Part 2. Stacks

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Outline

- **Stacks?**
- Applications using Stacks
- Implementing Stacks
- Relationship between Stacks and Recursive Programming

Linear, time ordered structures

- Data Structures that reflects *a temporal relationship*
  - *Order* of **removal** based on the *order* of **insertion**
- We will consider
  - ***"First come, first serve"***
    - First Come, First Out: *FIFO (queue)*
  - ***"take from the top of the pile"***
    - Last In, First Out: *LIFO (stack)*

What can we do with Coin dispenser?

- "**push**" a coin into the dispenser.
- "**pop**" a coin from the dispenser.
- "**see**" the coin on top.
- "**check**" whether this dispenser is empty or not.

Stacks

- ***Last In First Out (LIFO***) structure
- ***Add/Remove*** from the **same** end

Stack Operations

- **`isEmpty()`**: determine whether stack is empty
- **`push()`**: add a new item to the stack
- **`pop()`**: remove the item added most recently
- **`peek()`**: retrieve the item added most recently
- **`createStack()`**: create an empty stack
- **`removeAll()`**: remove all the items

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Applications – *Call Stack*

- Stack data structure to store information about ***active subroutines*** or ***computer program***.
- Memory allocation for tracking the execution of functions such as a nested function.
  - First method that returns is the last one invoked
- Element of call stack – activation record
  - *Parameters*
  - *Local variables*
  - *Return address*: pointer to the next instruction to be executed in calling method

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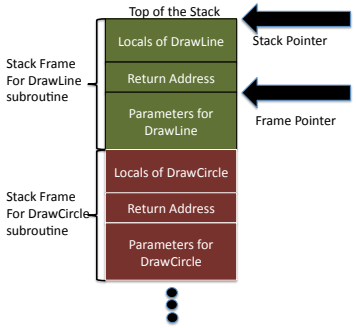
Call Stack



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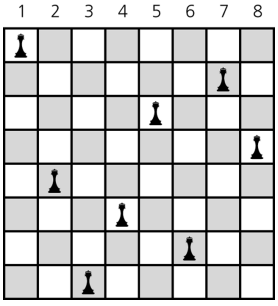
Applications – Backtracking

- Looking for a solution based on a ***guess***.
- Keeping the guesses (temporary answers) in the stack.
- When the process faces deadend, go back one step (visit the first one in the stack) and repeat the process.



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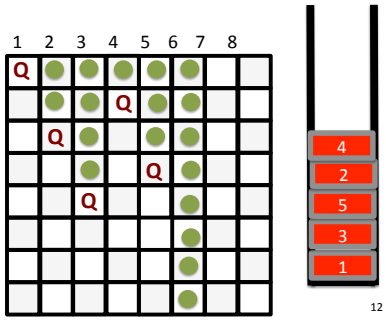

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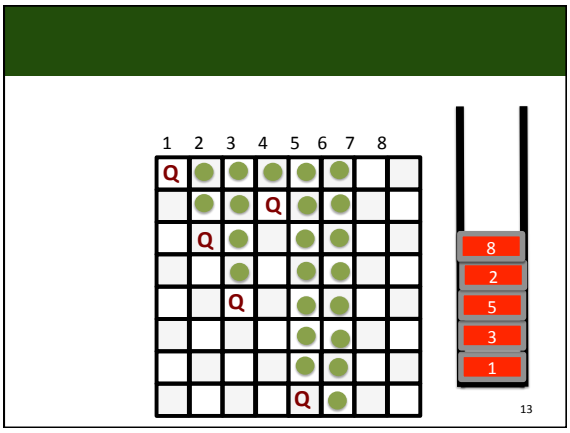

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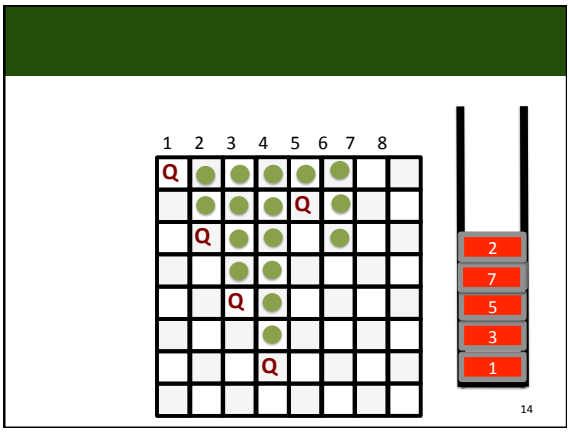

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Checking for Balanced Braces

