COMP 2710
Software Construction

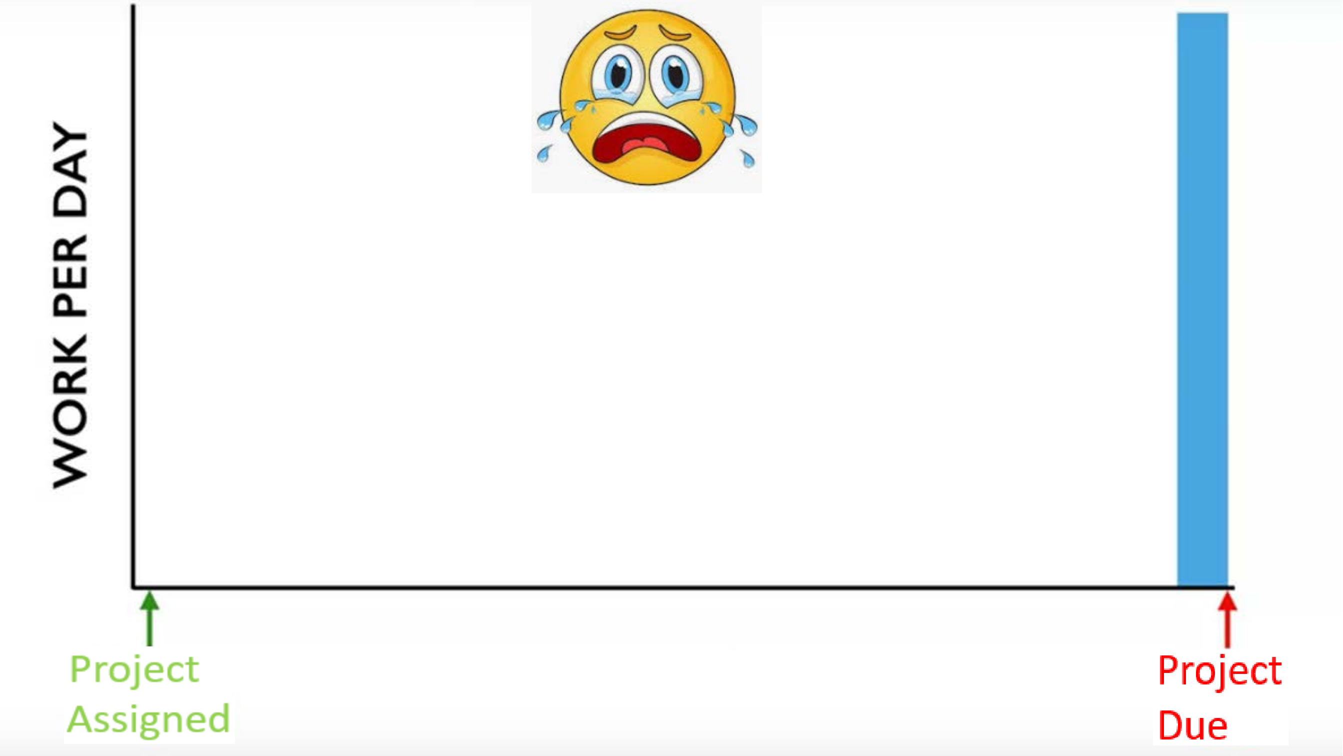
Chapter 4

Singly/Doubly Linked List

AUBURN UNIVERSITY

SAMUEL GINN COLLEGE OF ENGINEERING


WORK PER DAY
Project
Assigned
Project
Due


WORK PER DAY
Project
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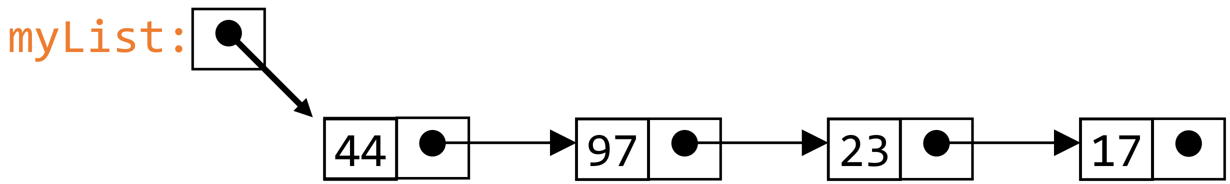
Singly Linked List

Creating links in Java



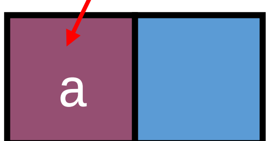

```
class Node {
     int value;
     Node next;

     Node (int v, Node n) { // constructor
          value = v;
          next = n;
     }

}

Node temp = new Node(17, null);

temp = new Node(23, temp);

temp = new Node(97, temp);

Node myList = new Node(44, temp);
```

Pointers and references

- In C and C++ we have "pointers," while in Java we have "references"
  - These are essentially the same thing
    - The difference is that C and C++ allow you to modify pointers in arbitrary ways, and to point to anything
  - In Java, a reference is more of a "black box," or ADT
    - Available operations are:
      - dereference ("follow")
      - copy
      - compare for equality
    - There are constraints on what kind of thing is referenced: for example, a reference to an `array of int` can *only* refer to an `array of int`

Pointer Implementation (Linked List)

- First, define a Node.

