The big picture... so far

DATA STRUCTURES
- Array
- Unordered list
- Ordered list
- Stacks
- Queues

ALGORITHMS
- Insert, delete, linear search, shuffle, **sorting**
- Insert, delete, shuffle, **binary search**
- Push, pop, peek, etc.
- Insert, remove, etc.
Stacks and Queues - Philosophy

- They are abstract data structures defined only by their interfaces (examples: insert, remove, etc.)
- The underlying mechanism (for example: an array) is not visible to the user
- Interfaces are designed to enforce restricted access – only one item should be removed or added at a time.... designed to be O(1)
- These data structures are not appropriate to operate on database, they are used more often as programmer's tools
- Once created and used to carry out a particular task, they are often discarded (short life-time)
Stacks- overview

Stacks allow to get access to the last item inserted. If removed, you get access to the next-to-last item inserted, and so on.

- Analogies:
  - Mail: open the first letter on top of the stack and work your way to the bottom
  - Re-prioritize tasks of your work day as they come along
  - Daily life examples: elevators, bus, etc.
- Simple but very useful in programming
Stacks- overview

- Adding an item on top of the stack → "Push"
- Removing an item from the top → "Pop"

Applications of stack (few examples):
- Reverse a string
- Parsing arithmetic expressions
- Undo operations in many editor tools
- Stack-based memory allocation (local variables in methods)
- Compilers (delimiters)
- Hardware stack-based architecture in CPU (memory registers)
In an Excel file (for example), input your data in a row:
- 100, 200, 300, 400
- Find something wrong? Use *undo* to return to previous state

**Operations using a Stack**
Stacks- *reverse* operations

- What do we get after Pop, Pop, Pop? ….. CBA

Operations using a Stack

1. Push A
2. Push B
3. Push C
4. 1\textsuperscript{st} Pop $→$ C
5. 2\textsuperscript{nd} Pop $→$ B
6. 3\textsuperscript{rd} Pop $→$ A
## Stacks- implementation

- One can use an array of object to implement a stack

<table>
<thead>
<tr>
<th>maxSize-1</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>A</td>
</tr>
</tbody>
</table>

- `maxSize` is the capacity of the stack
- Stacks are typically small
- `top` is the index of the item on the top
- A,B,C are primitive data (int, long, double, etc.) or objects

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**List of basic operations using a Stack**

- **push(item);**
- **pop();**
- **peek()**
- **isEmpty()**
- **isFull()**
- **size()**

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**To do:** Test Java applet Stack.html
Stacks- generic array implementation 1/3

- "Object" stands for any data types or objects

```java
class Stack {
    // variables
    private int maxSize; // Stack capacity initialized by user
    private int top; // top of stack
    private Object[] array; // array that holds the items

    // constructors
    public Stack(int maxSize) {
        this.maxSize = maxSize; // set array size
        array = new Object[maxSize]; // create array
        top = -1; // no item yet
    }
}
```
class Stack {
    // variables
    // constructors
    // methods
}

class Stack {
    // variables
    // constructors
    // methods
}

class Stack {
    // variables
    // constructors
    // methods
}

public boolean isEmpty() {
    return (top == -1); // true if stack is empty
}

public boolean isFull() {
    return (top == maxSize - 1); // true if stack is full
}

public int size() {
    return (top + 1); // return current number of items
}
class Stack {

// variables

// constructors

// methods

public Object peek() {
    if (!isEmpty()) {
        return array[top]; // return top item
    } else {
        throw new IllegalStateException("Stack is empty");
    }
}

public Object pop() {
    if (!isEmpty()) {
        top--; // decrement top
        return array[top+1]; // return top item
    } else {
        throw new IllegalStateException("Stack is empty");
    }
}

public void push(Object item) {
    if (!isFull()) {
        top++;
        array[top] = item; // insert item
    }
}
We consider a Stack composed of \textit{int}, can you guess the result?

class StackApp1
{
    public static void main(String[] args)
    {
        Stack mystack = new Stack(5);
        for(int i=1; i<=10; i++) mystack.push(i);
        mystack.pop();
        mystack.pop();
        System.out.print(mystack.size());
        System.out.print(mystack.peek());
        System.out.print(mystack.pop());
        System.out.print(mystack.peek());
    }
}

Result is 3332
Reversing a word using a Stack composed of `char`,

```java
class StackApp2 {
    public static void main(String[] args) {
        EasyIn easy = new EasyIn();
        String word = easy.readString();
        Stack mystack = new Stack(word.length());
        char ch;
        for (int i=0; i<word.length(); i++) {
            ch = word.charAt(i);
            mystack.push(ch);
        }
        while (!mystack.isEmpty())
            System.out.print(mystack.pop());
    }
}
```
- Delimiter Matching (Bracket Balance)

- Examples:
  - ‘[’ matches ‘] ’, and ‘(’ matches ‘) ’
  - Bracket matched: (a+b), [a/b], a/[(b-c)*d]
  - Bracket unmatched: a+b), m*(n]+k

- How does the stack look like after each char is read from the String?
  - Using a[b(c[d]e)f]
  - Character read: 'a', '[', 'b', '(', 'c', '[', 'd', ']', 'e', '}', 'f', ']'

Opening delimiters
push on the Stack
import java.util.Stack;
import java.util.Scanner;

public class StackApp3n {
    public static void main(String[] args) {
        Scanner scanner = new Scanner(System.in);
        String word = scanner.nextLine();
        Stack mystack = new Stack(word.length());
        char ch, cp;
        boolean test = true;
        int i = 0;
        while (true) {
            ch = word.charAt(i);
            i++;
            if (ch == '(' || ch == '[') mystack.push(ch);
            else if (ch == ')' || ch == ']') {
                if (!mystack.isEmpty()) {
                    cp = (Character)mystack.pop();
                    if ((cp == '[' && ch != ']') || (cp == '(' && ch != ')'))
                        test = false;
                } else test = false;
            }
        }
        if (!test || !mystack.isEmpty()) System.out.println("matching problem!");
    }
}