COMP 250

Lecture 7

stack ADT

Sept. 21, 2016

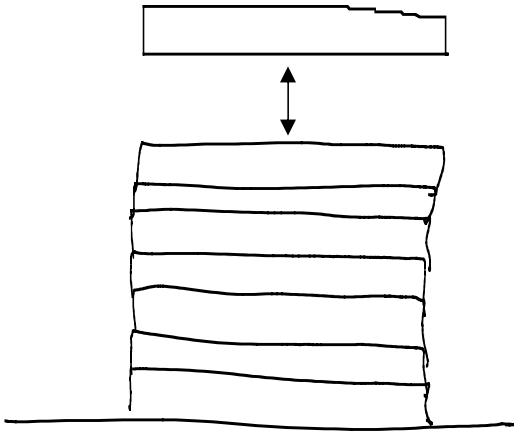
Stack ADT (abstract data type)

push(element)

pop( )

isEmpty( )

peek( )



A stack is a list. However, one typically is not allowed to access the element i directly.

How to implement a stack?

array list:

push(e) = ?

pop() = ?

singly linked list:

push(e) = ?

pop() = ?

doubly linked list:

push(e) = ?

pop() = ?

How to implement a stack?

array list:

push(e) = addLast(e)

pop () = removeLast()

singly linked list:

push(e) = addFirst(e)

pop () = removeFirst ()

doubly linked list :

// either of the above

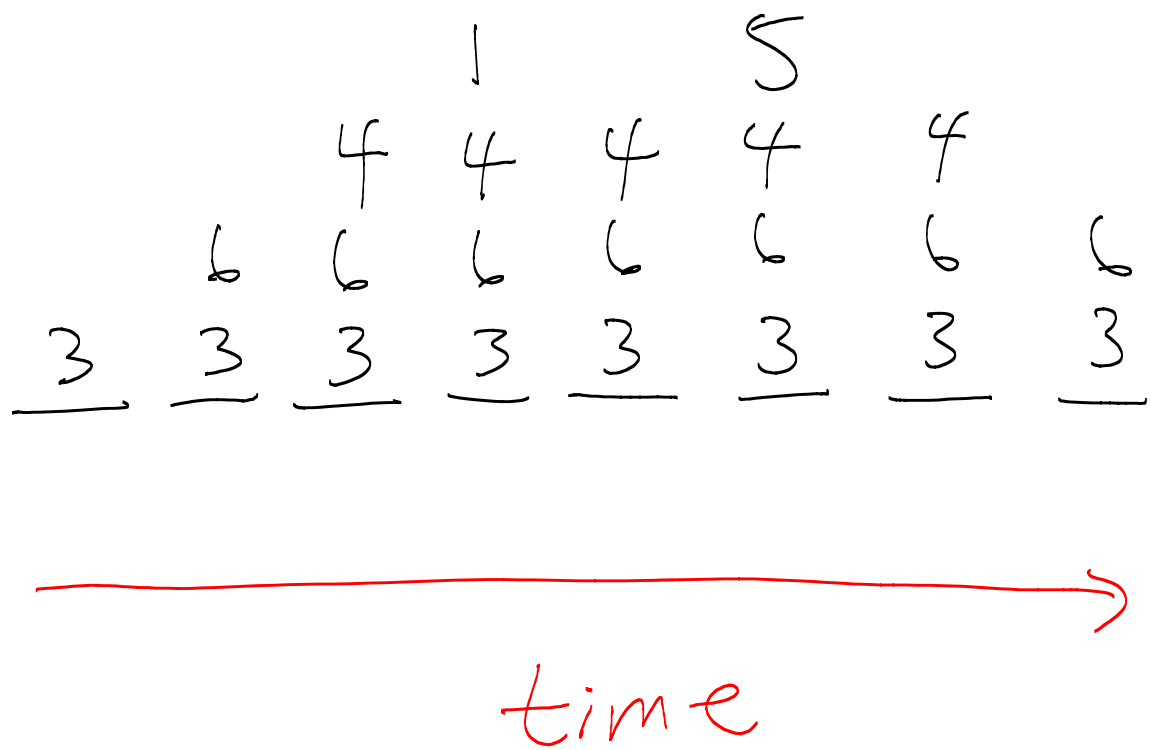
Example 1: stack of int

push(3)
push (6)
push (4)
push (1)
pop ( )
push (5)
pop ( )
pop ( )

time

Example 1: stack of int

push(3)
push (6)
push (4)
push (1)
pop ( )
push (5)
pop ( )
pop ( )



