CIS 2168 Data Structures **Fall 2014**

Lecture 4: Sep. 16 &18

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4.1 Singly Linked List

A linked list is a data structure consisting of a group of nodes which together represent a sequence. Each node is composed of a data and a reference (in other words, a link) to the next node in the sequence. A Node class usually look like this:

Listing 1: Singly Linked List Node

```
class Node<E> {
  public E data;
  public Node<E> next;
  Node(E item){
    data = item;
  }
}
```

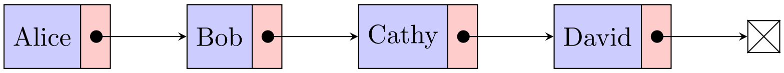
Usually Node class is nested inside the LinkedList class, and members of Node are private.

4.1.1 Create a simple linked list

Now, let us create a simple linked list.

```
Node<String> n1 = new Node(”Alice”);
Node<String> n2 = new Node(”Bob”);
Node<String> n3 = new Node(”Cathy”);
Node<String> n4 = new Node(”David”);
n1.next = n2;
n2.next = n3;
n3.next = n4;
```

This linked list represents this:



4.1.2 Display the Linked List

We can display all the linked list:

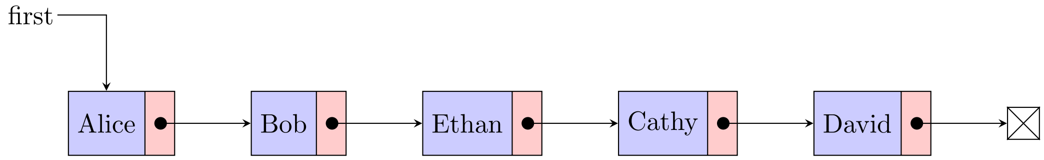
```
Node<String> current = first;
while(current != null){
        System.out.println(current.data);
        current = current.next;
}
```

4.1.3 Insert a node

Now, let us insert a node between "Bob" and "Cathy".

```
Node<Stirng> n5 = new Node("Ethan");
n5.next = n2.next;
n2.next = n5;
//use "first" to reference the first node of the list.
Node<String> first = n1;
```

This linked list represents this:



4.1.4 Delete a node

4.1.4.1 Delete the first node

To delete the first node, we can simply move "first" to next node.

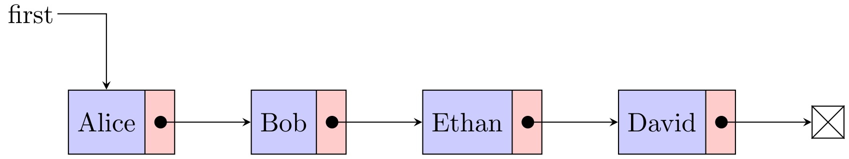
```
first = first.nex;
```

4.1.4.2 Delete other nodes

In order to delete a Node, we have to know the parent of the node. Assume "parent" references the node "Ethan", to delete the node "Cathy" reference by "current", we ca do this:

```
parent.next = current.next;
```

No, we have:



4.2 Linked List Class

```
/**
 *  The Bag class represents a collection of generic items.
 *  It supports insertion and iterating over the items in arbitrary order.
 */

import java.util.ArrayList;
import java.util.Iterator;

public class LinkedBag<E extends Comparable<E>> implements Iterable<E>
{
        protected int N;  //number of items in the bag
        private Node<E> first;    //beginning of bag

        // helper linked list class
        private class Node<E> {
            private E data;
            private Node<E> next;
            Node(E item){
                data = item;
            }
        }

        /**
        * Initializes an empty bag.
        */
        public LinkedBag() {
            first = null;
            N = 0;
        }
        /**
        *   Returns an iterator that iterates through the items in the bag
        * @return an iterator that iterates through the items in the bag
        */
        public Iterator<E> iterator() {
            return new BagIterator(first);
        }
        /**
        *   The iterator implementation
        */
        private class BagIterator implements Iterator<E> {
            private Node<E> current = null;
            public BagIterator(Node<E> first) {
                current = first;
            }
            public boolean hasNext()  { return current != null;}
            public void remove()   { System.out.println("to be implemented.");
}
            public E next() {
                if(!hasNext()) {return null;}
                E item = current.data;
                current = current.next;
                System.out.println(”work”);
                return item;
            }

        }

        /**
        * Adds the item to this bag.
        * @param item the item to add to this bag
        */
        public void insert(E item) {
            Node<E> oldfirst = first;
            first = new Node<E>(item);
            first.next = oldfirst;
            N++;
        }

        /**
        * Returns an item by index
        * @param index is the item index
        */
        public E get(int index)
        {
            Node<E> current = first;
            int i = 0;
            while(current != null && i < index){
                current = current.next;
                i++;
            }
            if(current != null){
                return current.data;
           }else{
                return null;
           }
        }
        /**
        * Deletes an item
        * @param item is the item to be deleted
        * @return true if item is deleted. false otherwise
        */
        public boolean remove(E item)
        {
            Node<E> current = first;
            Node<E> parent = first;
            while(current != null){
                if(current.data.equals(item)){
                    if(current == first){
                        first = first.next;//remove first node
                    }else{
```

```
                    parent.next = current.next; //remove non-first node
                }
                return true;
            }
            parent = current;
            current = current.next;
        }
        return false;
    }

    /**
    * Is this bag empty?
    * @return true if this bag is empty; false otherwise
    */
    public boolean isEmpty() {
        return first == null;
    }

    /**
    * Returns the number of items in this bag.
    * @return the number of items in this bag
    */
    public int size() {
        return N;
    }

    /**
    *   if the bag contains a given item?
    * @return true if bag contains the item. false otherwise
    */
    public boolean contains(E item)
    {
        Node<E> current = first;
        while(current != null){
            if(current.data.equals(item)) return true;
            current = current.next;
        }
        return false;

    }
}
```

