CSE 143

Computer Programming II

Stacks & Queues

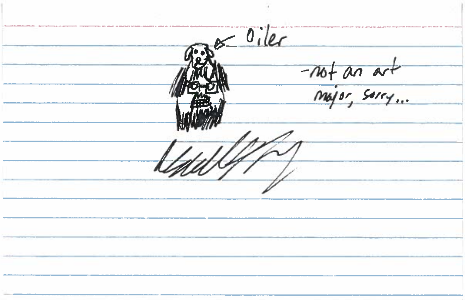
Why do Computer Scientists come up with their own definitions for common words?

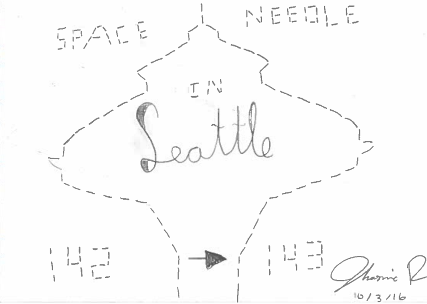
List, Tree, Type, Class, Bug, Escape

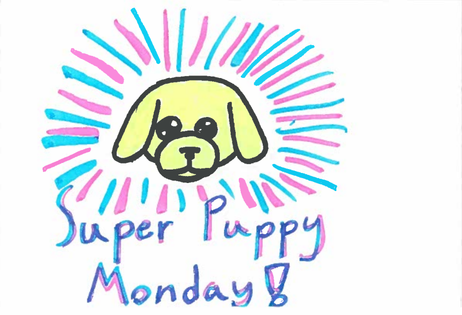
To make a list of the types of bugs escaping up the tree. Classy.

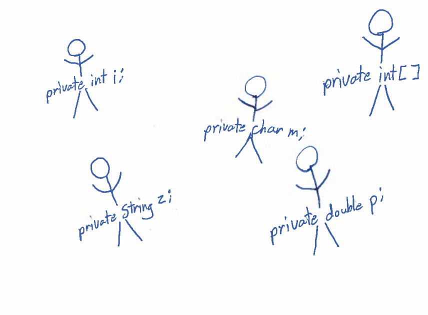
Questions From Last Time

Drawings


Oiler
-not an art major, sorry...

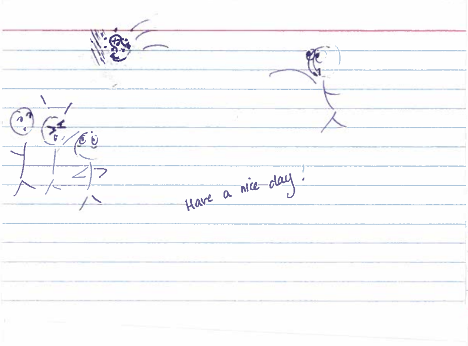

SPACE NEEDLE
IN
Seattle
142
143
10/3/16


Super Puppy Monday!

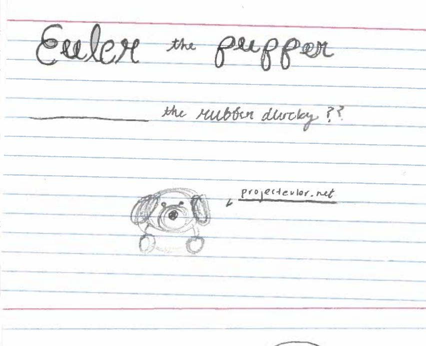

private int i;
private char m;
private int[]
private String z;
private double p;

CSE 143 to the rescue!
Help me Super Adam!
Faster than a speeding For-Loop!
Stronger than the most unbreakable code!
He can leap to the end of a method in a single bound...
It's Super Adam!

Home to the most houses on earth and broken legs.
Welcome to
NULLPOINTER
It's a nice town.



Have a nice day!



Euler the pupper
the rubber ducky ??
projecteuler.net

What Are We Doing Again?

What Are We Doing. . . ?

We're learning some new data structures (we're going to be the client of them!).