Example 2 - balancing parentheses

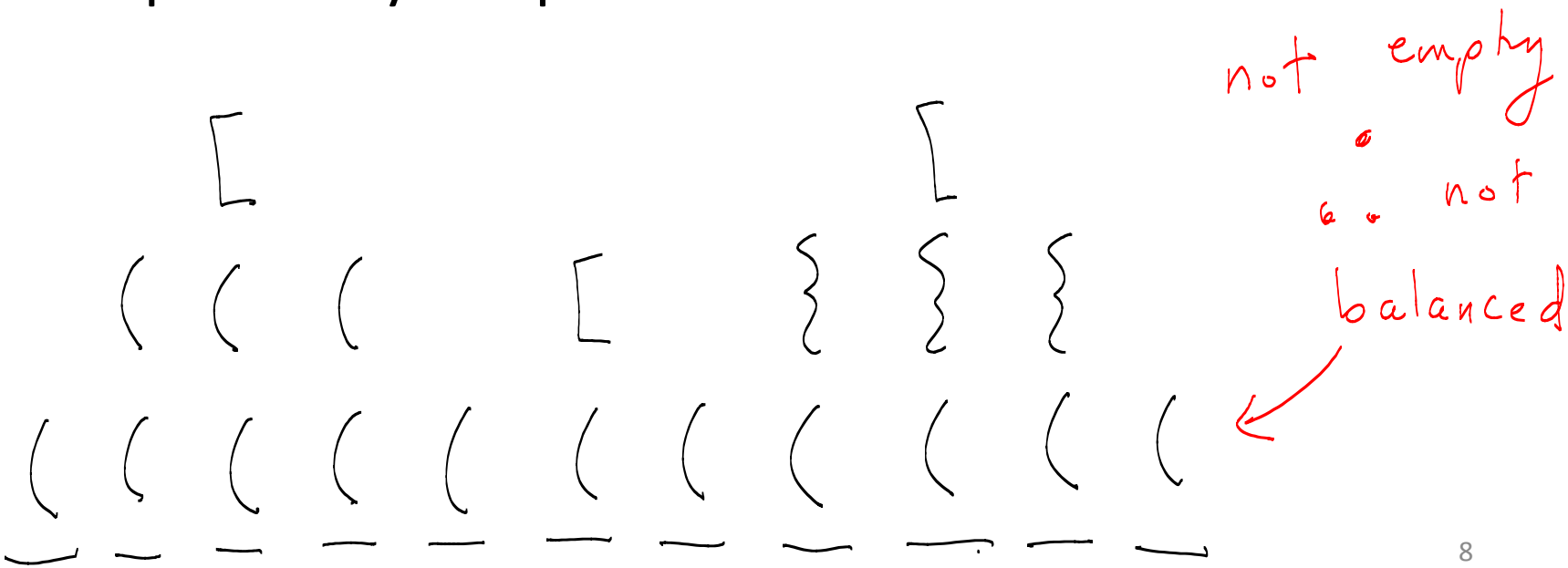
(([ ]) [ ] { [ ] }

To ensure proper nesting, we need a stack.
We push only left parentheses on the stack.

Example 2a - balancing parentheses

(([ ]) [ ] { [ ] }

To ensure proper nesting, we need a stack.
We push only left parentheses on the stack.



