Linked Lists

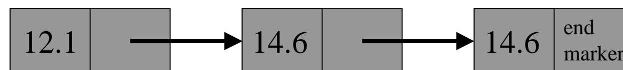
Kruse and Ryba Textbook
4.1 and Chapter 6

Linked Lists

- Linked list of items is arranged in order
- Size of linked list changes as items are inserted or removed
- Dynamic memory allocation is often used in linked list implementation
- Ten fundamental functions are used to manipulate linked lists (see textbook).

Fundamentals

- A linked list is a sequence of items arranged one after another.
- Each item in list is connected to the next item via a *link*



- Each item is placed together with the link to the next item, resulting in a simple component called a *node.*

Declaring a Class for Node

```
struct Node
{
        typedef double Item;
        Item data;    // data stored in node
        Node *link;  // pointer to next node
};
```

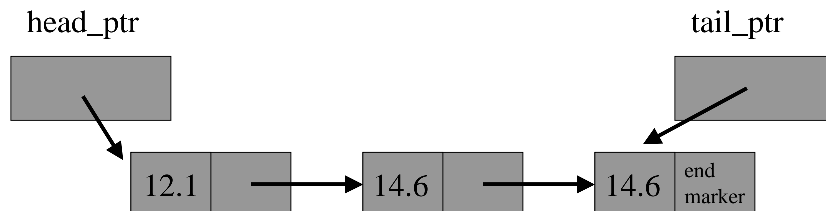
A *struct* is a special kind of class where all members are public. In this case there are two public member variables: data, link.

Whenever a program needs to refer to the item type, we can use the expression Node::Item.

Head Pointers, Tail Pointers

Usually, programs do not actually declare node variables. Instead, the list is accessed through one or more pointers to nodes.

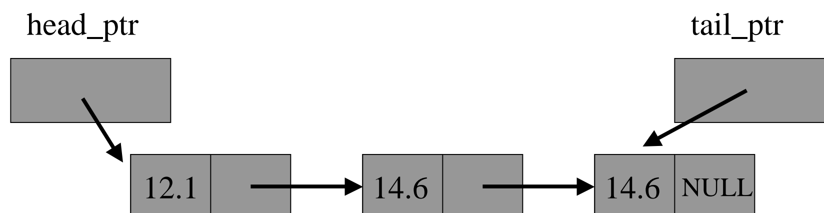
```
Struct Node
{
    typedef double Item;
    Item data;
    Node *link;
};

Node *head_ptr;
Node *tail_ptr;
```



Null Pointer

- The final node in the linked list does not point to a next node.
- If link does not point to a node, its value is set to *NULL.*
- NULL is a special C++ constant, from the standard library facility <stdlib.h>
- NULL pointer is often written 0 (zero).

Use of NULL pointer in last node of linked list:



Empty List

- When the list is empty, both the head_ptr and tail_ptr are NULL.
- When creating a new linked list, it starts out empty (both tail and head pointers NULL).

```
Node *head_ptr,*tail_ptr;
head_ptr = NULL;
tail_ptr = NULL;
```

head_ptr tail_ptr

Null Null

- Any linked list functions you write should handle the case of empty list (head and tail pointers NULL).

Member Selection Operator

Suppose a program has built a linked list:

head_ptr tail_ptr

head_ptr is a pointer to a node. How can we get/set the value of the Item inside the node?

Member Selection Operator

One possible syntax:

```
(*head_ptr).data = 4.5;
cout << (*head_ptr).data;
```

The expression (*head_ptr).data means *the data member of the node pointed to by head_ptr.*

Member Selection Operator

Preferred syntax:

```
head_ptr->data = 4.5;
cout << head_ptr->data;
```

The symbol “->” is considered a single operator. Reminds you of an arrow pointing to the member.

