Stacks

Victor Milenkovic

Department of Computer Science
University of Miami

CSC220 Programming II – Spring 2022

Stack

Stack

- A Stack is a standard Interface

Stack

- A Stack is a standard Interface
  - which is so standard

Stack

- A Stack is a standard Interface
  - which is so standard
  - that Java didn't even bother making it an Interface.

Stack

- A Stack is a standard Interface
  - which is so standard
  - that Java didn't even bother making it an Interface.
- Like any kind of stack we can think of,

Stack

- A Stack is a standard Interface
  - which is so standard
  - that Java didn't even bother making it an Interface.
- Like any kind of stack we can think of,
  - the top entry is easy to add, view, or remove.

Stack

- A Stack is a standard Interface
  - which is so standard
  - that Java didn't even bother making it an Interface.
- Like any kind of stack we can think of,
  - the top entry is easy to add, view, or remove.
  - Trying to add, view, or remove entries in the middle is messy and awkward.

Stack Methods

Stack Methods

- The names for the Stack methods are a little strange:

Stack Methods

- The names for the Stack methods are a little strange:
  - **push** add a new entry to the top of the stack

Stack Methods

- The names for the Stack methods are a little strange:
  - **push** add a new entry to the top of the stack
  - **pop** remove one entry from the top of the stack

Stack Methods

- The names for the Stack methods are a little strange:
  - **push** add a new entry to the top of the stack
  - **pop** remove one entry from the top of the stack
  - **peek** look at the top entry of the stack without changing it

Stack Methods

- The names for the Stack methods are a little strange:
  - **push** add a new entry to the top of the stack
  - **pop** remove one entry from the top of the stack
  - **peek** look at the top entry of the stack without changing it
  - **empty** true if there is nothing in the stack, false otherwise

Stack Methods

- The names for the Stack methods are a little strange:
  - **push** add a new entry to the top of the stack
  - **pop** remove one entry from the top of the stack
  - **peek** look at the top entry of the stack without changing it
  - **empty** true if there is nothing in the stack, false otherwise
- When I put something on top of one of the towering stacks of papers on my desk,

Stack Methods

- The names for the Stack methods are a little strange:
  - **push** add a new entry to the top of the stack
  - **pop** remove one entry from the top of the stack
  - **peek** look at the top entry of the stack without changing it
  - **empty** true if there is nothing in the stack, false otherwise
- When I put something on top of one of the towering stacks of papers on my desk,
  - I don't think of it as *pushing*,

Stack Methods

- The names for the Stack methods are a little strange:
  - **push** add a new entry to the top of the stack
  - **pop** remove one entry from the top of the stack
  - **peek** look at the top entry of the stack without changing it
  - **empty** true if there is nothing in the stack, false otherwise
- When I put something on top of one of the towering stacks of papers on my desk,
  - I don't think of it as *pushing*,
  - nor do I think of it as *popping* when I remove it.

Stack Methods

- The names for the Stack methods are a little strange:
  - **push** add a new entry to the top of the stack
  - **pop** remove one entry from the top of the stack
  - **peek** look at the top entry of the stack without changing it
  - **empty** true if there is nothing in the stack, false otherwise
- When I put something on top of one of the towering stacks of papers on my desk,
  - I don't think of it as *pushing*,
  - nor do I think of it as *popping* when I remove it.
  - Peek and empty make sense though.

Name Origins

I think what the original inventors had in mind was a 1950s buffet diner spring loaded plate dispenser.

Name Origins

I think what the original inventors had in mind was a 1950s buffet diner spring loaded plate dispenser.

- The power cord is to run a dish warmer.

Name Origins

I think what the original inventors had in mind was a 1950s buffet diner spring loaded plate dispenser.

- The power cord is to run a dish warmer.
- It doesn't shoot the dishes up when it pops!

Name Origins

I think what the original inventors had in mind was a 1950s buffet diner spring loaded plate dispenser.

- The power cord is to run a dish warmer.
- It doesn't shoot the dishes up when it pops!
- Instead, it always keeps the top dish level with the top of the dispenser,

Name Origins

I think what the original inventors had in mind was a 1950s buffet diner spring loaded plate dispenser.

- The power cord is to run a dish warmer.
- It doesn't shoot the dishes up when it pops!
- Instead, it always keeps the top dish level with the top of the dispenser,
- although I don't think that requires electricity.

