CSE 143X

Accelerated Computer Programming I/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.

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:

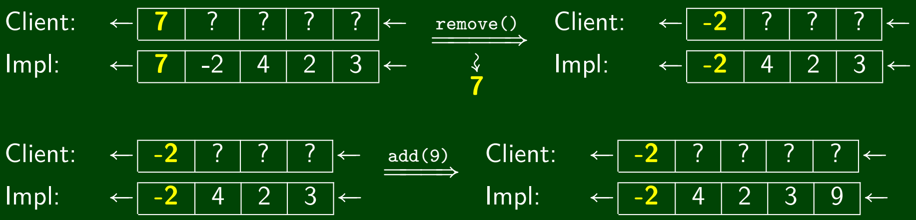
- To understand what stacks and queues are
- To understand the difference betweeen an interface and an implementation

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 (**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

Okay; Wait; Why?

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.

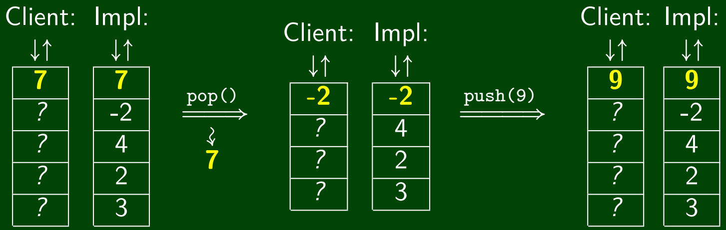
Stacks

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)!

```java
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 **NOT** 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 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

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

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

```
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());
}
```

Illegal Stack Operations

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**.