Data Structures in Java

Session 5

Instructor: Bert Huang

http://www1.cs.columbia.edu/~bert/courses/3134

Announcements

- Homework 1 is due now.
  - Late penalty in effect
- Homework 2 released on website
  - Due Oct. 6th at 5:40 PM (14 days)

Review

- Extra Big-Oh analysis example
- List Abstract Data Type
- Array Lists
- Linked Lists

Today's Plan

- List code study
  - MyArrayList
  - MyLinkedList
- The Iterable interface
- Definition of Stack ADT

MyArrayList


```
public class MyArrayList<AnyType> implements Iterable<AnyType> {



    private static final int DEFAULT_CAPACITY = 10;

    private AnyType [ ] theItems;
    private int theSize;
}
```

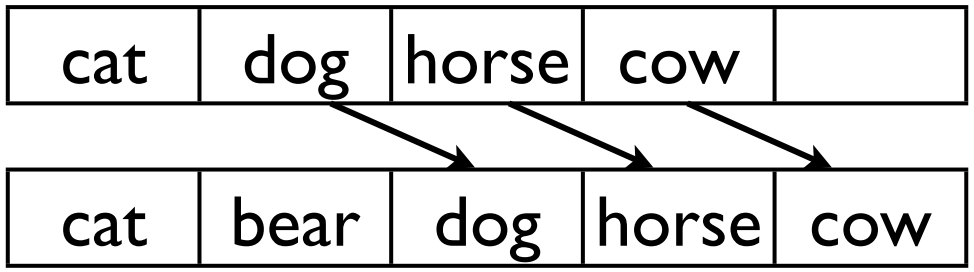
```java
/**
 * Construct an empty ArrayList.
 */
public MyArrayList( )
{
    clear( );
}

/**
 * Change the size of this collection to zero.
 */
public void clear( )
{
    theSize = 0;
    ensureCapacity( DEFAULT_CAPACITY );
}
```

```java
/**
* Checks if there is room for newCapacity items. If not
* increases size of list
*/
@SuppressWarnings("unchecked")
public void ensureCapacity( int newCapacity )
{
    if( newCapacity < theSize )
        return;

    AnyType [ ] old = theItems;
    theItems = (AnyType []) new Object[ newCapacity ];
    for( int i = 0; i < size( ); i++ )
        theItems[ i ] = old[ i ];
}
```

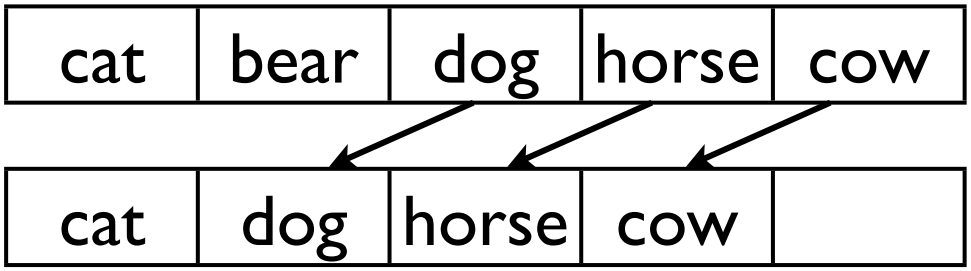
```java
/**
 * Returns the number of items in this collection.
 */
public int size( )
{
    return theSize;
}

/**
 * Returns true if this collection is empty.
 */
public boolean isEmpty( )
{
    return size( ) == 0;
}
```

```
/**
 * Returns the item at position idx.
 */
public AnyType get( int idx )
{
    if( idx < 0 || idx >= size( ) )
        throw new ArrayIndexOutOfBoundsException( "Index " + idx + "; size "
                                                  + size( ) );
    return theItems[ idx ];
}

/**
 * Changes the item at position idx.
 */
public AnyType set( int idx, AnyType newVal )
{
    if( idx < 0 || idx >= size( ) )
        throw new ArrayIndexOutOfBoundsException( "Index " + idx + "; size "
                                                  + size( ) );
    AnyType old = theItems[ idx ];
    theItems[ idx ] = newVal;

    return old;
}
```

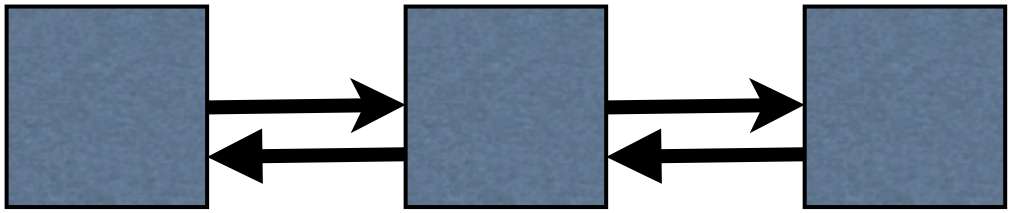
```java
/* Adds an item to this collection at the end. */
public boolean add( AnyType x )
{
    add( size( ), x );
    return true;
}

/**
 * Adds an item to this collection, at the specified index.
 */
public void add( int idx, AnyType x )
{
    if( theItems.length == size( ) )
        ensureCapacity( size( ) * 2 + 1 );

    for( int i = theSize; i > idx; i-- )
        theItems[ i ] = theItems[ i - 1 ];

    theItems[ idx ] = x;
    theSize++;
}
```



```
 /**
 * Removes an item from this collection.
 */
public AnyType remove( int idx )
{
    AnyType removedItem = theItems[ idx ];

    for( int i = idx; i < size( ) - 1; i++ )
        theItems[ i ] = theItems[ i + 1 ];
    theSize--;

    return removedItem;
}
```

