HEAP HELP SESSION

OVERVIEW

- Java Generics
- Comparators
- Project Structure
  - NDS4
- Exceptions
- Junit Testing

JAVA GENERICS

You may have noticed syntax like '`Position<E>`' and '`MyHeapEntry<K, V>`' in the stencil and wondered what the `E`, `K` and `V` are …

These are called ***generic*** types, and are essentially placeholders for some actual Java object (like a `String`, or an `Integer`) that a `Position` or heap `Entry` would hold.

`E`, `K` and `V` are three of the most conventional type parameter names. They represent the following: **E**lement, **K**ey, and **V**alue.

WHY *GENERICS*?

They make your classes more flexible because you can reuse the class to store different type objects.

Imagine if the Java makers implemented an `ArrayList` that can only hold `String`s:

```
public class ArrayList {
     public ArrayList {
          // constructor
     }
     public String add(String s) {
          // some code to add string to list
     }
}
```

Now we have an `ArrayList` whose `add()` method can only take in a `String` object.

WHAT ABOUT THINGS BESIDES STRINGS?

But what if I wanted a list of Integers? Booleans? Boxes? Tetris pieces?

We'd have to write a *new* class `ArrayList` whose `add()` method would take in *that* type of object.

So one solution is defining the `add()` method as:

```
public Object add(Object obj) {
        // code to add object to the list
}
```

Since we know that `Object` is a superclass of every Java class, we can now add any type to our list.

Do you foresee any problems with this?

WHAT ABOUT THINGS BESIDES STRINGS?

Here's an example of our 'extensible' `ArrayList`:

```
ArrayList a = new ArrayList();
a.add("hello");
a.add(9578);
a.add(new ArrayList());
a.add(new Comparator());
a.add(3.1459);
```

Now do you see a problem?

If you wanted a list of just one specific type, this polymorphic implementation has no way of enforcing that type-checking. Which is why we use …generics!

SOLUTION WITH GENERICS!

```
public class ArrayList<E> {
      public ArrayList() {
          // constructor code
      }
      public E add(E element) {
          // code to add element to list
     }
}
```

Now how can we use this list? Say I wanted a list of `int`s, I can use this list:

```
ArrayList<Integer> a = new ArrayList<>();
a.add(1);
a.add(2);
a.add(99999);
```

SOLUTION WITH GENERICS!

But what if I now did `a.add("hello")`?

The compiler would complain because my list was instantiated to only hold `int`s.

Now we have an extensible list implementation that can hold any object type, but we limited that extensibility to creation time, so we can enforce type checking on one instance of the list.

SUMMARY OF GENERICS

Remember to implement classes and methods with generic types.

```
public class MyClass<E> {
        public MyClass() {
            //Constructor
        }
}
```

But instantiate them and call methods on specific types.

```
MyClass<String> theBestObject = new MyClass<>();
```

Hooray for generics!

COMPARATORS

In the handout, you are told to use a `Comparator` to compare the values in the heap.

….so what is a `Comparator`?

It defines and enforces an ordering of things that don't have an intuitive ordering (like `Integer`s do).

So you could order `String`s using a `Comparator`.

A `Comparator` is passed into an instance of `MyHeap` through the constructor.

HOW DO I USE A COMPARATOR?

Comparator is an interface

Aside: What is an interface?

That means every Comparator has the following method:

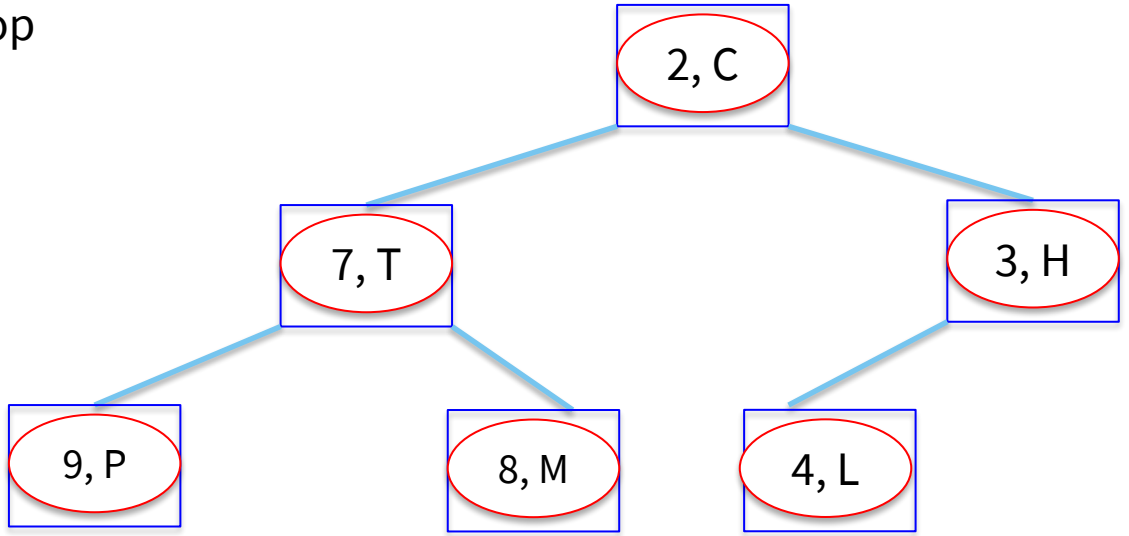
```
//Input: Two objects to compare to each other
//Output: A negative int if o1 < o2
                Zero if o1 = o2
                A positive int if o1 > o2
public int compare(Object o1, Object o2) {}
```

The Comparator defines what it means to be <, =, and > something

LET'S GET TO HEAP

What is it?

- Minimum key on top
- Binary structure
- Left complete



HOW DO WE MAKE IT?

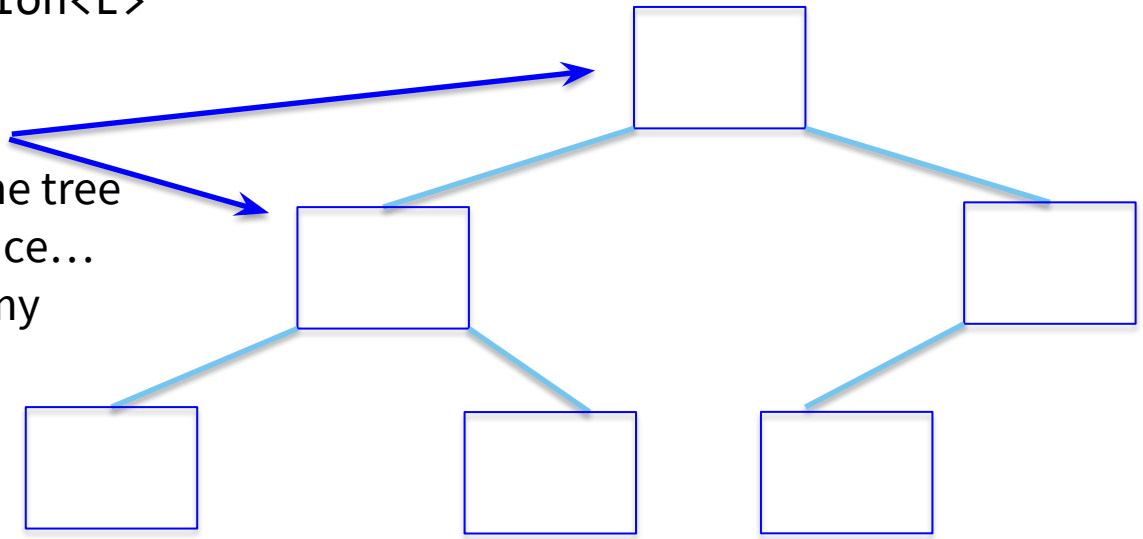
A binary tree!

