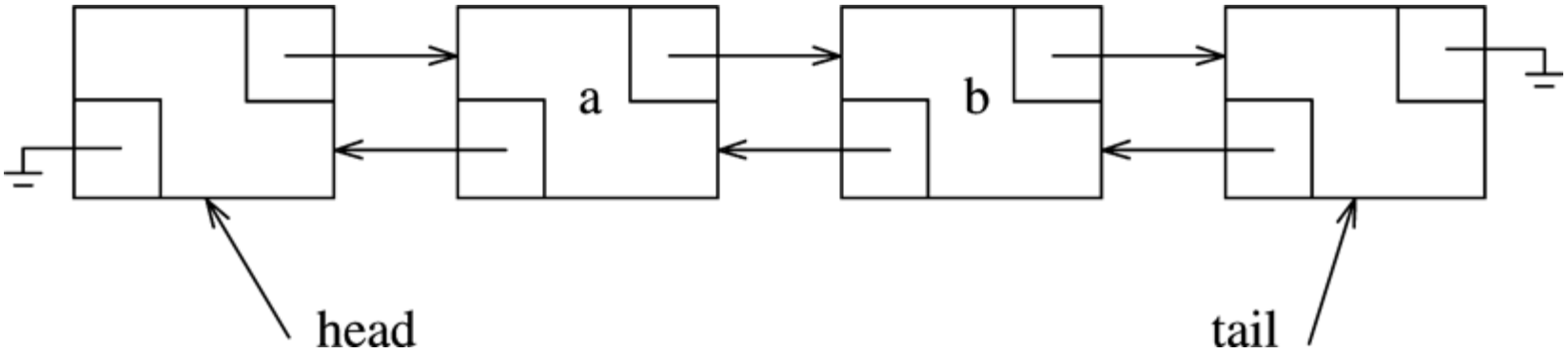
CMSC 341

Linked Lists

Textbook Section 3.5

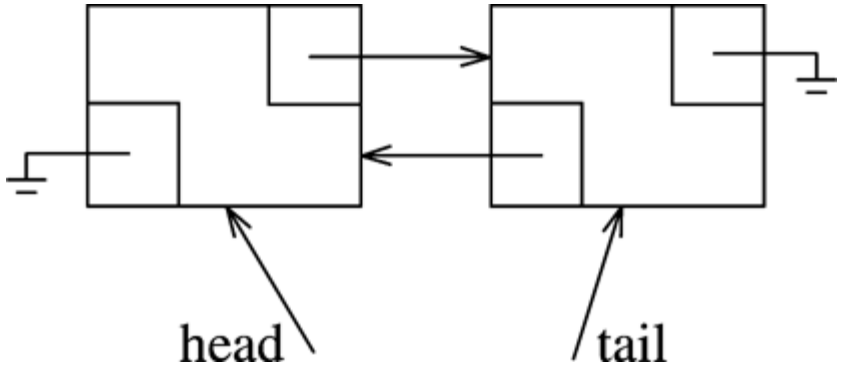
Implementing A Linked List

- To create a doubly linked list as seen below
  - MyLinkedList class
  - Node class
  - LinkedListIterator class
  - Sentinel nodes at head and tail



Empty Linked List

- An empty double linked list with sentinel nodes.



Inner classes

- Inner class objects require the construction of an outer class object before they are instantiated.
- Compiler adds an implicit reference to outer class in an inner class (MyArrayList.this).
- Good for when you need several inner objects to refer to exactly one outer object (as in an Iterator object).

Nested classes

- Considered part of the outer class, thus no issues of visibility.
- Making an inner class private means that only the outer class may access the data fields within the nested class.
- Is Node a prime candidate for nested or inner class? public or private?

Implementation for MyLinkedList

1. Class declaration and nested Node class

```
public class MyLinkedList<AnyType> implements
    Iterable<AnyType>
{
    // Node is a nested class
    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;
    }
```

2. Data Fields and Accessors

```
private int theSize;
//used to help iterator detect changes in List
private int modCount = 0;
private Node<AnyType> beginMarker; //head node
private Node<AnyType> endMarker;   //tail node

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

3. Constructor(s)

```
public MyLinkedList( ) { clear( ); }

// Changes 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;
   modCount++;
 }
```

4. More Accessors and Mutators

```
public boolean add( AnyType x )
  { add( size( ), x );  return true; }
public void add( int idx, AnyType x )
   { addBefore( getNode( idx ), x ); }
public AnyType get( int idx )
   { return getNode( idx ).data; }
public AnyType set( int idx, AnyType newVal )
{
    Node<AnyType> p = getNode( idx );
    AnyType oldVal = p.data;
    p.data = newVal;
    return oldVal;
}
public AnyType remove( int idx )
  { return remove( getNode( idx ) ); }
```

5. getNode Method

```
private Node<AnyType> getNode( int idx ) {
 Node<AnyType> p;
 if( idx < 0 || idx > size( ) )
     throw new IndexOutOfBoundsException( );
 if( idx < size( ) / 2 ) {
     p = beginMarker.next;
     for( int i = 0; i < idx; i++ )
         p = p.next;
 } else {
     p = endMarker;
     for( int i = size( ); i > idx; i-- )
         p = p.prev;
 }
 return p;
}
```

6. addBefore Method

```
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++;
     modCount++;

 }
```

7. remove and iterator methods

```
private AnyType remove( Node<AnyType> p )
{
    p.next.prev = p.prev;
    p.prev.next = p.next;
    theSize--;
    modCount++;

    return p.data;
}

//required by the Iterable interface
public java.util.Iterator<AnyType> iterator( )
   { return new LinkedListIterator( ); }
```

8a. LinkedListIterator class

```
private class LinkedListIterator
implements Iterator<AnyType>
{
    private Node<AnyType> current = beginMarker.next;

    //used to check for modifications to List
    private int expectedModCount = modCount;
    private boolean okToRemove = false;

     public boolean hasNext( )
     {
          return current != endMarker;
     }

     //continues on next slide…
```

8b. LinkedListIterator class

```
public AnyType next( ) {
  if( modCount != expectedModCount )
     throw new ConcurrentModificationException( );

  if( !hasNext( ) )
     throw new NoSuchElementException( );

  AnyType nextItem = current.data;
  current = current.next;
  okToRemove = true;
  return nextItem;

} //continues on next slide…
```

8c. LinkedListIterator class

```
  public void remove( ){
     if( modCount != expectedModCount )
       throw new ConcurrentModificationException( );
     if( !okToRemove )
        throw new IllegalStateException( );
     MyLinkedList.this.remove(current.prev);
     okToRemove = false;
     ++expectedModCount;

     } // end of remove Method

  } // end of LinkedListIterator class

}//end of MyLinkedList class
```