Stack methods in action

```
Stack stack = new Stack();
```

Stack methods in action

```
Stack stack = new Stack();
stack.empty();
```

Stack methods in action

```
Stack stack = new Stack();
stack.empty();                    // returns true
```

Stack methods in action

```
Stack stack = new Stack();
stack.empty();                  // returns true
stack.push("mango");
```

Stack methods in action

```
Stack stack = new Stack();
stack.empty();                  // returns true
stack.push("mango");
stack.push("banana");
```

Stack methods in action

```
Stack stack = new Stack();
stack.empty();                  // returns true
stack.push("mango");
stack.push("banana");
stack.push("coconut");
```

Stack methods in action

```
Stack stack = new Stack();
stack.empty();                  // returns true
stack.push("mango");
stack.push("banana");
stack.push("coconut");
stack.pop();
```

Stack methods in action

```
Stack stack = new Stack();
stack.empty();                  // returns true
stack.push("mango");
stack.push("banana");
stack.push("coconut");
stack.pop();                    // returns "coconut"
```

Stack methods in action

```
Stack stack = new Stack();
stack.empty();                  // returns true
stack.push("mango");
stack.push("banana");
stack.push("coconut");
stack.pop();                    // returns "coconut"
stack.peek();
```

Stack methods in action

```
Stack stack = new Stack();
stack.empty();                  // returns true
stack.push("mango");
stack.push("banana");
stack.push("coconut");
stack.pop();                    // returns "coconut"
stack.peek();                   // returns "banana"
```

Stack methods in action

```
Stack stack = new Stack();
stack.empty();                  // returns true
stack.push("mango");
stack.push("banana");
stack.push("coconut");
stack.pop();                    // returns "coconut"
stack.peek();                   // returns "banana"
stack.push("cantaloupe");
```

Stack methods in action

```
Stack stack = new Stack();
stack.empty();                  // returns true
stack.push("mango");
stack.push("banana");
stack.push("coconut");
stack.pop();                    // returns "coconut"
stack.peek();                   // returns "banana"
stack.push("cantaloupe");
stack.pop();
```

Stack methods in action

```
Stack stack = new Stack();
stack.empty();                  // returns true
stack.push("mango");
stack.push("banana");
stack.push("coconut");
stack.pop();                    // returns "coconut"
stack.peek();                   // returns "banana"
stack.push("cantaloupe");
stack.pop();                    // returns "cantaloupe"
```

Stack methods in action

```
Stack stack = new Stack();
stack.empty();                  // returns true
stack.push("mango");
stack.push("banana");
stack.push("coconut");
stack.pop();                    // returns "coconut"
stack.peek();                   // returns "banana"
stack.push("cantaloupe");
stack.pop();                    // returns "cantaloupe"
stack.pop();
```

Stack methods in action

```
Stack stack = new Stack();
stack.empty();                  // returns true
stack.push("mango");
stack.push("banana");
stack.push("coconut");
stack.pop();                    // returns "coconut"
stack.peek();                   // returns "banana"
stack.push("cantaloupe");
stack.pop();                    // returns "cantaloupe"
stack.pop();                    // returns "banana"
```

Stack methods in action

```
Stack stack = new Stack();
stack.empty();                  // returns true
stack.push("mango");
stack.push("banana");
stack.push("coconut");
stack.pop();                    // returns "coconut"
stack.peek();                   // returns "banana"
stack.push("cantaloupe");
stack.pop();                    // returns "cantaloupe"
stack.pop();                    // returns "banana"
stack.empty();
```

Stack methods in action

```
Stack stack = new Stack();
stack.empty();                  // returns true
stack.push("mango");
stack.push("banana");
stack.push("coconut");
stack.pop();                    // returns "coconut"
stack.peek();                   // returns "banana"
stack.push("cantaloupe");
stack.pop();                    // returns "cantaloupe"
stack.pop();                    // returns "banana"
stack.empty();                  // returns false
```

Stack methods in action

```
Stack stack = new Stack();
stack.empty();                  // returns true
stack.push("mango");
stack.push("banana");
stack.push("coconut");
stack.pop();                    // returns "coconut"
stack.peek();                   // returns "banana"
stack.push("cantaloupe");
stack.pop();                    // returns "cantaloupe"
stack.pop();                    // returns "banana"
stack.empty();                  // returns false
stack.pop();
```

Stack methods in action

```
Stack stack = new Stack();
stack.empty();                  // returns true
stack.push("mango");
stack.push("banana");
stack.push("coconut");
stack.pop();                    // returns "coconut"
stack.peek();                   // returns "banana"
stack.push("cantaloupe");
stack.pop();                    // returns "cantaloupe"
stack.pop();                    // returns "banana"
stack.empty();                  // returns false
stack.pop();                    // returns "mango"
```