The expression head_ptr->data means *the data member of the node pointed to by head_ptr.*

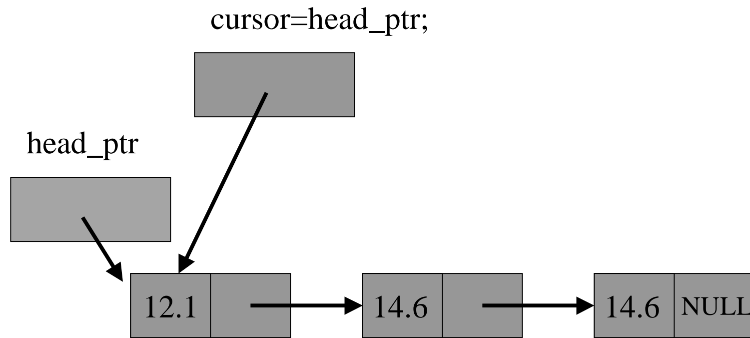
Two Common Pointer Bugs

- Attempting to dereference a pointer via *p or p-> when p=NULL.
- Attempting to dereference a pointer via *p or p-> when p is not properly initialized.
- NOTE: this error does not cause a syntax error, but instead causes errors:
  - Bus Error
  - Segmentation violation
  - Address protection violation

Computing the Length of a Linked List

```
size_t list_length(Node * head_ptr)
{
        Node *cursor;
        size_t answer=0;

        for(cursor=head_ptr; cursor != NULL; cursor=cursor->link)
                answer++;
        return answer;
}
```

Computing the Length of a Linked List



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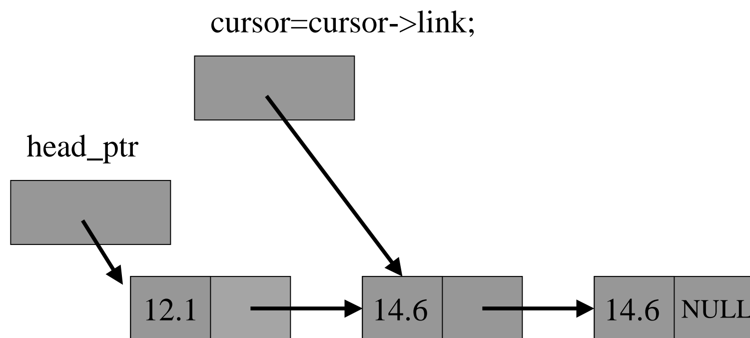

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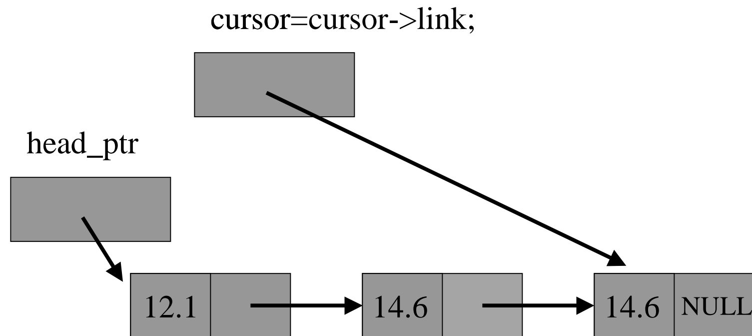

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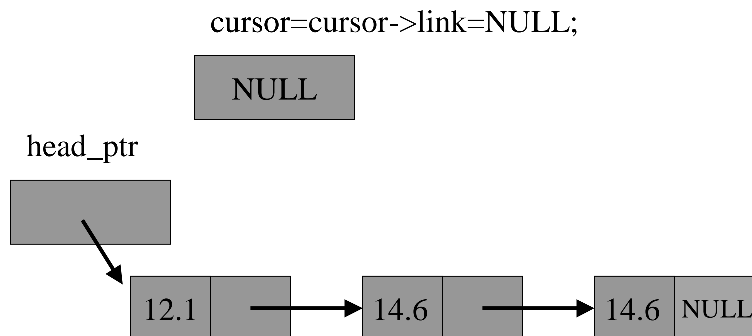

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        for(cursor=head_ptr; cursor != NULL; cursor=cursor->link)
                answer++;
        return answer;
}
```

Traversing a Linked List

Common pattern in functions that need to traverse a linked list:

```
…
  for(cursor=head_ptr; cursor != NULL; cursor=cursor->link)
…
```

Will this work for an empty list?

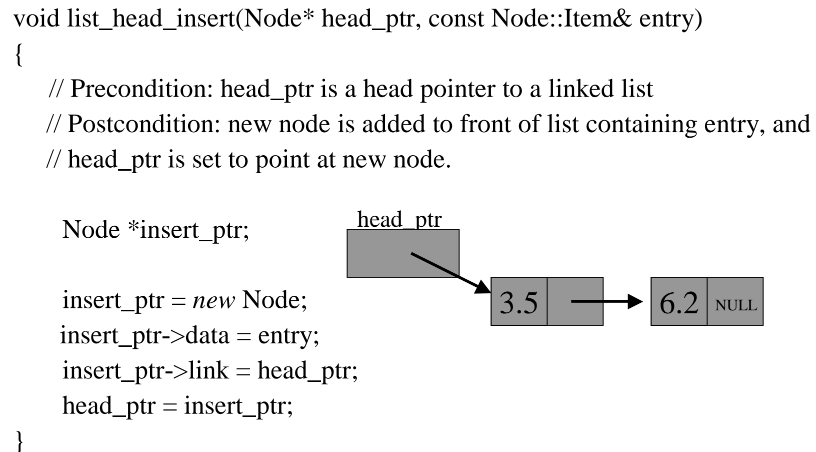
Always make sure your functions work in the empty list case!!

Inserting a Node at List Head

```
void list_head_insert(Node* head_ptr, const Node::Item& entry)
{
    // Precondition: head_ptr is a head pointer to a linked list
    // Postcondition: new node is added to front of list containing entry, and
    // head_ptr is set to point at new node.

    Node *insert_ptr;

