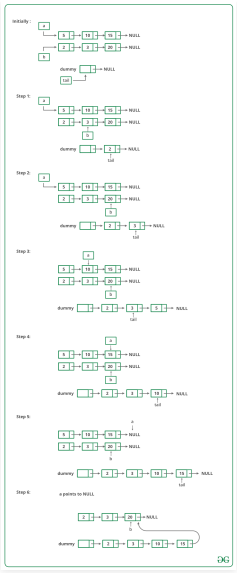
Merge two sorted linked lists

Difficulty Level : Medium ● Last Updated : 24 Mar, 2021

Write a SortedMerge() function that takes two lists, each of which is sorted in increasing order, and merges the two together into one list which is in increasing order. SortedMerge() should return the new list. The new list should be made by splicing together the nodes of the first two lists.
For example if the first linked list a is 5->10->15 and the other linked list b is 2->3->20, then SortedMerge() should return a pointer to the head node of the merged list 2->3->5->10->15->20.
There are many cases to deal with: either 'a' or 'b' may be empty, during processing either 'a' or 'b' may run out first, and finally, there's the problem of starting the result list empty, and building it up while going through 'a' and 'b'.

Recommended: Please solve it on "***PRACTICE***" first, before moving on to the solution.

Method 1 (Using Dummy Nodes)
The strategy here uses a temporary dummy node as the start of the result list. The pointer Tail always points to the last node in the result list, so appending new nodes is easy.
The dummy node gives the tail something to point to initially when the result list is empty. This dummy node is efficient, since it is only temporary, and it is allocated in the stack. The loop proceeds, removing one node from either 'a' or 'b', and adding it to the tail. When We are done, the result is in dummy.next.
The below image is a dry run of the above approach:



Below is the implementation of the above approach:

C++

```
/* C++ program to merge two sorted linked lists */
#include <bits/stdc++.h>
using namespace std;

/* Link list node */
class Node
{
    public:
    int data;
    Node* next;
};

/* pull off the front node of
the source and put it in dest */
void MoveNode(Node** destRef, Node** sourceRef);

/* Takes two lists sorted in increasing
order, and splices their nodes together
to make one big sorted list which
is returned. */
Node* SortedMerge(Node* a, Node* b)
{
    /* a dummy first node to hang the result on */
    Node dummy;

    /* tail points to the last result node */
    Node* tail = &dummy;

    /* so tail->next is the place to
    add new nodes to the result. */
    dummy.next = NULL;
    while (1)
```

```
            /* if either list runs out, use the
            other list */
            tail->next = b;
            break;
        }
        else if (b == NULL)
        {
            tail->next = a;
            break;
        }
        if (a->data <= b->data)
            MoveNode(&(tail->next), &a);
        else
            MoveNode(&(tail->next), &b);

        tail = tail->next;
    }
    return(dummy.next);
}

/* UTILITY FUNCTIONS */
/* MoveNode() function takes the
node from the front of the source,
and move it to the front of the dest.
It is an error to call this with the
source list empty.

Before calling MoveNode():
source == {1, 2, 3}
dest == {1, 2, 3}

Affter calling MoveNode():
source == {2, 3}
dest == {1, 1, 2, 3} */
void MoveNode(Node** destRef, Node** sourceRef)
{
    /* the front source node */
    Node* newNode = *sourceRef;
    assert(newNode != NULL);

    /* Advance the source pointer */
    *sourceRef = newNode->next;

    /* Link the old dest off the new node */
    newNode->next = *destRef;

    /* Move dest to point to the new node */
    *destRef = newNode;
}


/* Function to insert a node at
the beginging of the linked list */
void push(Node** head_ref, int new_data)
{
```

```
    /* put in the data */
    new_node->data = new_data;

    /* link the old list off the new node */
    new_node->next = (*head_ref);

    /* move the head to point to the new node */
    (*head_ref) = new_node;
}

/* Function to print nodes in a given linked list */
void printList(Node *node)
{
    while (node!=NULL)
    {
        cout<<node->data<<" ";
        node = node->next;
    }
}

/* Driver code*/
int main()
{
    /* Start with the empty list */
    Node* res = NULL;
    Node* a = NULL;
    Node* b = NULL;

    /* Let us create two sorted linked lists
    to test the functions
    Created lists, a: 5->10->15, b: 2->3->20 */
    push(&a, 15);
    push(&a, 10);
    push(&a, 5);

    push(&b, 20);
    push(&b, 3);
    push(&b, 2);

    /* Remove duplicates from linked list */
    res = SortedMerge(a, b);

    cout << "Merged Linked List is: \n";
    printList(res);

    return 0;
}

// This code is contributed by rathbhupendra
```

