

Linked Lists: Inserting Nodes



Computer Science Department
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COP 3502 – Computer Science I



Review of Linked Lists

- What is a linked list?
 - Sequence of nodes chained together
 - Data part
 - Link part (points to next node in the chain)
 - Need a head pointer to point to the front of list
 - Called `myList` or `Head` or whatever you want
 - It's goal in life is just to point to the head of the list
 - Need a helper pointer to point to traverse list
 - `help_ptr`
 - We then save the value stored in `myList` into `help_ptr`, thus allowing `help_ptr` to also point to the front of the list
 - And we can now use `help_ptr` to traverse the list



Linked Lists

■ Accessing Nodes of a Linked List

■ Traversing (moving through) the list

- We can use `help_ptr` to traverse the list pointed to by `myList`
- Here would be the instruction to walk one node over:

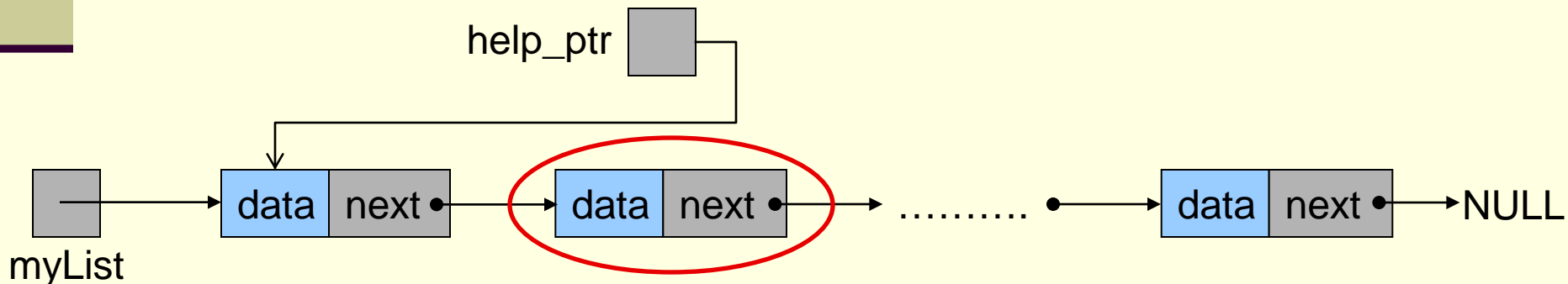
```
help_ptr = help_ptr->next;
```

- Note that the syntax here is correct
 - Why?
 - Cuz both sides of the assignment statement are pointers to `struct ll_node`
- Let's now examine this statement in detail
 - And how it changes our picture



Linked Lists

- Accessing Nodes of a Linked List
 - Traversing (moving through) the list
 - Here's our before picture:
 - Remember, what is the goal here?
 - We want `help_ptr` to point to the second node in the list
 - The question is:
 - How do we accomplish this?

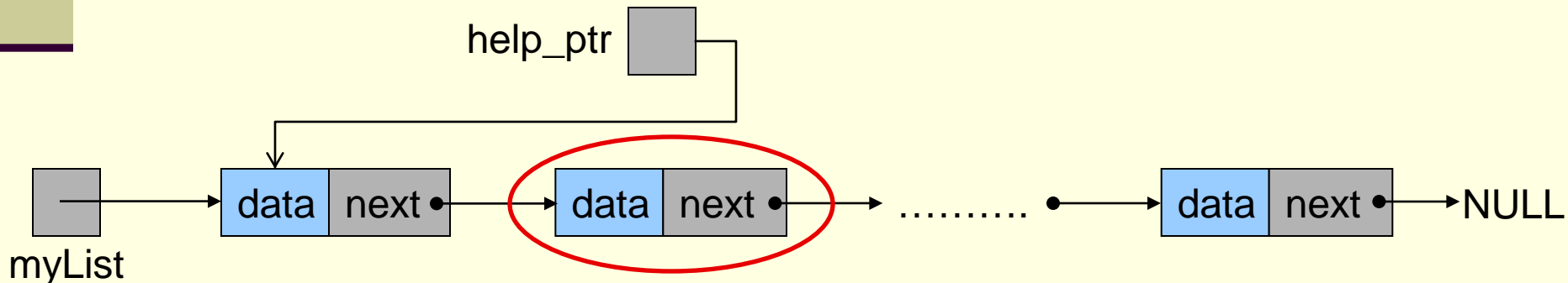


A linked list containing many elements



Linked Lists

- Accessing Nodes of a Linked List
 - Traversing (moving through) the list
 - Think:
 - That second node is located somewhere in memory
 - It has an address
 - Currently where is that address saved?
 - In other words, locate the pointer that is pointing to the second node



A linked list containing many elements



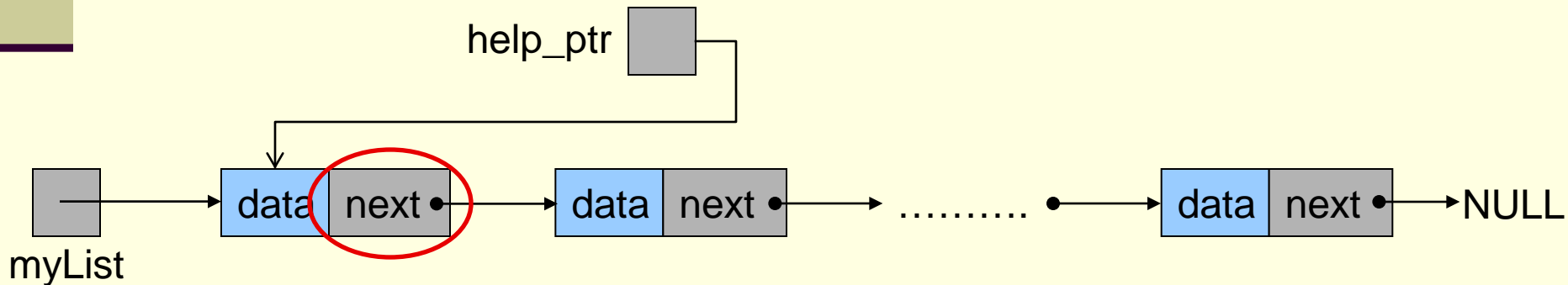
Linked Lists

- Accessing Nodes of a Linked List

- Traversing (moving through) the list

- Think:

- The “next” pointer, of the first node, is currently pointing to the second node
 - And what is a pointer? An address!
 - So the address of the second node is currently saved in the “next” pointer of the first node

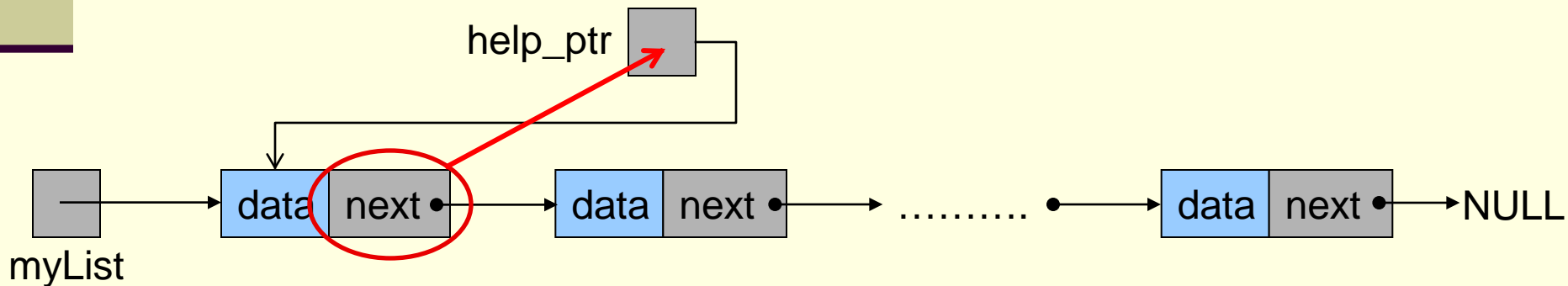


A linked list containing many elements



Linked Lists

- Accessing Nodes of a Linked List
 - Traversing (moving through) the list
 - Remember:
 - We want `help_ptr` to point to the second node
 - So we need to take the address that is stored in the “next” of the first node and save it into `help_ptr`
 - This will make `help_ptr` point to the second node