Example 2b - balancing parentheses

(([ )] [ ] { [ ] })

does not match

[

((

(((

(Each type parenthesis on its own is balanced.)

```
//    we refer to brackets as “tokens”

//    Algorithm:    decide is parentheses are matched.
//     If yes, return true,  else return false.

while (there are more tokens) {
    token  =  get next token
    if token is a left parenthesis
          push(token)
    else  if token is a right parenthesis {
                if stack.isEmpty()
                    return false
                else {
                      poppedleft = pop()
                      if  !( poppedleft.matches(token) )
                          return false
                 }
            }
}
return  stack.isEmpty()
```

e.g. HTML tags

 I am bold. < i > I am italic. < /i >

I am bold. *I am italic.*

HTML Elements

An HTML *element* starts with a start tag.
An HTML *element* ends with an end tag.

HTML documents consist of nested HTML *elements*.

```
<html>
<body>
<b>  I am bold </b>
<i>  I am italic </i>
</body>
</html>
```

These tags can be thought of as brackets.

Suppose you want:

I am bold. ***I am bold and italic.*** *I am italic.*

What if you were to write the following ?

 I am bold. I am bold and italic. I am italic.

Suppose you want:

I am bold. ***I am bold and italic.*** *I am italic.*

What if you were to write the following ?

 I am bold. I am bold and italic. I am italic.

This is incorrect, because elements are not nested.

< i >

____   Error: mismatch between

Most web browsers will interpret it correctly, however.

I am bold. ***I am bold and italic.*** *I am italic.*

The correct way to write it is:

 I am bold. I am bold and italic.   I am italic.

		< i >				
___	< b >	< b >	< b >	___	< i >	___

What problems can arise if you write it incorrectly?

Suppose you are editing a html document that contains the following:

… Hello. I am bold.

<i> I am bold and italic. I am italic. < /i >

Goodbye ……

Q: What happens if you delete the middle line ?

What problems can arise if you do not write it correctly?

Suppose you are editing a html document that contains the following:

… Hello. I am bold.

<i> I am bold and italic. I am italic. < /i >

Goodbye ……

Q: What happens if you delete the middle line ?

A: … Hello. **I am bold. Goodbye ……**

Example 3 : IF - THEN - ELSE

Suppose a language allows statements of the form:

if bool then statement else statement

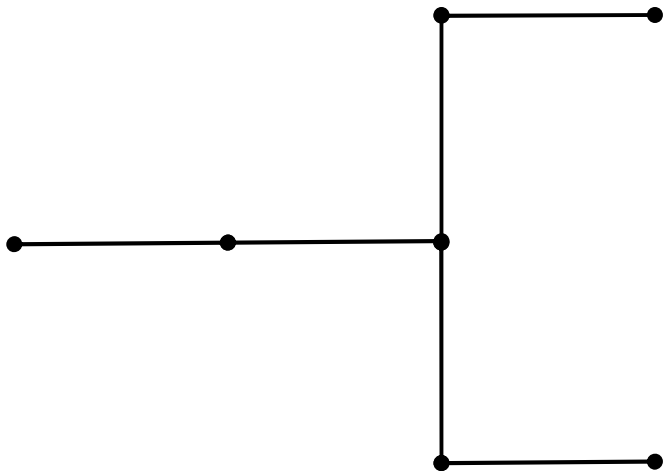
Such a language allows *nested* if-then-else statements, e.g.

if (i > 0) then if (a > 0) then b = 4 else b = 5 else c = 2

You can use a stack to "parse" such statements (Assignment 2).

