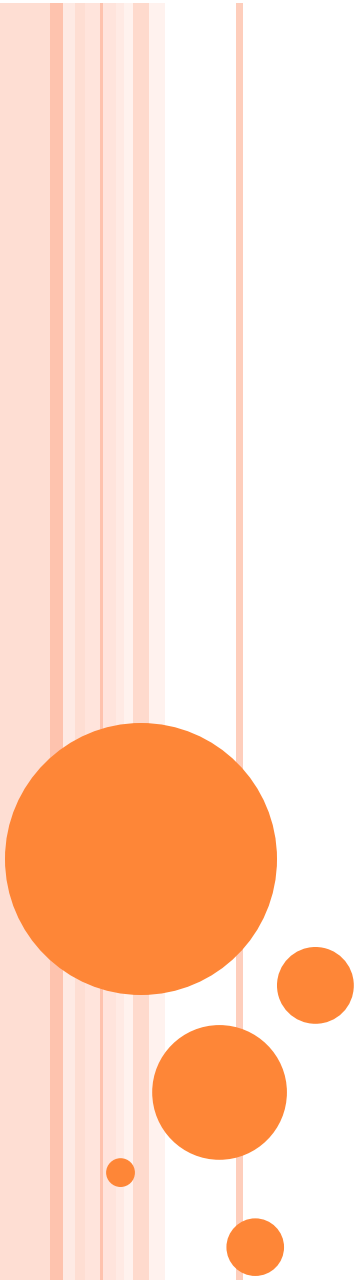


Doubly Linked Lists

CS A250 – C++ Programming II

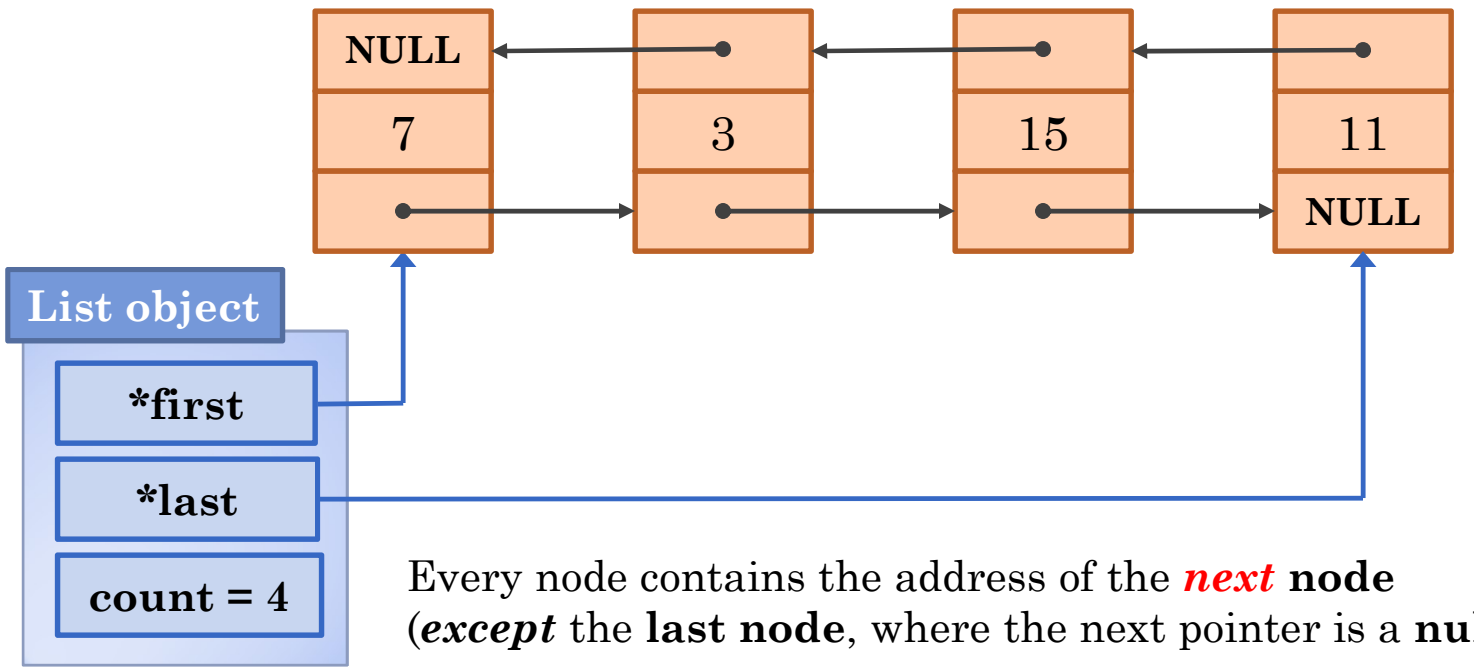
Review

- Singly-linked list
  - Constructed using **pointers**
  - **Grows** and **shrinks** during ***runtime***
  - **Doubly-linked lists**:
    - A variation with **pointers** in ***both directions***
- **Pointers** are the backbone of such structures
  - Use ***dynamic*** variables
- **Standard Template Library**
  - Has predefined versions of some structures

Doubly-Linked Lists

- A **doubly-linked list**
  - Links to **next** node ***and*** to **previous** node
  - Can follow link in **either direction**
  - Can make some operations easier
  - **NULL** signifies the **beginning** *and* the **end** of the list

Doubly-Linked Lists (cont.)



Every node contains the address of the ***next*** **node** (***except*** the **last node**, where the next pointer is a **nullptr**),

AND

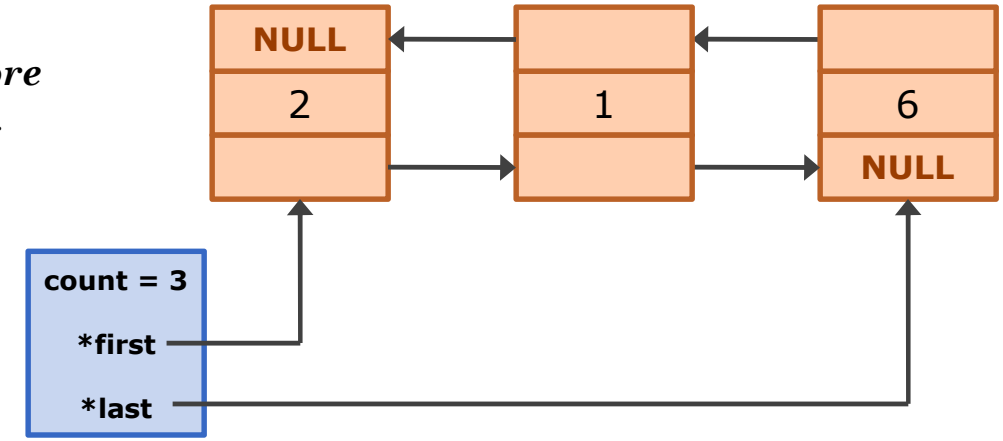
every node contains the address of the ***previous*** **node** (***except*** the **first node**, which contains a **nullptr**).

