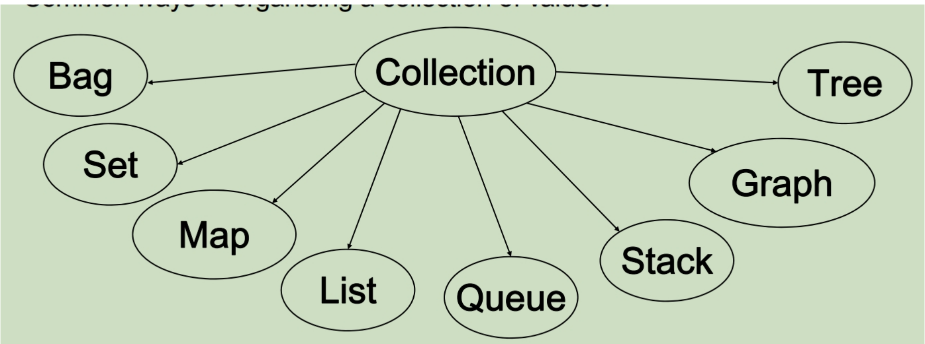
Collections 容器



Abstract Data Type 抽象数据类型

Set, Bag, Queue, List, Stack, Map, etc are

Abstract Data Types (outcome of abstraction / encapsulation)

an ADT is a type of data, described at an abstract level: ADT 是一种数据类型，在抽象级别进行描述：

· Specifies the **operations** that can be done to an object of this type

· Specifies how it will **behave**.

· 指定对此类型的对象执行的**操作**

· 指定它的行为方式。

e.g. Set (simple version)

- Operations: **add**(value), **remove(*value*)**, **contains(*value*)*→**boolean*
- Behaviors:
  - A new set conatins no values
  - A set will contain a value *iff*

    · the value has been added to the set and

    · it has not been removed since adding it.
  - A set will not contain a value *iff*

    · the value has never been added to the set, or

    · it has been removed from the set and has not been added since it was removed.

Interface 接口

A Java **Interface** corresponds to an **Abstract Data Type**

· Specifies what methods can be called on objects of this type (specifies name, parameters and types, and type of return value)

指定可以对此类型的对象调用哪些方法（指定名称、参数和类型以及返回值的类型）

· Behaviour of methods is only given in comments（but cannot be enforced)

方法的行为仅在注释中给出（但不能强制执行）

- No constructors – can't make an instance: **new** Set()；没有构造器
- No fields – doesn't say how to store the data 没有属性变量
- No method bodies. – doesn't say how to perform the operations 没有具体实现方法

Parameterised Types 参数化类型 泛型

The structure and access discipline of a collection is the same, regardless of the type of value in it:

集合的结构和访问规则是相同的，无论其中的值类型如何：

(A set of Strings, a set of Persons, a set of Shapes, a set of integers all behave the same way.)

不管集合中存放的数据类型是什么，只要同属一种类型的容器，那么他们就都使用相同的方法来修改容器中的内容

但是这些使用同一种容器的集合需要实现相容类型的容器接口

The collection Interfaces (and classes) are parameterised:

集合接口（和类）是参数化的：

· Interface has a type parameter 接口有类型参数
· When declaring a variable collection, you specify
    · the type of the collection and 声明使用的容器是什么类型的
    · the type of the elements of the collection 声明容器中存放的内容是什么类型的

例如：

```
public interface Set {

    public void add(T item);

}

Set integer = new Set<>();
```

Classes in the Java Collection Library **implement** the interfaces

Java 集合库中的类**实现**接口

· Define constructors to construct new instances Java 集合库中的类**实现**接口

· Define method bodies for performing the operations 定义用于执行操作的方法体

· Define fields to store the values 定义用于存储值的字段

ArrayList

· Part of the Java **Collections** framework. 容器类的一个分支

  · predefined class

  · stores a list of items，存储项目列表，

    · a collection of items **kept in a particular order**. 有序列表

  · part of the java.util package

    ⇒ need to **import java.util.*;** at head of file

不需要设置长度，但是需要指定存储类型 可以无限长 需要用指定的方法进行增删改查

- ArrayList has many methods! , including: 方法
  - size(): returns the number of items in the list
  - add(*item*): adds an item to the *end* of the list
  - add(*index, item*): inserts an item at *index* (relocates later items)
  - set(*index, item*): replaces the item at *index* with *item*
  - contains(*item*): true if the list contains an item that equals *item*
  - get(*index*): returns the item at position *index*
  - remove(*item*): removes an occurrence of item (what if there are duplicates in the ArrayList?)
  - remove(*index*): removes the item at position *index* (both relocate later items)

要使用foreach增强for循环来迭代

for (Student st : students)

  System.out.println(st.toString());

Collection Types 容器类型

Interfaces can **extend** other interfaces:

The **sub** interface has all the methods of the **super** interfaceplus its own methods (**sub** means? **super** means?)