A linked list containing many elements



Linked Lists

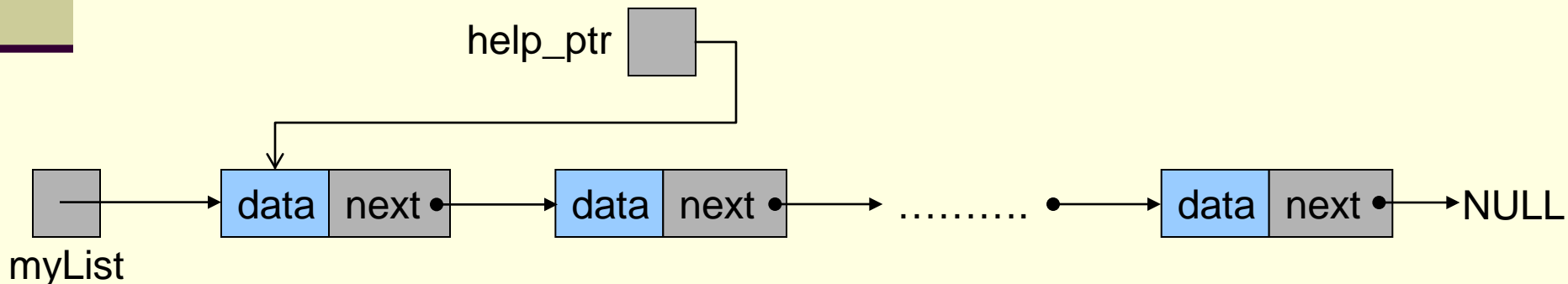
■ Accessing Nodes of a Linked List

■ Traversing (moving through) the list

- Again, here's the instruction that does this:

```
help_ptr = help_ptr->next;
```

- Here's how that statement changes our picture:



A linked list containing many elements

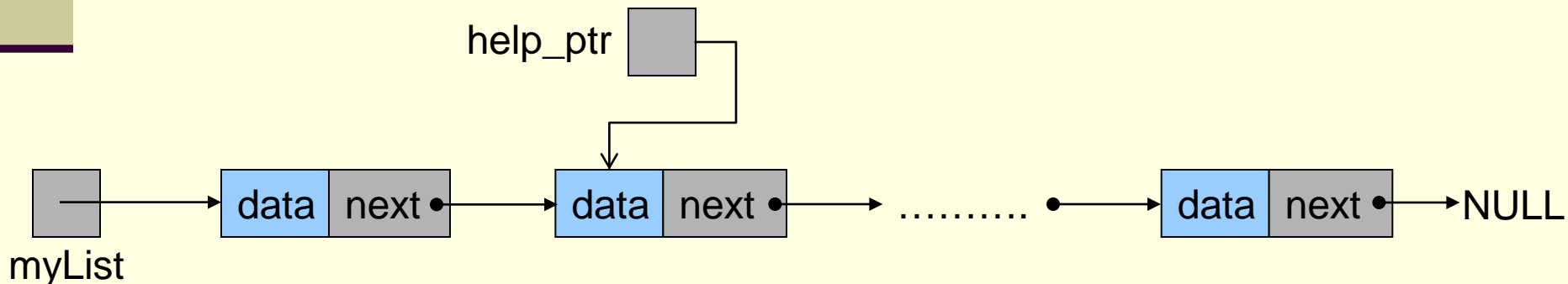


Linked Lists

- Accessing Nodes of a Linked List
 - Traversing (moving through) the list
 - Again, here's the instruction that does this:

```
help_ptr = help_ptr->next;
```

- Here's how that statement changes our picture:

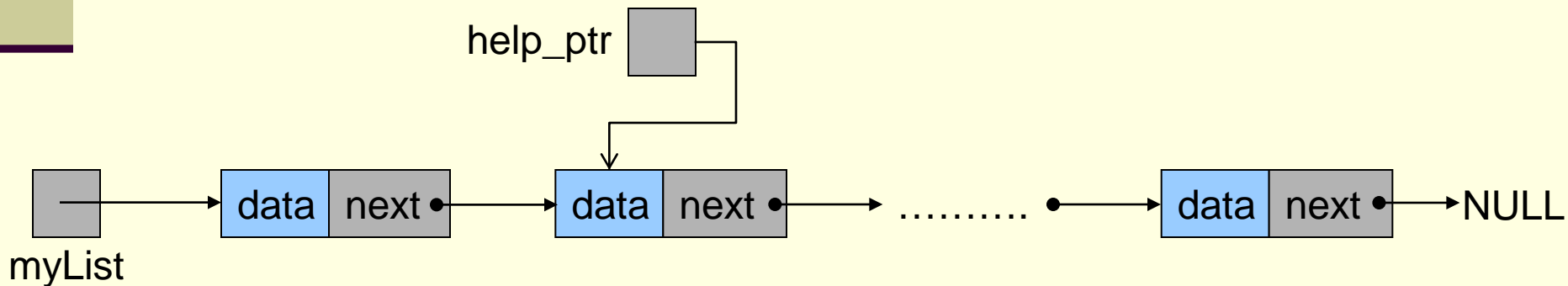


A linked list containing many elements



Linked Lists

- Accessing Nodes of a Linked List
 - Traversing (moving through) the list
 - Now we could refer to the data field of the second node as: `help_ptr->data`
 - We can also repeatedly use `help_ptr` in this fashion to iterate through the list



A linked list containing many elements



Traversing Linked Lists

- Traverse and Print out data of a linked list
 - **Assume** that `myList` is already pointing to a valid linked list of nodes of type `ll_node`
 - Here's the code to **Traverse** a linked list:

```
struct ll_node *help_ptr;
help_ptr = myList;

while (help_ptr != NULL) {
    printf("%d ", help_ptr->data);
    help_ptr = help_ptr->next;
}
```

- Review previous slides for more info on this



Linked Lists: Inserting Nodes

New Material: Inserting Nodes



Linked Lists: Basic Operations

- Operations Performed on Linked Lists
 - Several operations can be performed on linked lists
 - Add a new node
 - Delete a node
 - Search for a node
 - Counting nodes
 - Modifying nodes
 - and more
 - We will build **functions** to perform these operations



Linked Lists: Basic Operations

■ Design Approach

- Before going further, we must understand the design approach of our functions
 - Functions that change the contents of lists (insertion and deletion) will return the list head pointer
 - Why?
 - Let's say we have a list with 4 nodes and we are adding a new node
 - As an example, let's say that based on its key value, the new node is inserted at the beginning of the list
 - As a result, the address of the front of the list (address of the first node) has now changed!
 - We **must return the newly updated head of the list**



Linked Lists: Basic Operations

■ Design Approach

- Before going further, we must understand the design approach of our functions
 - Functions that change the contents of lists (insertion and deletion) will return the list head pointer
 - Here's an example of when this happens (insertion):
 - `myList = insertNewNode(...);`
 - So if the head of the list changes within the `insertNewNode` function
 - The function **MUST** return the updated head pointer
 - `myList` will be updated accordingly
 - If the head pointer doesn't change within the function:
 - `myList` is simply reset to its original address



Linked Lists: Basic Operations

■ Design Approach

- Before going further, we must understand the design approach of our functions
 - Functions that do **not** change the contents of the list return values that are consistent with their purpose
 - Example: a function to locate a node will return an integer (1 perhaps) to indicate whether or not the node was found
 - Example: a function to determine the number of nodes in the list will most likely return an integer count
 - Finally, functions that process the entire list, such as printing the list, will usually simply return void



Linked Lists: Basic Operations

■ Linked List Order

■ Linked Lists are linear structures

- They should always have some type of order
 - This could be chronological order: order of arrival and insertion into the list
 - **Key-based order**: lexical ordering based on some key value of the data items (alphabetical by last name, or ordered by NID, etc)
- Key based lists are the most common
 - New nodes are added to the linked list based on the lexical ordering of key values
- We will focus these slides on how to insert into a sorted list (key-based list)



Linked Lists: Insertion

■ Adding Nodes to a Linked List

■ There are four main steps involved here:

1) Allocate memory for the new node

2) Determine the insertion point

- You need to locate the new node's predecessor
 - Basically, we need to find the node that comes before where you want to insert the new node

3) Point the new node to its successor

- To the node that will come after it, once inserted

4) Point the predecessor node to the new node



Linked Lists: Insertion

- Adding Nodes to a Linked List
 - Step 2 is to determine the insertion point
 - For this, we need the location of the new node's predecessor
 - There are four possibilities:
 - 1) The list is empty. Therefore, there is no predecessor, and the new node will become the first node.
 - 2) The new node is to be inserted at the beginning of the list, so again, there is no predecessor node.
 - 3) The new node is the last node of the list. So its predecessor was the previous last node.
 - 4) The new node is inserted at some arbitrary point, which is neither the first node or the last node. Meaning, the new node will go somewhere in the middle of the list.