C

```
/* C program to merge two sorted linked lists */
```

```
#include<assert.h>

/* Link list node */
struct Node
{
    int data;
    struct Node* next;
};

/* pull off the front node of the source and put it in dest */
void MoveNode(struct Node** destRef, struct Node** sourceRef);

/* Takes two lists sorted in increasing order, and splices
   their nodes together to make one big sorted list which
   is returned.  */
struct Node* SortedMerge(struct Node* a, struct Node* b)
{
    /* a dummy first node to hang the result on */
    struct Node dummy;

    /* tail points to the last result node  */
    struct Node* tail = &dummy;

    /* so tail->next is the place to add new nodes
      to the result. */
    dummy.next = NULL;
    while (1)
    {
        if (a == NULL)
        {
            /* if either list runs out, use the
               other list */
            tail->next = b;
            break;
        }
        else if (b == NULL)
        {
            tail->next = a;
            break;
        }
        if (a->data <= b->data)
            MoveNode(&(tail->next), &a);
        else
            MoveNode(&(tail->next), &b);

        tail = tail->next;
    }
    return(dummy.next);
}

/* UTILITY FUNCTIONS */
/* MoveNode() function takes the node from the front of the
   source, and move it to the front of the dest.
   It is an error to call this with the source list empty.
```

```
   Affter calling MoveNode():
   source == {2, 3}
   dest == {1, 1, 2, 3} */
void MoveNode(struct Node** destRef, struct Node** sourceRef)
{
    /* the front source node  */
    struct Node* newNode = *sourceRef;
    assert(newNode != NULL);

    /* Advance the source pointer */
    *sourceRef = newNode->next;

    /* Link the old dest off the new node */
    newNode->next = *destRef;

    /* Move dest to point to the new node */
    *destRef = newNode;
}


/* Function to insert a node at the beginging of the
   linked list */
void push(struct Node** head_ref, int new_data)
{
    /* allocate node */
    struct Node* new_node =
        (struct Node*) malloc(sizeof(struct Node));

    /* put in the data  */
    new_node->data  = new_data;

    /* link the old list off the new node */
    new_node->next = (*head_ref);

    /* move the head to point to the new node */
    (*head_ref)    = new_node;
}

/* Function to print nodes in a given linked list */
void printList(struct Node *node)
{
    while (node!=NULL)
    {
        printf("%d ", node->data);
        node = node->next;
    }
}

/* Drier program to test above functions*/
int main()
{
    /* Start with the empty list */
    struct Node* res = NULL;
    struct Node* a = NULL;
```

the functions

Related Articles

```
    push(&b, 3);
    push(&b, 2);

    /* Remove duplicates from linked list */
    res = SortedMerge(a, b);

    printf("Merged Linked List is: \n");
    printList(res);

    return 0;
}
```