子类接口拥有**父类**接口的所有方法加上它自己的方法（**sub**表示？**super**表示？）

以ArrayList为例，也就是ArrayList类会继承List接口所有的方法以及Collections接口所有的方法并加以实现

Iterators 迭代器

Iterator is an interface iterator是一个接口:

public interface Iterator {

  public boolean hasNext(); // 判断接下来是否还有内容

  public E next(); // 提取下一个内容的值

}

Example

```
public class TodoList implements ActionListener{

:

private List<Task> tasks;

:

/* read list of tasks from a file, */

public void readTasks(String fname){

    try {

        Scanner sc = new Scanner(new File(fname));

        tasks = new ArrayList<Task>();

        while ( sc.hasNext() ) {

            tasks.add(new Task(sc.next()));

        }
        sc.close();

} catch(IOException e){…}

    displayTasks();

}
```

// 三种打印内容的方式

1. 增强for循环

public void displayTasks(){

    textArea.setText(tasks.size() +“ tasks to be done:\n”);

    for (Task task : tasks){

        textArea.append(task + "\n");

    }

}

2. 索引循环

for (int i=0; i<tasks.**size**(); i++)

    textArea.append(tasks.**get**(i) + "\n");

3. 迭代循环

iterator iter = tasks.iterator();

while (iter.hasNext()){

    textArea.append(iter.next() + "\n");

Collections Libraries 容器库

Interfaces:

· *Collection <E >*

    = Bag (most general)

· *List <E >*

    = ordered collection

- *Set <E >*

  = unordered, no duplicates

- *Stack*

  ordered collection, limited access(add/remove at end)

- *Map <K, V >*

  = key-value pairs (or mapping)

- *Queue <E >*

  ordered collection, limited access (add at end, remove from front)

Classes:

- List classes:

  ArrayList, LinkedList,

- Set classes:

  HashSet, TreeSet, ...

- Stack classes:

  ArrayStack, LinkedStack

- Map classes:

  HashMap, TreeMap

Bages

A Bag is a collection with Bag是一个系列，并具有一下的性质

  - no structure or order maintained 没有维持结构或顺序
  - no access constraints (access any item any time) 无访问限制（随时访问任何项目）
  - duplicates allowed 允许重复

A Bag 是一个系列，具有

- 没有维持结构或秩序
- 无访问限制（随时访问任何项目）
- 允许重复

Minimal Operations:

- **add**(value) → returns true *iff* a collection was changed
- **remove**(value) → returns true *iff* a collection was changed
- **contains**(value) → returns true *iff* value is in baguses equal to test.
- **findElement**(value) → returns a matching item, *iff* in bag

Plus 附带List自带的一些方法:

- **size**(), **isEmpty**(), **iterator**(),**clear**(), **addAll**(collection), **removeAll**(collection), **containsAll**(collection), ...

Bag没有标准实现

Set 集合

Set is a collection with:

- no structure or order maintained
- no access constraints (access any item any time)
- Only property
- 没有维持的结构或者顺序
- 无访问限制（随时访问任何项目）
- 仅有值

Operations 运行方法:

(Same as Bag, but different behaviour)

- add(value) → true *iff* value *was added (ie, no duplicate)* 添加
- remove(value) → *true iff value removed (was in set)* 删除
- contains(value) → *true iff value is in the set* 包含
- findElement(value) → *matching item, iff value is in the set* 查找

Stack 栈

- Organizes entries according to the order in which added 根据添加的顺序组织条目
- Additions are made to one end, the top 每次添加的内容都在最上面
- The item most recently added is always on the top 先进后出

Stacks are special kind of List: 栈是特殊的列表

• Sequence of values 插入的数据有顺序

• Constrained access: add, get, and remove only from one end. 修改有限制，必须沿着遵照先进后出的原则