Stack methods in action

```
Stack stack = new Stack();
stack.empty();                  // returns true
stack.push("mango");
stack.push("banana");
stack.push("coconut");
stack.pop();                    // returns "coconut"
stack.peek();                   // returns "banana"
stack.push("cantaloupe");
stack.pop();                    // returns "cantaloupe"
stack.pop();                    // returns "banana"
stack.empty();                  // returns false
stack.pop();                    // returns "mango"
stack.peek();
```

Stack methods in action

```
Stack stack = new Stack();
stack.empty();                  // returns true
stack.push("mango");
stack.push("banana");
stack.push("coconut");
stack.pop();                    // returns "coconut"
stack.peek();                   // returns "banana"
stack.push("cantaloupe");
stack.pop();                    // returns "cantaloupe"
stack.pop();                    // returns "banana"
stack.empty();                  // returns false
stack.pop();                    // returns "mango"
stack.peek();                   // throws EmptyStackException
```

Lab

Lab

For the next prog, you will learn three ways to implement Stack.

Lab

For the next prog, you will learn three ways to implement Stack.
In StackInterface.java, you will notice something new:

Lab

For the next prog, you will learn three ways to implement Stack.
In StackInterface.java, you will notice something new:

- < E >

Lab

For the next prog, you will learn three ways to implement Stack.
In StackInterface.java, you will notice something new:

- < E >

That is a generic declaration. In means you can have

Lab

For the next prog, you will learn three ways to implement Stack.
In StackInterface.java, you will notice something new:

- < E >

That is a generic declaration. In means you can have

- StackInterface<String>

Lab

For the next prog, you will learn three ways to implement Stack.
In StackInterface.java, you will notice something new:

- < E >

That is a generic declaration. In means you can have

- StackInterface<String>
- StackInterface<DirectoryEntry>

Lab

For the next prog, you will learn three ways to implement Stack.
In StackInterface.java, you will notice something new:

- < E >

That is a generic declaration. In means you can have

- StackInterface<String>
- StackInterface<DirectoryEntry>
- or a stack of any type of class.

Lab

For the next prog, you will learn three ways to implement Stack.
In StackInterface.java, you will notice something new:

- < E >

That is a generic declaration. In means you can have

- StackInterface<String>
- StackInterface<DirectoryEntry>
- or a stack of any type of class.

When you do this, the Java compiler will make sure you only put that kind of thing into that stack.

Lab

For the next prog, you will learn three ways to implement Stack.
In StackInterface.java, you will notice something new:

- < E >

That is a generic declaration. In means you can have

- StackInterface<String>
- StackInterface<DirectoryEntry>
- or a stack of any type of class.

When you do this, the Java compiler will make sure you only put that kind of thing into that stack.
It has to be a class, however, so for primitive data types you have to use the class version of those types:

Lab

For the next prog, you will learn three ways to implement Stack.
In StackInterface.java, you will notice something new:

- $< E >$

That is a generic declaration. In means you can have

- StackInterface<String>
- StackInterface<DirectoryEntry>
- or a stack of any type of class.

When you do this, the Java compiler will make sure you only put that kind of thing into that stack.
It has to be a class, however, so for primitive data types you have to use the class version of those types:

- char $\rightarrow$ Character

Lab

For the next prog, you will learn three ways to implement Stack.
In StackInterface.java, you will notice something new:

- $<$ E $>$

That is a generic declaration. In means you can have

- StackInterface$<$String$>$
- StackInterface$<$DirectoryEntry$>$
- or a stack of any type of class.

When you do this, the Java compiler will make sure you only put that kind of thing into that stack.
It has to be a class, however, so for primitive data types you have to use the class version of those types:

- char $\rightarrow$ Character
- int $\rightarrow$ Integer

Lab

For the next prog, you will learn three ways to implement Stack.
In StackInterface.java, you will notice something new:

- $<$ E $>$

That is a generic declaration. In means you can have

- StackInterface<String>
- StackInterface<DirectoryEntry>
- or a stack of any type of class.

When you do this, the Java compiler will make sure you only put that kind of thing into that stack.
It has to be a class, however, so for primitive data types you have to use the class version of those types:

- char $\rightarrow$ Character
- int $\rightarrow$ Integer
- double $\rightarrow$ Double

Lab

For the next prog, you will learn three ways to implement Stack.
In StackInterface.java, you will notice something new:

- $<$ E $>$

That is a generic declaration. In means you can have

- StackInterface<String>
- StackInterface<DirectoryEntry>
- or a stack of any type of class.