    insert_ptr = new Node;
    insert_ptr->data = entry;
    insert_ptr->link = head_ptr;
    head_ptr = insert_ptr;
}
```



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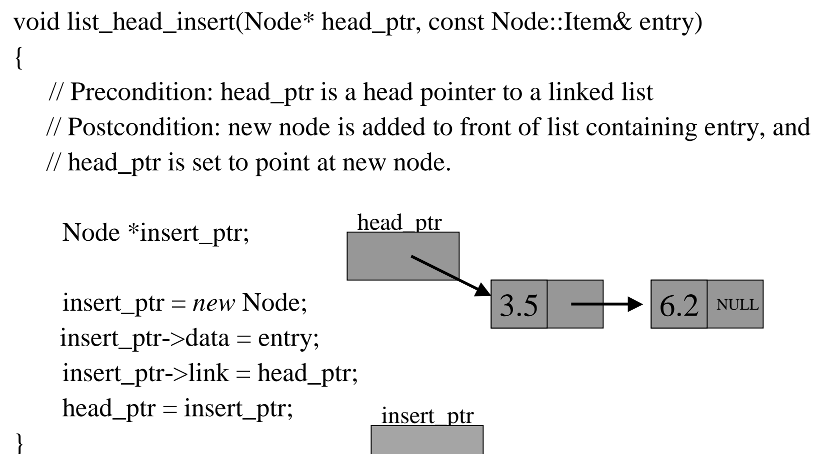

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```

head_ptr

3.5

6.2 NULL

insert_ptr

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```

head_ptr

3.5

6.2 NULL

insert_ptr

8.9

Inserting a Node at List Head

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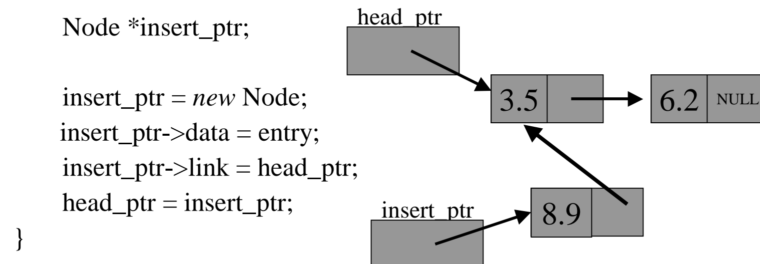

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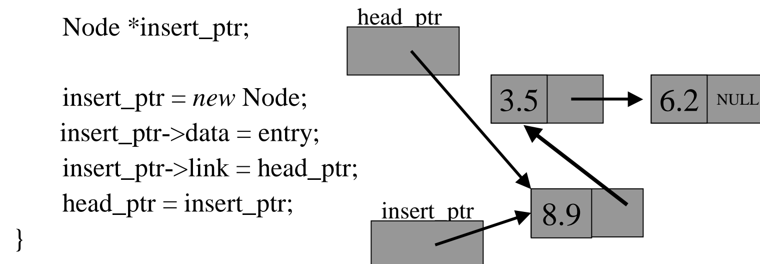

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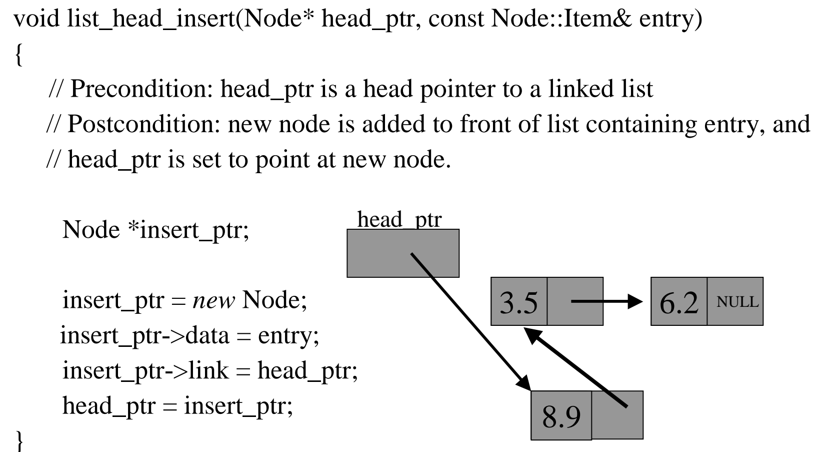

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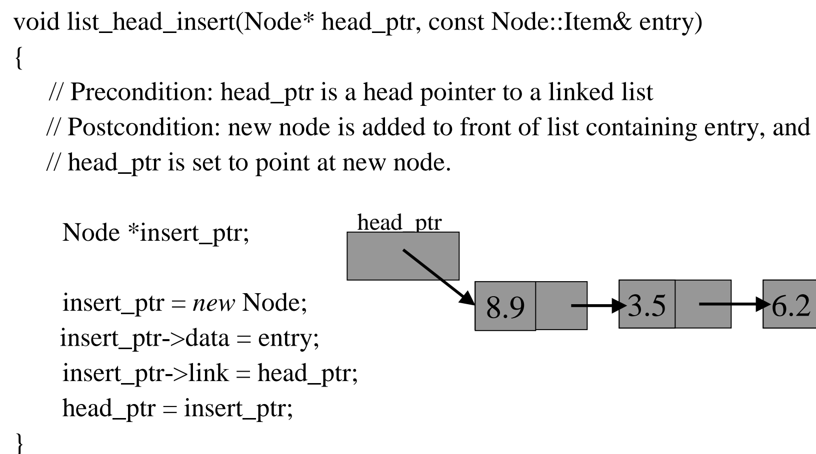
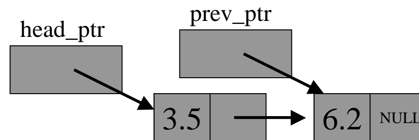


Inserting a Node *not* at List Head

```
void list_insert(Node* previous_ptr, const Node::Item& entry)
{
    // Precondition: previous_ptr is a pointer to a node in a valid linked list
    // Postcondition: new node is added after the node pointed to by
    // previous_ptr