• There exists a Stack interface and different implementations of it (ArrayStack, LinkedStack, etc)

有一个Stack接口，同时有ArrayStack等Stack接口的实现类

• In Java Collections library:

  • Stack is a class that implements List. Stack接口继承了List接口

  • Has extra operations: **push**(value), **pop**(), **peek**() 除了List接口的方法之后，Stack还新增了**push**，**pop**和**peek**

Addtional Operations:

  • push(value): Put value on top of stack. 将值放在堆栈的顶部

  • pop(): Removes and returns top of stack. 返回栈最上面的内容，也就是最后放入的内容 同时将该内容从栈中删除

  • peek(): Returns top of stack, *without* removing. 查看栈最上方的内容，但是不移除

The Program Stack for Execution

• When a method is called 当一个方法被调用的时候

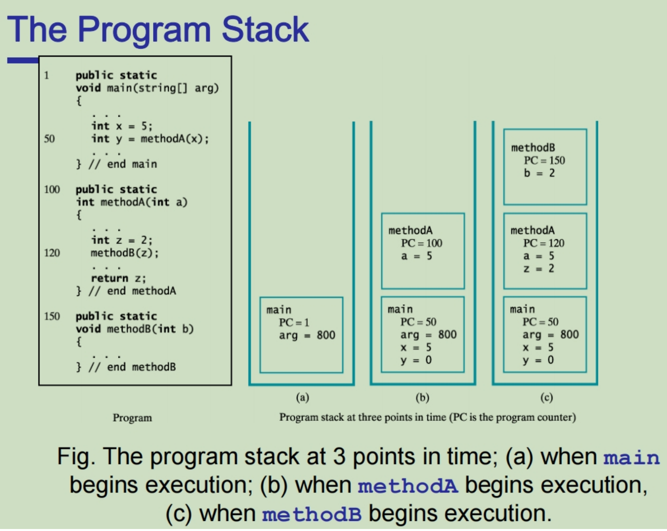
  • Runtime environment creates activation record 运行时环境创建激活记录

  • Shows method's state during execution 显示方法在执行期间的状态

• Activation record pushed onto the program stack (Java stack) 将激活记录推送到进程堆栈（Java 堆栈）

  • Top of stack belongs to currently executing method 堆栈顶部属于当前正在执行的方法

  • Next record down the stack belongs to the one that called current method 堆栈的下一条记录属于调用当前方法的记录



The Program Stack

```
1     public static
      void main(string[] arg)
      {
         . . .
         int x = 5;
50       int y = methodA(x);
         . . .
      } // end main

100   public static
      int methodA(int a)
      {
         . . .
         int z = 2;
120      methodB(z);
         . . .
         return z;
      } // end methodA

150   public static
      void methodB(int b)
      {
         . . .
      } // end methodB
```

Fig. The program stack at 3 points in time; (a) when main begins execution; (b) when methodA begins execution, (c) when methodB begins execution.

- 特别注意的是递归方法(Recursive Methods)因此递归方法会调用很多次，因此会产生特别多激活记录，解释了为什么递归消耗更多内存

Using a Stack to Process Algebraic Expressions 使用堆栈处理代数表达式

Infix expressions 中缀表达式

  - Binary operators appear between operands 二进制运算符出现在操作数之间
  - **a + b**

- **Prefix expressions** 前缀表达式
  - Binary operators appear before operands 二元运算符出现在操作数之前
  - **+ a b**
- **Postfix expressions** 后缀表达式
  - Binary operators appear after operands 二进制运算符出现在操作数之后
  - **a b +**