When you do this, the Java compiler will make sure you only put that kind of thing into that stack.
It has to be a class, however, so for primitive data types you have to use the class version of those types:

- char $\rightarrow$ Character
- int $\rightarrow$ Integer
- double $\rightarrow$ Double

This is less efficient (by a constant factor in space and time) than creating a specific StackOfChar, etc., but it is usually good enough.

Examples

Stack<Puppy>

Stack<Cat>

Stack<Stack<Cash>>

ArrayStack

ArrayStack.java

ArrayStack

ArrayStack.java

- Array based implementation of StackInterface.

ArrayStack

ArrayStack.java

- Array based implementation of StackInterface.
- Items are pushed at first unused location of the array.

ArrayStack

ArrayStack.java

- Array based implementation of StackInterface.
- Items are pushed at first unused location of the array.
- So push is O(1),

ArrayStack

ArrayStack.java

- Array based implementation of StackInterface.
- Items are pushed at first unused location of the array.
- So push is O(1),
- (unless the array is full and needs to be reallocated).

ArrayStack

ArrayStack.java

- Array based implementation of StackInterface.
- Items are pushed at first unused location of the array.
- So push is O(1),
- (unless the array is full and needs to be reallocated).
- This is the fastest way to implement a stack,

ArrayStack

ArrayStack.java

- Array based implementation of StackInterface.
- Items are pushed at first unused location of the array.
- So push is O(1),
- (unless the array is full and needs to be reallocated).
- This is the fastest way to implement a stack,
- but it might not be good for real time programming.

(Sorry the laser stopped in the middle of your eye, but we have to allocate a bigger array!)

LinkedStack

LinkedStack.java

LinkedStack

LinkedStack.java

- Linked list implementation

LinkedStack

LinkedStack.java

- Linked list implementation
- O(1) per operation (really?).

LinkedStack

LinkedStack.java

- Linked list implementation
- O(1) per operation (really?).

You will notice some new techniques.

LinkedStack

LinkedStack.java

- Linked list implementation
- O(1) per operation (really?).

You will notice some new techniques.

- The entire Node class is private

LinkedStack

LinkedStack.java

- Linked list implementation
- O(1) per operation (really?).

You will notice some new techniques.

- The entire Node class is private
- and declared inside LinkedStack.

LinkedStack

LinkedStack.java

- Linked list implementation
- O(1) per operation (really?).

You will notice some new techniques.

- The entire Node class is private
- and declared inside LinkedStack.
- No separate Java file

LinkedStack

LinkedStack.java

- Linked list implementation
- O(1) per operation (really?).

You will notice some new techniques.

- The entire Node class is private
- and declared inside LinkedStack.
- No separate Java file
- No need for accessor methods (getNext(), etc).

LinkedStack

LinkedStack.java

- Linked list implementation
- O(1) per operation (really?).

You will notice some new techniques.

- The entire Node class is private
- and declared inside LinkedStack.
- No separate Java file
- No need for accessor methods (getNext(), etc).
- node.next gets you the next node (instead of something like node.getNext()).

LinkedStack

LinkedStack.java

- Linked list implementation
- O(1) per operation (really?).

You will notice some new techniques.

- The entire Node class is private
- and declared inside LinkedStack.
- No separate Java file
- No need for accessor methods (getNext(), etc).
- node.next gets you the next node (instead of something like node.getNext()).

A linked list is like a scavenger hunt:

LinkedStack

LinkedStack.java

- Linked list implementation
- O(1) per operation (really?).

You will notice some new techniques.

- The entire Node class is private
- and declared inside LinkedStack.
- No separate Java file
- No need for accessor methods (getNext(), etc).
- node.next gets you the next node (instead of something like node.getNext()).

A linked list is like a scavenger hunt:

- topNode points to the Node containing the top data item.

LinkedStack

LinkedStack.java

- Linked list implementation
- O(1) per operation (really?).

You will notice some new techniques.

- The entire Node class is private
- and declared inside LinkedStack.
- No separate Java file
- No need for accessor methods (getNext(), etc).
- node.next gets you the next node (instead of something like node.getNext()).

A linked list is like a scavenger hunt:

- topNode points to the Node containing the top data item.
- The nextNode field of that Node, accessed by topNode.nextNode,

LinkedStack

LinkedStack.java

- Linked list implementation
- O(1) per operation (really?).