Doubly-Linked Node Definition

```
class Node
{
public:
    Node () : data(0), previousLink(nullptr), nextLink(nullptr) {}
    Node (int theData, Node *previous, Node *next)
            : data(theData), previousLink(previous), nextLink(next) {}
    int getData( ) const { return data; }
    Node *getPreviousLink( ) const { return previousLink; }
    Node *getNextLink( ) const { return nextLink; }
    void setData(int theData) { data = theData; }
    void setPreviousLink(Node *pointer) { previousLink = pointer; }
    void setNextLink(Node *pointer) { nextLink = pointer; }
    ~Node()
private:
    int data;   //to simplify, we are using only one piece of data
    Node *previousLink;
    Node *nextLink;
};
```

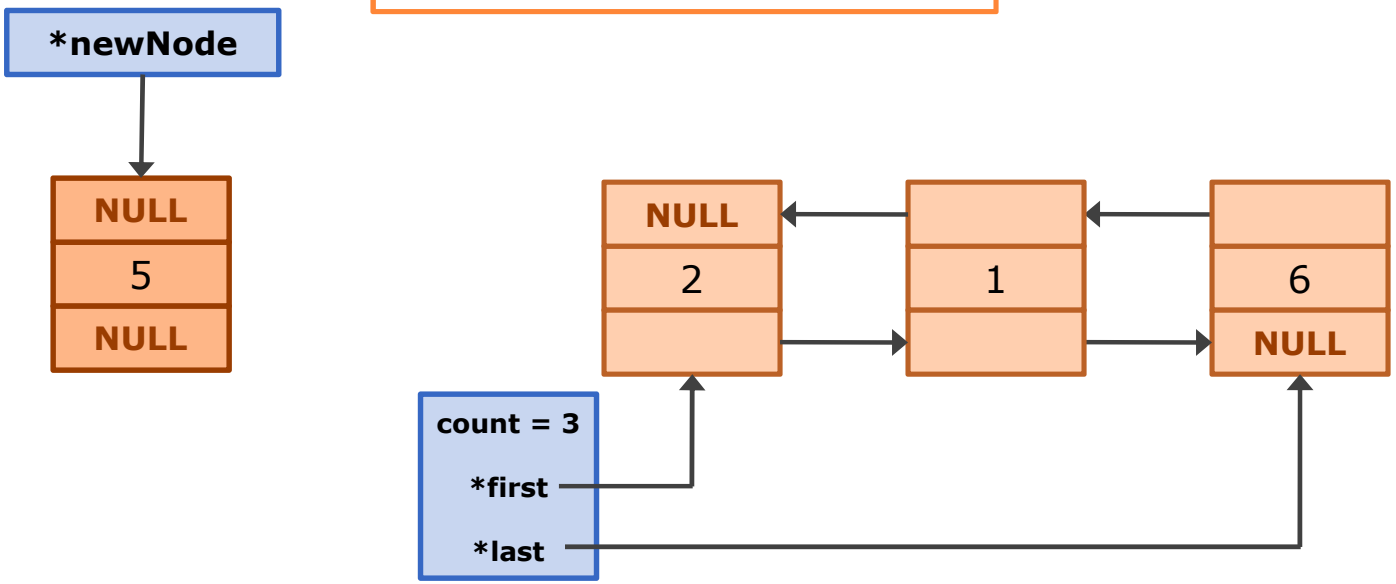
Adding a Node to the Front (1 of 2)

Existing list ***before*** adding new node.

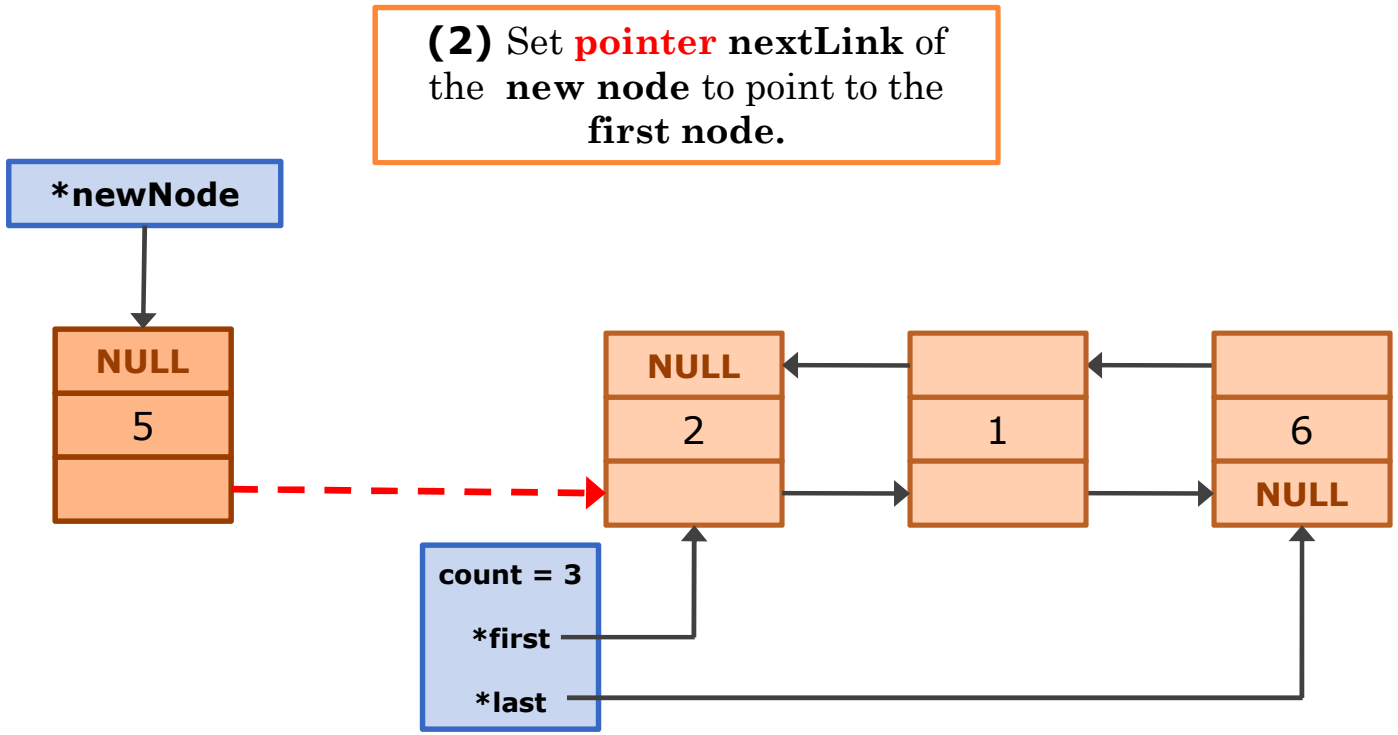


Adding a Node to the Front (1 of 2)