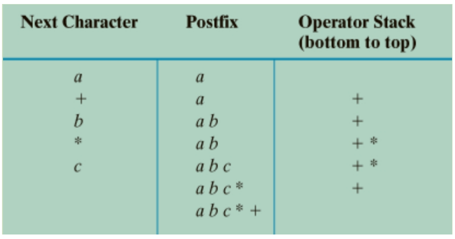
使用Java实现判断大括号，中括号和小括号的组合是否正确

```
import java.util.Stack;

public class BracketPriorityChecker {

public static boolean checkBracketPriority(String input) {
    Stack<Character> stack = new Stack<>();

    for (char c : input.toCharArray()) {
        if (c == '(' || c == '[' || c == '{') {
            stack.push(c);
        } else if (c == ')' && !stack.isEmpty() && stack.peek() == '(') {
            stack.pop();
        } else if (c == ']' && !stack.isEmpty() && stack.peek() == '[') {
            stack.pop();
        } else if (c == '}' && !stack.isEmpty() && stack.peek() == '{') {
            stack.pop();
        } else {
            return false; // 如果出现不匹配的情况，返回false
        }
    }

    return stack.isEmpty(); // 如果栈为空，表示所有括号都匹配成功
 }

public static void main(String[] args) {
    String input1 = "({})[]"; // 括号匹配
    String input2 = "([)]"; // 括号不匹配

    System.out.println(input1 + " 括号优先级是否匹配: " +
checkBracketPriority(input1));
    System.out.println(input2 + " 括号优先级是否匹配: " +
checkBracketPriority(input2));
 }
}
```

Transforming Infix to Postfix 将中缀表达式转换成后缀表达式

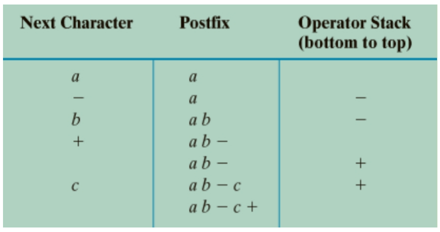
1. 创建一个空栈来存储运算符
2. 从左想用扫描Infix表达式中的每个元素（操作数，运算符）
3. 如果当前的元素是操作数，则直接输出到Postfix表达式中
4. 如果当前是运算符:
    - 如果栈为空，或这栈顶元素是左括号，则将该运算符入栈
    - 如果该运算符的优先级高于栈顶运算符的优先级，也将运算符入栈（*和/是同级，高于+和-的优先级，+和-也是同级）
    - 如果运算符的优先级低于或者等于栈顶运算符优先级，将栈顶运算符pop弹出来并添加到当前postfix表达式的后面，然后再将当前读取到的运算符入栈
    - 如果遇到右括号，则不断弹出栈顶元素并添加到postfix表达式的后面，知道栈为空，最后将左括号弹出

- Examples:
    - Converting the infix expression **a + b * c** to postfix form **a b c * +**



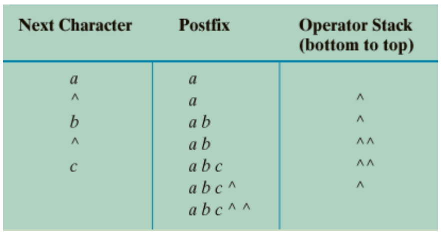
Next Character	Postfix	Operator Stack (bottom to top)
a	*a*	
+	*a*	+
b	*a b*	+
*	*a b*	+ *
c	*a b c*	+ *
	a b c *	+
	a b c * +	

    - Converting infix expression **a – b + c** to postfix form: **a b – c +**



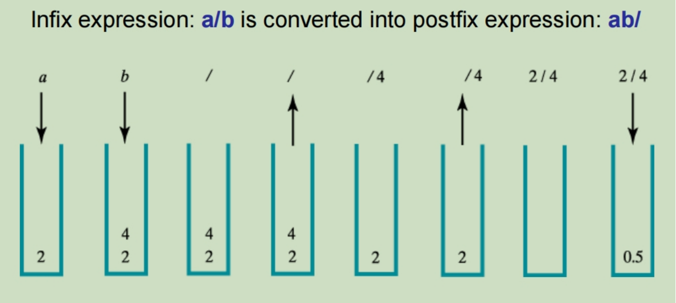
Next Character	Postfix	Operator Stack (bottom to top)
a	*a*	
−	*a*	−
b	*a b*	−
+	*a b* −	
	a b −	+
c	*a b* − *c*	+
	a b − *c* +	

- Converting infix expression **a ^ b ^ c** to postfix form: **a b c ^ ^**



Next Character	Postfix	Operator Stack (bottom to top)
a	*a*	
^	*a*	^
b	*a b*	^
^	*a b*	^^
c	*a b c*	^^
	a b c ^	^
	a b c ^ ^	

