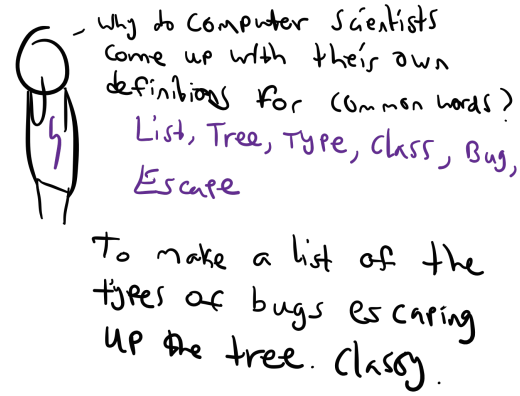
CSE 143

Computer Programming II

Stacks & Queues



Questions From Last Time

- Can we include implementation details in the inside comments? **Yes, but not in the method headers.**
- When do I use static methods? **If you want to write a method that doesn't use a particular instance of the class, it should be static**

```
// This method doesn't use a particular instance; it is a property
// that all the instances share
public static int numberOfArrayListsCreated() {}

// This is a property of a particular instance. For example,
// the max of [1,2,3] is 3, but the max of [1, 1, 1] is 1.
public int max() {}
```

- Are we going to be given index cards every day? **Pretty much. Yes, I'm aware of the trees.**
- What if I'm completely lost in lecture? **Come to office hours; I'm happy to explain the entire lecture again. Also, raise your hand for clarifications!**
- I didn't have enough space to answer all the questions that were asked. Feel free to come up afterwards/at office hours to get the other questions answered.

Drawings

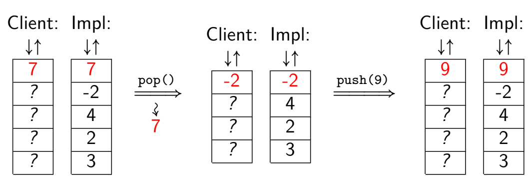
TODO

Stacks

Stack

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**



Okay; Wait; Why?

A stack 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.
  - add(**idx**, **val**): $\mathcal{O}(n)$
  - remove(**idx**): $\mathcal{O}(n)$
  - push(**val**): $\mathcal{O}(1)$
  - pop(): $\mathcal{O}(1)$
- Having Fewer operations makes stacks easy to reason about.

Applications of Stacks 5

- 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
5
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 Reference 6

`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 `EmptyStackException` if stack is empty
`peek()`	Returns top value from the stack without removing it; throws `EmptyStackException` if stack is empty
`size()`	Returns the number of elements in the stack
`isEmpty()`	Returns true if the stack has no elements

In Java, `Stack` has other methods. **YOU MAY NOT USE THEM.** The Java `Stack` class allows you to call methods that are not part of standard stacks; they are also inefficient.

Stack Reference

Back to `ReverseFile` 7

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

Print out words in reverse, then WORDS IN REVERSE

```
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` 8

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());
}
```

Illegal Stack Operations 9

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.

Abstract Data Types (ADT) 10

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**.

Using the List ADT

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));
}
```

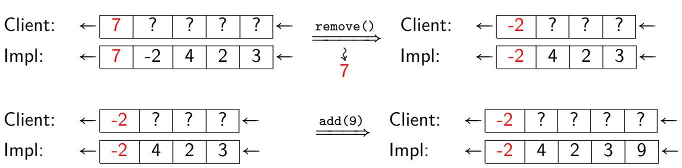
The other benefit is that the code doesn't change based on which implementation we (or a client!) want to use!

Queues

Queue

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 (**remove**/**peek**).
- Clients can ask for the size.
- Clients can add to the back of the queue (**add**).
- 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>();
```

`add(`**val**`)`	Adds **val** to the back of the queue
`remove()`	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; returns `null` if the queue is empty
`size()`	Returns the number of elements in the queue
`isEmpty()`	Returns true if the queue has no elements

Queue Reference

War (the card game)

War is played with a standard 52 card deck.

1. The deck is shuffled.
2. The deck is completely dealt out among players.
3. Both players place down a card.
4. If the cards have equal value, go back to step 3. Otherwise, the player with the higher card appends all the cards to her deck.
5. Play continues until someone runs out of cards.

Let's Write Code for War!