Introduction to Stacks

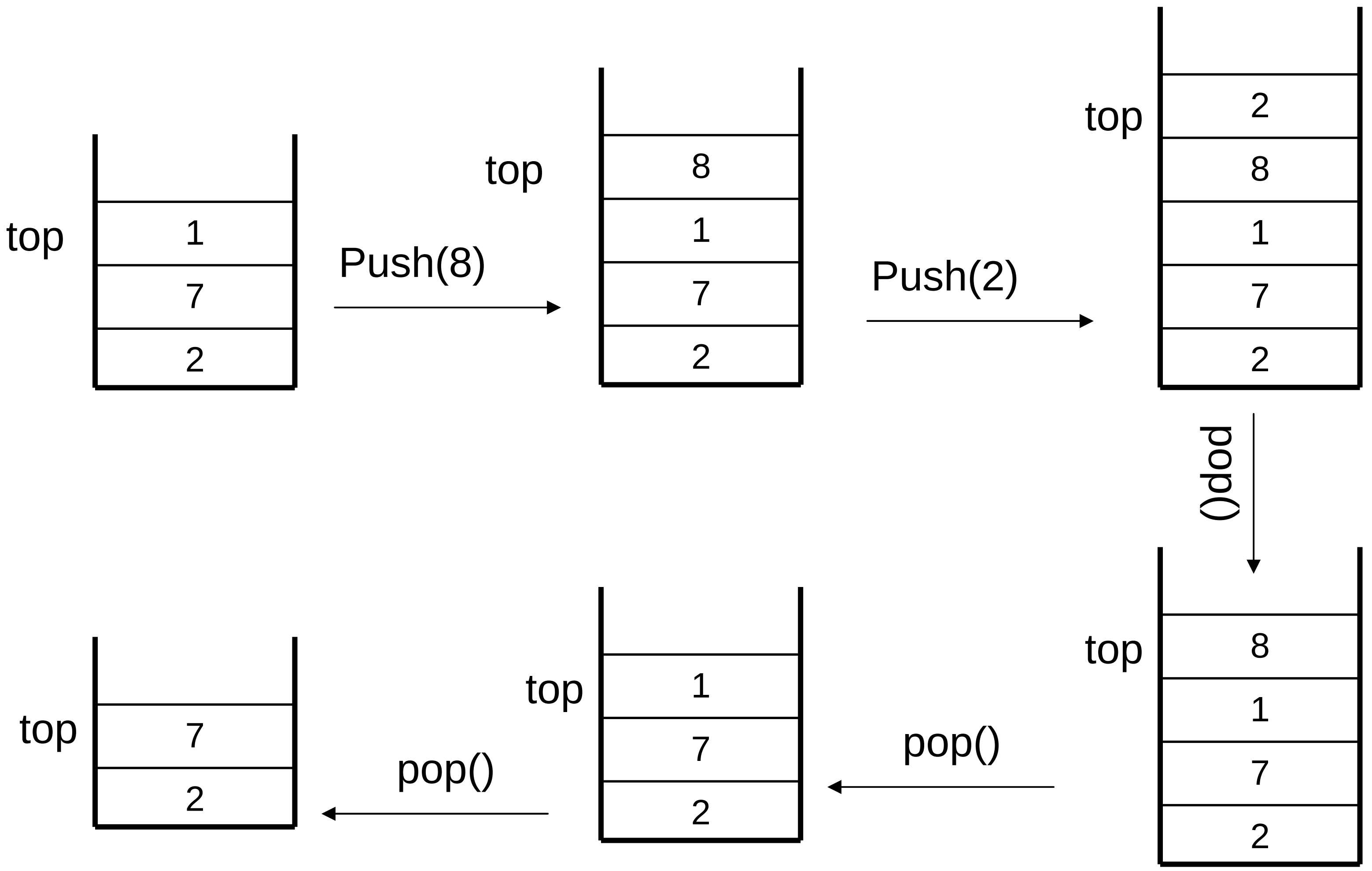
- What is a Stack
- Stack implementation using array.
- Stack implementation using linked list.
- Applications of Stack.

What is a Stack?

- Stack is a data structure in which data is added and removed at only one end called the top.
- To add (push) an item to the stack, it must be placed on the top of the stack.
- To remove (pop) an item from the stack, it must be removed from the top of the stack too.
- Thus, the last element that is pushed into the stack, is the first element to be popped out of the stack.

  i.e., Last In First Out (LIFO)

An Example of Stack



Stack Implementations

```
public interface Stack extends Container {
    public abstract Object getTop();
    public abstract void push(Object obj);
    public abstract Object pop();
}
```

- In our implementation, a stack is a **container** that extends the **AbstractContainer** class and implements the **Stack** interface.

- Two implementations:
  - **StackAsArray**
    - The underlying data structure is an array of **Object**
  - **StackAsLinkedList**
    - The underlying data structure is an object of **MyLinkedList**

StackAsArray – Constructor

- In the StackAsArray implementation that follows, the top of the stack is **array[count – 1]** and the bottom is **array[0]**:

- The constructor's single parameter, size, specifies the maximum number of items that can be stored in the stack.