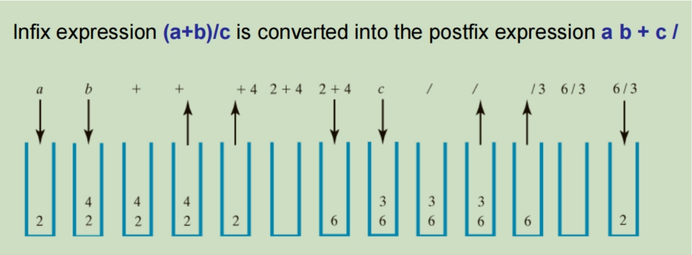
Evaluating Postfix Expression 评估后缀表达式



Infix expression: a/b is converted into postfix expression: ab/

原本的infix表达式为a/b，通过转换成postfix表达式后为ab/，然后根据prefix表达式进行运算：

- 给a赋值入栈
- 给b赋值并入栈
- 遇到操作符，准备弹出栈顶内容
- 栈顶的b被弹出从右往左放置因此放在运算符的右边
- 栈顶的a被弹出从右往左放置因此放在运算符的左边
- 这个时候计算a/b之后就得到结果



Infix expression (a+b)/c is converted into the postfix expression a b + c /

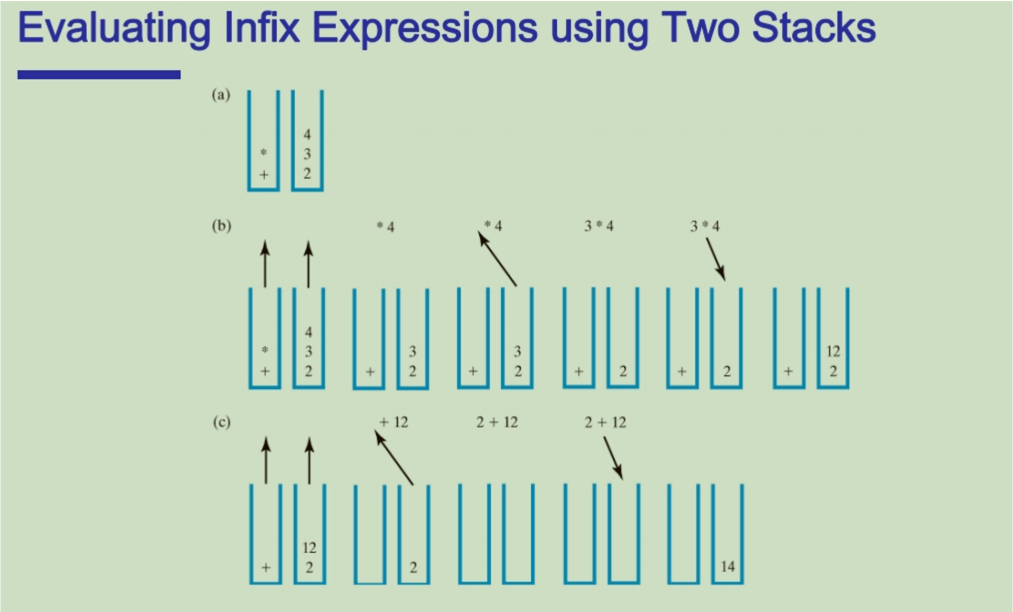
原本的infix表达式为（a+b）/ c，通过转换成postfix表达式后为ab+c/，然后根据prefix表达式进行运算： 注意有括号

- 先将最左侧的(放入栈中
- 给a赋值入栈
- +入栈

- 给b赋值入栈
- 此时b后面是)，因此需要将栈中的内容都弹出并进行计算之后再装回栈内
- 栈顶的b被弹出从右往左放置因此放在运算符+的右边
- 栈顶的a被弹出从右往左放置因此放在运算符的左边
- 计算a+b之后将结果再推入栈中
- 给c赋值入栈
- 遇到操作符/，准备弹出栈中数字
- 栈顶c被弹出从右往左放置因此放在运算符/的右边
- 栈顶a+b的值被弹出从右往左放置因此放在运算符+的左边
- 计算结果

```
import java.util.Stack;

public class PostfixEvaluation {
    public static double evaluatePostfix(String postfixExpression) {
        Stack<Double> stack = new Stack<>();

        for (char c : postfixExpression.toCharArray()) {
            if (c >= '0' && c <= '9') {
                // 如果是操作数，则将其转换为double类型并入栈
                stack.push((double)(c - '0'));
            } else {
                // 如果是运算符，则从栈顶弹出两个操作数进行运算，然后将结果入栈
                double operand2 = stack.pop();
                double operand1 = stack.pop();
                switch (c) {
                    case '+':
                        stack.push(operand1 + operand2);
                        break;
                    case '-':
                        stack.push(operand1 - operand2);
                        break;
                    case '*':
                        stack.push(operand1 * operand2);
                        break;
                    case '/':
                        stack.push(operand1 / operand2);
                        break;
                    // 其他运算符可以根据需要添加
                }
            }
        }

        // 最终栈中剩下的元素即为计算结果
        return stack.pop();
    }

    public static void main(String[] args) {
        String postfixExpression = "24/";
        double result = evaluatePostfix(postfixExpression);
        System.out.println("Evaluation result: " + result);
    }
}
```