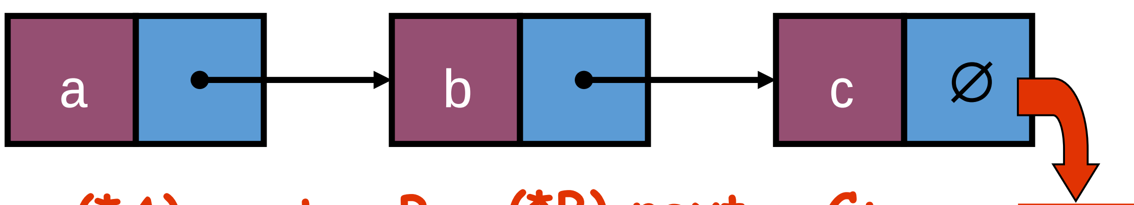



```
struct Node {
    double data;        // data
    Node* next;         // pointer to next
};
```

"self-referentiality"

- Second, linked them together.

Node * A; Node * B; Node * C;



(*A).next = B; (*B).next = C;

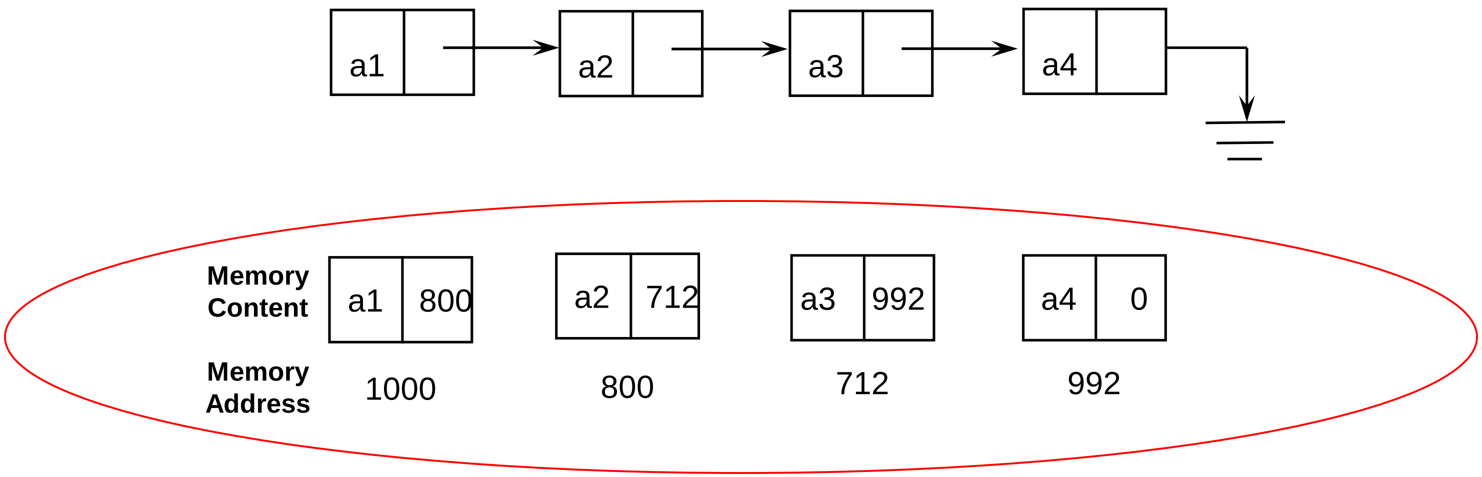
(*C).next = NULL;

We want a new symbol ☺

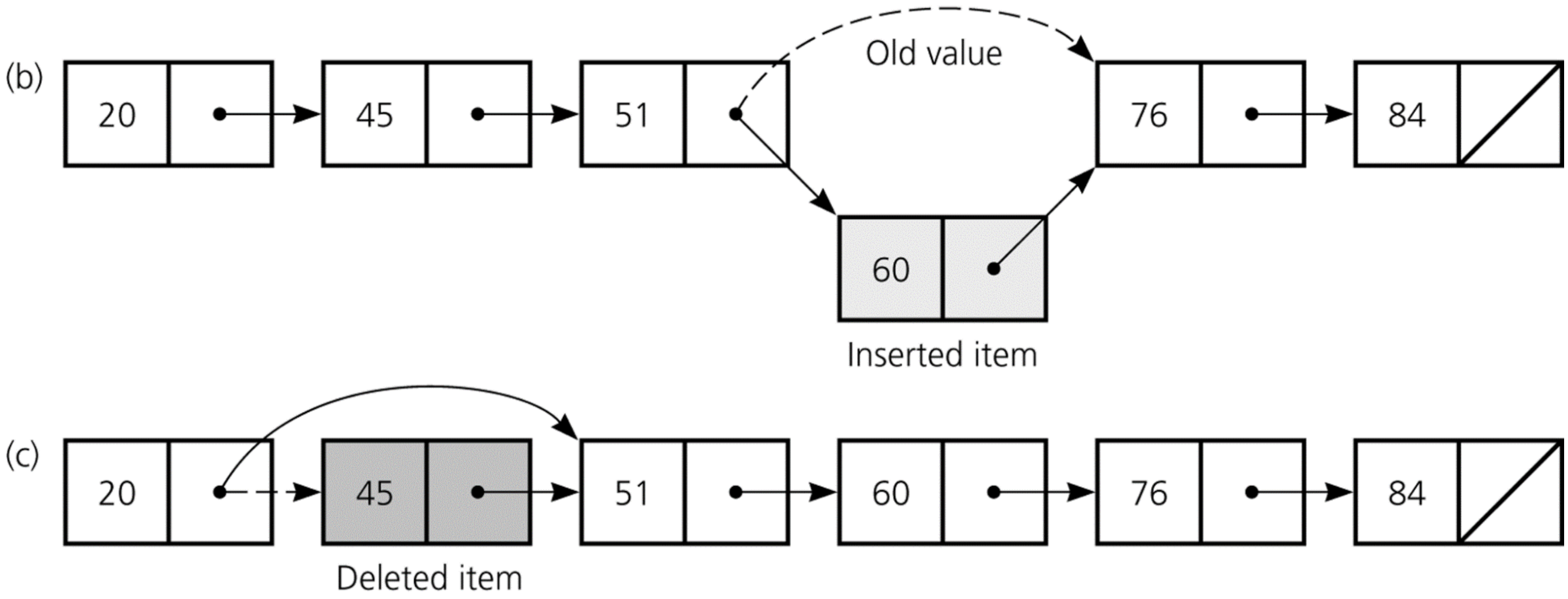
A->next = B; B->next = C;

C->next = NULL;

What does the memory look like?