    Node *insert_ptr;

    insert_ptr = new Node;
    insert_ptr->data = entry;
    insert_ptr->link = previous_ptr->link;
    previous_ptr->link = insert_ptr;
}
```



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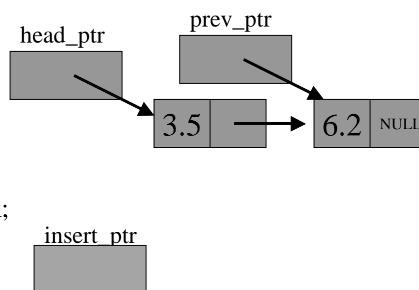

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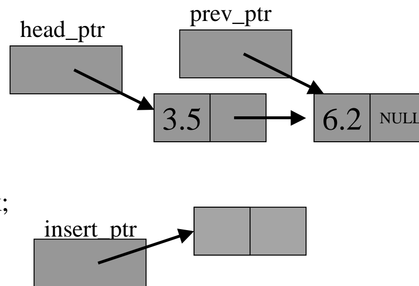

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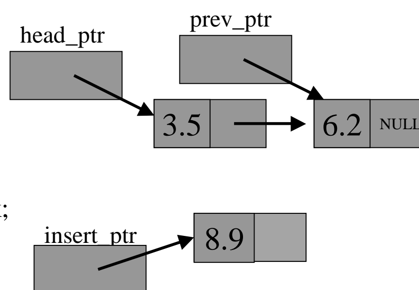

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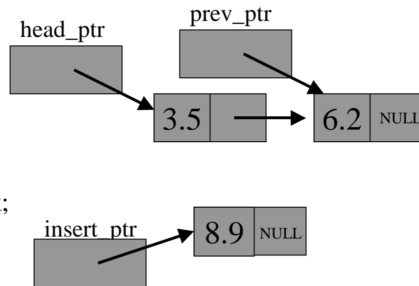

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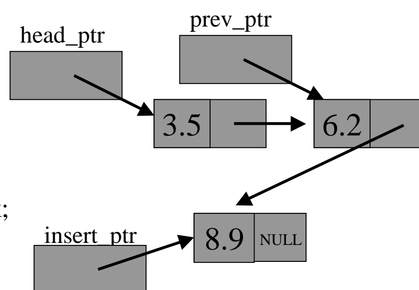

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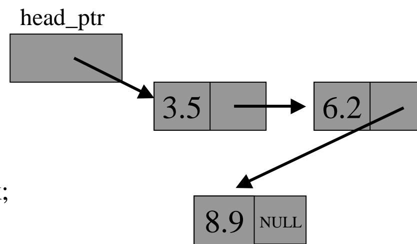


List Search

- Find the first node in a list that contains the specified item.
- Return pointer to that node.

Searching List for Item

```
Node* list_search(Node* head_ptr, const Node::Item& target)
{
    // Precondition: head_ptr is a head pointer to a linked list
    // Postcondition: return value is pointer to first node containing
    // specified target.  Returns NULL if no matching node found.

    Node *cursor;
    for(cursor = head_ptr; cursor != NULL; cursor = cursor->link)
        if(target == cursor->data)
            return cursor;
    return NULL;
}
```

Locating nth Node in List

```
Node* list_locate(Node* head_ptr, size_t position)
{
    // Precondition: head_ptr is a head pointer to a linked list
    // Postcondition: return value is pointer to node at specified position
    // first node in list has position=0

    Node *cursor;
    size_t i;

    cursor = head_ptr;
    for(i=0; (i<position) && (cursor != NULL); ++i)
        cursor = cursor->link;

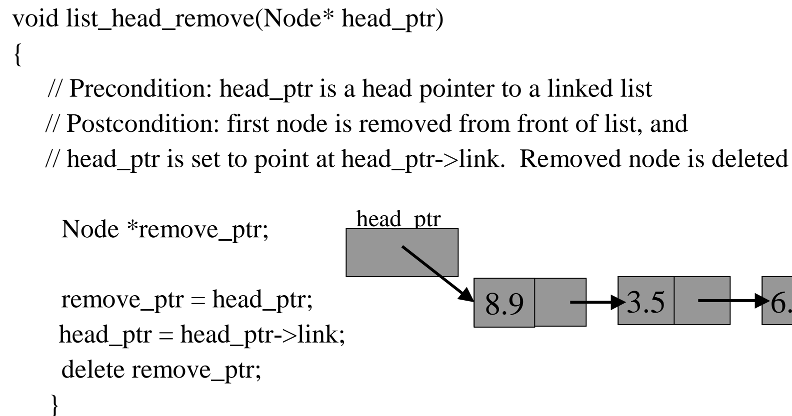
    return cursor;
}
```

Removing a Node at List Head