You will notice some new techniques.

- The entire Node class is private
- and declared inside LinkedStack.
- No separate Java file
- No need for accessor methods (getNext(), etc).
- node.next gets you the next node (instead of something like node.getNext()).

A linked list is like a scavenger hunt:

- topNode points to the Node containing the top data item.
- The nextNode field of that Node, accessed by topNode.nextNode, points to the Node containing the next data item (down) in the stack.

LinkedStack

LinkedStack.java

- Linked list implementation
- O(1) per operation (really?).

You will notice some new techniques.

- The entire Node class is private
- and declared inside LinkedStack.
- No separate Java file
- No need for accessor methods (getNext(), etc).
- node.next gets you the next node (instead of something like node.getNext()).

A linked list is like a scavenger hunt:

- topNode points to the Node containing the top data item.
- The nextNode field of that Node, accessed by topNode.nextNode, points to the Node containing the next data item (down) in the stack.
- The nextNode of that Node points to the Node with the next data item

LinkedStack

LinkedStack.java

- Linked list implementation
- O(1) per operation (really?).

You will notice some new techniques.

- The entire Node class is private
- and declared inside LinkedStack.
- No separate Java file
- No need for accessor methods (getNext(), etc).
- node.next gets you the next node (instead of something like node.getNext()).

A linked list is like a scavenger hunt:

- topNode points to the Node containing the top data item.
- The nextNode field of that Node, accessed by topNode.nextNode, points to the Node containing the next data item (down) in the stack.
- The nextNode of that Node points to the Node with the next data item
- and so forth.

LinkedStack

LinkedStack.java

- Linked list implementation
- O(1) per operation (really?).

You will notice some new techniques.

- The entire Node class is private
- and declared inside LinkedStack.
- No separate Java file
- No need for accessor methods (getNext(), etc).
- node.next gets you the next node (instead of something like node.getNext()).

A linked list is like a scavenger hunt:

- topNode points to the Node containing the top data item.
- The nextNode field of that Node, accessed by topNode.nextNode, points to the Node containing the next data item (down) in the stack.
- The nextNode of that Node points to the Node with the next data item
- and so forth.

To push:

LinkedStack

LinkedStack.java

- Linked list implementation
- O(1) per operation (really?).

You will notice some new techniques.

- The entire Node class is private
- and declared inside LinkedStack.
- No separate Java file
- No need for accessor methods (getNext(), etc).
- node.next gets you the next node (instead of something like node.getNext()).

A linked list is like a scavenger hunt:

- topNode points to the Node containing the top data item.
- The nextNode field of that Node, accessed by topNode.nextNode, points to the Node containing the next data item (down) in the stack.
- The nextNode of that Node points to the Node with the next data item
- and so forth.

To push:

- Set newNode to a new Node with the new data item.

LinkedStack

LinkedStack.java

- Linked list implementation
- O(1) per operation (really?).

You will notice some new techniques.

- The entire Node class is private
- and declared inside LinkedStack.
- No separate Java file
- No need for accessor methods (getNext(), etc).
- node.next gets you the next node (instead of something like node.getNext()).

A linked list is like a scavenger hunt:

- topNode points to the Node containing the top data item.
- The nextNode field of that Node, accessed by topNode.nextNode, points to the Node containing the next data item (down) in the stack.
- The nextNode of that Node points to the Node with the next data item
- and so forth.

To push:

- Set newNode to a new Node with the new data item.
- Set its nextNode to the current top Node.

LinkedStack

LinkedStack.java

- Linked list implementation
- O(1) per operation (really?).

You will notice some new techniques.

- The entire Node class is private
- and declared inside LinkedStack.
- No separate Java file
- No need for accessor methods (getNext(), etc).
- node.next gets you the next node (instead of something like node.getNext()).