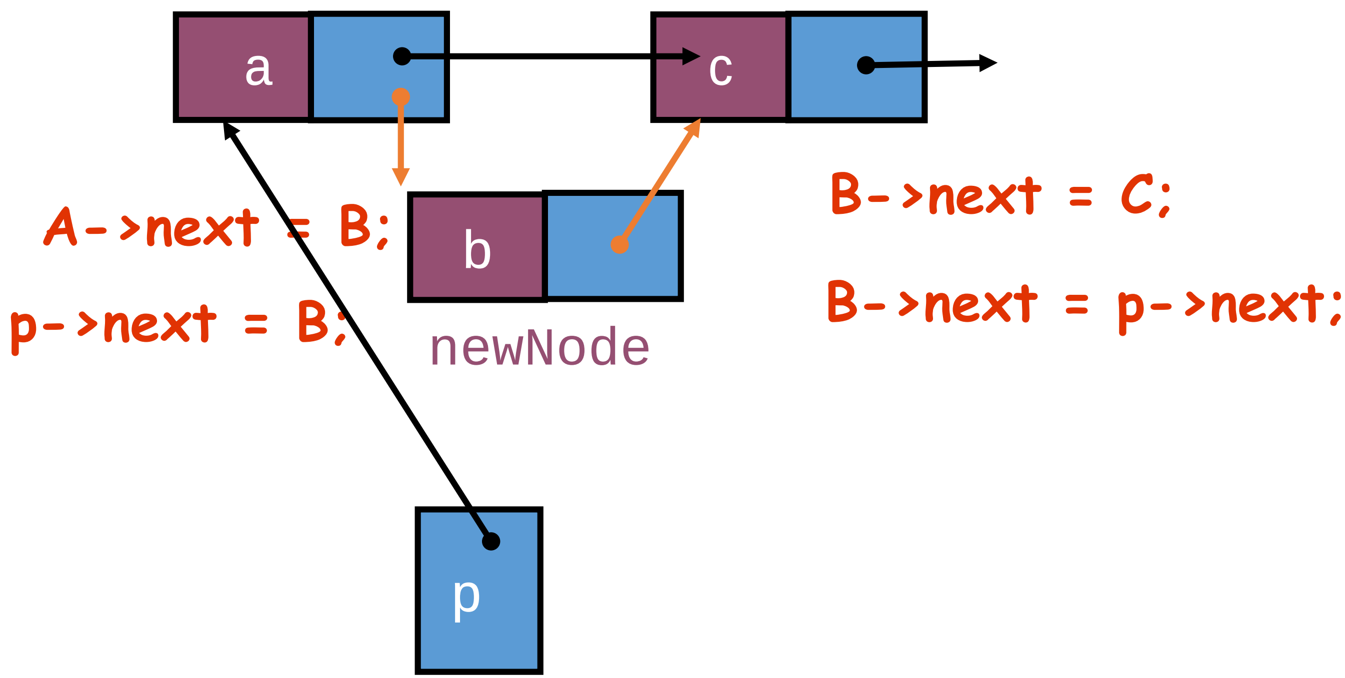


Update linked list



Inserting a node

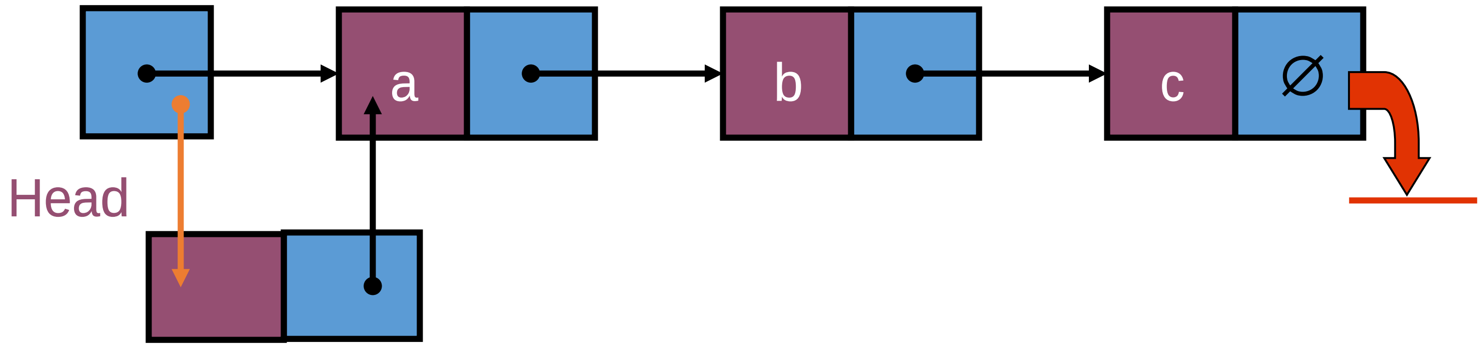
- What if I only want to use a pointer that points to A?