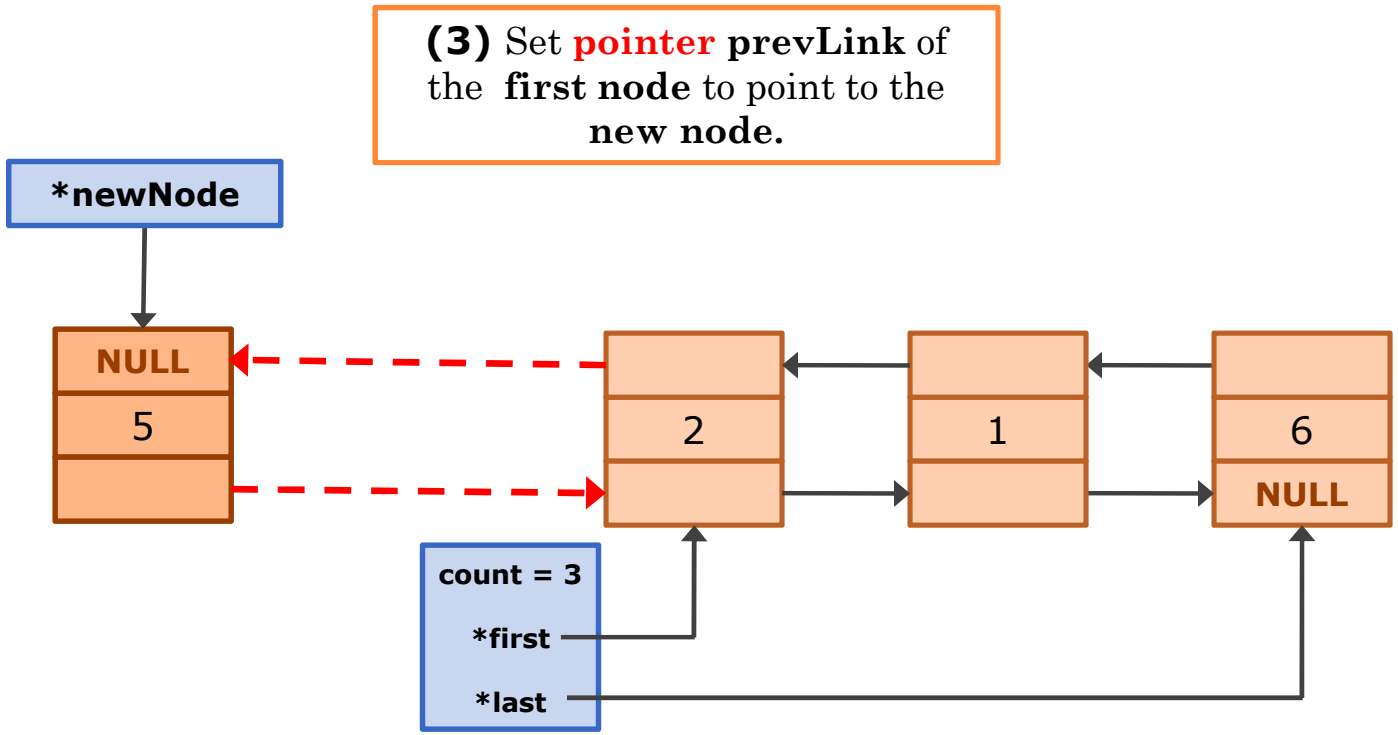
(1) Create a **pointer** **newNode** that points to a **new node** storing the value 5.



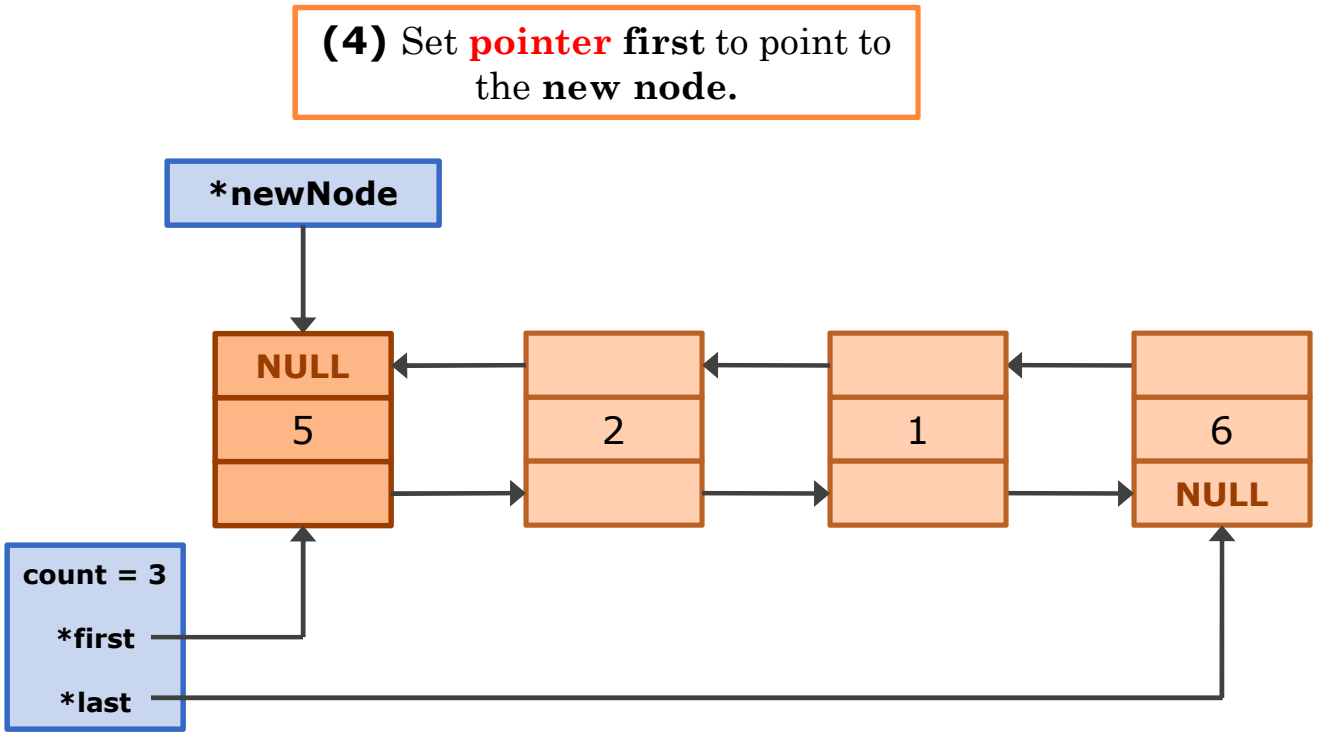
ADDING A NODE TO THE FRONT (1 OF 2)