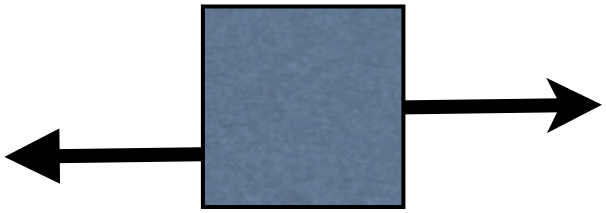


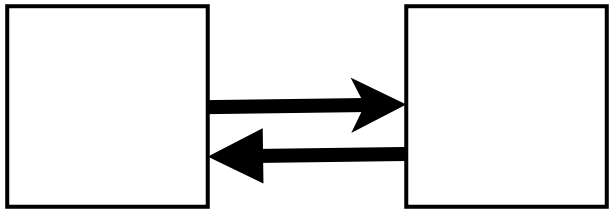
MyLinkedList



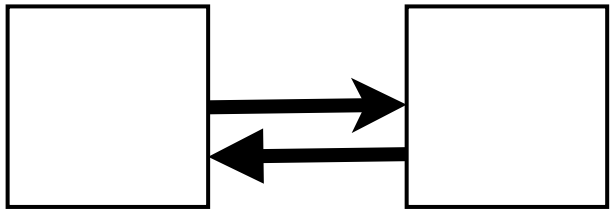
```
/**
 * LinkedList class implements a doubly-linked list.
 */
public class MyLinkedList<AnyType> implements Iterable<AnyType>
{

    private int theSize;
    private Node<AnyType> beginMarker;
    private Node<AnyType> endMarker;
}
```

```
/**
 * LinkedList class implements a doubly-linked list.
 */
public class MyLinkedList<AnyType> implements Iterable<AnyType>
{

    /**
     * This is the doubly-linked list node.
     */
    private static class Node<AnyType>
    {
        public Node( AnyType d, Node<AnyType> p, Node<AnyType> n )
        {
            data = d; prev = p; next = n;
        }

        public AnyType data;
        public Node<AnyType>   prev;
        public Node<AnyType>   next;
    }

    private int theSize;
    private Node<AnyType> beginMarker;
    private Node<AnyType> endMarker;
}
```





```java
/**
 * Construct an empty LinkedList.
 */
public MyLinkedList( )
{
    clear( );
}
```



```java
/**
 * Change the size of this collection to zero.
 */
public void clear( )
{
    beginMarker = new Node<AnyType>( null, null, null );
    endMarker = new Node<AnyType>( null, beginMarker, null );
    beginMarker.next = endMarker;

    theSize = 0;
}
```

```java
/**
 * Returns the number of items in this collection.
 */
public int size( )
{
    return theSize;
}

public boolean isEmpty( )
{
    return size( ) == 0;
}
```

```java
/**
 * Adds an item to this collection, at the end.
 */
public boolean add( AnyType x ) {
    add( size( ), x );
    return true;
}

/**
 * Adds an item to this collection, at specified position.
 * Items at or after that position are slid one position higher.
 */
public void add( int idx, AnyType x ) {
    addBefore( getNode( idx, 0, size( ) ), x );
}

/**
 * Adds an item to this collection, at specified position p.
 * Items at or after that position are slid one position higher.
 */
private void addBefore( Node<AnyType> p, AnyType x ) {
    Node<AnyType> newNode = new Node<AnyType>( x, p.prev, p );
    newNode.prev.next = newNode;
    p.prev = newNode;
    theSize++;
}
```

```
/**
 * Returns the item at position idx.
 */
public AnyType get( int idx )
{
    return getNode( idx ).data;
}

/**
 * Changes the item at position idx.
 */
public AnyType set( int idx, AnyType newVal )
{
    Node<AnyType> p = getNode( idx );
    AnyType oldVal = p.data;

    p.data = newVal;
    return oldVal;
}
```

```
/**
 * Removes an item from this collection.
 */
public AnyType remove( int idx )
{
    return remove( getNode( idx ) );
}

/**
 * Removes the object contained in Node p.
 */
private AnyType remove( Node<AnyType> p )
{
    p.next.prev = p.prev;
    p.prev.next = p.next;
    theSize--;

    return p.data;
}
```

```
/**
 * Gets the Node at position idx,
 * which must range from 0 to size( ) - 1.
 */
private Node<AnyType> getNode( int idx )
{
    return getNode( idx, 0, size( ) - 1 );
}
```

Iterable

- The Iterable interface standardizes efficient navigation of Collection classes
- Creates Iterator object, which has methods hasNext(), next()
- Enhanced for loop:

```
for (Object x : list)
     // Do something with x
```

Tidbits on ADTs

- We explicitly code our ADTs as Object classes; we don't have to!
  - e.g., you should use ADTs even when programming machine language
- We can do list operations on arrays, but thinking in terms of lists is cleaner

Stacks

- A Stack is an ADT very similar to a list
- Can be implemented with a list, but limited to some O(1) operations
- Yet many important and powerful algorithms use stacks

Stack Definition

- Essentially a very restricted List
- Two (main) operations:
  - Push(AnyType x)
  - Pop(AnyType x)
- Analogy – Cafeteria Trays, PEZ

Stack Applications

- Recursion
- Parsing text: infix vs. postfix
- Syntax checking ( ), { }, “”

Reading

- Weiss Ch. 3 up to 3.7