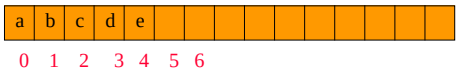
Stacks

```
public interface Stack
{
    public boolean empty();
    public Object peek();
    public void push(Object theObject);
    public Object pop();
}
```

Derive From A Linear List Class

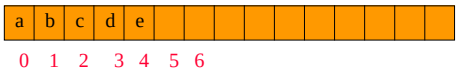
- ArrayLinearList
- Chain

Derive From ArrayLinearList



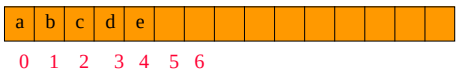
- stack top is either left end or right end of linear list
- empty() => isEmpty()
  - O(1) time
- peek() => get(0) or get(size() - 1)
  - O(1) time

Derive From ArrayLinearList



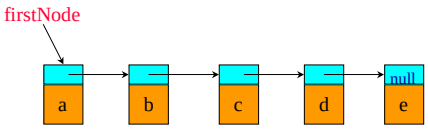
- when top is left end of linear list
  - push(theObject) => add(0, theObject)
  - O(size) time
  - pop() => remove(0)
  - O(size) time

Derive From ArrayLinearList



- when top is right end of linear list
  - push(theObject) => add(size(), theObject)
  - O(1) time
  - pop() => remove(size()-1)
  - O(1) time
- use right end of list as top of stack

Derive From Chain



- stack top is either left end or right end of linear list
- empty() => isEmpty()
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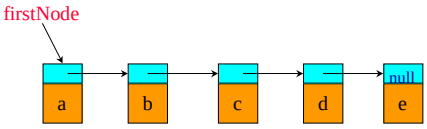
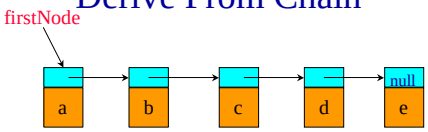
Derive From Chain



– when top is left end of linear list
- peek() => get(0)
- O(1) time
- push(theObject) => add(0, theObject)
- O(1) time
- pop() => remove(0)
- O(1) time

Derive From Chain



– when top is right end of linear list
- peek() => get(size() - 1)
- O(size) time
- push(theObject) => add(size(), theObject)
- O(size) time
- pop() => remove(size()-1)
- O(size) time

– use left end of list as top of stack

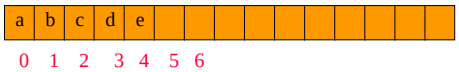
Derive From ArrayLinearList

```
package dataStructures;
import java.util.*;  // has stack exception

public class DerivedArrayStack
             extends ArrayLinearList
             implements Stack
{
  // constructors come here
  // Stack interface methods come here
}
```

Constructors

```
/** create a stack with the given initial
  * capacity */
public DerivedArrayStack(int initialCapacity)
  {super(initialCapacity);}

/** create a stack with initial capacity 10 */
public DerivedArrayStack()
  {this(10);}
```

empty() And peek()




```
public boolean empty()
  {return isEmpty();}

public Object peek()
{
  if (empty())
    throw new EmptyStackException();
  return get(size() - 1)
}
```

push(theObject) And pop()


```
public void push(Object theElement)
  {add(size(), theElement);}

public Object pop()
{
  if (empty())
    throw new EmptyStackException();
  return remove(size() - 1);
}
```

Evaluation

- Merits of deriving from ArrayLinearList
  - Code for derived class is quite simple and easy to develop.
  - Code is expected to require little debugging.
  - Code for other stack implementations such as a linked implementation are easily obtained.
    - Just replace extends ArrayLinearList with extends Chain
    - For efficiency reasons we must also make changes to use the left end of the list as the stack top rather than the right end.

Demerits

- All public methods of ArrayLinearList may be performed on a stack.
  - get(0) … get bottom element
  - remove(5)
  - add(3, x)
  - So we do not have a true stack implementation.
  - Must override undesired methods.

```
public Object get(int theIndex)
  {throw new UnsupportedOperationException();}
```

Change earlier use of get(i) to super.get(i).

Demerits

- Unecessary work is done by the code.
  - peek() verifies that the stack is not empty before get is invoked. The index check done by get is, therefore, not needed.
  - add(size(), theElement) does an index check and a for loop that is not entered. Neither is needed.
  - pop() verifies that the stack is not empty before remove is invoked. remove does an index check and a for loop that is not entered. Neither is needed.
  - So the derived code runs slower than necessary.

Evaluation

- Code developed from scratch will run faster but will take more time (cost) to develop.
- Tradeoff between software development cost and performance.
- Tradeoff between time to market and performance.
- Could develop easy code first and later refine it to improve performance.

A Faster pop()

```
if (empty())
    throw new EmptyStackException();
 return remove(size() - 1);
```

vs.

```
try {return remove(size() - 1);}
catch(IndexOutOfBoundsException e)
  {throw new EmptyStackException();}
```

Code From Scratch

- Use a 1D array stack whose data type is Object.
  - same as using array element in ArrayLinearList
- Use an int variable top.
  - Stack elements are in stack[0:top].
  - Top element is in stack[top].
  - Bottom element is in stack[0].
  - Stack is empty iff top = -1.
  - Number of elements in stack is top+1.

Code From Scratch

```
package dataStructures;
import java.util.EmptyStackException;
import utilities.*;  // ChangeArrayLength
public class ArrayStack implements Stack
{
  // data members
  int top;              // current top of stack
  Object [] stack;  // element array
  // constructors come here
  // Stack interface methods come here
}
```

Constructors


```
public ArrayStack(int initialCapacity)
{
  if (initialCapacity < 1)
    throw new IllegalArgumentException
     ("initialCapacity must be >= 1");
  stack = new Object [initialCapacity];
  top = -1;
}
public ArrayStack()
  {this(10);}
```

push(…)


```
public void push(Object theElement)
{
  // increase array size if necessary
   if  (top == stack.length - 1)
       stack = ChangeArrayLength.changeLength1D
             (stack, 2  * stack.length);
  // put theElement at the top of the stack
  stack[++top] = theElement;
}
```

pop()


```
public Object pop()
{
  if (empty())
     throw new EmptyStackException();
  Object topElement = stack[top];
  stack[top--] = null;   // enable garbage collection
  return topElement;
}
```

Linked Stack From Scratch

- See text.

java.util.Stack

- Derives from java.util.Vector.
- java.util.Vector is an array implementation of a linear list.

Performance

500,000 pop, push, and peek operations

	initial capacity	
Class	10	500,000
ArrayStack	0.44s	0.22s
DerivedArrayStack	0.60s	0.38s
DerivedArrayStackWithCatch	0.55s	0.33s
java.util.Stack	1.15s	-
DerivedLinkedStack	3.20s	3.20s
LinkedStack	2.96s	2.96s