Today's Main Goals:

- Finish up last time
- To understand the difference betweeen an interface and an implementation
- To understand what stacks and queues are

We'd like to have two constructors for `ArrayIntList`:

- One that uses a default size
- One that uses a size given by the user

Redundant Constructors

```java
/* Inside the ArrayIntList class... */
public ArrayIntList() {
   this.data = new int[10];
   this.size = 0;
}

public ArrayIntList(int capacity) {
   this.data = new int[capacity];
   this.size = 0;
}
```

This is a lot of redundant code! How can we fix it?

Fixed Constructor

Java allows us to call one constructor from another using `this(...)`:

```java
public ArrayIntList() {
   this(10);
}
```

Looking back at the constructor, what's ugly about it?

```
public ArrayIntList() {
   this(10);
}
```

The 10 is a "magic constant"; this is really bad style!! We can use:

`public static final` **type name** = **value**

to declare a **class constant**.

So, for instance:

`public static final int DEFAULT_CAPACITY = 10.`

Class CONSTANT

A class constant is a **global**, **unchangable** value in a class. Some examples:

- `Math.PI`
- `Integer.MAX_VALUE`, `Integer.MIN_VALUE`
- `Color.GREEN`

Outline

1. Interfaces
2. Queues
3. Stacks

Abstract Data Types (ADT)

Abstract Data Type

An **abstract data type** is a description of what a collection of data **can do**. We usually specify these with **interfaces**.

`List` ADT

In Java, a **List** can `add`, `remove`, `size`, `get`, `set`.

`List` Implementations

An **ArrayList** is a particular type of List. Because it is a list, we promise it can do everything a List can. A **LinkedList** is another type of List.

Even though we don't know how it works, we know it can do everything a List can, **because it's a List**.

This is INVALID CODE

```
List<String> list = new List<String>(); // BAD : WON'T COMPILE
```

`List` is a description of methods. It doesn't specify **how they work**.

This Code Is Redundant

```
ArrayList<Integer> list = new ArrayList<Integer>();
list.add(5);
list.add(6);

for (int i = 0; i < list.size(); i++) {
   System.out.println(list.get(i));
}

LinkedList<Integer> list = new LinkedList<Integer>();
list.add(5);
list.add(6);

for (int i = 0; i < list.size(); i++) {
   System.out.println(list.get(i));
}
```

We can't condense it any more when written this way, because `ArrayList` and `LinkedList` are totally different things.

NOT Using the List ADT

Instead, we can use the List interface and swap out different implementations of lists:

This Uses Interfaces Correctly!

```
List<Integer> list = new ArrayList<Integer>();
                // = new LinkedList<Integer>();
                // We can choose which implementation
                // And the code below will work the
                // same way for both of them!
list.add(5);
list.add(6);

for (int i = 0; i < list.size(); i++) {
   System.out.println(list.get(i));
}
```

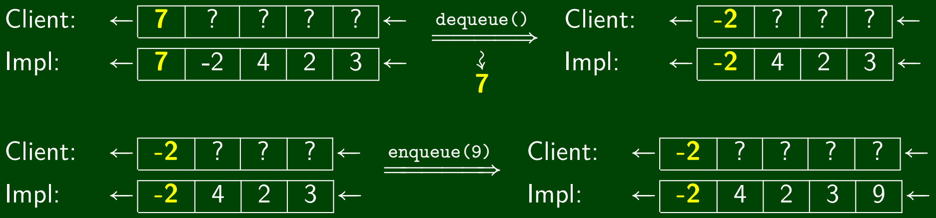
The other benefit is that the code doesn't change based on which implementation we (or a client!) want to use!

Queue

Real-world queues: a service line, printer jobs

A **queue** is a collection which orders the elements first-in-first-out ("FIFO"). Note that, unlike lists, queues **do not have indices**.

- Elements are stored internally in order of insertion.
- Clients can ask for the first element (**dequeue**/**peek**).
- Clients can ask for the size.
- Clients can add to the back of the queue (**enqueue**).
- Clients **may only see the first element of the queue**.



Applications Of Queues

- Queue of print jobs to send to the printer
- Queue of programs / processes to be run
- Queue of keys pressed and not yet handled
- Queue of network data packets to send
- Queue of button/keyboard/etc. events in Java
- Modeling any sort of line
- Queuing Theory (subfield of CS about complex behavior of queues)

Queue Reference

Queue is an interface. So, you create a new Queue with:

```
Queue<Integer> queue = new LinkedList<Integer>();
```

enqueue(**val**)	Adds **val** to the back of the queue
dequeue()	Removes the first value from the queue; throws a NoSuchElementException if the queue is empty
peek()	Returns the first value in the queue without removing it; throws a NoSuchElementException if the queue is empty
size()	Returns the number of elements in the queue
isEmpty()	Returns true if the queue has no elements

A queue seems like what you get if you take a list and **remove** methods.