However, what if we want to insert in the front?

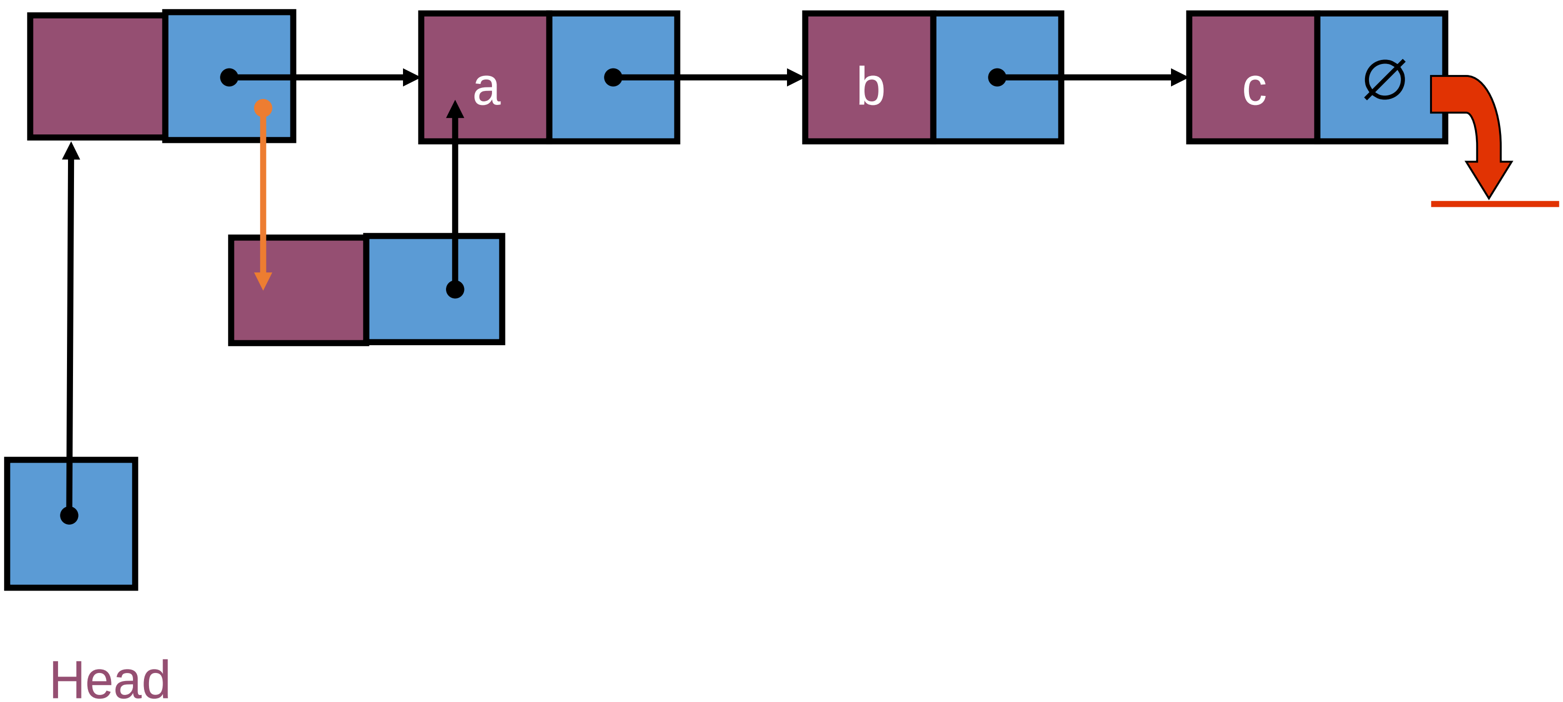
Option One

- Deal with it differently.