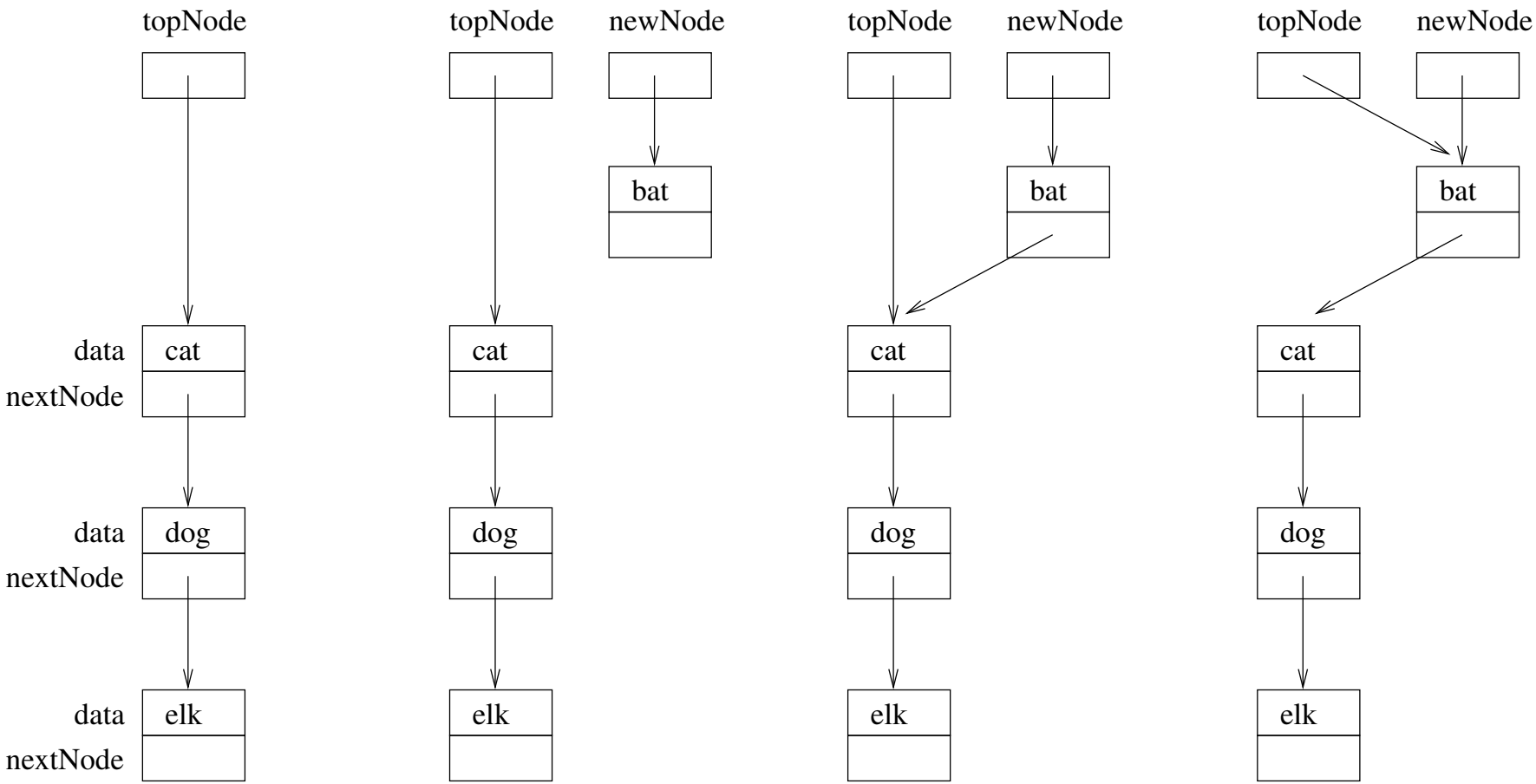
A linked list is like a scavenger hunt:

- topNode points to the Node containing the top data item.
- The nextNode field of that Node, accessed by topNode.nextNode, points to the Node containing the next data item (down) in the stack.
- The nextNode of that Node points to the Node with the next data item
- and so forth.

To push:

- Set newNode to a new Node with the new data item.
- Set its nextNode to the current top Node.
- Set topNode to the new Node.

LinkedStack



ListStack

ListStack

ListStack.java

ListStack

ListStack.java

- Implementation using java.util.List

ListStack

ListStack.java

- Implementation using java.util.List
- and its implementation java.util.ArrayList.

ListStack

ListStack.java

- Implementation using java.util.List
- and its implementation java.util.ArrayList.

List is an *interface*

ListStack

ListStack.java

- Implementation using java.util.List
- and its implementation java.util.ArrayList.

List is an *interface*

- Describes a list.

ListStack

ListStack.java

- Implementation using java.util.List
- and its implementation java.util.ArrayList.

List is an *interface*

- Describes a list.
- add(item) means add an item to the end of the list.

ListStack

ListStack.java

- Implementation using java.util.List
- and its implementation java.util.ArrayList.

List is an *interface*

- Describes a list.
- add(item) means add an item to the end of the list.
- We will use add() to implement push().