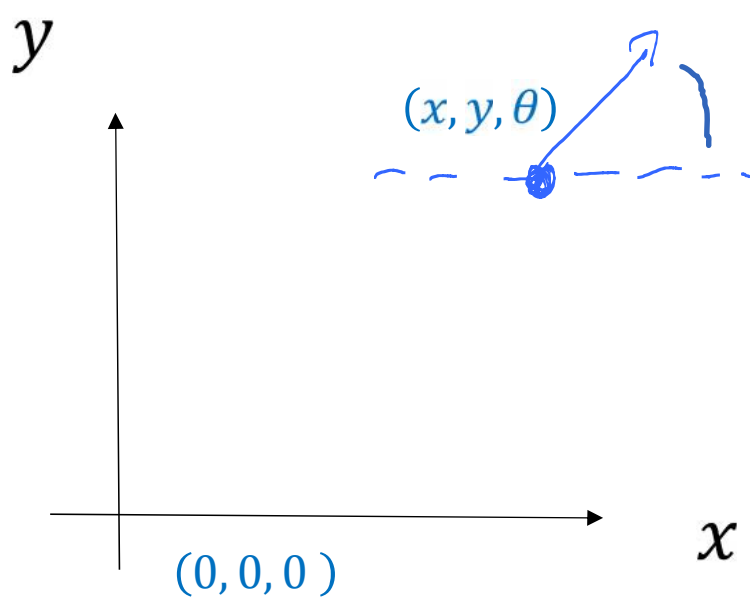
Example 4: Stacks in Graphics

Define a ‘programming language’ for drawing simple figures like this:



Define a pen position and direction (x, y, θ) .

The initial state of the pen is (0, 0, 0).



Let instructions be symbols :

D - draw unit length line in direction (changes (x, y))

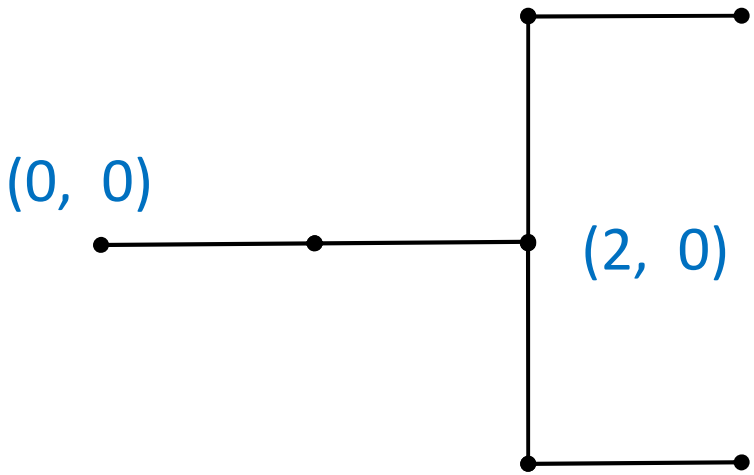
R - turn 90 degrees clockwise (changes θ)

L - turn 90 degrees counterclockwise (changes θ)

[- push state (x, y, θ)

] - pop state

The initial state of the pen is (0, 0, 0).



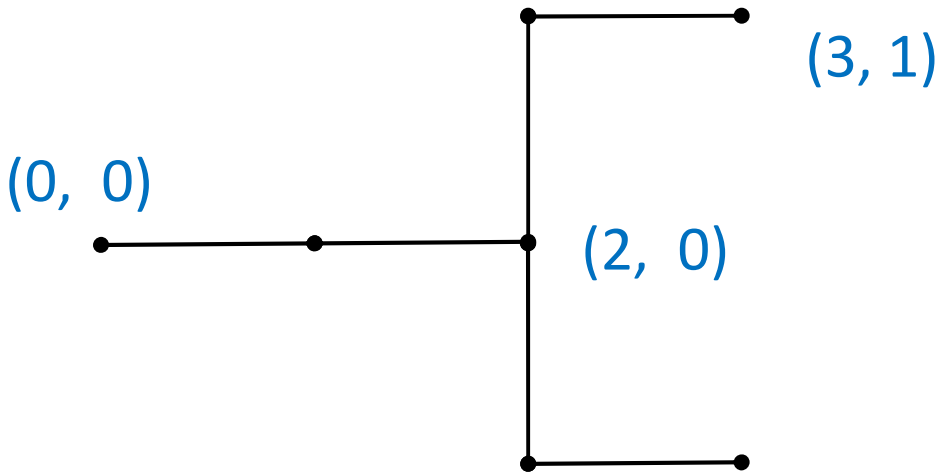
D - draw
R - turn right 90 deg
L - turn left 90 deg
[- push state
] - pop state

D D [R D L D] L D R D

_____ (2, 0, 0) _____

Q: What will be the final pen state ?

The initial state of the pen is (0, 0, 0).