- The variable array is initialized to be an array of length size.

```
public class StackAsArray extends AbstractContainer
         implements Stack {

   protected Object[] array;

   public StackAsArray(int size){
      array = new Object[size];
   }

   // …
```

StackAsArray – purge() Method

- The purpose of the purge method is to remove all the contents of a container.
- To empty the stack, the purge method simply assigns the value null to the first count positions of the array.

```
public void purge(){
   while (count > 0)
      array[--count] = null;
}
```

Complexity is O(n)

StackAsArray – push() Method

- push() method adds an element at the top the stack.
- It takes as argument an Object to be pushed.
- It first checks if there is room left in the stack. If no room is left, it throws a **ContainerFullException** exception. Otherwise, it puts the object into the array, and then increments count variable by one.

```
public void push(Object object){
   if (count == array.length)
      throw new ContainerFullException();
   else
      array[count++] = object;
}
```

Complexity is O(1)

StackAsArray – pop() Method

- The pop method removes an item from the stack and returns that item.
- The pop method first checks if the stack is empty. If the stack is empty, it throws a **ContainerEmptyException**. Otherwise, it simply decreases count by one and returns the item found at the top of the stack.

```
public Object pop(){
   if(count == 0)
      throw new ContainerEmptyException();
   else {
      Object result = array[--count];
      array[count] = null;
      return result;
   }
}
```

Complexity is O(1)

StackAsArray – getTop() Method

- getTop() method first checks if the stack is empty.
- getTop() method is a stack accessor which returns the top item in the stack without removing that item. If the stack is empty, it throws a **ContainerEmptyException.** Otherwise, it returns the top item found at position count-1.

```
public Object getTop(){
   if(count == 0)
      throw new ContainerEmptyException();
   else
      return array[count – 1];
}
```

Complexity is O(1)

StackAsArray – iterator() Method

```
public Iterator iterator() {
   return new Iterator() {
      private int position = count-1;
      public boolean hasNext() {
         return position >=0;
      }
      public Object next () {
         if(position < 0)
            throw new NoSuchElementException();
         else
            return array[position--];
      }
   };
}
```

StackAsLinkedList Implementation

```
public class StackAsLinkedList
      extends AbstractContainer
      implements Stack {

   protected MyLinkedList list;

   public StackAsLinkedList(){
      list = new MyLinkedList();
   }

   public void purge(){
      list.purge();
      count = 0;
   }

   // …
```

Complexity is O(1)

StackAsLinkedList Implementation (Cont.)

```
public void push(Object obj){
    list.prepend(obj);
    count++;
}

public Object pop(){
    if(count == 0)
        throw new ContainerEmptyException();
    else{
        Object obj = list.getFirst();
        list.extractFirst();
        count--;
        return obj;
    }
}
public Object getTop(){
    if(count == 0)
        throw new ContainerEmptyException();
    else
        return list.getFirst();
}
```

Complexity is O(1)

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StackAsLinkedList Implementation (Cont.)

```
public Iterator iterator()  {
   return new Iterator()  {
      private MyLinkedList.Element position =
            list.getHead();

      public boolean hasNext()  {
         return position != null;
      }

      public Object next()  {
         if(position == null)
            throw new NoSuchElementException();
         else  {
            Object obj = position.getData();
            position = position.getNext();
            return obj;
         }
      }
   };
}
```

Applications of Stack

- Some direct applications:
  - Page-visited history in a Web browser
  - Undo sequence in a text editor
  - Chain of method calls in the Java Virtual Machine
  - Evaluating postfix expressions

- Some indirect applications
  - Auxiliary data structure for some algorithms
  - Component of other data structures

Application of Stack - Evaluating Postfix Expression

(5+9)*2+6*5

- An ordinary arithmetical expression like the above is called infix-expression -- binary operators appear in between their operands.

- The order of operations evaluation is determined by the precedence rules and parenthesis.

- When an evaluation order is desired that is different from that provided by the precedence, parentheses are used to override precedence rules.

Application of Stack - Evaluating Postfix Expression

- Expressions can also be represented using postfix notation - where an operator comes after its two operands.

- The advantage of postfix notation is that the order of operation evaluation is unique without the need for precedence rules or parenthesis.

Infix	**Postfix**
16 / 2	16 2 /
(2 + 14)* 5	2 14 + 5 *
2 + 14 * 5	2 14 5 * +
(6 – 2) * (5 + 4)	6 2 - 5 4 + *

Application of Stack - Evaluating Postfix Expression

- The following algorithm uses a stack to evaluate a postfix expressions.

```
Start with an empty stack
for (each item in the expression) {
        if (the item is a number)
            Push the number onto the stack
        else if (the item is an operator){
            Pop two operands from the stack
            Apply the operator to the operands
            Push the result onto the stack
        }
}
Pop the only one number from the stack – that's the result of the evaluation
```

Application of Stack - Evaluating Postfix Expression

- Example: Consider the postfix expression, **2 10 + 9 6 - /,** which is **(2 + 10) / (9 - 6)** in infix, the result of which is 12 / 3 = 4.
- The following is a trace of the postfix evaluation algorithm for the above.