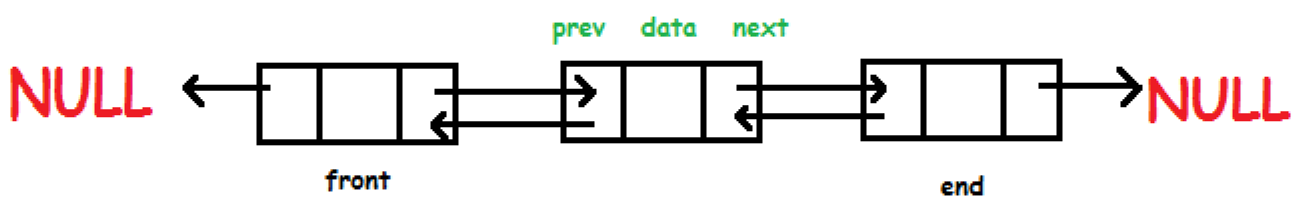
Doubly Linked List

Doubly linked list is a type of linked list in which each node apart from storing its data has two links. The first link points to the previous node in the list and the second link points to the next node in the list. The first node of the list has its previous link pointing to NULL similarly the last node of the list has its next node pointing to NULL.



The two links help us to traverse the list in both backward and forward direction. But storing an extra link requires some extra space.

Implementation of Doubly Linked List

First we define the node.

```
struct node

{

     int data;          // Data

     node *prev;        // A reference to the previous node

     node *next;        // A reference to the next node

};
```

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Now we define our class Doubly Linked List. It has the following methods:

- **add_front:** Adds a new node in the beginning of list
- **add_after:** Adds a new node after another node
- **add_before:** Adds a new node before another node
- **add_end:** Adds a new node in the end of list
- **delete:** Removes the node
- **forward_traverse:** Traverse the list in forward direction
- **backward_traverse:** Traverse the list in backward direction

```
class Doubly_Linked_List

{

     node *front;      // points to first node of list
     node *end;      // points to first las of list

     public:

     Doubly_Linked_List()

     {

          front = NULL;

          end = NULL;

     }

     void add_front(int );

     void add_after(node* , int );

     void add_before(node* , int );

     void add_end(int );

     void delete_node(node*);

     void forward_traverse();

     void backward_traverse();

};
```
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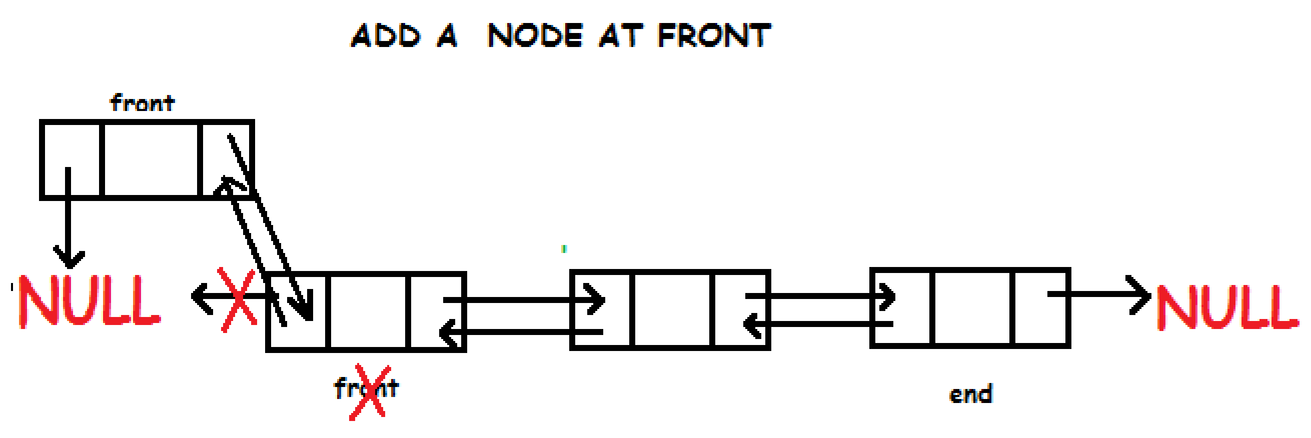
Insert Data in the beginning

1. The **prev** pointer of first node will always be NULL and **next** will point to **front**.
2. If the node is inserted is the first node of the list then we make **front** and **end** point to this node.
3. Else we only make **front** point to this node.