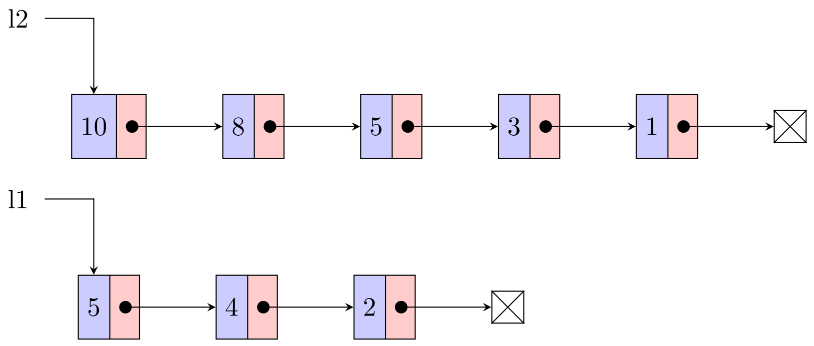
4.2.1 Test the Linked List

```
/**
 * test Linked List Bag
*/
public class LinkedBagUnitTest {
    public static void main(String[] args){
        LinkedBag<Integer> bag = new LinkedBag();
        for(int i=1; i <= 3; i++){
            bag.insert(i);
        }
        System.out.println("Size="+bag.size());
        if(bag.contains(3)){
            System.out.println("Bag␣contains␣3");
        }else{
            System.out.println("Not␣Found");
        }
        //print all items using iterator
        for(Integer i:bag){
            System.out.print(i + ",");
        }
        //print all items using get method, which is not efficient.
        System.out.println("\n␣all␣items");
        for(int i = 0; i < bag.size(); i++){
            System.out.print(bag.get(i)+",");
        }
    }
}
```

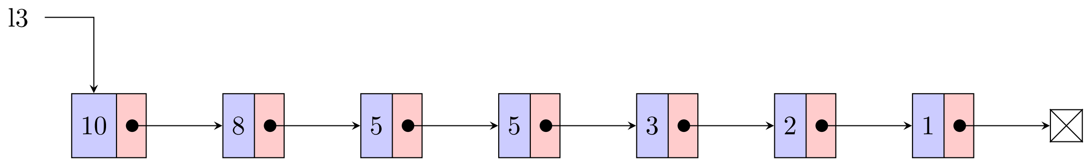
4.3 Code example

4.3.1 Merge two sorted linked list into one

We have two sorted linked lists *list*1 and *list*2.



We want to generate the list:



Here is the code that takes two lists as input, and merges them into one list. This function takes $O(n1+n2)$ time to merge two lists of size $n1$ and $n2$.

```
public static Node merge(Node l1, Node l2){

        //if one list is empty, return the other list
        if(l1 == null){
            return l2;
        }
        if(l2 == null){
            return l1;
        }
        //if both lists are not empty
        Node c1 = l1;
        Node c2 = l2;
        Node m = null;
        //pick the larger node from l1 and l2.
        if(c1.data > c2.data){
            m = c1;
            c1 = c1.next;
        }else{
            m = c2;
            c2 = c2.next;
        }
        /**
        *       walk through l1 and l2, every time pick the larger node.
        *       comparison only occurs at the head of two lists.
        */
        Node c3 = m;
        while(c1 != null && c2 != null){
            if(c1.data > c2.data){
                c3.next = c1;
                c1 = c1.next;
                c3 = c3.next;
            }else{
                c3.next = c2;
                c2 = c2.next;
                c3 = c3.next;
            }

        }

        if(c1 != null){
            c3.next = c1;
        }else{
            c3.next = c2;
        }
        return m;
    }
```