Linked Lists: Insertion

- Adding Nodes to a Linked List
 - We mentioned (few slides back) that we will use sorted linked lists
 - Meaning, when we insert, we need to insert a new node into the correct position
 - But for now, for the sake of ease:
 - Assume that nodes are simply added to the **front** of the list
 - We will use a function to add nodes
 - The function must then return the new HEAD of the list
 - It will be a new head right? Of course! Cuz we just added a node at the front. This changes what the head pointer will point to!



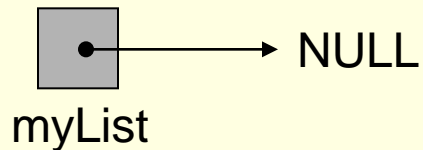
Linked Lists: Insertion

- Adding Nodes to a Linked List
 - Adding to the FRONT of a list:
 - There are two scenarios:
 - 1) The list could be empty
 - Meaning, the head pointer, myList, simply points to NULL
 - 2) Or there are existing nodes already in the list
 - Let's look at both of these scenarios...

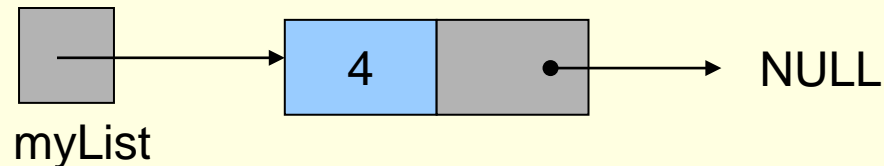
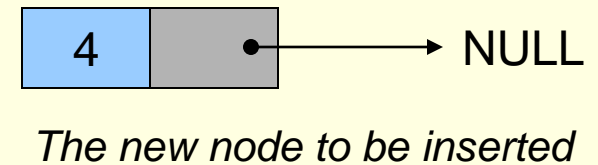


Linked Lists: Insertion

- Adding Nodes to a Linked List
 - Adding to the FRONT of a list:
 - There are two scenarios:
 - 1) Insertion into an Empty List



An empty linked list



A list after the insertion of the new node



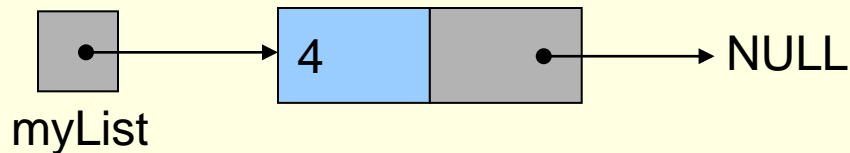
Linked Lists: Insertion

- Adding Nodes to a Linked List

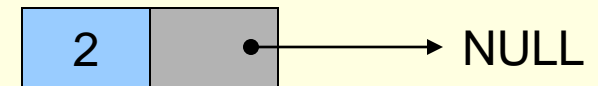
- Adding to the FRONT of a list:

- There are two scenarios:

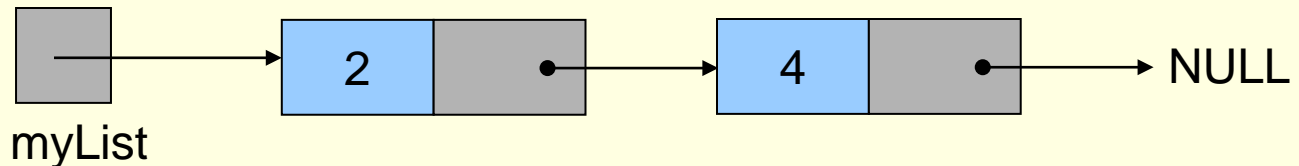
- 2) Insertion at the Head of an existing list



The initial linked list



The new node to be inserted



A list after the insertion of the new node



Linked Lists: Insertion

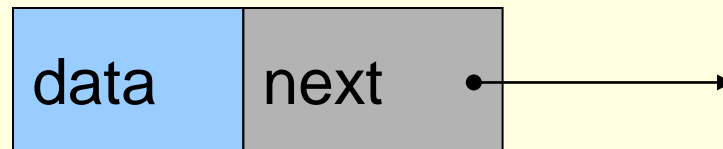
- Adding Nodes to a Linked List
 - Adding to the FRONT of a list:
 - There are two scenarios:
 - 1) Insertion into an Empty List
 - 2) Insertion at the Head of an existing list

 - Let's now look at the code for this in detail...



Linked Lists: Insertion

- Adding Nodes to a Linked List
 - First, here's a sample node:



- And here is its respective `struct` skeleton:

```
struct ll_node {  
    int data;  
    struct ll_node *next;  
};
```



Adding Nodes to Front (code)

```
// Function Prototype:
struct ll_node* addToFront(struct ll_node *list, int value) ;

int main( ) {
    int number = 0;
    // We now make our head pointer, myList and initialize to NULL
    struct ll_node *myList = NULL;
    // User enters data for new node (or -1 to exit)
    while(number!= -1) {
        // Get the next number.
        printf("Enter data for next node: ");
        scanf("%d", &number);

        // Add to linked list if it's not -1.
        if (number !=-1)
            myList = addToFront(myList, number);
    }
    return 1;
}
```



Adding Nodes to Front (code)

- So we will make this function: `addToFront`
- What are we sending to the function?
- Two parameters:
 - 1) `myList`, which is the pointer to the head of the list
 - This allows us to access the linked list from the function
 - 2) And we send over `number`, which will be the data value of the new node
- What does the function return?
- Remember, this function makes a NEW node at the front of the list
- We are making a new front of the list
- This means that `myList` will need to be changed to point to this new node
- So the updated address of `myList` is then returned to main

```
        myList = addToFront(myList, number);  
    }  
    return 1;  
}
```



Adding Nodes to Front (code)

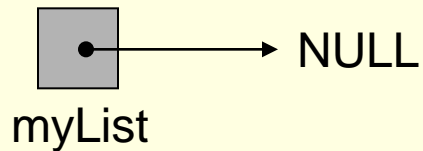
```
struct ll_node* addToFront(struct ll_node *list, int value) {
    // Create the new node and put data (from argument) into it
    struct ll_node * pNew = (struct ll_node *)
                               malloc(sizeof(struct ll_node));

    pNew->data = value;
    pNew->next = NULL;
}
```

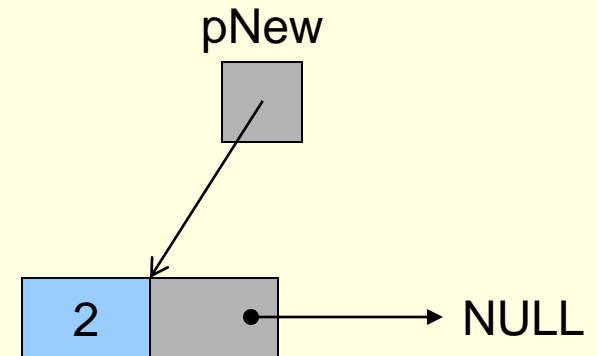


Linked Lists: Insertion

- Adding Nodes to a Linked List
 - Adding to the FRONT of a list:



An empty linked list



The new node to be inserted



Adding Nodes to Front (code)

```
struct ll_node* addToFront(struct ll_node *list, int value) {
    // Create the new node and put data (from argument) into it
    struct ll_node * pNew = (struct ll_node *)
                               malloc(sizeof(struct ll_node));

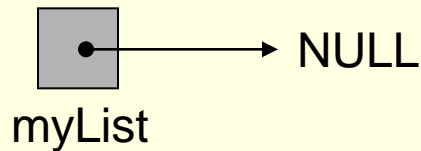
    pNew->data = value;
    pNew->next = NULL;
    // If the original list is empty, set the original head
    // pointer to point to the new node.
    if(list == NULL)
        list = pNew;
}
```



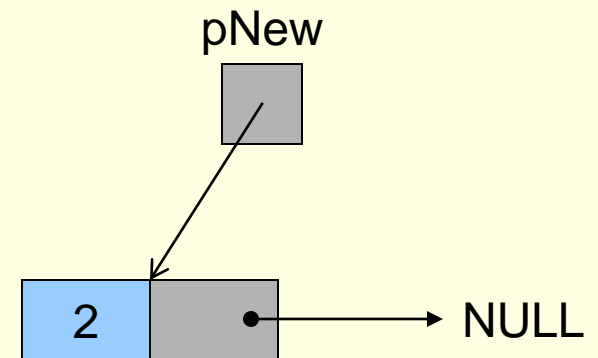
Linked Lists: Insertion

- Adding Nodes to a Linked List

- Adding to the FRONT of a list:



An empty linked list



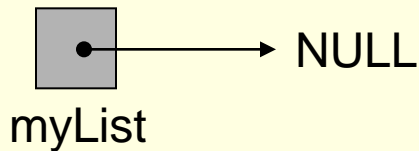
The new node to be inserted

- If the list is empty (`myList` points to `NULL`)
 - Take the address of `pNew` and put it into `myList`
 - This makes `myList` now point to the new Node

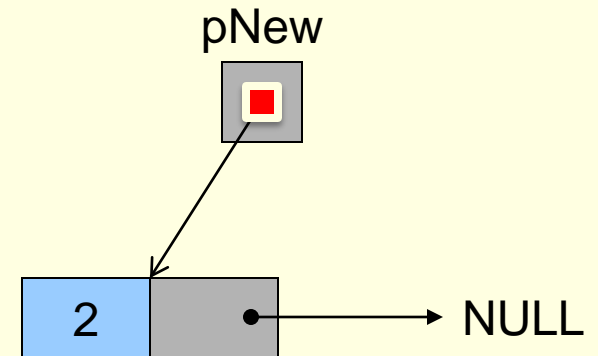


Linked Lists: Insertion

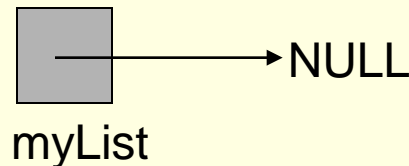
- Adding Nodes to a Linked List
 - Adding to the FRONT of a list:



An empty linked list



The new node to be inserted



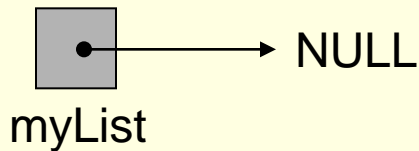
A list after the insertion of the new node



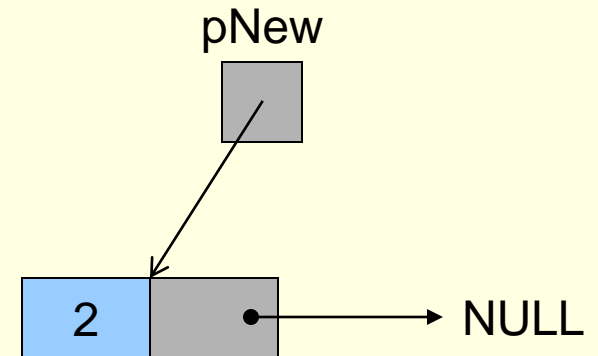
Linked Lists: Insertion

- Adding Nodes to a Linked List

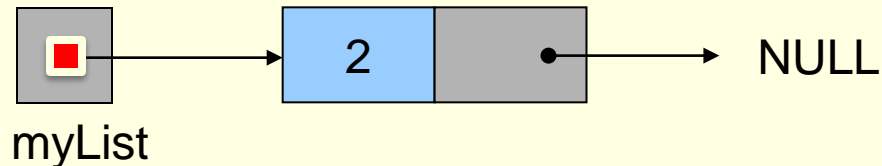
- Adding to the FRONT of a list:



An empty linked list



The new node to be inserted



A list after the insertion of the new node



Adding Nodes to Front (code)

```
struct ll_node* addToFront(struct ll_node *list, int value) {
    // Create the new node and put data (from argument) into it
    struct ll_node * pNew = (struct ll_node *)
                               malloc(sizeof(struct ll_node));

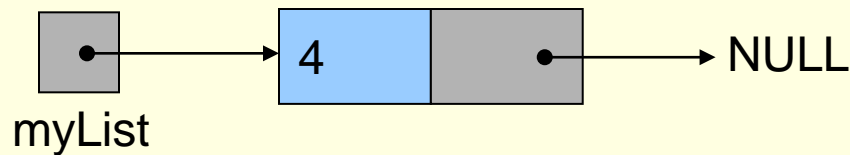
    pNew->data = value;
    pNew->next = NULL;
    // If the original list is empty, set the original head
    // pointer to point to the new node.
    if(list == NULL)
        list = pNew;
    // Else, list is currently pointing to a non-empty list.
    else {
        // Point new node to wherever Head pointer pointed to.
        pNew->next = list;
    }
}
```



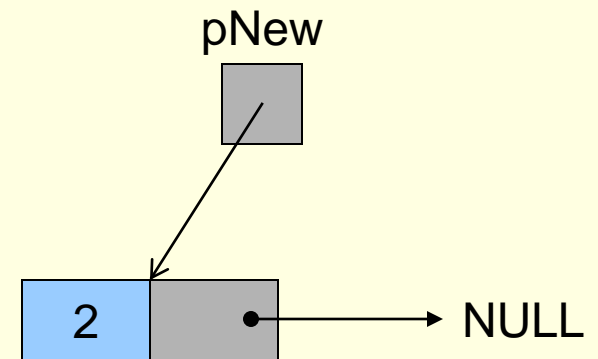
Linked Lists: Insertion

- Adding Nodes to a Linked List

- Adding to the FRONT of a list:



The initial linked list



The new node to be inserted

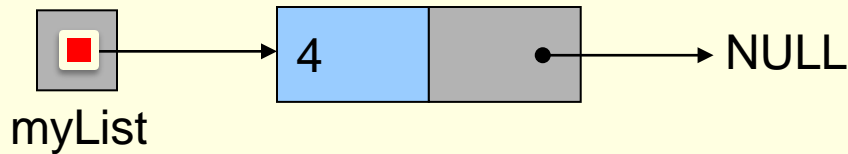
- ELSE, if the list is non-empty

- Take the address that `myList` points to and put in the next of `pNew`
 - This makes `pNew` point to the (previously) first node

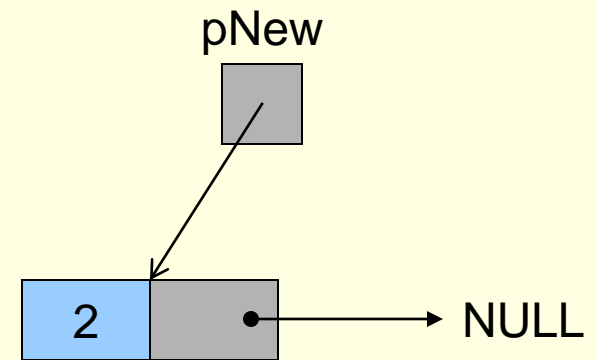


Linked Lists: Insertion

- Adding Nodes to a Linked List
 - Adding to the FRONT of a list:



The initial linked list



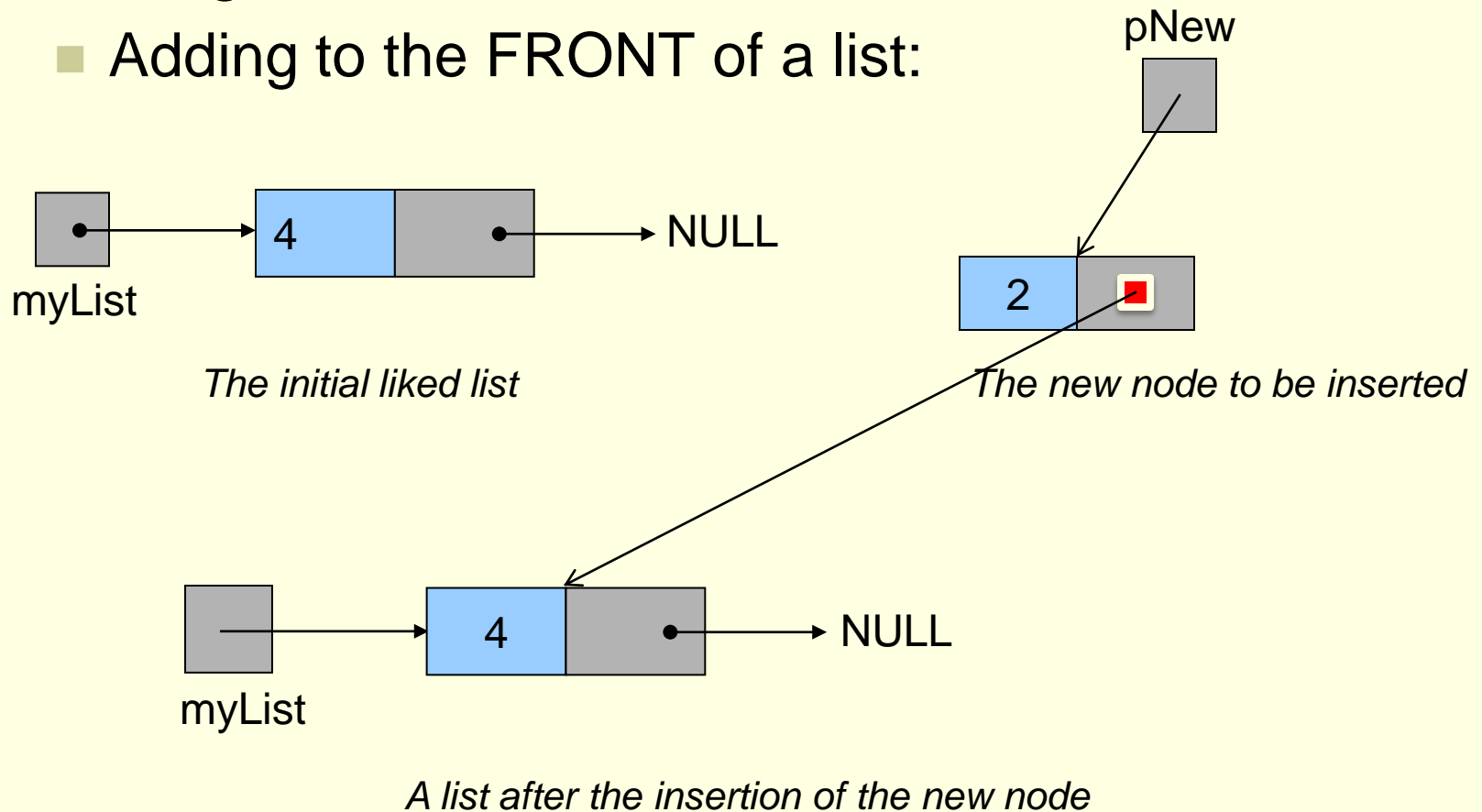
The new node to be inserted



Linked Lists: Insertion

- Adding Nodes to a Linked List

- Adding to the FRONT of a list:





Adding Nodes to Front (code)

```
struct ll_node* addToFront(struct ll_node *list, int value) {
    // Create the new node and put data (from argument) into it
    struct ll_node * pNew = (struct ll_node *)
                               malloc(sizeof(struct ll_node));

    pNew->data = value;
    pNew->next = NULL;
    // If the original list is empty, set the original head
    // pointer to point to the new node.
    if(list == NULL)
        list = pNew;
    // Else, list is currently pointing to a non-empty list.
    else {
        // Point new node to wherever Head pointer pointed to.
        pNew->next = list;

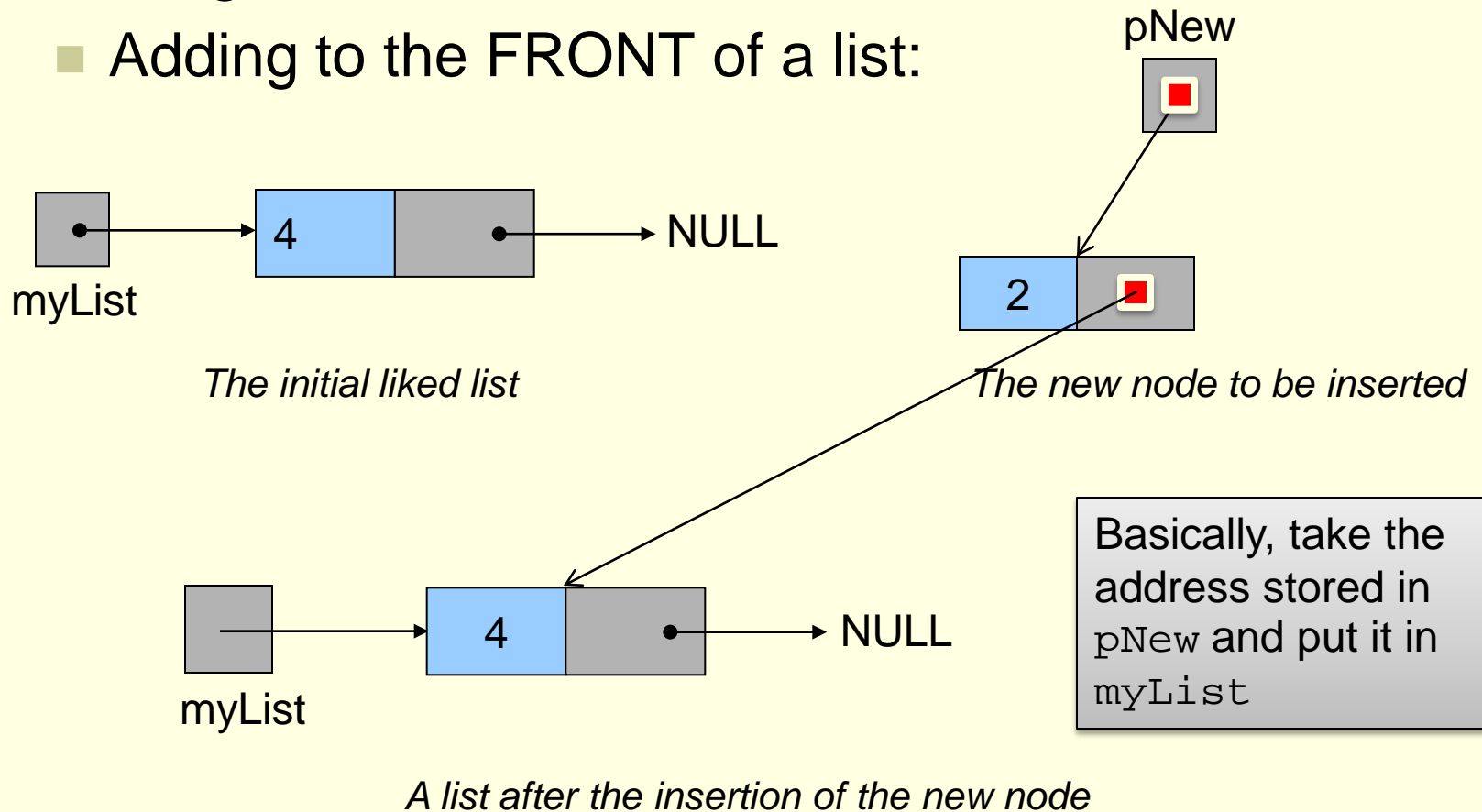
        // Now make Head pointer point to the new node.
        list = pNew;
    }
    return list;
}
```



