Lecture 11: Singly Linked Lists

CS 62
Spring 2018
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Writing code

- No complex code ever works the first time.
- Neither the "If I just fix this last thing…" attitude.
- Think about testing before you write the code.
- Comment before you write the code.
- Never write more than a method without testing it.
- We will talk about JUnits in lab next week.
- Once satisfied, commit your work.
public abstract class AbstractList<E> {
    public AbstractList() { }
    public boolean isEmpty() { return size() == 0; }
    public void addFirst(E value) { add(0, value); }
    public void addLast(E value) { add(size(), value); }
    public E getFirst() { return get(0); }
    public E getLast() { return get(size() - 1); }
    public E removeFirst() { return remove(0); }
    public E removeLast() { return remove(size() - 1); }
    public void add(E value) { addLast(value); }
    public E remove() { return removeLast(); }
    public E get() { return getLast(); }
    public boolean contains(E value) {
        return -1 != indexOf(value);
    }
}

List ADT
Linked List

• A data structure consisting of a linear sequence of nodes
  • Think of them as snap-lock beads
  • Varying length

• Alternate implementation of an abstract list
  • Vector (ArrayList) in structure5 also extends AbstractList

• Trade-offs in complexity:
  • In ArrayList, adding elements is expensive at beginning of list
  • For Linked lists, it is inexpensive to add elements in early positions
  • However, accessing the i-th element is slow
Singly Linked List

- A linked list consisting of a sequence of nodes, starting from a head pointer
- Each node stores
  - Element
  - Link to the next node
public class Node<E> {
    protected E data; // value stored in this element
    protected Node<E> nextElement; // ref to next

    public Node(E v, Node<E> next) {
        data = v;
        nextElement = next; // construct the new head of a singly linked list
    }
    public Node(E v) {
        this(v, null); // constructs a new tail of a list with value v
    }
    public Node<E> next() {
        return nextElement; // returns reference to next value in list
    }
    public void setNext(Node<E> next) {
        nextElement = next; // sets reference to new next value
    }
    public E value() {
        return data; // returns value associated with this element
    }
    public void setValue(E value) {
        data = value; // sets value associated with this element
    }
}
public class SinglyLinkedList<E> extends AbstractList<E> {
    protected int count; // list
    protected Node<E> head; // ref. to first element

    // construct an empty list
    public SinglyLinkedList() {
        head = null;
        count = 0;
    }

    public E getFirst() {
        return head.value(); // returns first value in list
    }

    public int size() {
        return count;
    }
}
Possible operations

A node can be added/removed:
  At the beginning of the list
  At the end of the list
  Between nodes
  In an empty list (addition only)
Adding at the head
Adding at the head is $O(1)$

```java
public void addFirst(E value){
    // note order that things happen:
    // head is parameter, then assigned
    head = new Node<E>(value, head);
    count++;
}
```
Removing at the head

Head

Elt0 → Elt1 → Elt2 → Elt3 → Elt4

Head

Elt0 → Elt1 → Elt2 → Elt3 → Elt4

Head

Elt0 → Elt1 → Elt2 → Elt3 → Elt4

Head

Elt1 → Elt2 → Elt3 → Elt4
Removing at the head is $O(1)$

```java
public E removeFirst(){
    Node<E> temp = head;
    head = head.next(); // move head down list
    count--; 
    return temp.value();
}
```
Adding at the end
Adding at the end is $O(n)$

```java
public void addLast(E value) {
    // location for new value
    Node<E> temp = new Node<>(value, null);
    if (head != null) {
        // pointer to possible tail
        Node<E> finger = head;
        while (finger.next() != null) {
            finger = finger.next();
        }
        finger.setNext(temp);
    } else {
        head = temp; // empty list
        count++;
    }
}
```
Removing from the end
Removing from the end is $O(n)$

```java
public E removeLast() {
    Node<E> finger = head;
    Node<E> previous = null;
    // throw an exception if list is empty
    while (finger.next() != null)
    {
        previous = finger;  // find end of list
        finger = finger.next();
    }
    // finger is null, or points to end of list
    if (previous == null) {
        head = null;  // has exactly one element
    } else{
        previous.setNext(null);  // pointer to last element is reset
    }
    count--;
    return finger.value();
}
```
Getting the last element
public E getLast() {
    Node<E> finger = head;
    //throw exception if list is empty
    while (finger != null && finger.next() != null) {
        finger = finger.next();
    }
    return finger.value();
}
Adding when having a tail pointer is $O(1)$.
Removing at the tail is $O(n)$

- We still have to traverse the whole linked list - not efficient!
Circular list

- Accessing/modifying the head or the tail is $O(1)$.
- Circular lists are as space-efficient as singly linked lists but tail-related operations are less costly.