Evaluating Infix Expressions using Two Stacks 使用两个堆栈计算中缀表达式



Evaluating Infix Expressions using Two Stacks

infix expression is a + b * c

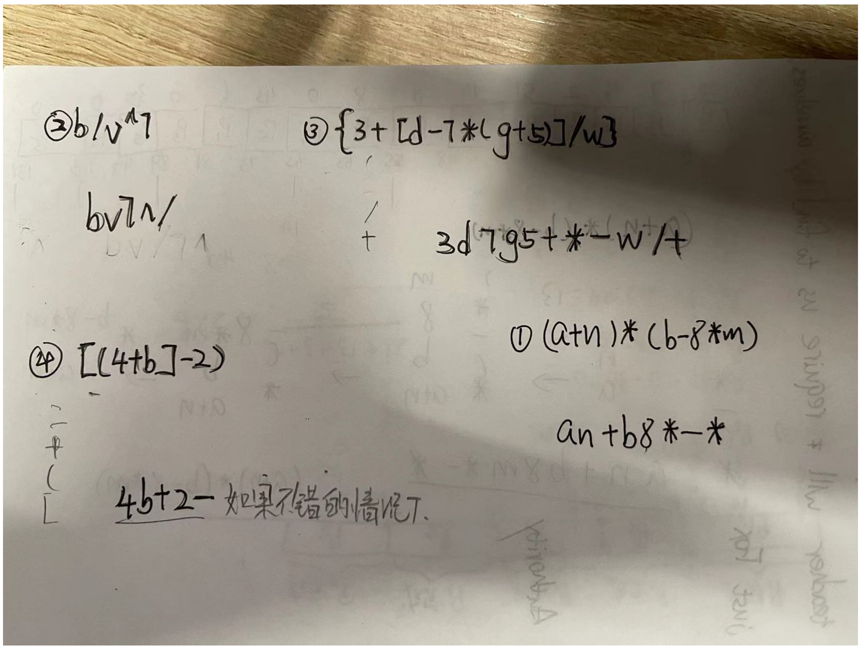
- 转换之后存放应该是abc*+，也就是操作符stack中弹出的先后顺序是 *+, 操作数弹出的先后顺序是cba
- 从右至左，先计算*，从运算数stack中取出最上层的两个运算数分别是c和b，然后计算a * b之后再将结果放回运算数stack，然后计算再从运算数stack中取出剩下的两个数字，进行+运算之后将结果放入运算数stack，则此时运算数stack中剩下的就是result

infix expression is a * b + c

- 转换之后应该是ab*c+
- 当已经放入a b和*之后，由于接下来+的优先级低于 * 因此先不放入+，先将ab都弹出操作数stack同时将*也从操作符stack中弹出，之后进行计算，然后将结果再传入操作数stack中，然后接下来再将+放入操作符stack中，最后将c放入操作数stack然后做最终计算

```
public interface StackInterface
{
/** Task: Adds a new entry to the top of the stack.
* @param newEntry an object to be added to the stack */
public void push(Object newEntry);
/** Task: Removes and returns the top of the stack.
* @return either the object at the top of the stack or null if the stack
was
empty */
public object pop();
/** Task: Retrieves the top of the stack.
* @return either the object at the top of the stack or null if the stack
is
empty */
public object peek();
/** Task: Determines whether the stack is empty.
* @return true if the stack is empty */
public boolean isEmpty();
/** Task: Removes all entries from the stack */
public void clear();
} // end StackInterface
```

More Examples:



② b/v^7

bv7^/

③ {3+[d-7*(g+5)]/w}

(
/
+

3d7g5+*-w/+

① (a+n)*(b-8*m)

an+b8*-*

④ [(4+b]-2)

-
(
+
(
[

4b+2- 如果不错的情况了.