Java

```
/* Java program to merge two
   sorted linked lists */
import java.util.*;

/* Link list node */
class Node
{
    int data;
    Node next;
    Node(int d) {data = d;
                 next = null;}
}

class MergeLists
{
Node head;

/* Method to insert a node at
   the end of the linked list */
public void addToTheLast(Node node)
{
    if (head == null)
    {
        head = node;
    }
    else
    {
        Node temp = head;
        while (temp.next != null)
            temp = temp.next;
        temp.next = node;
    }
```

```
    /* Method to print linked list */
    void printList()
    {
        Node temp = head;
        while (temp != null)
        {
            System.out.print(temp.data + " ");
            temp = temp.next;
        }
        System.out.println();
    }


    // Driver Code
    public static void main(String args[])
    {
        /* Let us create two sorted linked
           lists to test the methods
           Created lists:
                llist1: 5->10->15,
                llist2: 2->3->20
        */
        MergeLists llist1 = new MergeLists();
        MergeLists llist2 = new MergeLists();

        // Node head1 = new Node(5);
        llist1.addToTheLast(new Node(5));
        llist1.addToTheLast(new Node(10));
        llist1.addToTheLast(new Node(15));

        // Node head2 = new Node(2);
        llist2.addToTheLast(new Node(2));
        llist2.addToTheLast(new Node(3));
        llist2.addToTheLast(new Node(20));


        llist1.head = new Gfg().sortedMerge(llist1.head,
                                            llist2.head);
        llist1.printList();

    }
    }

    class Gfg
    {
    /* Takes two lists sorted in
    increasing order, and splices
    their nodes together to make
    one big sorted list which is
    returned. */
    Node sortedMerge(Node headA, Node headB)
    {

        /* a dummy first node to
           hang the result on */
```

```
        last result node */
        Node tail = dummyNode;
        while(true)
        {

            /* if either list runs out,
            use the other list */
            if(headA == null)
            {
                tail.next = headB;
                break;
            }
            if(headB == null)
            {
                tail.next = headA;
                break;
            }

            /* Compare the data of the two
            lists whichever lists' data is
            smaller, append it into tail and
            advance the head to the next Node
            */
            if(headA.data <= headB.data)
            {
                tail.next = headA;
                headA = headA.next;
            }
            else
            {
                tail.next = headB;
                headB = headB.next;
            }

            /* Advance the tail */
            tail = tail.next;
        }
        return dummyNode.next;
    }
    }

    // This code is contributed
    // by Shubhaw Kumar
```

Python3

```
""" Python program to merge two
sorted linked lists """


# Linked List Node
class Node:
    def __init__(self, data):
```

```
# Create & Handle List operations
class LinkedList:
    def __init__(self):
        self.head = None

    # Method to display the list
    def printList(self):
        temp = self.head
        while temp:
            print(temp.data, end=" ")
            temp = temp.next

    # Method to add element to list
    def addToList(self, newData):
        newNode = Node(newData)
        if self.head is None:
            self.head = newNode
            return

        last = self.head
        while last.next:
            last = last.next

        last.next = newNode


# Function to merge the lists
# Takes two lists which are sorted
# joins them to get a single sorted list
def mergeLists(headA, headB):

    # A dummy node to store the result
    dummyNode = Node(0)

    # Tail stores the last node
    tail = dummyNode
    while True:

        # If any of the list gets completely empty
        # directly join all the elements of the other list
        if headA is None:
            tail.next = headB
            break
        if headB is None:
            tail.next = headA
            break

        # Compare the data of the lists and whichever is smaller is
        # appended to the last of the merged list and the head is changed
        if headA.data <= headB.data:
            tail.next = headA
            headA = headA.next
        else:
```

```
            # Advance the tail
            tail = tail.next

        # Returns the head of the merged list
        return dummyNode.next


# Create 2 lists
listA = LinkedList()
listB = LinkedList()

# Add elements to the list in sorted order
listA.addToList(5)
listA.addToList(10)
listA.addToList(15)

listB.addToList(2)
listB.addToList(3)
listB.addToList(20)

# Call the merge function
listA.head = mergeLists(listA.head, listB.head)

# Display merged list
print("Merged Linked List is:")
listA.printList()

""" This code is contributed
by Debidutta Rath """
```