```
void list_head_remove(Node* head_ptr)
{
    // Precondition: head_ptr is a head pointer to a linked list
    // Postcondition: first node is removed from front of list, and
    // head_ptr is set to point at head_ptr->link.  Removed node is deleted

     Node *remove_ptr;

     remove_ptr = head_ptr;
     head_ptr = head_ptr->link;
     delete remove_ptr;
}
```



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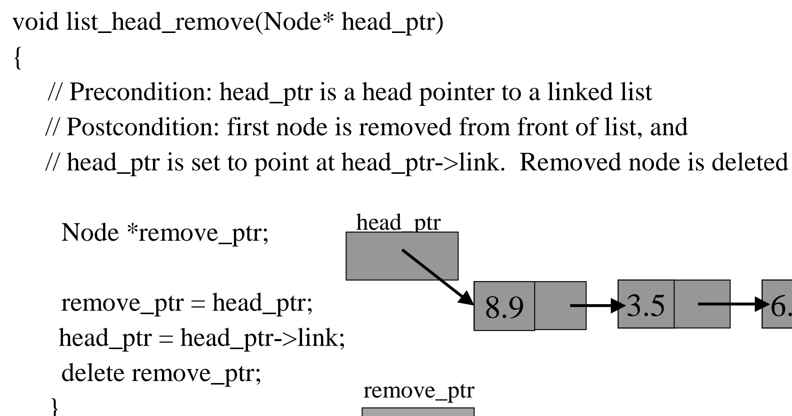

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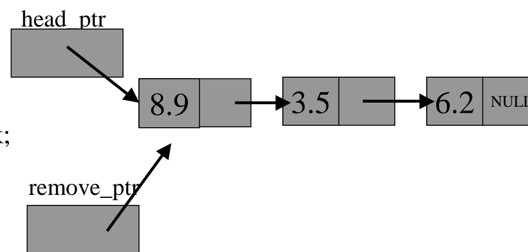

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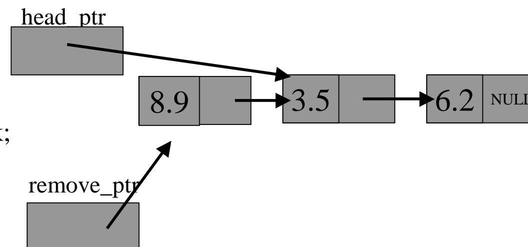

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}
```

head_ptr

3.5

6.2 NULL

remove_ptr

Will it work if head_ptr=NULL?

```
void list_head_remove(Node* head_ptr)
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    Node *remove_ptr;

    remove_ptr = head_ptr;
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    delete remove_ptr;
}
```

Will it work if head_ptr=NULL?

```
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{
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    // Postcondition: first node is removed from front of list, and
    // head_ptr is set to point at head_ptr->link.  Removed node is deleted

     Node *remove_ptr;
     if(head_ptr == NULL) return;
     remove_ptr = head_ptr;
     head_ptr->link = head_ptr->next;
     delete remove_ptr;
    }
```
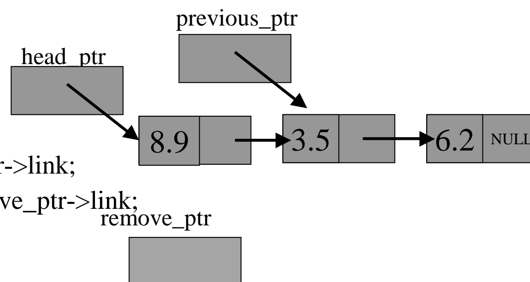