1. WE MAKE THE CURRENT FRONT NODE'S PREV POINT TO NEW NODE.
2. MAKE NEXT OF NEW NODE POINT TO CURRENT FRONT AND PREV OF NEW NODE POINT TO NULL.
3. WE CHANGE FRONT NODE TO THE NEW NODE.

```
void Doubly_Linked_List :: add_front(int d)

{

      // Creating new node

      node *temp;

      temp = new node();

      temp->data = d;

      temp->prev = NULL;

      temp->next = front;


      // List is empty

      if(front == NULL)

            end = temp;


      else

            front->prev = temp;


      front = temp;

}
```
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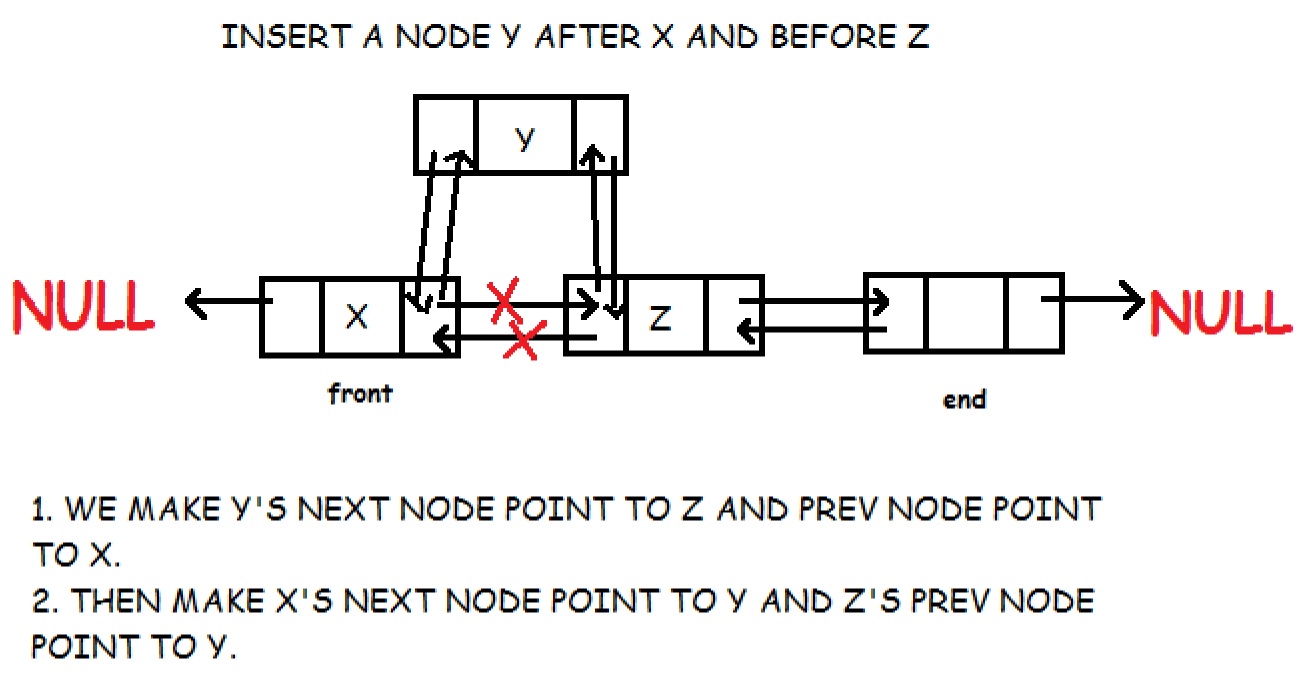
Insert Data before a Node

Let's say we are inserting node X before Y. Then X's next pointer will point to Y and X's prev pointer will point the node Y's prev pointer is pointing. And Y's prev pointer will now point to X. We need to make sure that if Y is the first node of list then after adding X we make front point to X.



INSERT A NODE Y AFTER X AND BEFORE Z
Y
NULL
X
Z
NULL
front
end
1. WE MAKE Y'S NEXT NODE POINT TO Z AND PREV NODE POINT TO X.
2. THEN MAKE X'S NEXT NODE POINT TO Y AND Z'S PREV NODE POINT TO Y.

```
void Doubly_Linked_List :: add_before(node *n, int d)

{

     node *temp;

     temp = new node();

     temp->data = d;

     temp->next = n;

     temp->prev = n->prev;

     n->prev = temp;



     //if node is to be inserted before first node

     if(n->prev == NULL)

          front = temp;

}
```
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Insert Data after a Node