1. Each time you **encounter a "}"**, it matches an **already encountered "{"**
2. When you reach the end of the string, you have **matched all of the "{"** you have encountered

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Peudocode

```
while ( not at the end of the string){
     if (the next character is a "{"){
          aStack.push("{")
     }
     else if (the character is a "}") {
          openBrace = aStack.pop()
     }
}
```

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String "abc{{def}ijm}" docode with example

"a" "b" "c" "{" "{" "d" "e" "f" "}" "i" "j" "m"

```
while ( not at the end of the String ){
     if (the next character is a "{")
          aStack.push("{")
     }
     else if (the character is a "}") {
          openBrace = aStack.pop()
     }
}
```

{ {

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Algebraic Expressions

- Evaluating *Postfix* Expressions
  - Assumptions:
    - String is a syntactically correct postfix expression
    - No unary operator
    - No exponentiation operators
    - Operands are single lowercase letters

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Peudocode

String "2 3 4 + *"

"2" "3" "4" "+" "*"

```
for ( each character ch in the string){
  if(ch is an operand){
     push value that operand ch
        represents onto stack
  } else{
     operand2 = Pop the top of the stack
     operand1 = Pop the top of the stack
     result = operand1 op operand2
     push result onto stack
  }
}
```

WHY?

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Implementing Stacks

- Should perform the ***stack operations***
- *Array-based* implementation
- *Reference-based* implementation
- *List-based* implementation

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Array-Based Implementation

- Use an array of Objects (called items)

```
public class StackArrayBased implements
kInterface{
inal int MAX_STACK = 50;
   private Object items[];
   private int top;
   public StackArayBased(){
     items = new Object [MAX_STACK];
     top = -1;
   } end default constructor
```

WHY?

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isEmpty()

```
public boolean isEmpty(){
   return top < 0;
}
```

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push()

```
public void push (Object newItem) throws
  StackException{
  if (!isFull()) {
     item[++top] = newItem;
  }else{
     throw new StackException(your_error_message);
  }
}
```

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pop( )

```
public Object pop() throws StackException{
    if (!isEmpty()){
        return items[top--];
    } else {
      throw new StackException(your_error_message);
    }
}
```

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peek( )

```
public Object peek() throws StackException{
  if(! isEmpty()){
        return items[top];
  }else {
    throw new StackException(your_error_message);
  }
}
```

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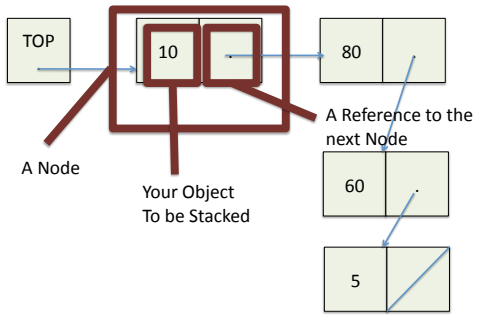
Reference-Based Implementation



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```
private Node top;
public void push (Object newItem){
    top = new Node(NewItem,top)
}

public Object pop() throws StackException{
    if (!isEmpty()){
        Node temp = top;
        top = top.next;
        return temp.item;
    } else {… exception handling}
}
```

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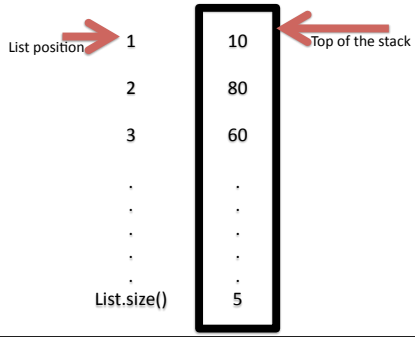
Implementation that uses *List*



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```
public void push(Object newItem){
     list.add(0, newItem);
}
public Object pop() throws StackException{
     if (!list.isEmpty()){
          Object temp = list.get(0);
          list.remove(0);
          return temp;
     } else exception handling
}
public void popAll(){
  list.removeAll();
}
```

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Comparison of Implementation

- What are the pros and cons for different implementation styles?
- *Array based?*
- *Reference based?*
- *List based?*

-- Array based implementation can provide fixed size stack

-- List based: Why not just List?

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How about java.util.Stack?

- Derived from Vector.
- `empty(), peek(), pop(), push(), search(Object o)`

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Relationship between Stacks and Recursion

- Most implementations of recursion can maintain a stack of activation records.
- Backtracking example
- Within recursive calls, the most recently executed call is stored at the top of the stack.
- Store and access the same point of the data structure.

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Next Reading

- Chap. 8 Queues

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