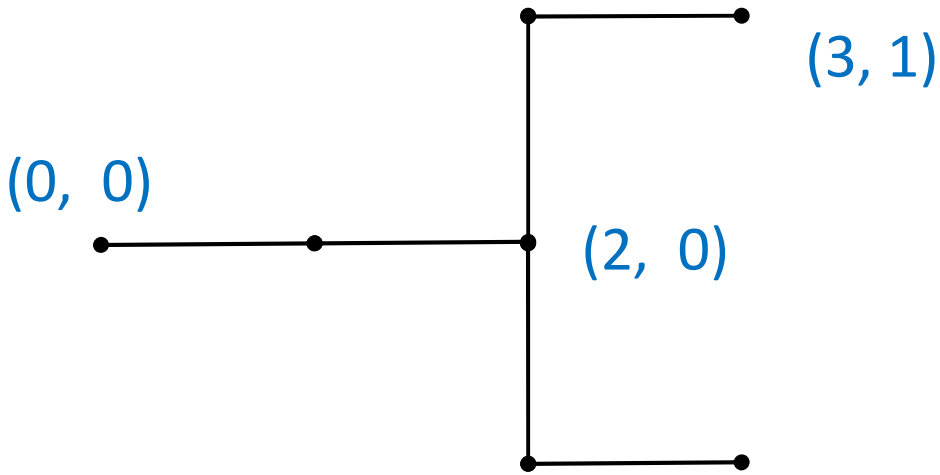
D - draw
R - turn right 90 deg
L - turn left 90 deg
[- push state
] - pop state

D D [R D L D] L D R D

_____ (2, 0, 0) _____

Q: What will be the final pen state ?
A: (3, 1, 0)

The initial state of the pen is (0, 0, 0).

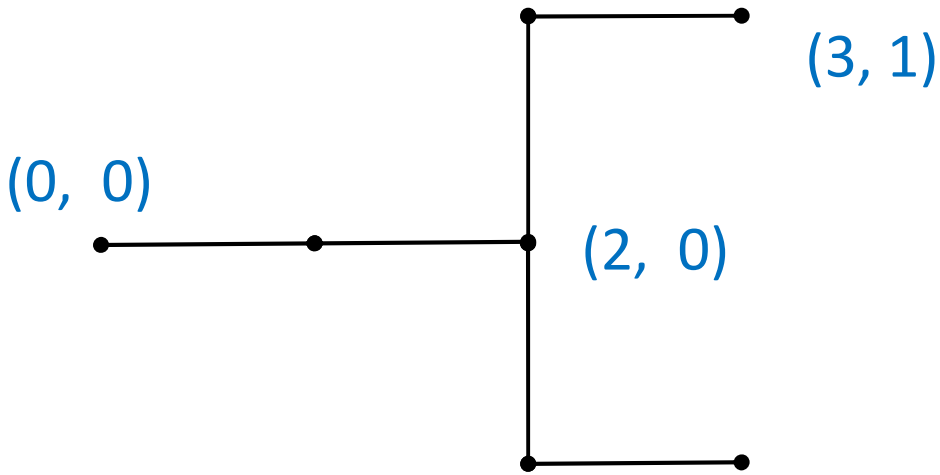


D - draw
R - turn right 90 deg
L - turn left 90 deg
[- push state
] - pop state

Q: What if we add brackets at beginning and ending ?

[D D [R D L D] L D R D]

The initial state of the pen is (0, 0, 0).

