)
[Shipping details updated]
calcTotalPrice(shippingCost, quantity,unitCost)
placeOrder(orderId)
Order Confirmation Notification

Sequence Diagram Question

- Is a sequence diagram an operational or a descriptive specification?
- If objects exchange a message, should there be an association between their classes?

Sequence Diagrams

- Represents a specific use case scenario
- How objects interact by exchanging messages
- Time progresses in the vertical direction
- The vertically oriented boxes show the object's lifeline