ADDING A NODE TO THE FRONT (1 OF 2)

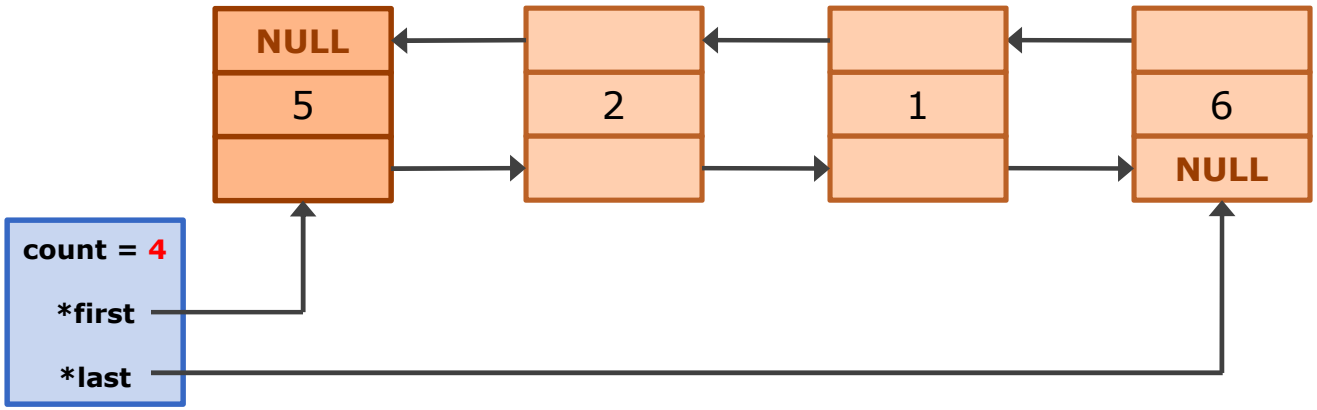


Adding a Node to the Front (1 of 2)



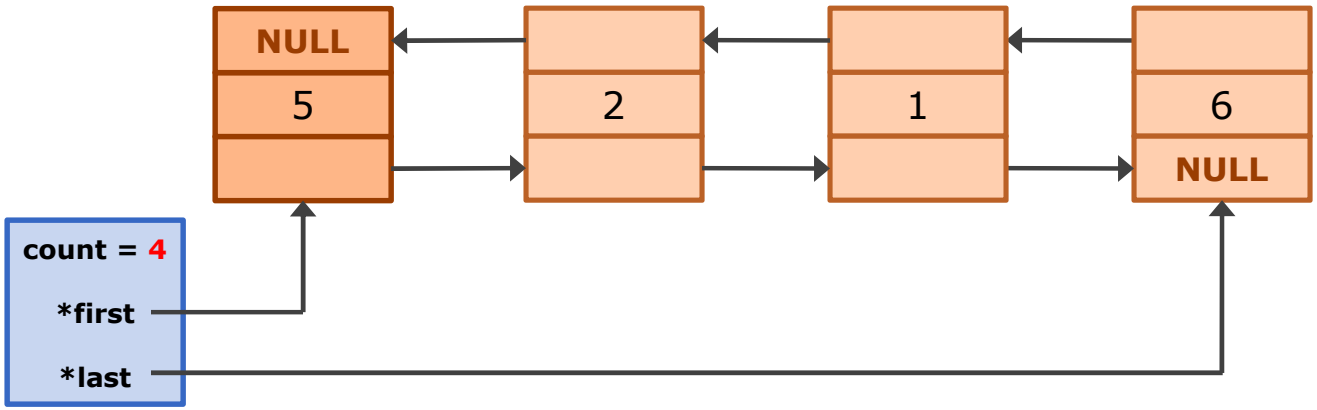
ADDING A NODE TO THE FRONT (1 OF 2)

(5) Re-set **pointer** **newNode** to **NULL**.



Adding a Node to the Front (1 of 2)

(6) Increment the count.

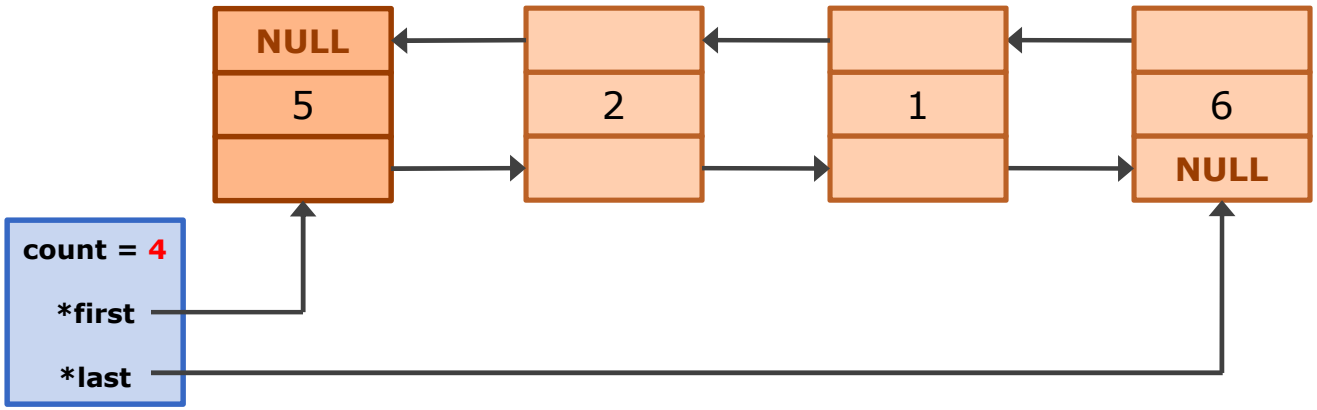


Adding a Node to the Front (1 of 2)

Note:

The **first** node **prevLink** is **NULL.**

The **last** node **nextLink** is **NULL.**

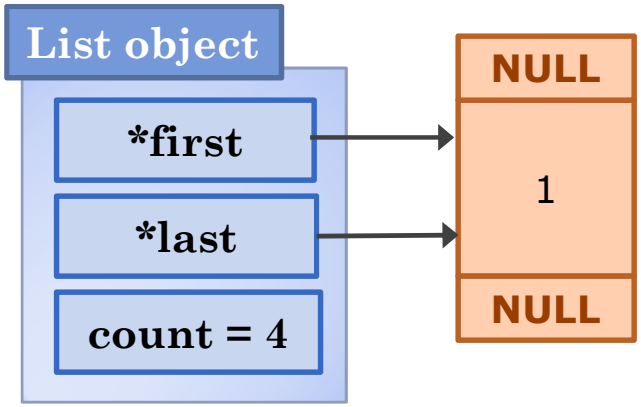


Deleting a Node from the list

- To **delete** a specific node from the list, we need to first find out whether that node exists by searching the list.
- The delete operation has several cases:
  - The *list is empty*
  - The item to be deleted *is in the first node* of the list, which would require us to change the value of pointer first
    - The *first node* is the only node in the list
  - The item to be deleted is *somewhere in the list*
    - The *last node* needs to be deleted
  - The item to be deleted is *not in the list*

Deleting a Node from the list (cont.)