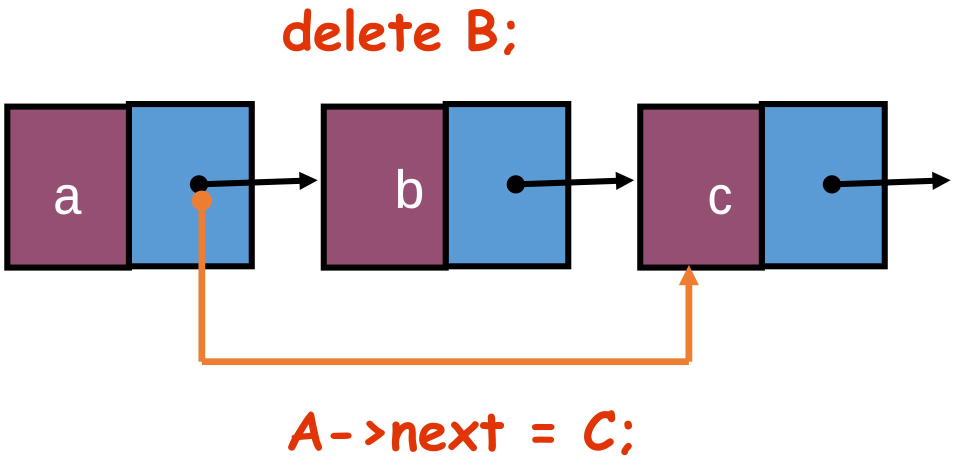


Option Two

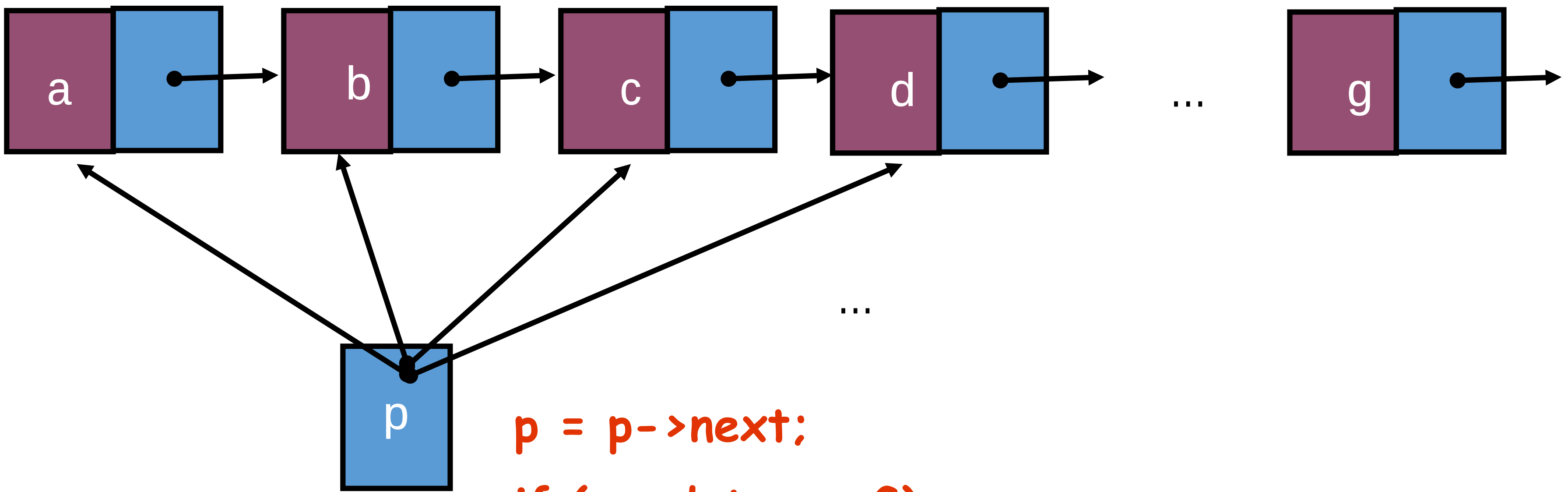
- Add a faked node. ☺ It is always there (even for an empty linked list)



Deleting a Node



Finding a node.




```
p = p->next;
if (p->data == G)
    ...
```

Inserting a new node

- Possible cases of `InsertNode`
  1. Insert into an empty list
  2. Insert in front
  3. Insert at back
  4. Insert in middle
- But, in fact, only need to handle two cases
  - Insert as the first node (Case 1 and Case 2)
  - Insert in the middle or at the end of the list (Case 3 and Case 4)

Inserting a new node

```
Node* InsertNode(int index, double x) {
    if (index < 0) return NULL;

    int currIndex   =   1;
    Node* currNode =   head;
    while (currNode && index > currIndex) {
        currNode    =   currNode->next;
        currIndex++;
    }
    if (index > 0 && currNode == NULL) return NULL;

    Node* newNode   =   new Node;
    newNode->data   =   x;
    if (index == 0) {
        newNode->next   =   head;
        head            =   newNode;
    }
    else {
        newNode->next   =   currNode->next;
        currNode->next =   newNode;
    }
    return newNode;
}
```

Try to locate index'th node. If it doesn't exist, return NULL.

Inserting a new node

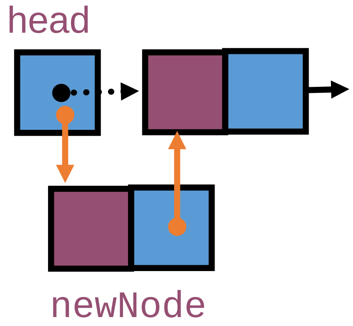
```
Node* InsertNode(int index, double x) {
    if (index < 0) return NULL;

    int currIndex  =   1;
    Node* currNode =   head;
    while (currNode && index > currIndex) {
        currNode    =   currNode->next;
        currIndex++;
    }
    if (index > 0 && currNode == NULL) return NULL;

    Node* newNode  =   new Node;
    newNode->data  =   x;
    if (index == 0) {
        newNode->next  =   head;
        head           =   newNode;
    }
    else {
        newNode->next  =   currNode->next;
        currNode->next =   newNode;
    }
    return newNode;
}
```

Create a new node

Inserting a new node

```
Node* InsertNode(int index, double x) {
    if (index < 0) return NULL;

    int currIndex  =   1;
    Node* currNode =   head;
    while (currNode && index > currIndex) {
        currNode    =   currNode->next;
        currIndex++;
    }
    if (index > 0 && currNode == NULL) return NULL;

    Node* newNode  =   new Node;
    newNode->data  =   x;
    if (index == 0) {
        newNode->next  =   head;
        head           =   newNode;
    }
    else {
        newNode->next  =   currNode->next;
        currNode->next =   newNode;
    }
    return newNode;
}
```

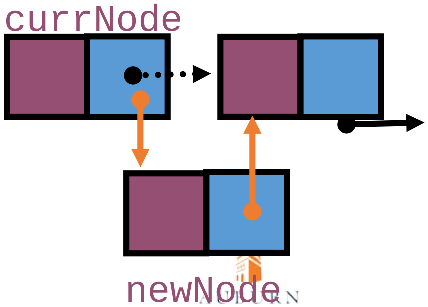
Insert as first element



Inserting a new node

```
Node* List::InsertNode(int index, double x) {
    if (index < 0) return NULL;

    int currIndex  =   1;
    Node* currNode =   head;
    while (currNode && index > currIndex) {
        currNode    =   currNode->next;
        currIndex++;
    }
    if (index > 0 && currNode == NULL) return NULL;

    Node* newNode  =   new Node;
    newNode->data  =   x;
    if (index == 0) {
        newNode->next   =   head;
        head            =   newNode;
    }
    else {
        newNode->next   =   currNode->next;
        currNode->next =   newNode;
    }
    return newNode;
}
```