Linked Lists: Insertion

- Adding Nodes to a Linked List

- Adding to the FRONT of a list:

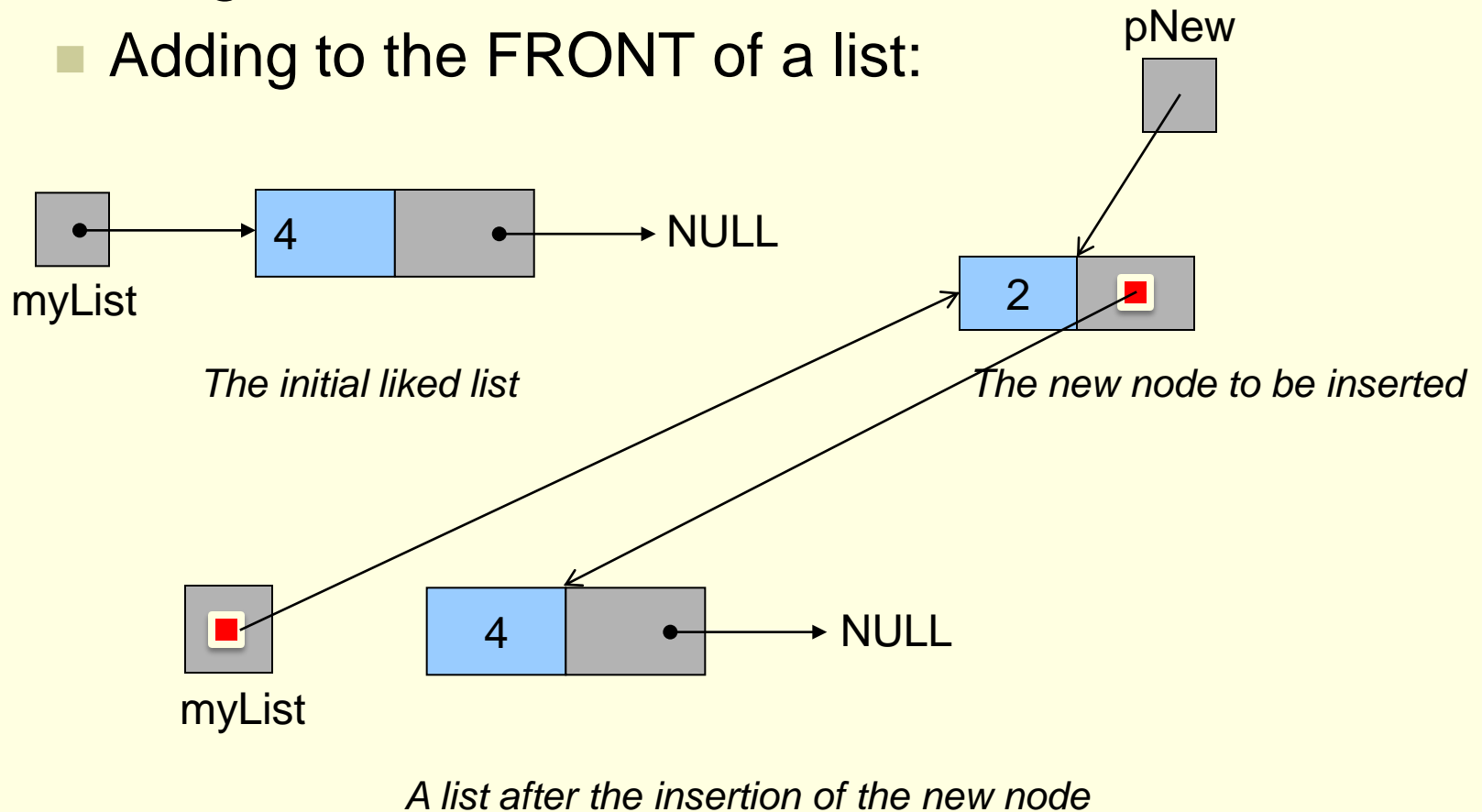




Linked Lists: Insertion

- Adding Nodes to a Linked List

- Adding to the FRONT of a list:

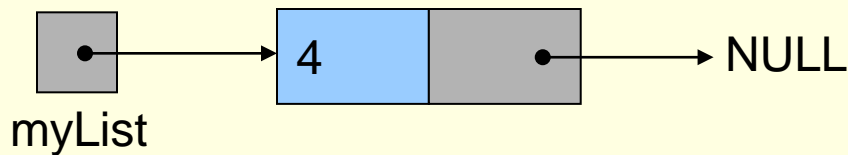




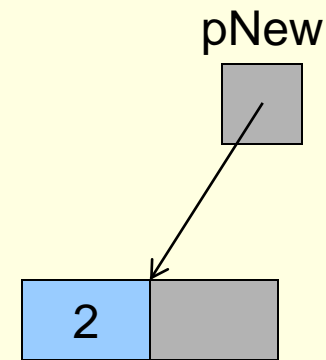
Linked Lists: Insertion

- Adding Nodes to a Linked List

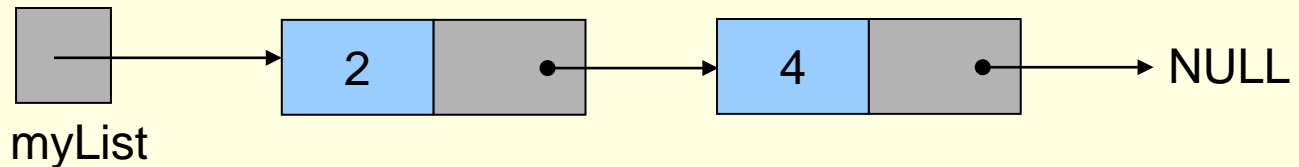
- Adding to the FRONT of a list:



The initial linked list



The new node to be inserted



A list after the insertion of the new node



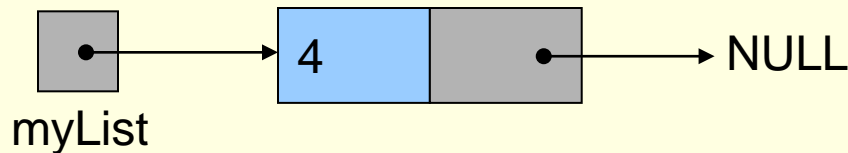
Linked Lists: Insertion

- Adding Nodes to a Linked List
 - Now let's assume that we are adding always to the end of the list
 - The code in main won't change a whole lot
 - But the function to add to the end is a bit different.
 - Can anyone tell us why?
 - Because we need to traverse the list in order to arrive at the insertion point (the end of the list)
 - Here's the picture followed by the code:

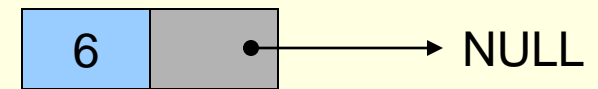


Linked Lists: Insertion

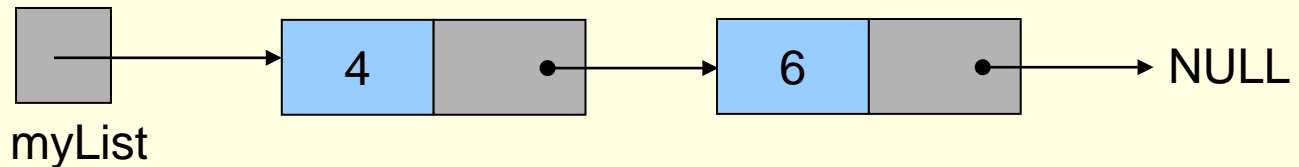
- Adding Nodes to a Linked List
 - Adding to the END of a list



