CS 61B Data Structures and Programming Methodology

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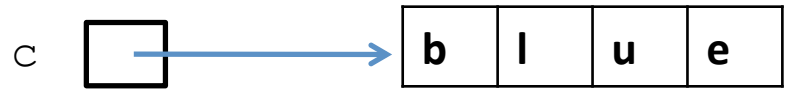
Announcements

- Project 1 will be handed out at the end of next week.
- Project 1 is now due after Midterm I on 7/15.
- Lab2 homework is due next Wed.
- George has extra space in his labs (5-7p.m) and discussions (5-6p.m).
- Another reminder, please send your emails to cs61b@imail.eecs.berkeley.edu

Yesterday…

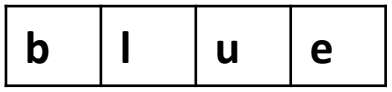
- **Key features of Arrays:**
  - Stores a sequence of variables in continuous memory.
  - Array elements are indexed by a variable.
  - This allows for fast *random access/lookup,* e.g.,

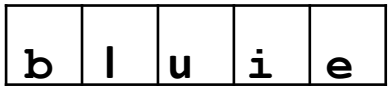
```
char[] c = {'b', 'l', 'u', 'e'};
```




```
char x = c[3]; //to get element 3
```

- **What about *insertion,* say the character 'i' position 3?**
  - Arrays have fixed length that can't be changed!
  - Cost of *Insertion* is proportional to the *length* of array.





Lists

Array Implementation

```
public class List {
        int[] a;
        int lastItem;

        public List() {
                a = new int[10];.
                lastItem = -1;
        }

        public void insertItem(int newItem, int location) {
                int i;
                for (i = lastItem; i >= location; i--) {
                        a[i + 1] = a[i];
                }
                a[location] = newItem;
                lastItem++;
        }
}
```

Shift the items to the right by one position

ArrayList

```
public void insertItem(int newItem, int location) {
   int i;

   if (lastItem + 1 == a.length) {
       int[] b = new int[2 * a.length];
       for (i = 0; i <= lastItem; i++) {
             b[i] = a[i];
       }
       a = b;
   }

   for (i = lastItem; i >= location; i--) {
       a[i + 1] = a[i];
   }

   a[location] = newItem;
   lastItem++;
}
```

creates a new array twice as long and copy the elements of the small array into the larger array.

could also use System.arraycopy(..)

Linked List

- **A linked list is made up of *nodes;* a node stores:**
  - an item
  - an reference to next node in the list

```
public class ListNode {
   int item;
  ListNode next;
}
```

- **Recursive definition: the definition of the class refers to itself.**

An Example

```
ListNode l1 = new ListNode();
ListNode l2 = new ListNode();
ListNode l3 = new ListNode();

l1.item = 1;
l2.item = 2;
l3.item = 3;

l1.next = l2;
l2.next = l3;

l3.next = null; //good practice to initialize
                // explicitly
```

ListNode Constructors

```
public ListNode(int item, ListNode next) {
       this.item = item;
       this.next = next;
}

public ListNode(int item) {
       this(item, null);
}

ListNode l1 = new ListNode(1, new ListNode(2,new ListNode(3)));
```

More Examples

```
ListNode Q, L;

L = new ListNode(3, null);
Q = L;

Q = new ListNode(42, null);
L.next = Q;

L.next.item += 1;
```

Insertion

- **Inserting an item into the middle of a linked list takes *constant* amount of time**
  - as long as you have a reference to the previous node
- **List can grow until memory runs out.**

```
public void insertAfter(int item) {
   next = new ListNode(item, next);
}
```

New value

Old value

```
l2.insertAfter(5);
```

Lookup

- **Finding an item at position *n* (random lookup) takes time proportional to *n.***
  - *Remember this operation is constant time for an array.*
- **We'll encounter data structures that finds a balance between arrays and linked lists.**

```
public ListNode get(int position) {
        if (position < 0)
                return null;
        ListNode toReturn = this;
        for (int i = 0; i < position && toReturn!= null; i++) {
                toReturn = toReturn.next;
        }
        return toReturn;
}
```

```
public ListNode get(int position) {
        if (position == 0} {
                return this;
        } else if ((position < 0) || (next == null)) {
                return null; //error checking
        } else {
                return next.get(position - 1);
        }
}
```

List Class

- **Why not just use ListNodes?**
- **The List class maintains:**
  - reference to the *head* of the List
  - *methods* to operate on the List
  - *information* about the List

```
public class List {
   private ListNode head;
   private int size;

   public List() {
        head = null;
        size = 0;
   }
   public void insertFront(Object item) {
        head = new ListNode(item, head); size++;
   }
}
```

Insertion at the end

```
public class List {
    private ListNode head;
    private ListNode tail;
    private int size;

    public List() {
          head = null;
          tail = null;
          size = 0;
    }
    public void insertTail(int item) {
          if (head == null) //tail must be null too
                    head = tail = new ListNode(item, null);
          else {
                    tail.next = new ListNode(item, null);
                    tail = tail.next;
          }

    }
}
```

Deletion

- **Deletion from the front of a list**

```
public class List {
      public void deleteFront() {
            if (head != null) {
                  head = head.next;
                  size--;
            }
      }
}
```

- **Deletion from the end of the list?**
  - Must search through the entire list!

Doubly Linked List

- **For a doubly linked list each node has:**
  - an item
  - *a reference to the **next** node*
  - *a reference to the **previous*** node

```
public class DListNode {
  int item;
   DListNode next;
  DListNode prev;
}
```

DList Class

```
public class DList {
  private DlistNode head;
  private DListNode tail;
}
```

```
tail.prev.next = null;
tail = tail.prev;
      or
tail = tail.prev;
tail.next = null
```

This works only when there is at least 2 elements in the list. You need special cases for when the number of elements is 0 and 1

Next Class

- **Reading:**
  - Objects, Abstraction, Data Structures Chapter 4
- **Next Class:**
  - More Lists