C#

```
/* C# program to merge two
sorted linked lists */
using System;

    /* Link list node */
    public class Node
    {
        public int data;
        public Node next;
        public Node(int d)
        {
            data = d;
            next = null;
        }
    }

    public class MergeLists
    {
        Node head;

        /* Method to insert a node at
```

```
{
    if (head == null)
    {
        head = node;
    }
    else
    {
        Node temp = head;
        while (temp.next != null)
            temp = temp.next;
        temp.next = node;
    }
}

/* Method to print linked list */
void printList()
{
    Node temp = head;
    while (temp != null)
    {
           Console.Write(temp.data + " ");
        temp = temp.next;
    }
    Console.WriteLine();
}


// Driver Code
public static void Main(String []args)
{
    /* Let us create two sorted linked
    lists to test the methods
    Created lists:
           llist1: 5->10->15,
        llist2: 2->3->20
    */
    MergeLists llist1 = new MergeLists();
    MergeLists llist2 = new MergeLists();

    // Node head1 = new Node(5);
    llist1.addToTheLast(new Node(5));
    llist1.addToTheLast(new Node(10));
    llist1.addToTheLast(new Node(15));

    // Node head2 = new Node(2);
    llist2.addToTheLast(new Node(2));
    llist2.addToTheLast(new Node(3));
    llist2.addToTheLast(new Node(20));


    llist1.head = new Gfg().sortedMerge(llist1.head,
                                        llist2.head);
    llist1.printList();

}
```

```
    {
    /* Takes two lists sorted in
    increasing order, and splices
    their nodes together to make
    one big sorted list which is
    returned. */
    public Node sortedMerge(Node headA, Node headB)
    {

        /* a dummy first node to
        hang the result on */
        Node dummyNode = new Node(0);

        /* tail points to the
        last result node */
        Node tail = dummyNode;
        while(true)
        {

            /* if either list runs out,
            use the other list */
            if(headA == null)
            {
                tail.next = headB;
                break;
            }
            if(headB == null)
            {
                tail.next = headA;
                break;
            }

            /* Compare the data of the two
            lists whichever lists' data is
            smaller, append it into tail and
            advance the head to the next Node
            */
            if(headA.data <= headB.data)
            {
                tail.next = headA;
                headA = headA.next;
            }
            else
            {
                tail.next = headB;
                headB = headB.next;
            }

            /* Advance the tail */
            tail = tail.next;
        }
        return dummyNode.next;
    }
}
```

Output :

```
Merged Linked List is:
2 3 5 10 15 20
```

Method 2 (Using Local References)

This solution is structurally very similar to the above, but it avoids using a dummy node. Instead, it maintains a struct node** pointer, lastPtrRef, that always points to the last pointer of the result list. This solves the same case that the dummy node did — dealing with the result list when it is empty. If you are trying to build up a list at its tail, either the dummy node or the struct node** "reference" strategy can be used (see Section 1 for details).

C++

```
Node* SortedMerge(Node* a, Node* b)
{
Node* result = NULL;

/* point to the last result pointer */
Node** lastPtrRef = &result;

while(1)
{
    if (a == NULL)
    {
    *lastPtrRef = b;
    break;
    }
    else if (b==NULL)
    {
```

```
    if(a->data <= b->data)
    {
    MoveNode(lastPtrRef, &a);
    }
    else
    {
    MoveNode(lastPtrRef, &b);
    }

    /* tricky: advance to point to the next ".next" field */
    lastPtrRef = &((*lastPtrRef)->next);
}
return(result);
}

//This code is contributed by rathbhupendra
```

C

```
struct Node* SortedMerge(struct Node* a, struct Node* b)
{
  struct Node* result = NULL;

  /* point to the last result pointer */
  struct Node** lastPtrRef = &result;

  while(1)
  {
    if (a == NULL)
    {
      *lastPtrRef = b;
       break;
    }
    else if (b==NULL)
    {
       *lastPtrRef = a;
       break;
    }
    if(a->data <= b->data)
    {
      MoveNode(lastPtrRef, &a);
    }
    else
    {
      MoveNode(lastPtrRef, &b);
    }

    /* tricky: advance to point to the next ".next" field */
    lastPtrRef = &((*lastPtrRef)->next);
  }
  return(result);
}
```

Method 3 (Using Recursion)

Merge is one of those nice recursive problems where the recursive solution code is much cleaner than the iterative code. You probably wouldn't want to use the recursive version for production code, however, because it will use stack space which is proportional to the length of the lists.