Let's say we are inserting node Y after X. Then Y's prev pointer will point to X and Y's next pointer will point the node X's next pointer is pointing. And X's next pointer will now point to Y. We need to make sure that if X is the last node of list then after adding Y we make end point to Y.

```
void Doubly_Linked_List :: add_after(node *n, int d)

{

    node *temp;

    temp = new node();

    temp->data = d;

    temp->prev = n;

    temp->next = n->next;

    n->next = temp;


    //if node is to be inserted after last node

    if(n->next == NULL)

        end = temp;

}
```

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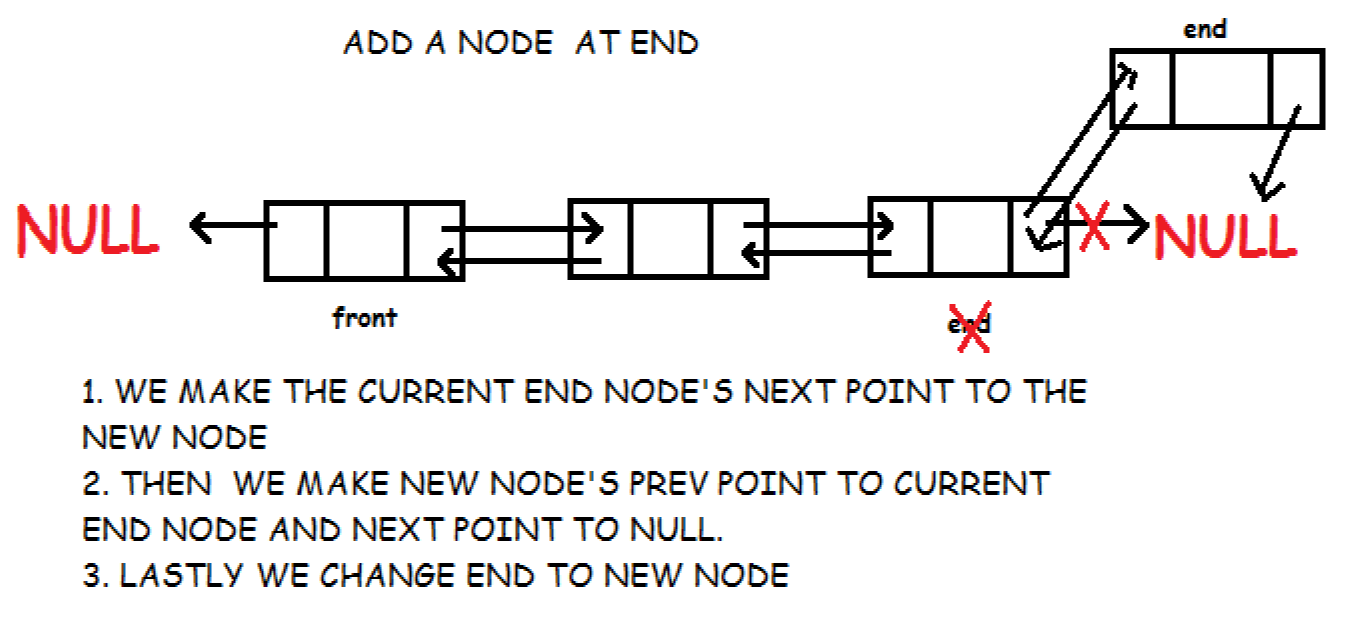
Insert Data in the end

1. The **next** pointer of last node will always be NULL and **prev** will point to end.
2. If the node is inserted is the first node of the list then we make front and end point to this node.
3. Else we only make end point to this node.