- **Case:** List contains only one node.
- **Delete**: Node 1

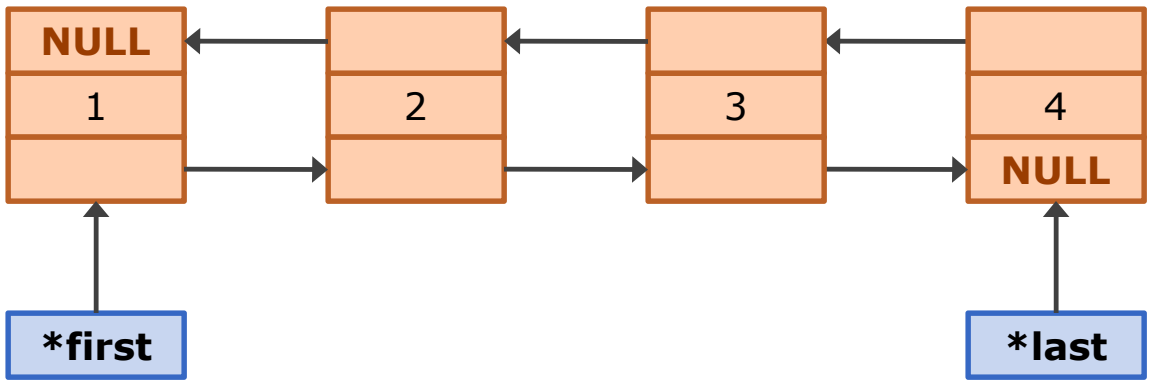


If there is only one node in the list, both pointers **first** and **last** will be pointing to it.

No need to create a pointer, **BUT** you need to re-set both pointers **first** and **last** to **NULL**.

Deleting a Node from the list (cont.)

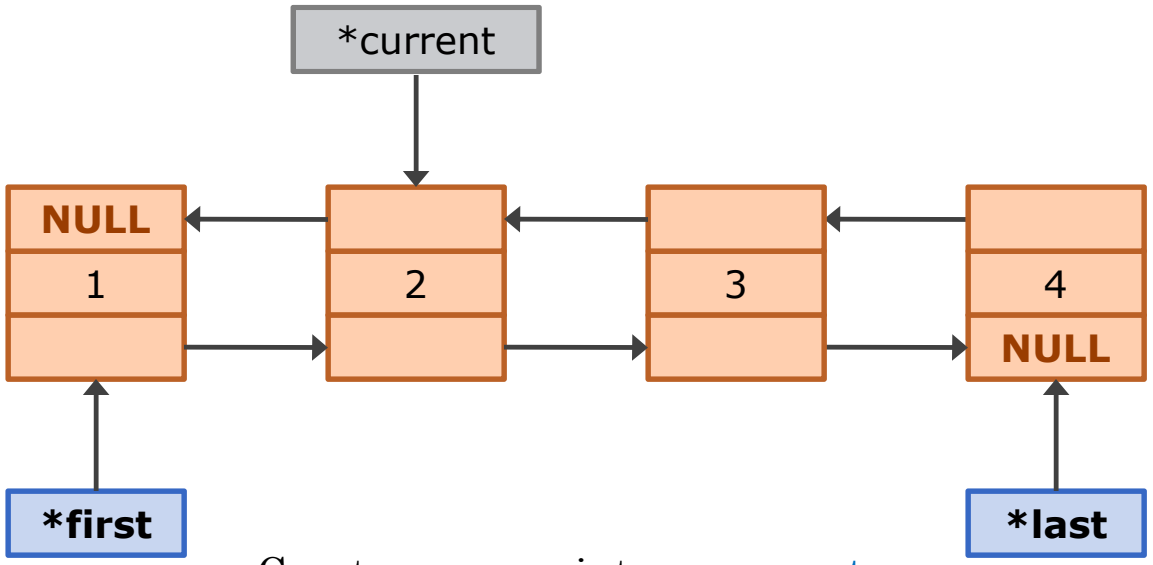
- **Case:** List contains more than one node.
- **Delete**: Node 3



*(For simplicity, the list object is **not** drawn, but only **pointers first** and **last**.)*

Deleting a Node from the List (cont.)

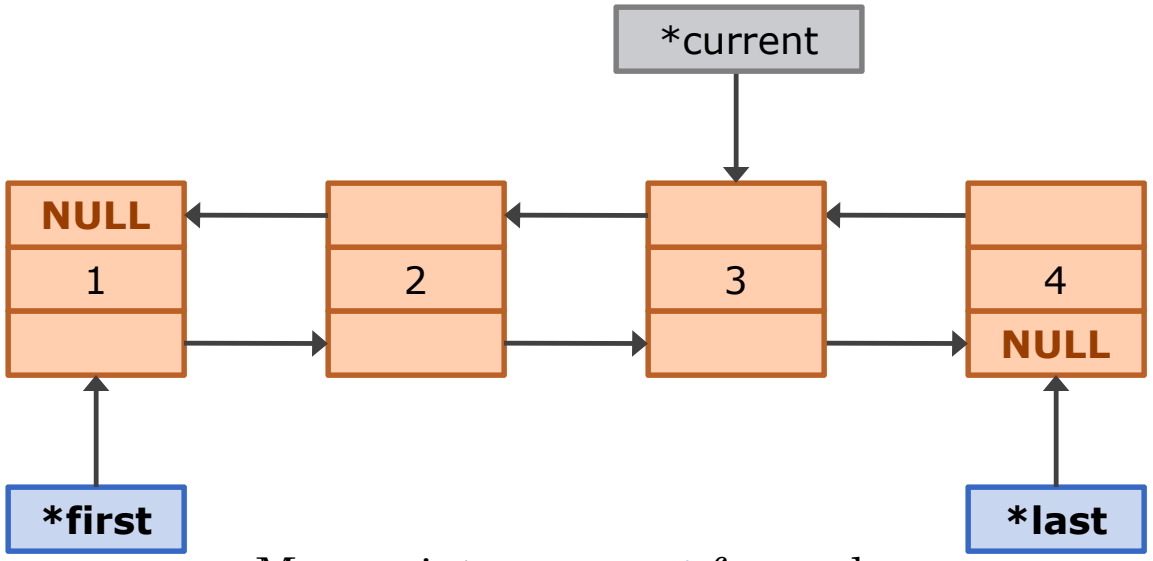
- **Case:** List contains more than one node.
- **Delete**: Node 3



Create a new pointer, **current**, and make it point to the **second** node (you have already checked the first node).

Deleting a Node from the List (cont.)