C++

```
Node* SortedMerge(Node* a, Node* b)
{
    Node* result = NULL;

    /* Base cases */
    if (a == NULL)
        return(b);
    else if (b == NULL)
        return(a);

    /* Pick either a or b, and recur */
    if (a->data <= b->data)
    {
        result = a;
        result->next = SortedMerge(a->next, b);
    }
    else
    {
        result = b;
        result->next = SortedMerge(a, b->next);
    }
    return(result);
}

// This code is contributed by rathbhupendra
```

C

```
struct Node* SortedMerge(struct Node* a, struct Node* b)
{
  struct Node* result = NULL;

  /* Base cases */
  if (a == NULL)
     return(b);
  else if (b==NULL)
     return(a);

  /* Pick either a or b, and recur */
  if (a->data <= b->data)
  {
```

```
  else
  {
     result = b;
     result->next = SortedMerge(a, b->next);
  }
  return(result);
}
```

Java

```
class GFG
{
    public Node SortedMerge(Node A, Node B)
    {

        if(A == null) return B;
        if(B == null) return A;

        if(A.data < B.data)
        {
            A.next = SortedMerge(A.next, B);
            return A;
        }
        else
        {
            B.next = SortedMerge(A, B.next);
            return B;
        }

    }
}

// This code is contributed by Tuhin Das
```

Python3

```
# Python3 program merge two sorted linked
# in third linked list using recursive.

# Node class
class Node:
    def __init__(self, data):
        self.data = data
        self.next = None


# Constructor to initialize the node object
class LinkedList:

    # Function to initialize head
```

```
        # Method to print linked list
        def printList(self):
            temp = self.head

            while temp :
                print(temp.data, end="->")
                temp = temp.next

        # Function to add of node at the end.
        def append(self, new_data):
            new_node = Node(new_data)

            if self.head is None:
                self.head = new_node
                return
            last = self.head

            while last.next:
                last = last.next
            last.next = new_node


    # Function to merge two sorted linked list.
    def mergeLists(head1, head2):

        # create a temp node NULL
        temp = None

        # List1 is empty then return List2
        if head1 is None:
            return head2

        # if List2 is empty then return List1
        if head2 is None:
            return head1

        # If List1's data is smaller or
        # equal to List2's data
        if head1.data <= head2.data:

            # assign temp to List1's data
            temp = head1

            # Again check List1's data is smaller or equal List2's
            # data and call mergeLists function.
            temp.next = mergeLists(head1.next, head2)

        else:
            # If List2's data is greater than or equal List1's
            # data assign temp to head2
            temp = head2

            # Again check List2's data is greater or equal List's
            # data and call mergeLists function.
            temp.next = mergeLists(head1, head2.next)
```

```
# Driver Function
if __name__ == '__main__':

    # Create linked list :
    # 10->20->30->40->50
    list1 = LinkedList()
    list1.append(10)
    list1.append(20)
    list1.append(30)
    list1.append(40)
    list1.append(50)

    # Create linked list 2 :
    # 5->15->18->35->60
    list2 = LinkedList()
    list2.append(5)
    list2.append(15)
    list2.append(18)
    list2.append(35)
    list2.append(60)

    # Create linked list 3
    list3 = LinkedList()

    # Merging linked list 1 and linked list 2
    # in linked list 3
    list3.head = mergeLists(list1.head, list2.head)

    print(" Merged Linked List is : ", end="")
    list3.printList()


# This code is contributed by 'Shriaknt13'.
```

C#

```
using System;

class GFG{

public Node sortedMerge(Node A, Node B)
{

    // Base cases
    if (A == null)
        return B;
    if (B == null)
        return A;

    // Pick either a or b, and recur
    if (A.data < B.data)
```

```
            return A;
        }
        else
        {
            B.next = sortedMerge(A, B.next);
            return B;
        }
    }
    }

    // This code is contributed by hunter2000
```

Time Complexity: Since we are traversing through the two lists fully. So, the time complexity is **O(m+n)** where m and n are the lengths of the two lists to be merged.