Insert after currNode



Deleting a node

- `int DeleteNode(double x)`
  - Delete a node with the value equal to `x` from the list.
  - If such a node is found, return its position. Otherwise, return 0.
- Steps
  - Find the desirable node (similar to `FindNode`)
  - Release the memory occupied by the found node
  - Set the pointer of the predecessor of the found node to the successor of the found node
- Like `InsertNode`, there are two special cases
  - Delete first node
  - Delete the node in middle or at the end of the list

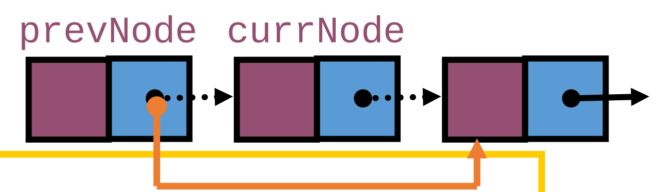
Deleting a node

```
int DeleteNode(double x) {
    Node* prevNode =   NULL;
    Node* currNode =   head;
    int currIndex  =   1;
    while (currNode && currNode->data != x) {
        prevNode    =   currNode;
        currNode    =   currNode->next;
        currIndex++;
    }
    if (currNode) {
        if (prevNode) {
            prevNode->next =   currNode->next;
            delete currNode;
        }
        else {
            head        =   currNode->next;
            delete currNode;
        }
        return currIndex;
    }
    return 0;
}
```

Try to find the node with its value equal to x

Deleting a node

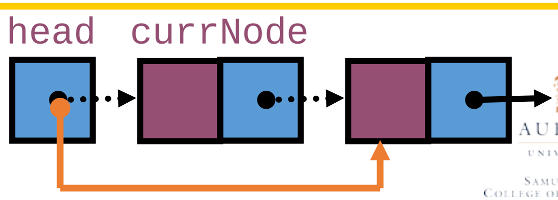
```
int DeleteNode(double x) {
    Node* prevNode =   NULL;
    Node* currNode =   head;
    int currIndex  =   1;
    while (currNode && currNode->data != x) {
        prevNode    =   currNode;
        currNode    =   currNode->next;
        currIndex++;
    }
    if (currNode) {
        if (prevNode) {
            prevNode->next =   currNode->next;
            delete currNode;
        }
        else {
            head        =   currNode->next;
            delete currNode;
        }
        return currIndex;
    }
    return 0;
}
```



Since the space for the node was allocated by “new”

Deleting a node

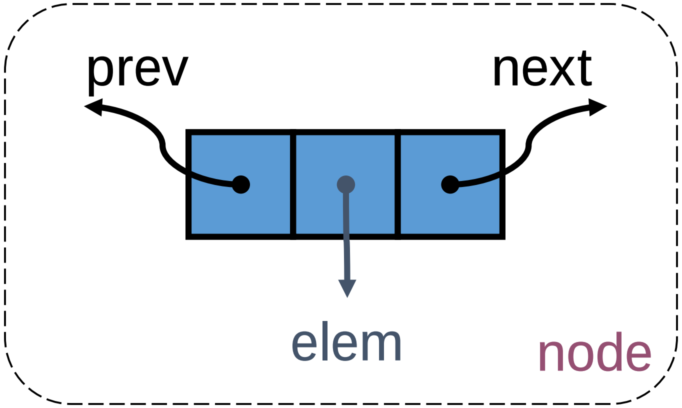
```
int DeleteNode(double x) {
    Node* prevNode =   NULL;
    Node* currNode =   head;
    int currIndex  =   1;
    while (currNode && currNode->data != x) {
        prevNode    =   currNode;
        currNode    =   currNode->next;
        currIndex++;
    }
    if (currNode) {
        if (prevNode) {
            prevNode->next =   currNode->next;
            delete currNode;
        }
        else {
            head        =   currNode->next;
            delete currNode;
        }
        return currIndex;
    }
    return 0;
}
```