The initial linked list



The new node to be inserted



A list after the insertion of the new node



Adding Nodes to End (code)

```
// Function Prototype:
struct ll_node* addToEnd(struct ll_node *list, int value) ;

int main( ) {
    int number = 0;
    // We now make our head pointer, myList and initialize to NULL
    struct ll_node *myList = NULL;
    // User enters data for new node (or -1 to exit)
    while(number!= -1) {
        // Get the next number.
        printf("Enter data for next node: ");
        scanf("%d", &number);

        // Add to linked list if it's not -1.
        if (number !=-1)
            myList = addToEnd(myList, number);
    }
    return 1;
}
```



Adding Nodes to End (code)

```
struct ll_node* addToEnd(struct ll_node *list, int value) {
    // Make helper pointer and store head of list into it
    struct ll_node *help_ptr = list;

    // Create the new node and put data (from argument) into it
    struct ll_node * pNew = (struct ll_node *)
                            malloc(sizeof(struct ll_node));

    pNew->data = value;
    pNew->next = NULL;
    // If list is empty, pNew becomes the first node
    if (list == NULL)
        return pNew;
```

If the list is empty:

- pNew will be the first (and only) node of the list
- So we have our head pointer, `myList` or `list`
 - And this head pointer MUST point to the new node, `pNew`
 - So we can simply return the address of `pNew` to main
 - Remember, we called this function with:
 - `myList = addToEnd(myList, number);`
 - So whatever we return will be saved in `myList` (head pointer)



Adding Nodes to End (code)

```
struct ll_node* addToEnd(struct ll_node *list, int value) {
    // Make helper pointer and store head of list into it
    struct ll_node *help_ptr = list;

    // Create the new node and put data (from argument) into it
    struct ll_node * pNew = (struct ll_node *)
                            malloc(sizeof(struct ll_node));

    pNew->data = value;
    pNew->next = NULL;
    // If list is empty, pNew becomes the first node
    if (list == NULL)
        return pNew;
    // Else, traverse the list to arrive a the last node
    while (help_ptr->next != NULL)
        help_ptr = help_ptr->next;
    // Make the last node point to the to-be-inserted node, i.e.
    // put the address of new node into the last node's "next"
    help_ptr->next = pNew;

    // Return a pointer to the modified list
    return list;
}
```



Brief Interlude: Human Stupidity





Linked Lists: Insertion

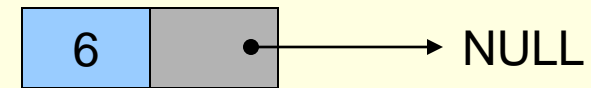
- Adding Nodes to a Linked List
 - Adding to the MIDDLE of a list:
 - Think about what must happen.
 - We are inserting a new node between two other nodes
 - So the new node must now point to its successor node
 - Meaning, it must point to where its predecessor node was pointing to (before insertion of new node)
 - Then the address of the new node must be saved into the “next” of the predecessor node.
 - These two steps maintain the integrity of the list
 - Again, here’s some purty pictures



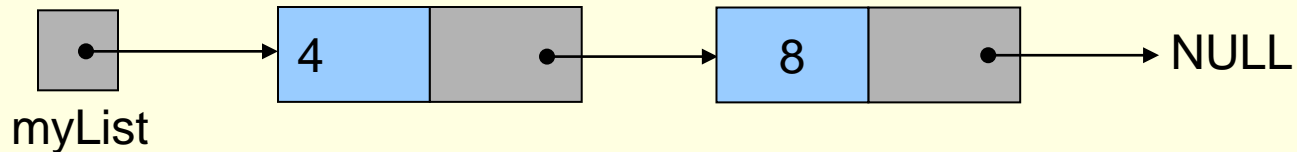
Linked Lists: Insertion

- Adding Nodes to a Linked List

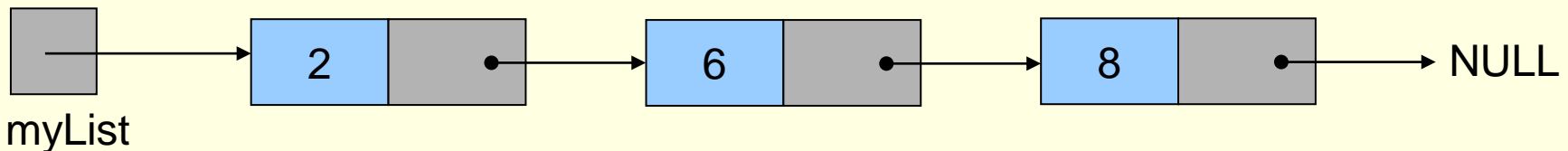
- Adding to the MIDDLE of a list:



The new node to be inserted



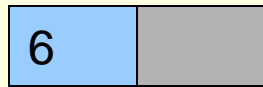
The initial linked list



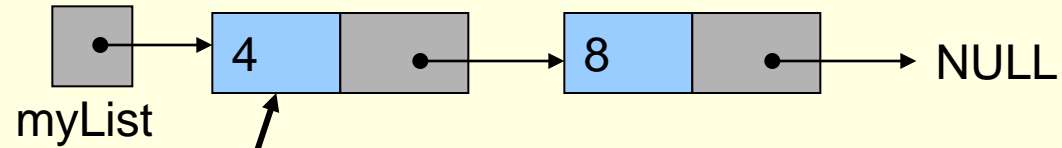
A list after the insertion of the new node



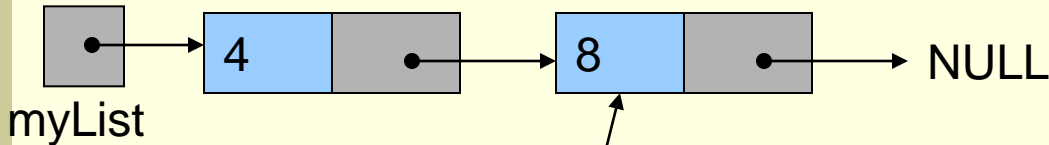
Linked Lists: Insertion in Detail



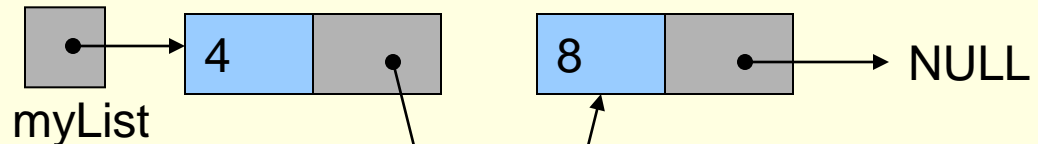
Step 1: Allocate memory



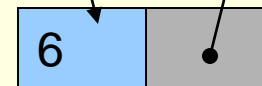
Step 2: Find logical predecessor



Step 3: Point new node to its logical successor



Step 4: Point predecessor node to the new node





Adding Nodes to Sorted List

- Adding Nodes to a Linked List
 - Adding nodes to a sorted list
 - Now we are hopefully ready to add a new node to a sorted linked list
 - This new node may end up being inserted at the beginning, the middle, or at the end.
 - The following code takes care of all possibilities
 - Again, we are just using an `int` as the `data` item
 - The nodes of the linked list are sorted in ascending order based on the value stored in each node's `data`



Adding Nodes to Sorted List (code)

```
// Function Prototype:
struct ll_node* insert(struct ll_node *list, int value) ;

int main( ) {
    int number = 0;
    // We now make our head pointer, myList and initialize to NULL
    struct ll_node *myList = NULL;
    // User enters data for new node (or -1 to exit)
    while(number!= -1) {
        // Get the next number.
        printf("Enter data for next node: ");
        scanf("%d", &number);

        // Add to linked list if it's not -1.
        if (number !=-1)
            myList = insert(myList, number);
    }
    return 1;
}
```



Adding Nodes to Sorted List (code)

```
struct ll_node* insert(struct ll_node *list, int value) {
    // Make helper pointer and store head of list into it
    struct ll_node *help_ptr = list;

    // Create the new node and put data (from argument) into it
    struct ll_node * pNew = (struct ll_node *)
                            malloc(sizeof(struct ll_node));

    pNew->data = value;
    pNew->next = NULL;
    // Insertion into an empty list
    // OR Insertion at the front of a non-empty list
    if (list == NULL || list->data > value) {
        pNew->next = list;
        list = pNew;
        return list;
    }
}
```

Let's now look at this IF statement in detail.