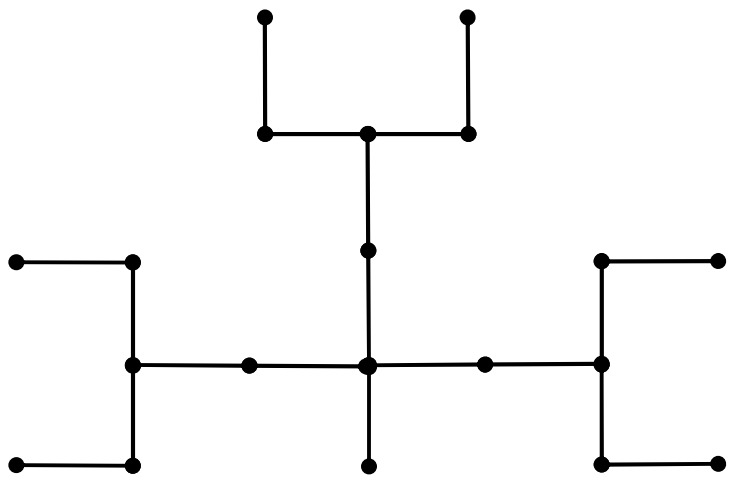


D - draw
R - turn right 90 deg
L - turn left 90 deg
[- push state
] - pop state

Q: What if we add brackets at beginning and ending ?

[D D [R D L D] L D R D]

A: The pen state will return to (0, 0, 0).



(0, 0)

[L D

R [D D [R D L D] L D R D] This line draws figure on previous slide

L [D D [R D L D] L D R D]

L [D D [R D L D] L D R D]]

Example 5a : stack of tasks

As I work in my office, emails arrive, the phone rings, people drop by, …..

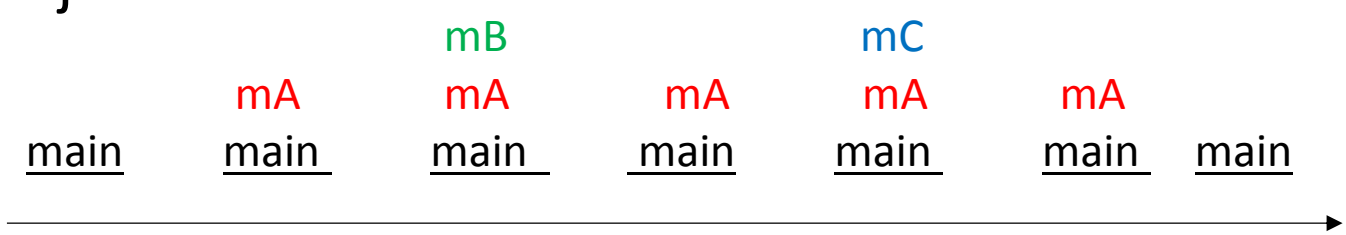
To make sure items all get finished, I must keep a stack.
(“What was I doing when ….? “)

Example 5b : "Call Stack"

```
Class   Demo {
   void   mA( ) {
              mB( );
              mC( );
           }
   void  mB( ) { … }
   void  mC( ) { … }
   void  main( ){
              mA(  );
       }
}
```

```
Class   Demo {
   void   mA( ) {
                mB( );
                mC( );
            }
   void  mB( ) { … }
   void  mC( ) { … }

   void  main( ){
                mA(  );
        }
}
```



Eclipse debug mode

Debug -

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Debug

TestSLinkedList1.java | SLinkedList1.java

```
7⊖    public static void main(String[] args){
8
9         //  HERE IS A SIMPLE TEST.
10
11        SLinkedList1<String> list = new SLinkedList1<
12
13        list.addFirst("a");
14        list.addLast("b");
15        list.addLast("c");
16        list.addLast("d");
17        list.addLast("e");
```

TestSLinkedList classes'es main() method calls addLast() method of SLinkedList1 class.

Eclipse debug mode

call stack

breakpoint

Debug -

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Debug

TestSLinkedList1 [Java Application]

linkedlists.TestSLinkedList1 at localhost:52013

Thread [main] (Suspended (breakpoint at line 85 in SLinkedList1))

SLinkedList1<E>.addLast(E) line: 85

TestSLinkedList1.main(String[]) line: 14

C:\Program Files\Java\jre7\bin\javaw.exe (Sep 19, 2016, 4:14:02 PM)

TestSLinkedList1.java | SLinkedList1.java

```
78      /**
79       * add a new element to the end of the list
80       * @param element  the new element
81       */
82
83      public void addLast(E element){
84          SNode<E> newNode = new SNode<E>(element);
85          size++;
86          if (head == null){
87              head = newNode;
88              tail = newNode;
```