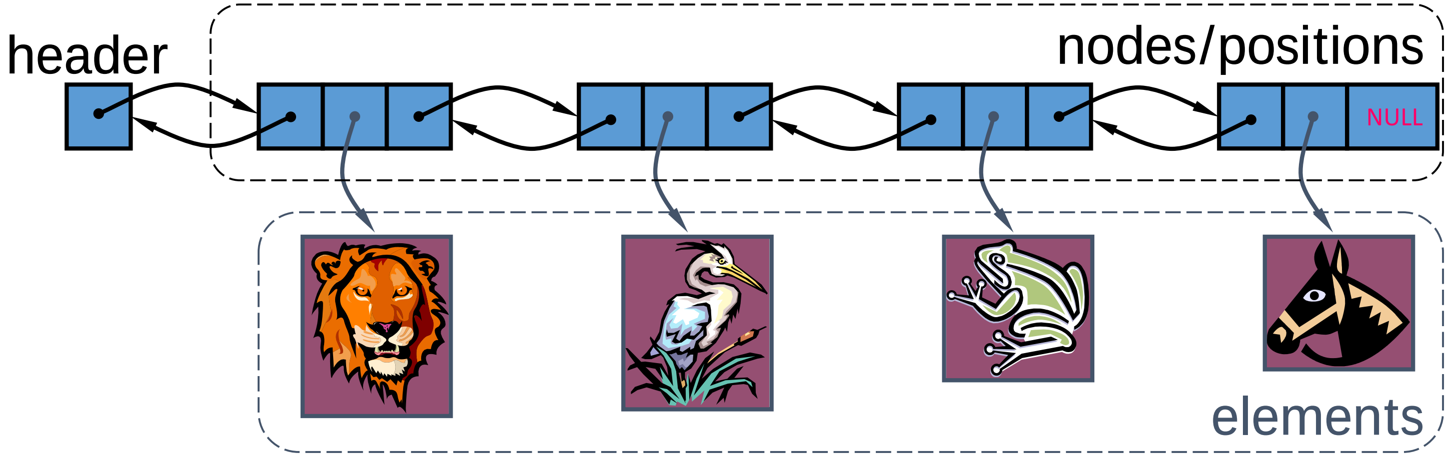


Doubly Linked List

Doubly Linked List

- A doubly linked list provides a natural implementation of the List ADT
- Nodes implement Position and store:
  - **element**
  - **link to the previous node**
  - **link to the next node**





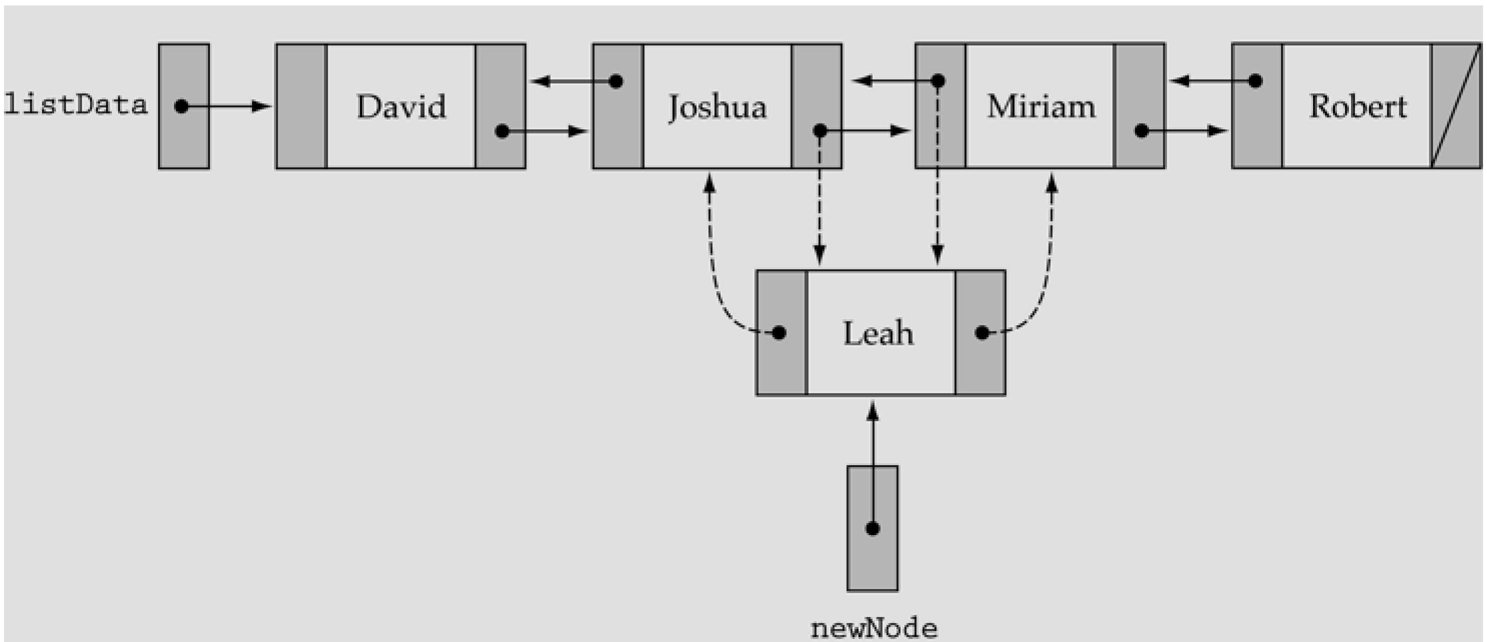
Advantages over Singly-linked Lists

- Quick update operations:

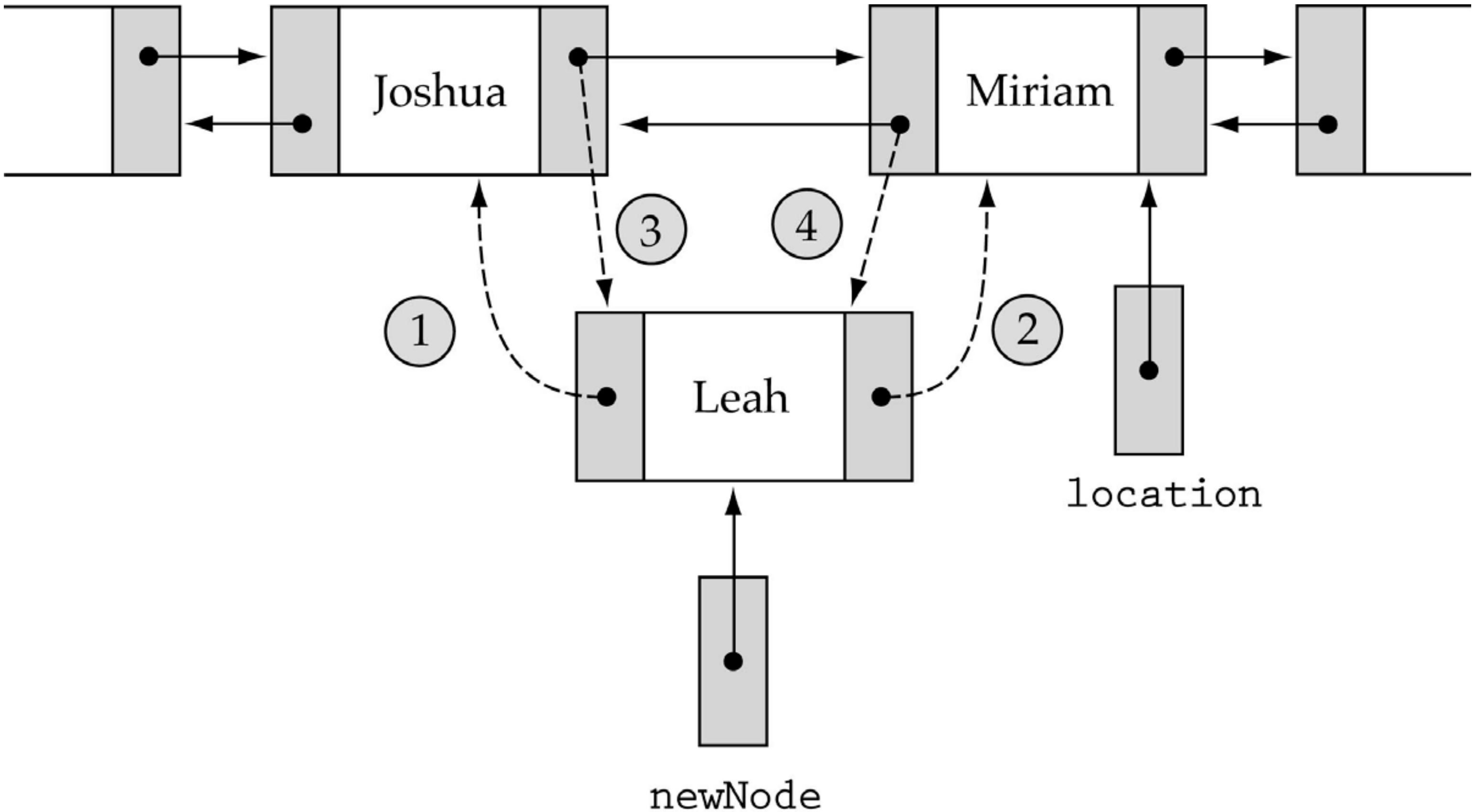
  such as: insertions, deletions at *both* ends (head and tail), and also at the middle of the list.

- A node in a doubly-linked list store two references:
  - A ***next*** link; that points to the next node in the list, and
  - A ***prev*** link; that points to the previous node in the list.

Insertion

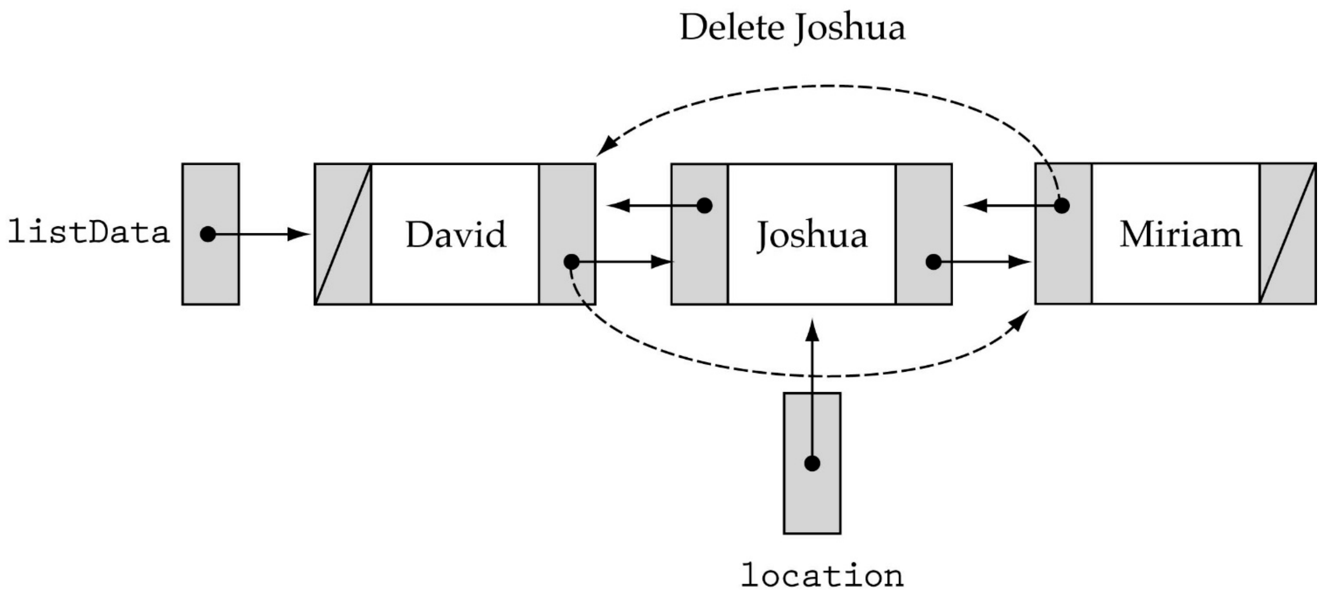


Insertion implementation



1. newNode->back = location->back; 3. location->back->next=newNode;
2. newNode->next = location 4. location->back = newNode;

Deletion



- Be very careful about the end cases!!