Method 4 (Reversing The Lists)

This idea involves first **reversing** both the given lists , and after reversing , traversing both the lists till the end and then comparing the nodes of both the lists and inserting the node with a larger value at the beginning of the result list. And in this way we will get the resulting list in increasing order.

```
1) Initialize result list as empty: head = NULL.
2) Let 'a' and 'b' be the heads of first and second list respectively.
3) Reverse both the lists.
4) While (a != NULL and b != NULL)
    a) Find the larger of two (Current 'a' and 'b')
    b) Insert the larger value of node at the front of result list.
    c) Move ahead in the list of larger node.
5) If 'b' becomes NULL before 'a', insert all nodes of 'a'
   into result list at the beginning.
6) If 'a' becomes NULL before 'b', insert all nodes of 'b'
   into result list at the beginning.
```

Below is the implementation of above solution.

C++

```
/*Given two sorted linked lists consisting of N and M nodes
respectively. The task is to merge both of the list
(in-place) and return head of the merged list.*/
#include <iostream>
using namespace std;
```

```
    int key;
    struct Node* next;
};

// Function to reverse a given Linked List using Recursion
Node* reverseList(Node* head)
{

    if (head->next == NULL)
        return head;

    Node* rest = reverseList(head->next);
    head->next->next = head;
    head->next = NULL;

    return rest;
}

// Given two non-empty linked lists 'a' and 'b'
Node* sortedMerge(Node* a, Node* b)
{

    // Reverse Linked List 'a'
    a = reverseList(a);

    // Reverse Linked List 'b'
    b = reverseList(b);

    // Initialize head of resultant list
    Node* head = NULL;

    Node* temp;

    // Traverse both lists while both of them
    // have nodes.
    while (a != NULL && b != NULL) {

        // If a's current value is greater than or equal to
        // b's current value.
        if (a->key >= b->key) {

            // Store next of current Node in first list
            temp = a->next;

            // Add 'a' at the front of resultant list
            a->next = head;

            // Make 'a' - head of the result list
            head = a;

            // Move ahead in first list
            a = temp;
        }

        // If b's value is greater. Below steps are similar
```

```
            temp = b->next;
            b->next = head;
            head = b;
            b = temp;
        }
    }

    // If second list reached end, but first list has
    // nodes. Add remaining nodes of first list at the
    // beginning of result list
    while (a != NULL) {

        temp = a->next;
        a->next = head;
        head = a;
        a = temp;
    }

    // If first list reached end, but second list has
    // nodes. Add remaining nodes of second list at the
    // beginning of result list
    while (b != NULL) {

        temp = b->next;
        b->next = head;
        head = b;
        b = temp;
    }

    // Return the head of the result list
    return head;
}

/* Function to print Nodes in a given linked list */
void printList(struct Node* Node)
{
    while (Node != NULL) {
        cout << Node->key << " ";
        Node = Node->next;
    }
}

/* Utility function to create a new node with
   given key */
Node* newNode(int key)
{
    Node* temp = new Node;
    temp->key = key;
    temp->next = NULL;
    return temp;
}

/* Driver program to test above functions*/
int main()
{
```

```
    /* Let us create two sorted linked lists to test
       the above functions. Created lists shall be
         a: 5->10->15->40
         b: 2->3->20  */
    Node* a = newNode(5);
    a->next = newNode(10);
    a->next->next = newNode(15);
    a->next->next->next = newNode(40);

    Node* b = newNode(2);
    b->next = newNode(3);
    b->next->next = newNode(20);

    cout << "List A before merge: \n";
    printList(a);

    cout << "\nList B before merge: \n";
    printList(b);

    /* merge 2 sorted Linked Lists */
    res = sortedMerge(a, b);

    cout << "\nMerged Linked List is: \n";
    printList(res);

    return 0;
}
```

Output:

```
List A before merge:
5 10 15 40
List B before merge:
2 3 20
Merged Linked List is:
2 3 5 10 15 20 40
```

Time Complexity: Since we are traversing through the two lists fully. So, the time complexity is O(m+n) where m and n are the lengths of the two lists to be merged.

This idea is similar to this post.

Please refer below post for simpler implementations :

Merge two sorted lists (in-place)

Source: http://cslibrary.stanford.edu/105/LinkedListProblems.pdf

Please write comments if you find the above code/algorithm incorrect, or find better ways to solve the same problem.

Improved By : Shubhaw Kumar, 29AjayKumar, rathbhupendra, tuhindas221b, AmiyaRanjanRout, hunter2000, ryadav2, mathurmehul01

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