Well. . . yes. . .

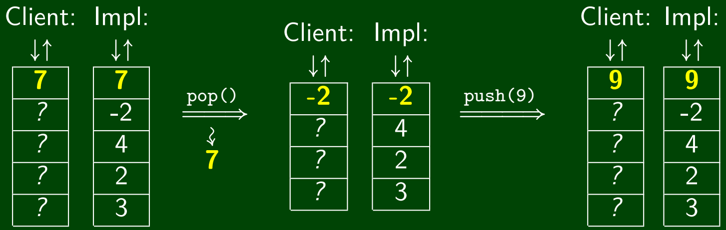
- This prevents the client from doing something they shouldn't.
- This ensures that all valid operations are fast.
- Having fewer operations makes queues easy to reason about.

Stack

Real-world stacks: stock piles of index cards, trays in a cafeteria

A **stack** is a collection which orders the elements last-in-first-out ("LIFO"). Note that, unlike lists, stacks **do not have indices**.

- Elements are stored internally in order of insertion.
- Clients can ask for the top element (**pop**/**peek**).
- Clients can ask for the size.
- Clients can add to the top of the stack (**push**).
- Clients **may only see the top element of the stack**



Applications of Stacks

- Your programs use stacks to run:

  (pop = return, method call = push)!

```
public static fun1() {
   fun2(5);
}
public static fun2(int i) {
   return 2*i; //At this point!
}
public static void main(String[] args) {
   System.out.println(fun1());
}
```

Execution:

↓↑

fun2
fun1
main

- Compilers parse expressions using stacks
- Stacks help convert between infix (3 + 2) and postfix (3 2 +). (This is important, because postfix notation uses fewer characters.)
- Many programs use "undo stacks" to keep track of user operations.

Stack is an interface. So, you create a new Stack with:

```
Stack<Integer> stack = new Stack<Integer>();
```

Stack<E>()	Constructs a new stack with elements of type **E**
push(**val**)	Places **val** on top of the stack
pop()	Removes top value from the stack and returns it; throws NoSuchElementException if stack is empty
peek()	Returns top value from the stack without removing it; throws NoSuchElementException if stack is empty
size()	Returns the number of elements in the stack
isEmpty()	Returns true if the stack has no elements

Stack Reference

Back to `ReverseFile`

Consider the code we ended with for `ReverseFile` from the first lecture:

Print out words in reverse, then the words in all capital letters

```java
ArrayList<String> words = new ArrayList<String>();

Scanner input = new Scanner(new File("words.txt"));
while (input.hasNext()) {
   String word = input.next();
   words.add(word);
}

for (int i = words.size() - 1; i >= 0; i--) {
   System.out.println(words.get(i));
}
for (int i = words.size() - 1; i >= 0; i--) {
   System.out.println(words.get(i).toUpperCase());
}
```

We used an `ArrayList`, but then we printed in reverse order. A `Stack` would work better!

ReverseFile with Stacks

This is the equivalent code using Stacks instead:

Doing it with Stacks

```
Stack<String> words = new Stack<String>();

Scanner input = new Scanner(new File("words.txt"));

while (input.hasNext()) {
   String word = input.next();
   words.push(word);
}

Stack<String> copy = new Stack<String>();
while (!words.isEmpty()) {
   copy.push(words.pop());
   System.out.println(words.peek());
}

while (!copy.isEmpty()) {
   System.out.println(copy.pop().toUpperCase());
}
```

You may NOT use get on a stack!

```
Stack<Integer> s = new Stack<Integer>();
for (int i = 0; i < s.size(); i++) {
   System.out.println(s.get(i));
}
```

`get`, `set`, etc. are **not valid stack operations**.

Instead, use a `while` loop

```
Stack<Integer> s = new Stack<Integer>();
while (!s.isEmpty()) {
   System.out.println(s.pop());
}
```

Note that as we discovered, the `while` loop **destroys the stack**.