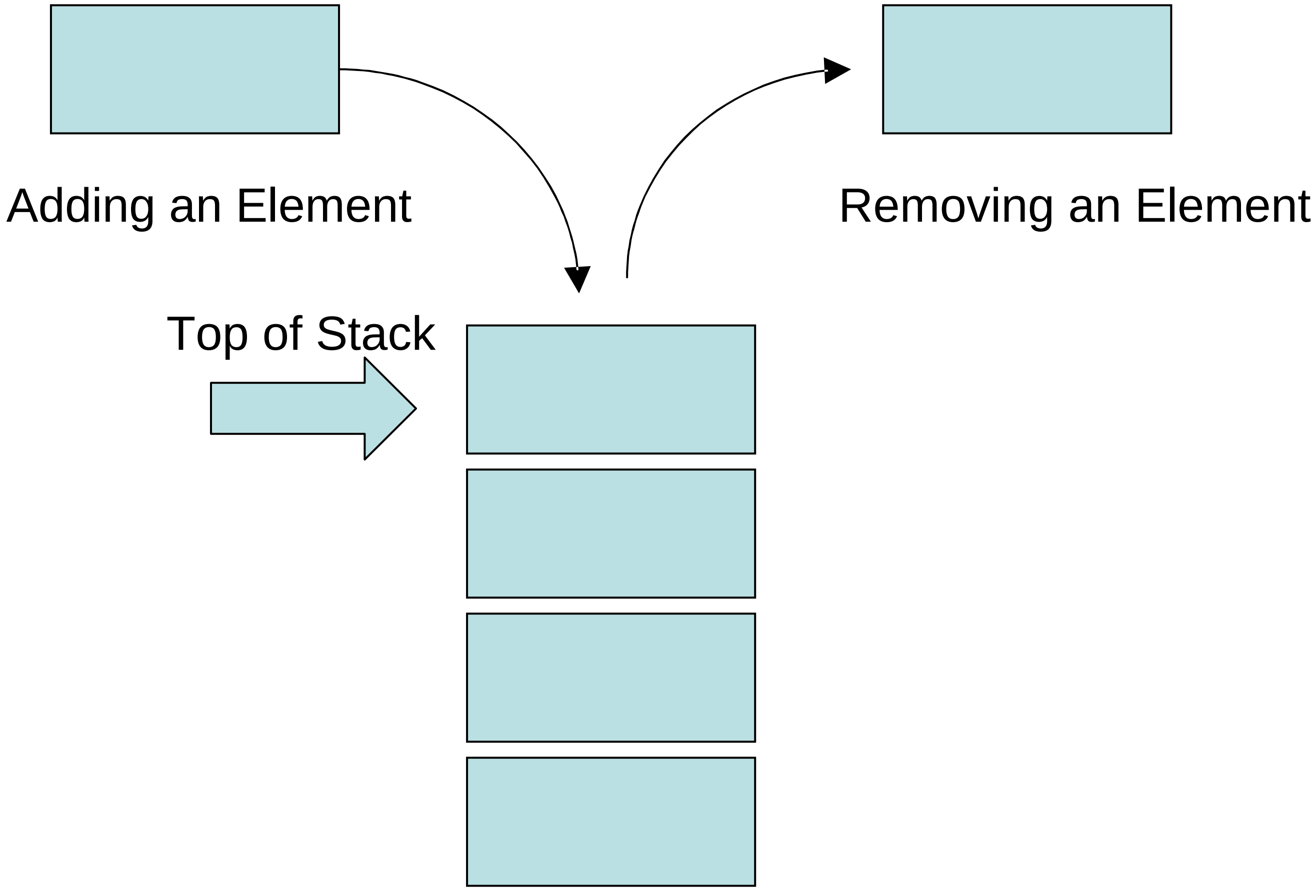
Stacks

- Stack Abstract Data Type (ADT)
- Stack ADT Interface
- Stack Design Considerations
- Stack Applications
- Evaluating Postfix Expressions
- Introduction to Project 2
- Reading: L&C Section 3.2, 3.4-3.8

