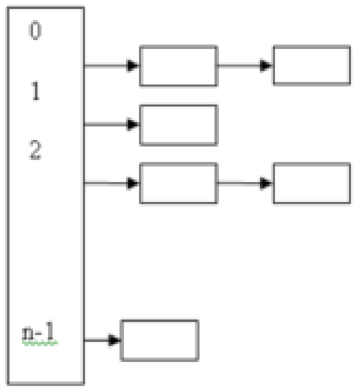
Applications of Linked Lists

Linked List concept can be used to deal with many practical problems.

Problem 1: Suppose you need to program an application that has a pre-defined number of categories, but the exact items in each category is unknown.

Solution: Pre-defined number of categories implies that we can use a simple static structure like array to represent the categories. Since we do not know the number of items in each category, we can represent items in each category using a linked list. So what we need is an array of linked lists

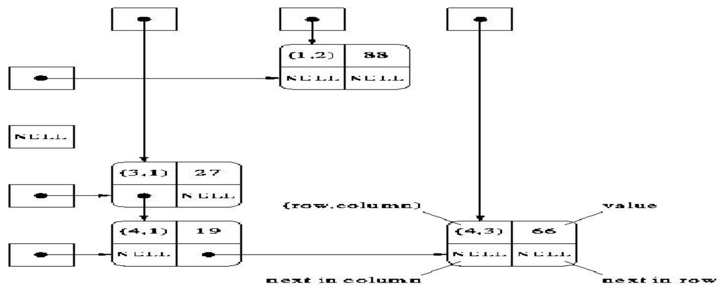


More Examples

You can also think of representing a web index using an array of linked lists, where array contains the keywords and linked lists contains the web URL's where that keyword occurs.

Sparse Matrices

- Most problems can be modeled by a system of linear equations
  - Thousands of equations (constraints)
  - Thousands of variables (unknowns)
  - It is not practical to allocate n by n space to store a linear system
  - How much space is necessary for a matrix of size 10000x10000 where each entry is a double?
  - Sparse matrix representation

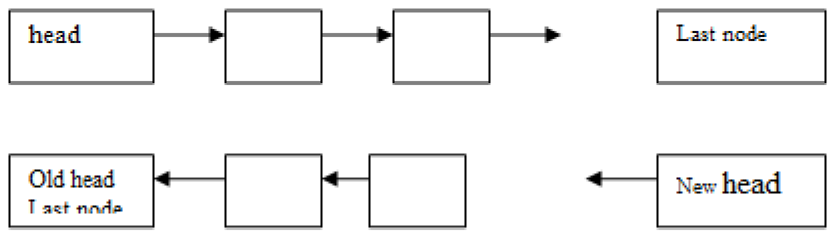


Designing the Node for Sparse Matrix

```
public class Node

{

    public Comparable data;

    public int row, col;

    public Node nextrow;

    public Node nextcol;

    Node(int row, int col, Comparable data) {

            this.data = data; this.row = row; this.col = col;

            nextrow = null; nextcol = null;

    }

    public String toString(){return data.toString();}

}
```

Other Advanced Operations on Linked Lists

Reversing a Linked List



Cloning a Linked List

Let us begin by evaluating the following code

```
LinkedList list = new LinkedList();
list.prepend(new Node("first"));
list.append(new Node("last"));
LinkedList list2 = list;
```

The reference `list2` is an alias, it points to the same object as list1. This means that once we change `list`, these changes occur in `list2` as well. In this case, we consider list2 as a **shallow copy** of list1. In other words, list1 and list2 shares the same nodes in one linked list. In many cases it will be quite useful to have a **deep copy** of an object. To create a deep copy, we need to duplicate all nodes in the list. For this purpose, the Object class provides the method clone(), which we will override in the LinkedList class:

```
public Object clone() throws java.lang.CloneNotSupportedException
{
   LinkedList twin = new LinkedList();
   if(head == null) return twin;

   Node tmp = head;

   for(int i = 0; i < size; i++)
   {
      twin.append(tmp.data);
      tmp = tmp.getNext();
   }

   return twin;
}
```

Sorting a Linked List

- Sorting a List is one of the common operations that are performed.
- Sorting a linked list is not that trivial since linked list nodes cannot be randomly accessed.
- One useful way to sort a linked list is to remove a node from the old list and insert into a new list in order.
    - However for large lists, this is not very practical as insertion sort requires $O(n^2)$ operations.
- An alternative method is to define a toArray method for the linked list class that allows the linked list to be converted to an array first and then apply a more efficient algorithm like quick sort to sort.
  o Once sorted the array can be converted into a linked list again.

Questions

- Choosing the proper data structure depends on the application. Specify what data structure you would choose in each of the following cases. You can choose from a static array, singly linked list, circular LL, doubly LL, array of LL's, multilinked list etc
    - A sorted file is given and a list in reverse order needs to be built in O(n)
    - An application requires a structure where new nodes can easily added to the front and back of a given node in O(1)
    - An application requires a data structure that can be randomly accessed
    - A set of entries needs to be sorted by a category first. Each category will receive an unknown number of entries
    - An application requires frequent insertions, generally in the same region
    - A list needs to be maintained in multiple sorted orders, but space for each entry can be allocated only once.