ListStack

ListStack.java

- Implementation using java.util.List
- and its implementation java.util.ArrayList.

List is an *interface*

- Describes a list.
- add(item) means add an item to the end of the list.
- We will use add() to implement push().

Look at the List documentation,

ListStack

ListStack.java

- Implementation using java.util.List
- and its implementation java.util.ArrayList.

List is an *interface*

- Describes a list.
- add(item) means add an item to the end of the list.
- We will use add() to implement push().

Look at the List documentation,

- particularly size(), get(), and remove().

ListStack

ListStack.java

- Implementation using java.util.List
- and its implementation java.util.ArrayList.

List is an *interface*

- Describes a list.
- add(item) means add an item to the end of the list.
- We will use add() to implement push().

Look at the List documentation,

- particularly size(), get(), and remove().
- How do we implement empty()?

ListStack

ListStack.java

- Implementation using java.util.List
- and its implementation java.util.ArrayList.

List is an *interface*

- Describes a list.
- add(item) means add an item to the end of the list.
- We will use add() to implement push().

Look at the List documentation,

- particularly size(), get(), and remove().
- How do we implement empty()?
- How do we implement peek()?

ListStack

ListStack.java

- Implementation using java.util.List
- and its implementation java.util.ArrayList.

List is an *interface*

- Describes a list.
- add(item) means add an item to the end of the list.
- We will use add() to implement push().

Look at the List documentation,

- particularly size(), get(), and remove().
- How do we implement empty()?
- How do we implement peek()?
- How do we implement pop()?

ListStack

Use ArrayList implementation of List.

ListStack

Use ArrayList implementation of List.

- Partially filled array.

ListStack

Use ArrayList implementation of List.

- Partially filled array.
- Just like we have been doing.

ListStack

Use ArrayList implementation of List.

- Partially filled array.
- Just like we have been doing.
- When size==length, it reallocates.

ListStack

Use ArrayList implementation of List.

- Partially filled array.
- Just like we have been doing.
- When size==length, it reallocates.
- Array variable and size are private.

ListStack

Use ArrayList implementation of List.

- Partially filled array.
- Just like we have been doing.
- When size==length, it reallocates.
- Array variable and size are private.

java.util.LinkedList

ListStack

Use ArrayList implementation of List.

- Partially filled array.
- Just like we have been doing.
- When size==length, it reallocates.
- Array variable and size are private.

java.util.LinkedList

- Doubly linked list implementation of List.

ListStack

Use ArrayList implementation of List.

- Partially filled array.
- Just like we have been doing.
- When size==length, it reallocates.
- Array variable and size are private.

java.util.LinkedList

- Doubly linked list implementation of List.
- “Doubly” means each Node has a nextNode and a previousNode.

ListStack

Use ArrayList implementation of List.

- Partially filled array.
- Just like we have been doing.
- When size==length, it reallocates.
- Array variable and size are private.

java.util.LinkedList

- Doubly linked list implementation of List.
- “Doubly” means each Node has a nextNode and a previousNode.
- We could easily use it if we wanted to,

ListStack

Use ArrayList implementation of List.

- Partially filled array.
- Just like we have been doing.
- When size==length, it reallocates.
- Array variable and size are private.

java.util.LinkedList

- Doubly linked list implementation of List.
- “Doubly” means each Node has a nextNode and a previousNode.
- We could easily use it if we wanted to,
- thanks to the List interface.

Summary

Summary

- Stack

Summary

Stack

- The StackInterface interface describes a *Stack*.

Summary

Stack

- The StackInterface interface describes a *Stack*.
- Only adding or removing at the top is possible.

Summary

Stack

- The StackInterface interface describes a *Stack*.
- Only adding or removing at the top is possible.
- Operations called *push*, *pop*, *peek*, *empty*.

Summary

Stack

- The StackInterface interface describes a *Stack*.
- Only adding or removing at the top is possible.
- Operations called *push*, *pop*, *peek*, *empty*.
- Implemented using array, linked list, or List interface.

Summary

Stack

- The StackInterface interface describes a *Stack*.
- Only adding or removing at the top is possible.
- Operations called *push*, *pop*, *peek*, *empty*.
- Implemented using array, linked list, or List interface.

ArrayStack

Summary

Stack

- The StackInterface interface describes a *Stack*.
- Only adding or removing at the top is possible.
- Operations called *push*, *pop*, *peek*, *empty*.
- Implemented using array, linked list, or List interface.

ArrayStack

- Implement using an array.