Stack Abstract Data Type

- A *stack* is a linear collection where the elements are added or removed from the same end
- The processing is *last in, first out (LIFO)*
- The last element put on the stack is the first element removed from the stack
- Think of a stack of cafeteria trays

A Conceptual View of a Stack



Stack Terminology

- We *push* an element on a stack to add one
- We *pop* an element off a stack to remove one
- We can also *peek* at the top element without removing it
- We can determine if a stack is *empty* or not and how many elements it contains (its *size*)
- The StackADT interface supports the above operations and some typical class operations such as `toString()`

Stack ADT Interface

```
<<interface>>
StackADT<T>

+ push(element : T) : void
+ pop () : T
+ peek() : T
+ isEmpty () : bool
+ size() : int
+ toString() : String
```

Stack Design Considerations

- Although a stack can be empty, there is no concept for it being full. An implementation must be designed to manage storage space
- For peek and pop operation on an empty stack, the implementation would throw an exception. There is no other return value that is equivalent to “nothing to return”
- A *drop-out stack* is a variation of the stack design where there is a limit to the number of elements that are retained

Stack Design Considerations

- No iterator method is provided
- That would be inconsistent with restricting access to the top element of the stack
- If we need an iterator or other mechanism to access the elements in the middle or at the bottom of the collection, then a stack is not the appropriate data structure to use

Applications for a Stack

- A stack can be used as an underlying mechanism for many common applications
  - Evaluate postfix and prefix expressions
  - Reverse the order of a list of elements
  - Support an “undo” operation in an application
  - Backtrack in solving a maze

Evaluating Infix Expressions

- Traditional arithmetic expressions are written in *infix* notation (aka algebraic notation)

  (operand) (operator) (operand) (operator) (operand)

  4 + 5 * 2

- When evaluating an infix expression, we need to use the precedence of operators
  – The above expression evaluates to 4 + (5 * 2) = 14
  – NOT in left to right order as written (4 + 5) * 2 = 18
- We use parentheses to override precedence

Evaluating Postfix Expressions

- *Postfix* notation is an alternative method to represent the same expression

(operand)	(operand)	(operand)	(operator)	(operator)
4	5	2	*	+

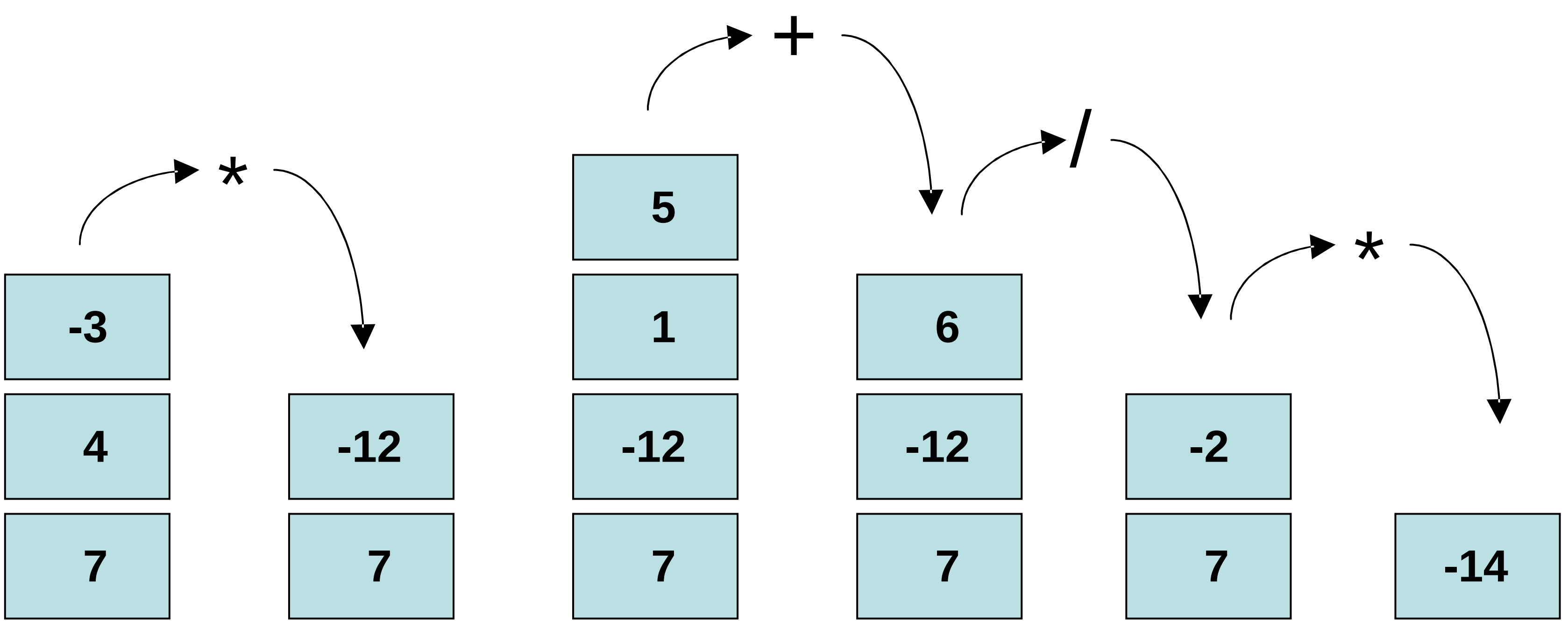
- When evaluating a postfix expression, we do not need to know the precedence of operators
- Note: We do need to know the precedence of operators to convert an infix expression to its corresponding postfix expression