`LinkedBinaryTree<E>`

Made up of `Position<E>`

These are `Position`s

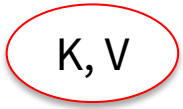
- Make up the structure of the tree
- But `Position` is an interface…
- If the number of nodes in my tree changes, I need to add/remove these



BUT THAT'S NOT A HEAP YET…

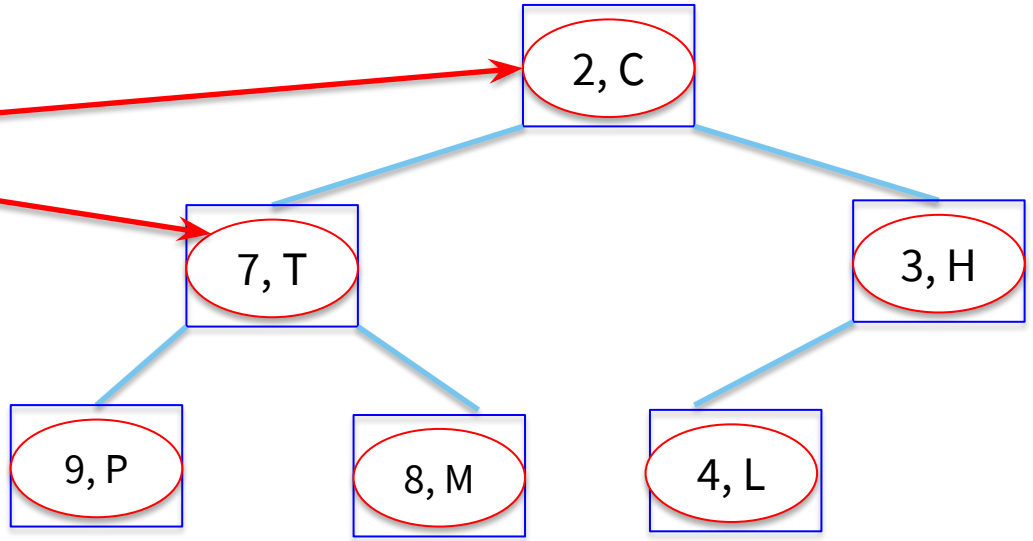
A heap has key/value pairs

`Entry<K, V>`



These are `Entry`s

- Maintain the data of the tree
- If I want to organize the tree, or add/remove data from the tree, I have to deal with these
- But `Entry` is an interface…



WHAT DO I HAVE TO WRITE?

`MyHeap<K, V>`

//next page

`MyLinkedHeapTree<E>`

- Extends NDS4 `LinkedBinaryTree<E>`
- The skeleton of your heap
- Where you want to deal with constant time adding/removing nodes from the structure of the tree
  - Your `Deque` (we'll talk about this in section next week!)

`MyHeapEntry<K, V>`

-Implements NDS4 `Entry<K, V>`

-Stores its key and value… anything else?

NDS4!

What is it?

- Your  for CS16 Java projects!

- "net.datastructures”
- A bunch of helpful classes, interfaces, and libraries to help you succeed in all of your endeavors

NDS4 FOR HEAP!

Let's say I want to use a Deque

Wait! It's an interface? I can't make one of those…

net.datastructures

Interface Deque<E>

All Known Subinterfaces:

Sequence<E>

Never Fear! "All Known Implementing Classes" is here!

All Known Implementing Classes:

NodeDeque

NDS4 FOR HEAP!

`LinkedBinaryTree<E>` -- class

`Position<E>` -- interface

- Hint: What kind of `Position`s does `LinkedBinaryTree` use?

`Entry<K, V>` - interface

`Deque<E>` - interface

EXCEPTIONS!

Throughout the project, it is your job to handle what can go wrong and handle the cases appropriately.

This can take a few forms, but the main cases are **raising** and **catching** exceptions.

Note that we mention in the handout and stencil when we require you to handle exceptions

EXCEPTIONS - RAISING VS. CATCHING

Raising (aka throwing)

You want to raise an exception when you are within a method and know something can go wrong. The exception notifies the calling method that an error occurred.

Example: Getting the min of an empty priority queue

Catching

You want to catch an exception when you are calling a method that raises an exception, and you want to intercept that error and act appropriately.