Removing a *not* Node at List Head

```
void list_remove(Node* previous_ptr)
{
    // Precondition: previous_ptr is a pointer to node in a linked list
    // Postcondition: node is removed from front of list, and
    // removed node is deleted

     Node *remove_ptr;

     remove_ptr = previous_ptr->link;
     previous_ptr->link = remove_ptr->link;
     delete remove_ptr;
    }
```



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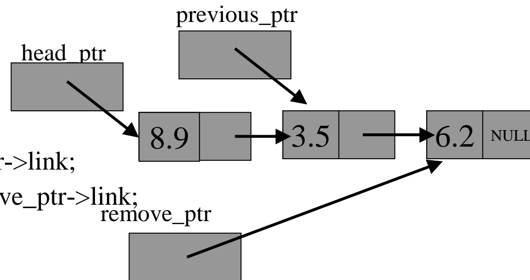

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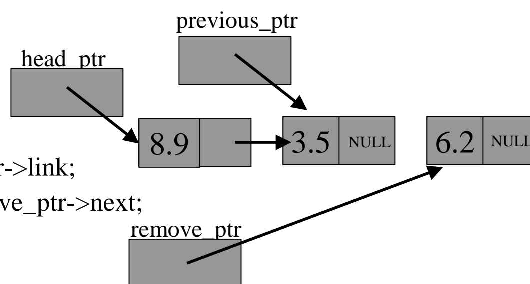
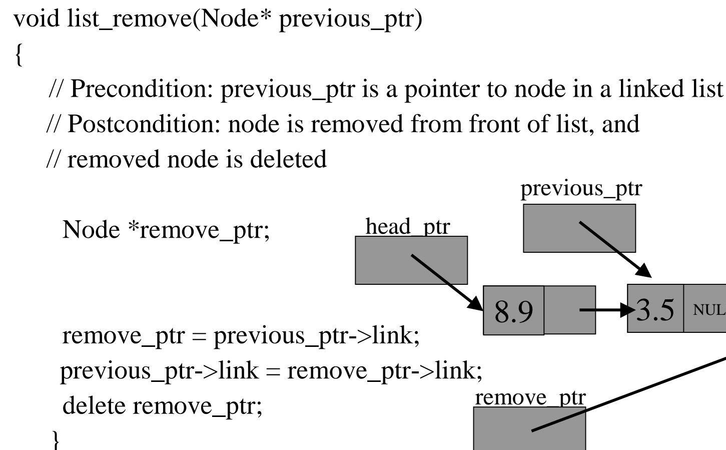


Removing a *not* Node at List Head

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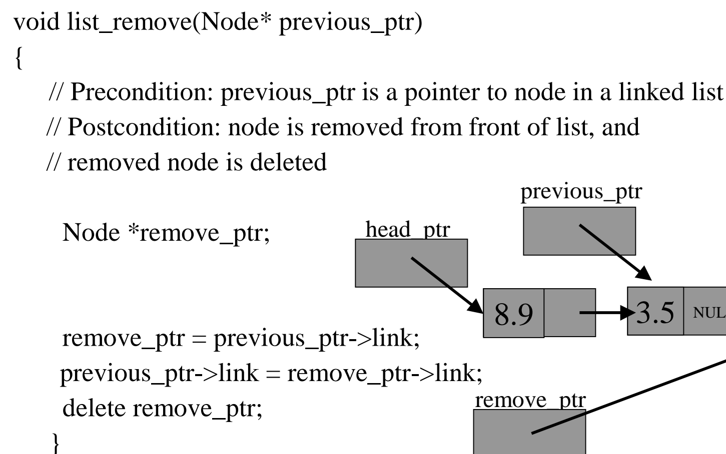
    }
```


Removing a *not* Node at List Head

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     remove_ptr = previous_ptr->link;
     previous_ptr->link = remove_ptr->link;
     delete remove_ptr;
    }
```

Other List Functions

- list clear: *empties a list, deleting all nodes.*
- list copy: *copies a list, and all its nodes.*
- list append: appends one list onto the end of another

Implementations and interfaces may vary, but the basic operations on lists remain more or less the same.

Better implementation: define a list class!! This is object oriented programming after all.