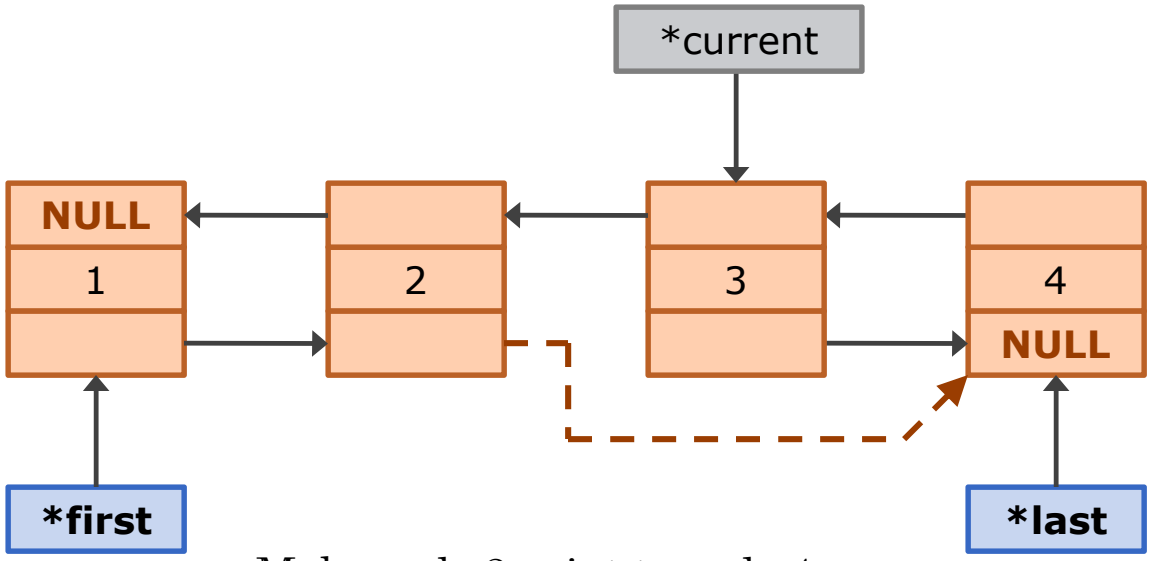
- **Case:** List contains more than one node.
- **Delete**: Node 3



Move pointer **current** forward until you find the node that contains the data to delete.

Deleting a Node from the List (cont.)

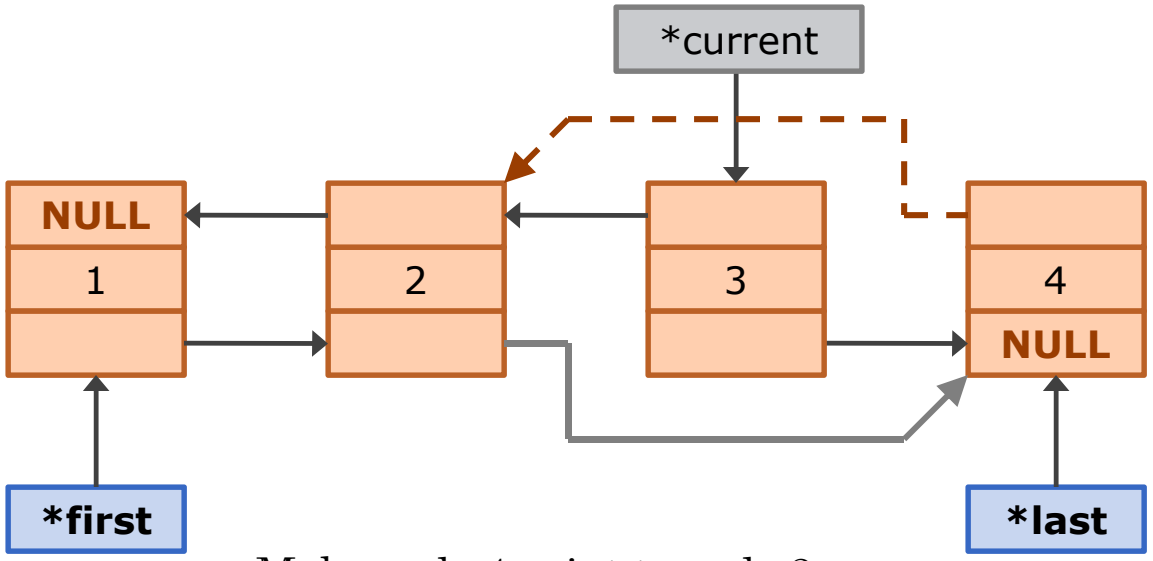
- **Case:** List contains more than one node.
- **Delete**: Node 3



Make node 2 point to node 4.

Deleting a Node from the List (cont.)

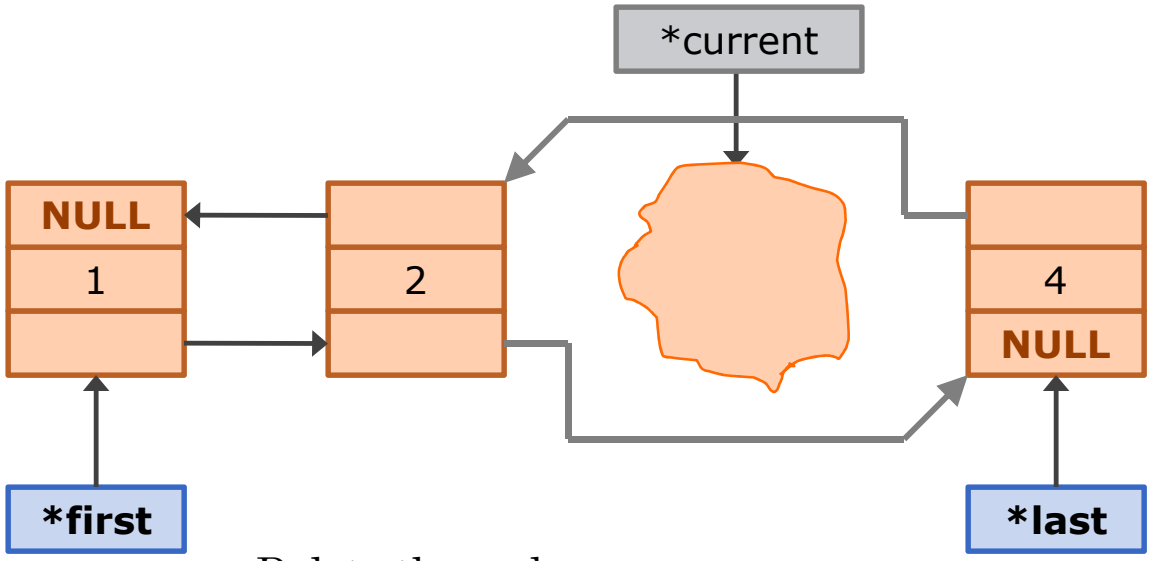
- **Case:** List contains more than one node.
- **Delete**: Node 3



Make node 4 point to node 2.