ADD A NODE AT END
end
NULL
NULL
front
end
1. WE MAKE THE CURRENT END NODE'S NEXT POINT TO THE NEW NODE
2. THEN WE MAKE NEW NODE'S PREV POINT TO CURRENT END NODE AND NEXT POINT TO NULL.
3. LASTLY WE CHANGE END TO NEW NODE

```
void Doubly_Linked_List :: add_end(int d)

{
     // create new node

     node *temp;

     temp = new node();

     temp->data = d;

     temp->prev = end;

     temp->next = NULL;


     // if list is empty

     if(end == NULL)

          front = temp;

     else

          end->next = temp;

     end = temp;

}
```
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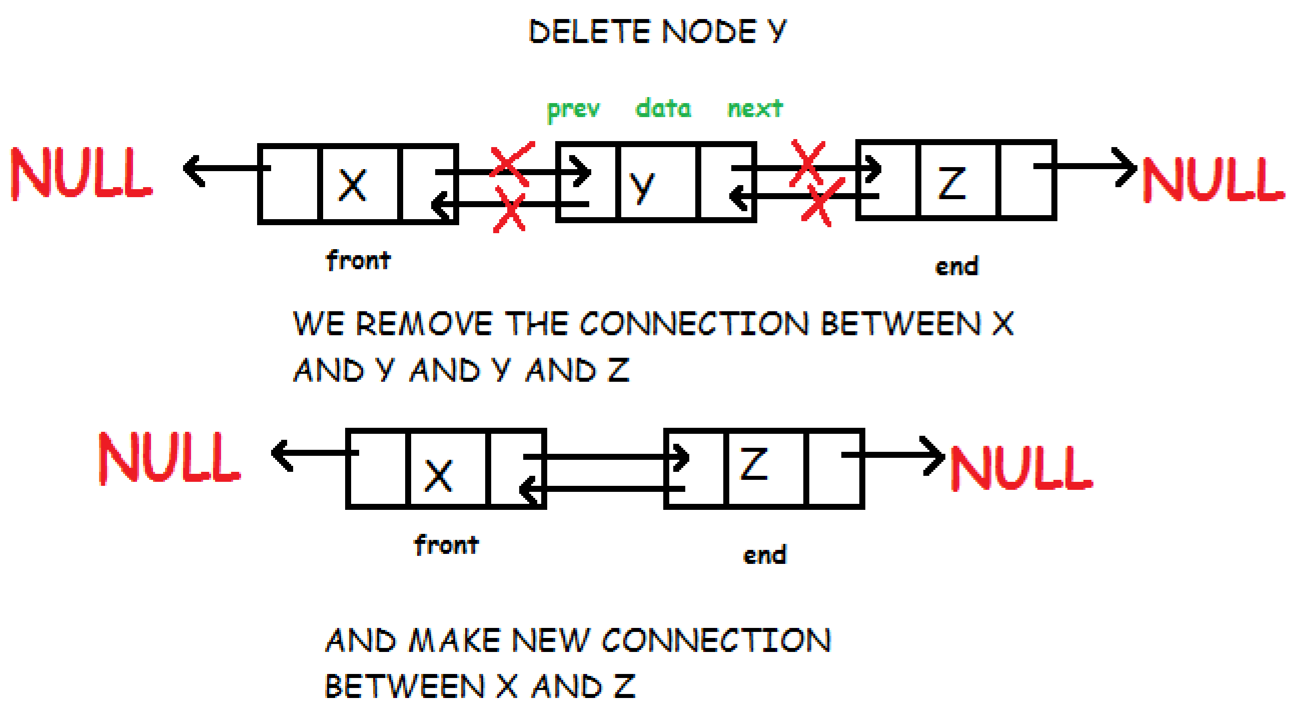
Remove a Node

Removal of a node is quite easy in Doubly linked list but requires special handling if the node to be deleted is first or last element of the list. Unlike singly linked list where we require the previous node, here only the node to be deleted is needed. We simply make the next of the previous node point to next of current node (node to be deleted) and prev of next node point to prev of current node. Look code for more details.



DELETE NODE Y
prev
data
next
NULL
X
Y
Z
NULL
front
end
WE REMOVE THE CONNECTION BETWEEN X AND Y AND Y AND Z
NULL
X
Z
NULL
front
end
AND MAKE NEW CONNECTION BETWEEN X AND Z

```
void Doubly_Linked_List :: delete_node(node *n)
```

```
{

      // if node to be deleted is first node of list

      if(n->prev == NULL)

      {

            front = n->next; //the next node will be front of list

            front->prev = NULL;

      }

      // if node to be deleted is last node of list

      else if(n->next == NULL)

      {

            end = n->prev;   // the previous node will be last of list

            end->next = NULL;

      }

      else

      {

            //previous node's next will point to current node's next

            n->prev->next = n->next;

            //next node's prev will point to current node's prev

            n->next->prev = n->prev;

      }

      //delete node

      delete(n);

}
```

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Forward Traversal

Start with the front node and visit all the nodes untill the node becomes NULL.

```
void Doubly_Linked_List :: forward_traverse()

{

      node *trav;
      trav = front;

      while(trav != NULL)

      {

            cout<<trav->data<<endl;

            trav = trav->next;

      }

}
```

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Backward Traversal

Start with the end node and visit all the nodes until the node becomes NULL.

```
void Doubly_Linked_List :: backward_traverse()

{

      node *trav;

      trav = end;

      while(trav != NULL)

      {

            cout<<trav->data<<endl;

            trav = trav->prev;

      }

}
```

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Now that we have learned about the Doubly Linked List, you can also check out the other types of Linked list as well:

- Linear Linked List
- Circular Linked List