Adding Nodes to Sorted List (code)

- Adding nodes to front of sorted list
 - Think about it:
 - When do we go inside the IF statement?
 - If `list` is `NULL`
 - Means the list is currently empty
 - OR if the `data` at the node that `list` points to is greater than `value`
 - Meaning, the new node will be at the front

```
if (list == NULL || list->data > value) {  
    pNew->next = list;  
    list = pNew;  
    return list;  
}
```



Adding Nodes to Sorted List (code)

- Adding nodes to front of sorted list
 - Now look at the three lines inside the statement
 - In both scenarios (empty list or insert at front)
 - We MUST take the address that is currently saved in `list` and save it in `pNew->next`
 - What does this do?
 - It makes `pNew` point to whatever `list` was pointing to
 - So if `list` was pointing to node A (the previous first node)
 - Now `pNew` will also point to node A
 - Which makes sense, since `pNew` will be the new first node

```
if (list == NULL || list->data > value) {  
    pNew->next = list;  
    list = pNew;  
    return list;  
}
```



Adding Nodes to Sorted List (code)

- Adding nodes to front of sorted list
 - Now look at the three lines inside the statement
 - In both scenarios (empty list or insert at front)
 - Also, we MUST take the address of `pNew` and save it into `list`
 - This makes `list` point to `pNew` (the new first node)
 - Which makes sense right? `list` is the head pointer!
 - Remember, the only goal in life of the head pointer is to point to the first node!
 - Finally, we return `list` (head pointer address) to main

```
if (list == NULL || list->data > value) {  
    pNew->next = list;  
    list = pNew;  
    return list;  
}
```




Adding Nodes to Sorted List (code)

```
struct ll_node* addToEnd(struct ll_node *list, int value) {  
  
    // ...  
    // CODE BELONGING HERE WAS ON PREVIOUS PAGE  
    // ...  
  
    // Continuing the code ...  
  
    // Insert at MIDDLE or END of list  
    // Find the right place to insert  
    while(help_ptr->next != NULL && help_ptr->next->data < value)  
        help_ptr = help_ptr->next;  
}
```

- While:

- there are still nodes in the list
- AND the data value at the node **AFTER** the one that `help_ptr` points to is less than the value of the new node to be inserted
 - Meaning, we haven't reached the insertion spot yet
 - KEEP traversing the list to find insertion spot



Adding Nodes to Sorted List (code)

```
struct ll_node* addToEnd(struct ll_node *list, int value) {  
  
    // ...  
    // CODE BELONGING HERE WAS ON PREVIOUS PAGE  
    // ...  
  
    // Continuing the code ...  
  
    // Insert at MIDDLE or END of list  
    // Find the right place to insert  
    while(help_ptr->next != NULL && help_ptr->next->data < value)  
        help_ptr = help_ptr->next;  
}
```

- Notice the && instead of ||
- So when do we exit the while loop?
 - If the data in the node **AFTER** the one that help_ptr points to is **greater than or equal to** value
 - Meaning, we've found our insertion spot (after help_ptr)
 - OR we exit once help_ptr->next is NULL (reached end of list)



Adding Nodes to Sorted List (code)

```
struct ll_node* addToEnd(struct ll_node *list, int value) {  
  
    // ...  
    // CODE BELONGING HERE WAS ON PREVIOUS PAGE  
    // ...  
  
    // Continuing the code ...  
  
    // Insert at MIDDLE or END of list  
    // Find the right place to insert  
    while(help_ptr->next != NULL && help_ptr->next->data < value)  
        help_ptr = help_ptr->next;  
  
    // So help_ptr is now pointing to the node right before  
    // the spot where we want to insert.  
    // Now insert pNew right after the position that help_ptr points to  
    pNew->next = help_ptr->next;  
    help_ptr->next = pNew;  
    return list;  
}
```

Let's now look at these last three lines in detail.



Adding Nodes to Sorted List (code)

- Adding nodes to middle or end of sorted list
 - Remember:
 - We just traversed the list with `help_ptr` to find our insertion spot
 - So right now, `help_ptr` is pointing to the node BEFORE our insertion spot.
 - It is pointing to the predecessor.
 - Example: if we need to insert at position 12, then `help_ptr` is currently pointing to position 11

```
// ... previous code was here
pNew->next = help_ptr->next;
help_ptr->next = pNew;
return list;
}
```



Adding Nodes to Sorted List (code)

- Adding nodes to middle or end of sorted list
 - Now, think about what happens:
 - If we are inserting `pNew` at the **END** of the list
 - `pNew->next` will need to point to NULL
 - Indicating the end of the list
 - So we execute this line of code
 - `pNew->next = help_ptr->next;`
 - Since `help_ptr` was pointing to the last node
 - `help_ptr->next` will have NULL in it
 - We save that value into `pNew->next`

```
// ... previous code was here
pNew->next = help_ptr->next;
help_ptr->next = pNew;
return list;
}
```



Adding Nodes to Sorted List (code)

- Adding nodes to middle or end of sorted list
 - Now, think about what happens:
 - If we are inserting `pNew` at the **END** of the list
 - Also, the previous last node in the list
 - Which is currently pointed to by `help_ptr`
 - Must now point to the new last node (`pNew`)
 - So we execute this line of code:
 - `help_ptr->next = pNew;`
 - Saves the address of `pNew` into `help_ptr->next`

```
// ... previous code was here
pNew->next = help_ptr->next;
help_ptr->next = pNew;
return list;
}
```



Adding Nodes to Sorted List (code)

- Adding nodes to middle or end of sorted list
 - Now, think about what happens:
 - If we are inserting `pNew` at the **END** of the list
 - The connections are now made
 - And we can simply return the head of the list
 - `return list;`

```
// ... previous code was here
pNew->next = help_ptr->next;
help_ptr->next = pNew;
return list;
}
```



Adding Nodes to Sorted List (code)

- Adding nodes to middle or end of sorted list
 - Now, think about what happens:
 - If we are inserting `pNew` in the **MIDDLE** of the list
 - `pNew->next` will need to point to the next node
 - The node that will come after it (once `pNew` is inserted)
 - So we execute this line of code
 - `pNew->next = help_ptr->next;`
 - Since `help_ptr` was pointing to the **predecessor**
 - `help_ptr->next` will have the address of the **successor**
 - We save that value into `pNew->next`

```
// ... previous code was here
pNew->next = help_ptr->next;
help_ptr->next = pNew;
return list;
}
```




Adding Nodes to Sorted List (code)

- Adding nodes to middle or end of sorted list
 - Now, think about what happens:
 - If we are inserting `pNew` in the **MIDDLE** of the list
 - Also, the predecessor
 - Which is currently pointed to by `help_ptr`
 - Must now point the newly inserted node (`pNew`)
 - So we execute this line of code:
 - `help_ptr->next = pNew;`
 - This saves the address of `pNew` into `help_ptr->next`

```
// ... previous code was here
pNew->next = help_ptr->next;
help_ptr->next = pNew;
return list;
}
```



Adding Nodes to Sorted List (code)

- Adding nodes to middle or end of sorted list
 - Now, think about what happens:
 - If we are inserting `pNew` in the **MIDDLE** of the list
 - The connections are now made
 - And we can simply return the head of the list
 - `return list;`

```
// ... previous code was here
pNew->next = help_ptr->next;
help_ptr->next = pNew;
return list;
}
```



Linked Lists: Inserting Nodes

**WASN'T
THAT
AWESOME!**



Daily Demotivator



Linked Lists: Inserting Nodes



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University of Central Florida

COP 3502 – Computer Science I