Evaluating Postfix Expressions

- We can process from left to right as long as we use the proper evaluation algorithm
- Postfix evaluation algorithm calls for us to:
  - Push each operand onto the stack
  - Execute each operator on the top element(s) of the stack (An operator may be unary or binary and execution may pop one or two values off the stack)
  - Push result of each operation onto the stack

Evaluating Postfix Expressions

- Expression = 7 4 -3 * 1 5 + / *



Evaluating Postfix Expressions

- Core of evaluation algorithm using a stack

```
while (tokenizer.hasMoreTokens()) {
  token = tokenizer.nextToken(); // returns String
  if (isOperator(token) {
    int op2 = (stack.pop()).intValue(); // Integer
    int op1 = (stack.pop()).intValue(); // to int
    int res = evalSingleOp(token.charAt(0), op1, op2);
    stack.push(new Integer(res));
  }
  else  // String to int to Integer conversion here
    stack.push (new Integer(Integer.parseint(token)));
} // Note:  Textbook’s code does not take advantage of
  // Java 5.0 auto-boxing and auto-unboxing
```

Evaluating Postfix Expressions

- Instead of this:

```
int op2 = (stack.pop()).intValue(); // Integer to int
int op1 = (stack.pop()).intValue(); // Integer to int
int res = evalSingleOp(token.charAt(0), op1, op2);
```

- Why not this:

```
int res = evalSingleOp(token.charAt(0),
                       (stack.pop()).intValue(),
                       (stack.pop()).intValue());
```

- In which order are the parameters evaluated?
- Affects order of the operands to evaluation

Evaluating Postfix Expressions

- The parameters to the `evalSingleOp` method are evaluated in left to right order
- The pops of the operands from the stack occur in the opposite order from the order assumed in the interface to the method
- Results:

	Original	Alternative
	`6 3 / = 2`	`6 3 / = 0`
	`3 6 / = 0`	`3 6 / = 2`

Evaluating Postfix Expressions

- Our consideration of the alternative code above demonstrates a very good point
- Be sure that your code keeps track of the state of the data stored on the stack
- Your code must be written consistent with the order data will be retrieved from the stack to use the retrieved data correctly