Example: A user-controlled system that reports the value of a priority queue, and the queue itself is empty

RAISING EXCEPTIONS- SYNTAX

```
public class PriorityQueue<K,V>{
     private V _min;
     //other methods elided
          //assumes somewhere we have a definition of EmptyQueueException

     public V min(){
               if (this.isEmpty()){
                    throw new EmptyQueueException("Can't get the min of an empty
    PQ!");
               }
          return _min;
          }
}
```

*No need for `else` case here, since exceptions stop the running of the method.

CATCHING EXCEPTIONS – SYNTAX

```
public class QueueReporter{
    private PriorityQueue<int, String> _pq;

    //other methods elided

    public void reportMin() {
        try {
            System.out.println("The current min is " + _pq.min();
        } catch(EmptyQueueException e) {
            System.out.println("The queue is currently empty.");
        }
    }
}
```

- If you care about the details of the exception beyond type, that info is contained in the variable **e**
- This is just an example to show the syntax. In this case, it might just be smarter to check the size of PQ

EXCEPTIONS - NOTES

You can have multiple catch blocks to handle different exceptions.

- The syntax is what you might expect:

```
public void someMethod() {
    try {
            //some code
    } catch(ExceptionType1 e1) {
        System.out.println(“12345”);
    } catch(ExceptionType2 e2) {
        System.out.println(“ABCDE”);
    }
}
```

This code prints 12345 if the code in the try block throws an error of type `ExceptionType1` and ABCDE if the exception is of type `ExceptionType2`

EXCEPTIONS – NOTES (2)

Since all exceptions are subclasses of `Exception`, putting `Exception` as the type in the `catch` block will catch any exception

- In general this is not a good idea. You generally don't want to just accept that something failed and sweep it under the rug, you want to do something with the error!

```
public void verySensitiveMethod(){
     Person recipient = this.getNemesis(); // just a placeholder, going to change
     try{
          this.replaceWithActualRecipient(recipient); // can fail to reset
          } catch(Exception e) {
               System.out.println("Uh oh!");
          }
     this.sendLotsOfMoney(recipient);
}
```

If you know the type of exception, you may know whether it is ok to proceed with sending the money.

EXCEPTIONS – NOTES (3)

In addition to **`try`** and **`catch`**, there is also a very important third kind of block, the **`finally`** block

- Just like the name says, it should happen after everything else. In fact, it happens whether or not the exception was caught. It **always** happens when a try block exits.

```
public void fileIOMethod(){
    try {
            //error-prone file operations
    } catch(IOException e) {
        //notify user that something went wrong
    } finally {
        //close up files and other resources
    }
}
```

- This way, the resources are closed up even if the exception is not an `IOException`
- However, if it is an `IOException`, perhaps we can handle it better

JUNIT TESTING!

- The reason for JUnit testing is to test individual parts of your program, ensuring that each component functions correctly.
- This is extremely useful, because as the size of projects grows – the more impact it has – the more time needs to be spent testing, as even small failures can be problematic!
- We've provided you with a JUnit Test file with some example tests. You are required to add you own tests in order to fully cover your code!
- It is convention to name the test file `<name of class>Test.java`

JUNIT TESTING (2)

```
public class MyHeapTest {

  /**
   * A simple test to ensure that insert() works.
   */
  @Test
  public void testInsertOneElement() {
    // set-up
    MyHeap<Integer, String> heap = new MyHeap<Integer, String>(new IntegerComparator());
    heap.insert(1, "A");

    // Assert that your data structure is consistent using
    // assertThat(actual, is(expected))
    assertThat(heap.size(), is(1));
    assertThat(heap.min().getKey(), is(1));
  }
```

Don’t forget to include this tag!

JUNIT TESTING (3)

Use this format to test throwing exceptions!

```
@Test(expected = EmptyTreeException.class)
public void testRemoveThrowsEmptyTreeException() {
  MyLinkedHeapTree<Integer> tree = new MyLinkedHeapTree<Integer>();
  tree.remove();
}
```

YOU CAN DO IT!

(BUILD SOMETHING OUT OF THIS WORLD!)