Deleting a Node from the List (cont.)

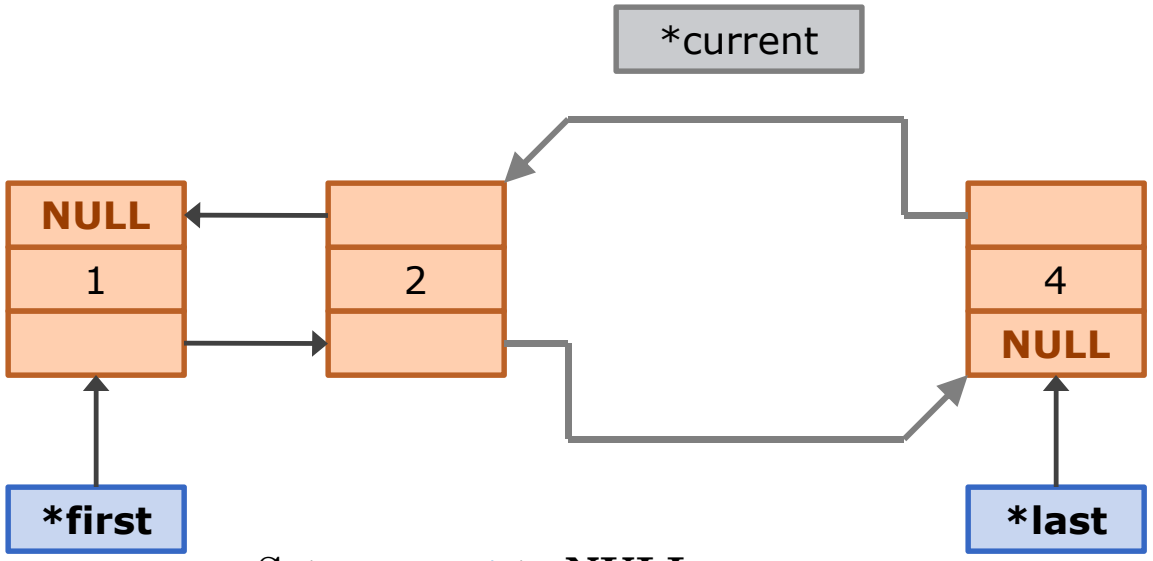
- **Case:** List contains more than one node.
- **Delete**: Node 3



Delete the node.

Deleting a Node from the List (cont.)

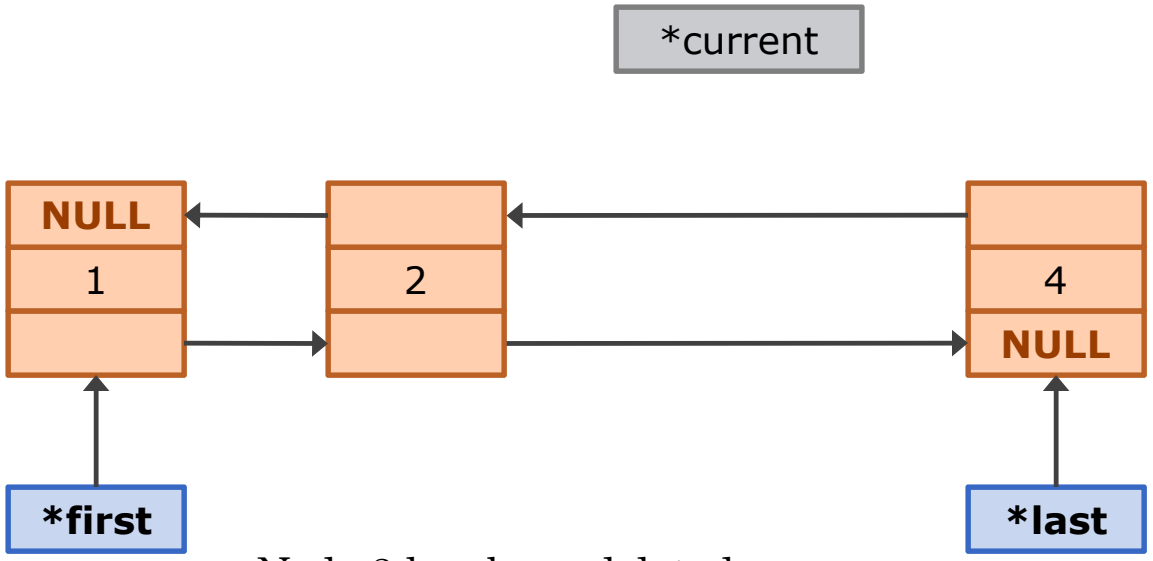
- **Case:** List contains more than one node.
- **Delete**: Node 3



Set **current** to **NULL**.

Deleting a Node from the List (cont.)

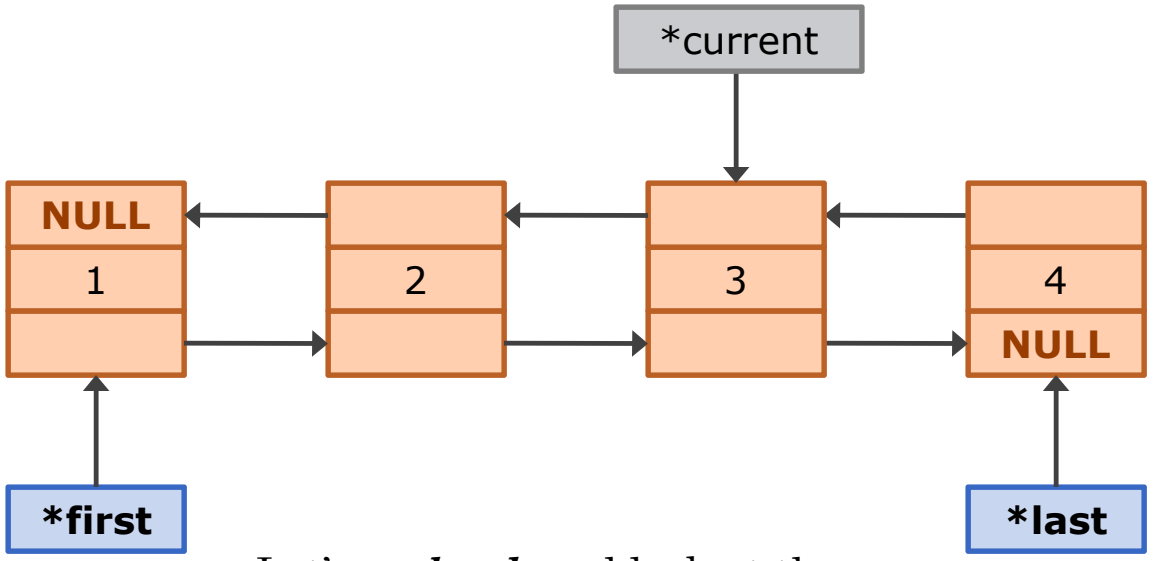
- **Case:** List contains more than one node.
- **Delete**: Node 3



Node 3 has been deleted.