Map

- Map = **Set** of pairs of keys to values map存放的都是键值对

- Constrained access: get values via keys. 访问受限，通过key来查找value

- **No duplicate keys** 不允许重复的键

- Lots of implementations, most common is **HashMap**. 由于多不同类型的实现接口

在声明Map的时候需要在<>加入key和value的属性类型

- Central operations: 主要的操作方法

    - get(key), → returns value associated with key (or null) 通过提供的键来查找值

- put(key, value), → sets the value associated with key (and returns the old value, if any) 添加一组新的键值对

- remove(key), → removes the key *and* associated value (and returns the old value, if any) 移除给定键的键值对

- containsKey(key), → boolean 判断是否包含提供键的键值对

- size() map中有多少键值对

Example:

```
/** Construct histogram of counts of all words in a file */
public Map<String, Integer> countWords(Scanner scan){
    Map<String, Integer> counts = new HashMap<String, Integer> ();
    for (String word : scan){
        if ( counts.containsKey(word) )
            counts.put(word, counts.get(word)+1);
        else
            counts.put(word, 1);
    return counts;
}
```

```
private Map<String, String> movieCast; // character → actor

public void lookup(){
    String name = askName(“Character to look up");
    if (movieCast.containsKey(name)) {
        textArea.setText(name +" : "+movieCast.get(name));
    }else {
        textArea.setText("No entry for "+ name);
    }
}
public void update(){
    String name = askName(“Character to update");
    String actor =askName(“Actor who played "+name);
    String old = movieCast.put(name, actor);
    if (old==null) {
        textArea.setText(" added "+name +" played by " + actor);
    }else {
        textArea.setText(" replaced "+old+" by "+actor+ " for " + name));
    }
}
```

Iterating through a Map 迭代Map

- keySet() → Set of all keys 获取所有的键并放入一个set
    - **for** (String name : phonebook.keySet()){....
- values() → Collection of all values 获取所有的值并放入一个set
    - **for** (Integer num : phonebook.values()){....
- entrySet() → Set of all Map.Entry's 获取所有的键值对并放入一个set
    - **for** (Map.Entry<String, Integer> entry : phonebook.entrySet()){....

        ... entry.getKey() ...

        ... entry.getValue()...

```
/** Find word in histogram with highest count 找到出现最多次数的单词 */
/** 通过KeySet */
public String findMaxCount(Map<String, Integer> counts){
    String maxWord = null;
    int maxCount = -1;
    for (String word : counts.keySet() ){
        int count = counts.get(word);
        if (count > maxCount){
            maxCount = count;
            maxWord = word;
        }
    }
    return maxWord;
}
```

```
/** 通过entrySet */
public String findMaxCount(Map<String, Integer> counts){
    String maxWord = null;
    int maxCount = -1;
    for (Map.Entry<String, Integer> entry : counts.entrySet() ){
        if (entry.getValue() > maxCount){
            maxCount = entry.getValue();
            maxWord = entry.getKey();
        }
    }
    return maxWord;
}
```

Queue 队列

Queue像Stack的地方:

- Queue中的数据也有先后顺序
- Queue也限制访问其中存放的数据，需要按照特定的顺序

Queue和Stack不相同的地方:

- Ordinary Queue 先进先出
- Priority Queue 根据存放内容的优先级提取对应的数据

队列主要应用于Operating System，Network Application，Multi-User System。队列实际上就是现实意义中的队列形式，先到先得

Java中实现队列的有LinkedList，PriorityQueue

Queue Operation 队列的一些方法:

· **offer**(value) ⇒ boolean 向队列中添加一个元素，添加成功返回true

  · add a value to the queue

  · (sometimes called “enqueue”)

· **poll**() ⇒ *value* 从队列顶部也就是最开始的位置上的元素移除，并可返回被移除的元素的值，如果队列为空则返回null

  · remove and return value at front/head of queue or null if the queue is empty

  · (sometimes called “dequeue”, like “pop”)

· **peek**() ⇒ *value* 返回队列顶部的数据，如果队列为空，则返回null

  · return value at head of queue, or null if queue is empty (doesn’t remove from queue)

· **remove**() and **element**() 移除一个元素 类似poll

  · like poll() and peek(), but throw exception if queue is empty