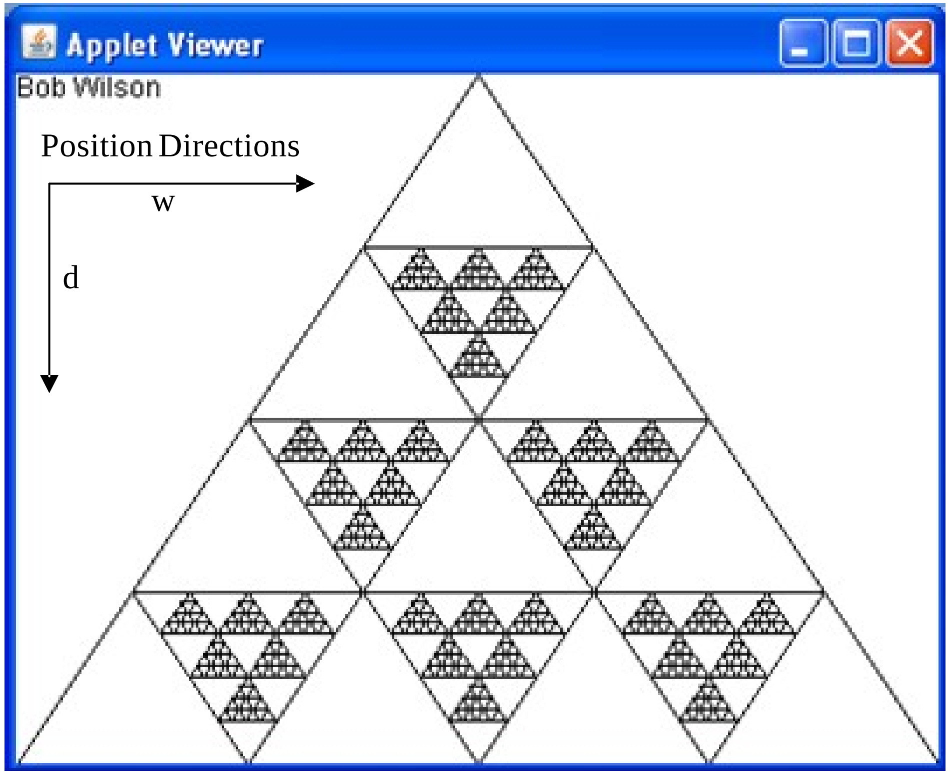
Introduction to Project 2

- The term fractal was coined by Mandelbrot in 1975 for a geometric shape that has a dimensional order between the normal 1D, 2D, 3D, etc dimensions
- The concept has been used to describe the rough ragged shape of shorelines and other phenomena
- If you measure shoreline length at a large scale, it is shorter than if you measure pieces of it at any smaller scale and add up the lengths
- Hence, a shoreline is greater than 1D but obviously is still less than 2D

Introduction to Project 2

- A visual characteristic of a fractal such as a shoreline is that it has the same appearance at a large scale as it does when you look at it at smaller and smaller scales
- It repeats the same shape at all scales
- The fractal we will be generating in Project 2 is a repeating sequence of triangles inside of each triangle – similar to a Sierpinski triangle
- See the following figure

Introduction to Project 2



Introduction to Project 2

- You are provided the following code:

  Applet.html – An html file to launch the applet (You can use the Appletviewer instead of this)

  Corner.java – Represents the corner of a triangle and has some useful methods (len and mid)

  Triangle.java – Represents a triangle with three corners and has some code you need to write

  Iterative.java and Recursive.java – The top level applets for drawing the sequence of triangles

Introduction to Project 2

- Study and understand the provided code
- You need to do the following:
  – Write Triangle class getNextLevel( ) and size( )
    - Use provided Corner class methods – len and mid
    - The getNextLevel method returns one of six possible Triangle objects based on the index parameter
    - The Size method returns the circumference based on the three Corner objects.
  – Write the Iterative class drawTriangle method
  – Write the Recursive class drawTriangle method

Introduction to Project 2

- In the iterative drawTriangle method:
  – Instantiate a stack to contain Triangle objects
  – Push the Triangle t parameter on the stack
  – Iterate while the stack is not empty
    - Remove and draw the Triangle on top of the stack
    - If it is still larger than Triangle.SMALLEST create and push its six sub-triangles on the stack
- Test the Applet
- Modify it to use a queue instead of a stack
- Test the Applet again

Introduction to Project 2

- In the recursive drawTriangle method:
  - Draw the Triangle t parameter
  - If it is still larger than Triangle.SMALLEST
    - Recursively call drawTriangle six times - once with each of the six sub-triangles of the Triangle t
- Test the Applet
- Write a report on all three Applets versions (two iterative and one recursive)