Summary

Stack

- The StackInterface interface describes a *Stack*.
- Only adding or removing at the top is possible.
- Operations called *push*, *pop*, *peek*, *empty*.
- Implemented using array, linked list, or List interface.

ArrayStack

- Implement using an array.
- Adding is $\mathrm{O}(1)$ except for reallocate().

Summary

Stack

- The StackInterface interface describes a *Stack*.
- Only adding or removing at the top is possible.
- Operations called *push*, *pop*, *peek*, *empty*.
- Implemented using array, linked list, or List interface.

ArrayStack

- Implement using an array.
- Adding is $\mathrm{O}(1)$ except for reallocate().

LinkedStack

Summary

Stack

- The StackInterface interface describes a *Stack*.
- Only adding or removing at the top is possible.
- Operations called *push*, *pop*, *peek*, *empty*.
- Implemented using array, linked list, or List interface.

ArrayStack

- Implement using an array.
- Adding is $\mathrm{O}(1)$ except for reallocate().

LinkedStack

- Private Entry class.

Summary

Stack

- The StackInterface interface describes a *Stack*.
- Only adding or removing at the top is possible.
- Operations called *push*, *pop*, *peek*, *empty*.
- Implemented using array, linked list, or List interface.

ArrayStack

- Implement using an array.
- Adding is $\mathrm{O}(1)$ except for reallocate().

LinkedStack

- Private Entry class.
- entry.next instead of entry.getNext()

Summary

Stack

- The StackInterface interface describes a *Stack*.
- Only adding or removing at the top is possible.
- Operations called *push*, *pop*, *peek*, *empty*.
- Implemented using array, linked list, or List interface.

ArrayStack

- Implement using an array.
- Adding is $O(1)$ except for reallocate().

LinkedStack

- Private Entry class.
- entry.next instead of entry.getNext()
- Push and pop at front (first) of list.

Summary

Stack

- The StackInterface interface describes a *Stack*.
- Only adding or removing at the top is possible.
- Operations called *push*, *pop*, *peek*, *empty*.
- Implemented using array, linked list, or List interface.

ArrayStack

- Implement using an array.
- Adding is $O(1)$ except for reallocate().

LinkedStack

- Private Entry class.
- entry.next instead of entry.getNext()
- Push and pop at front (first) of list.

ListStack

Summary

Stack

- The StackInterface interface describes a *Stack*.
- Only adding or removing at the top is possible.
- Operations called *push*, *pop*, *peek*, *empty*.
- Implemented using array, linked list, or List interface.

ArrayStack

- Implement using an array.
- Adding is $O(1)$ except for reallocate().

LinkedStack

- Private Entry class.
- entry.next instead of entry.getNext()
- Push and pop at front (first) of list.

ListStack

- Use Java *List* interface.

Summary

Stack

- The StackInterface interface describes a *Stack*.
- Only adding or removing at the top is possible.
- Operations called *push*, *pop*, *peek*, *empty*.
- Implemented using array, linked list, or List interface.

ArrayStack

- Implement using an array.
- Adding is $O(1)$ except for reallocate().

LinkedStack

- Private Entry class.
- entry.next instead of entry.getNext()
- Push and pop at front (first) of list.

ListStack

- Use Java *List* interface.
- Use add(item), size(), get(index), remove(index).

Summary

Stack

- The StackInterface interface describes a *Stack*.
- Only adding or removing at the top is possible.
- Operations called *push*, *pop*, *peek*, *empty*.
- Implemented using array, linked list, or List interface.

ArrayStack

- Implement using an array.
- Adding is $O(1)$ except for reallocate().

LinkedStack

- Private Entry class.
- entry.next instead of entry.getNext()
- Push and pop at front (first) of list.

ListStack

- Use Java *List* interface.
- Use add(item), size(), get(index), remove(index).
- ArrayList implementation uses partially filled array.

Summary

Stack

- The StackInterface interface describes a *Stack*.
- Only adding or removing at the top is possible.
- Operations called *push*, *pop*, *peek*, *empty*.
- Implemented using array, linked list, or List interface.

ArrayStack

- Implement using an array.
- Adding is $O(1)$ except for reallocate().

LinkedStack

- Private Entry class.
- entry.next instead of entry.getNext()
- Push and pop at front (first) of list.

ListStack

- Use Java *List* interface.
- Use add(item), size(), get(index), remove(index).
- ArrayList implementation uses partially filled array.
- LinkedList is another implementation of List using a doubly linked list.