Deleting a Node from the List (cont.)

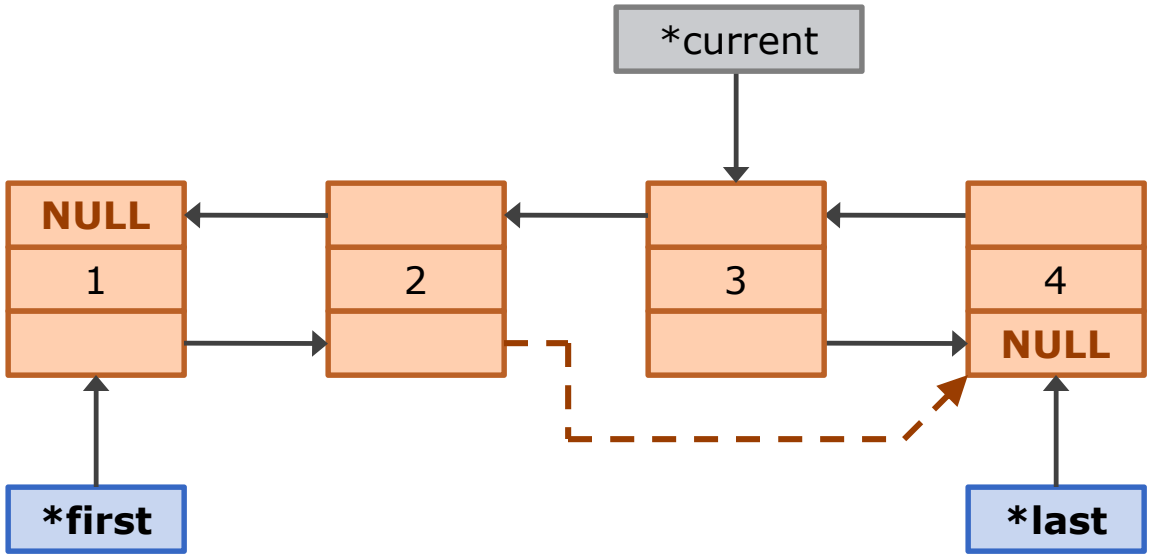
- **Case:** List contains more than one node.
- **Delete**: Node 3



Let's ***go back*** and look at the syntax needed when using only one pointer **current**.

Deleting a Node from the list (cont.)

- **Case:** List contains more than one node.
- **Delete**: Node 3

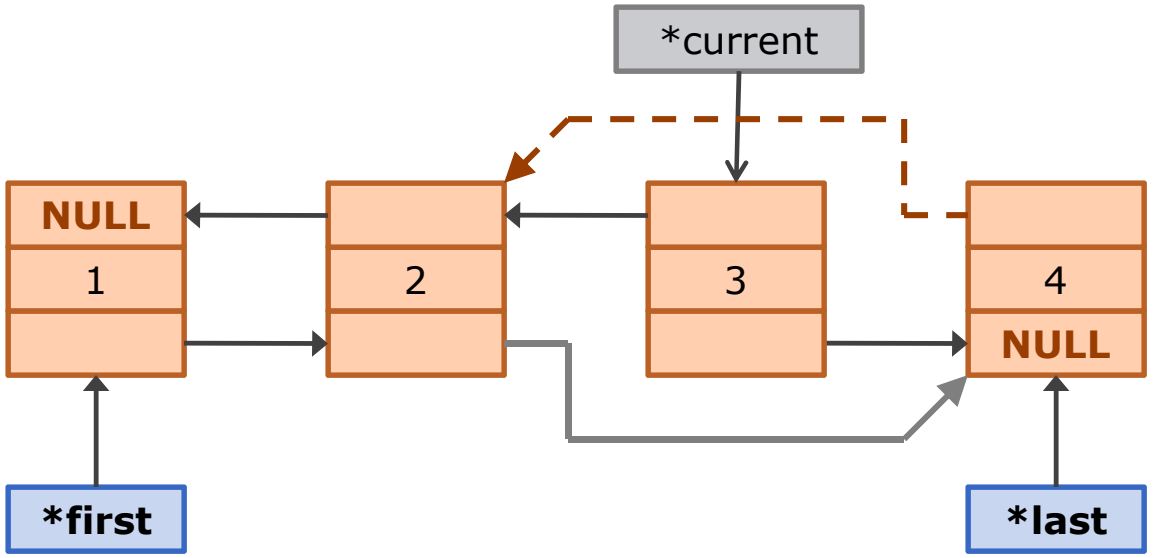



```
current->getPrev()->setNext(current->getNext());
```

(node 2) (node 4)

Deleting a Node from the List (cont.)

- **Case:** List contains more than one node.
- **Delete**: Node 3




```
current->getNext()->setPrev(current->getPrev());
```

(node 4) (node 2)

A List as an ADT

- A list as an **Abstract Data Type** (**ADT**) is a ***generic*** definition of a list
  - It has *basic* operations to manipulate the list
- Implementation is not relevant
  - User needs to know only basic operations
  - A **List ADT** can be implemented as
    - An array
    - A linked list (singly, doubly)
    - A vector
- Can be **sorted** or **unsorted**

Basic Operations of a List ADT

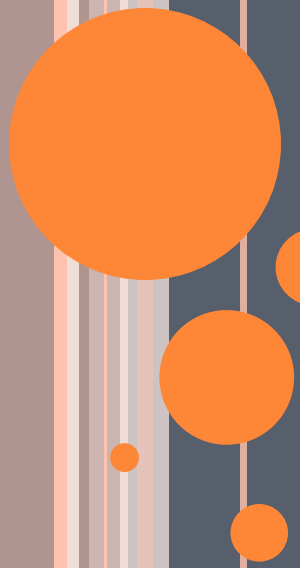
- Whether you are implementing the list as an **array** or a **linked list**, basic operations are necessary
  - **Default constructor**
    - Initialize the list to an empty state
  - **Empty the list**
    - Re-initializes a list to an empty state
  - **Insert**
    - Inserts an element in the list
    - Can be in a particular order
  - **Get number of elements**
    - Returns the number of elements in the list

Basic Operations of a List ADT (cont.)

- **Get first element**
  - Returns the first element in the list
- **Get last element**
  - Returns the last element in the list
- **Search list**
  - Searches the whole list for a given element
  - Returns a **boolean** value
- **Delete element**
  - Need to consider cases:
    - List is empty
    - The element is not in the list
- **Copy list**
  - Makes an identical copy of a list
- **Destructor**
  - If list is **dynamic**, deallocates list from memory

Example

- Project: Doubly-linked List



Doubly-Linked List (end)