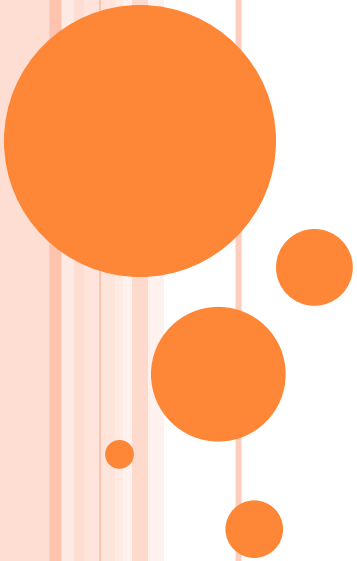


Singly Linked Lists

CS A250 – C++ Programming II

Introduction

- **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 linked lists

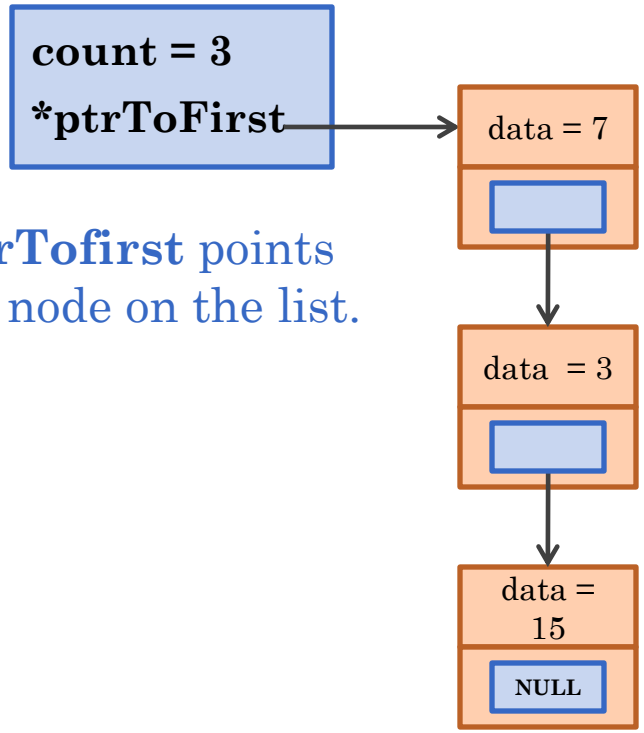
Approaches

- Three ways to handle such data structures:
  1. **C-style approach:** global functions and **structures** with everything **public**
  2. **Classes** with **private** **member variables** and **accessor** and **mutator** functions
  3. **Friend classes**
- We will use approach 2

Nodes and Linked Lists

- **Linked list**
  - Simple example of "dynamic data structure"
  - Composed of **nodes**
- Each "**node**" is a **variable** of **class type** that is ***dynamically*** created with `new`
  - Nodes also contain **pointers** to other nodes.

Nodes and Pointers



Pointer **ptrTofirst** points to the first node on the list.

nodes

In this example, each **node** contains an ***int*** and a ***pointer*** that points to the **next node**.

Linked List

- Lists as illustrated are called **linked lists**
- **First node** pointed to by pointer usually named **head** or **first**
  - We will call it **ptrToFirst** for now
- **Last node** is the ***end*** marker
  - Always set the pointer of last node to **`NULL`**
    - Considered "sentinel" because it indicates no further "links" after this node
    - Easy to test for "end" of linked list.

Linked List Implementation

- To implement a **linked list** we need **2 classes**:
  - A **class** to create a **single node**
  - A **class** to create a **list composed of nodes**
- For our example, we will have nodes that have ***only*** two pieces of data:
  - An **integer**
  - A **pointer** that links to another node

Linked List Implementation (cont.)

- **Node class**
  - Creates a **node** that has two member variables (can have more):
    - An **integer** name **data** storing some number
    - A **pointer** named **ptrToNext** that we set to point to the next node
      - This **pointer** is usually named **next** or **link**
- We will have all **member functions definitions *inline***
  - Because the class is short and simple enough.

Node Class Definition

```
class Node
{
public:
    Node() : data(0), ptrToNext(NULL){}
    Node(int newData, Node *newPtrToNext)
        : data(newData), ptrToNext(newPtrToNext){}
    Node* getPtrToNext( ) const { return ptrToNext; }
    int getData( ) const { return data; }
    void setPtrToNext( Node * newPtrToNext )
        { ptrToNext = newPtrToNext; }
     void setData( int newData ) { data = newData; }
     ~Node(){}
private:
    int data;
    Node *ptrToNext;
};
```

AnyList Class

- Once we have the **Node class**, we need a class that creates a **list** composed of **nodes**

- In our example, we implement a class named **AnyList**
  - Creates a **list** with
    - A **pointer ptrToFirst** that points to the ***first*** **node** of the **list**
    - A **counter count** to keep track of how many **nodes** are in the **list**.

Example

- **Project:** 01_singly_linked_lists
  - AnyList.h

How to Create the First Node

- `Node *ptrToNode;`
  - Creates a ***pointer*** to point to a **new** node
- `ptrToNode = new Node;`
  - Creates a **new** ***node***
- `ptrToNode->setData(3);`
  - Stores 3 in the member var **data** (assuming we have an ***int***)
- `ptrToNode->setPtrToNext(NULL);`
  - Pointer in new node set to NULL (since it is the only node)
- `ptrToFirst = ptrToNode;`
  - Set *pointer* **ptrToFirst** to point to the new node

- Operator **->**
  - Called **arrow operator**
  - Shorthand notation that combines " * " and " . "

Example

- **Project:** 01_singly_linked_lists
  - **Constructor**
  - How to create a node

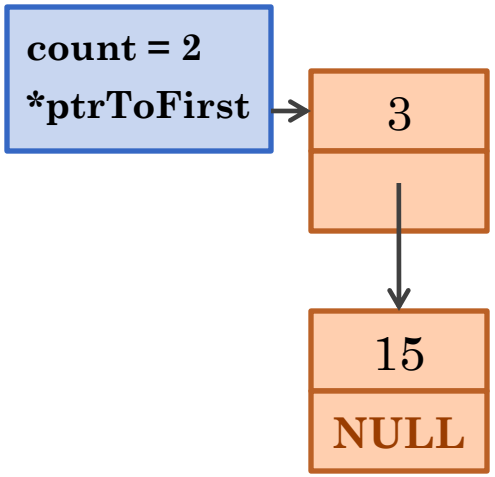
- **NOTE:** *Since one of the member variables of the* ***SinglyLinked List*** *class is dynamic, the class should include a* ***copy constructor*** *and an* ***overloaded assignment operator****. For practical purposes, we will omit these until we address these topics later in the semester.*

Inserting to the Front of the List

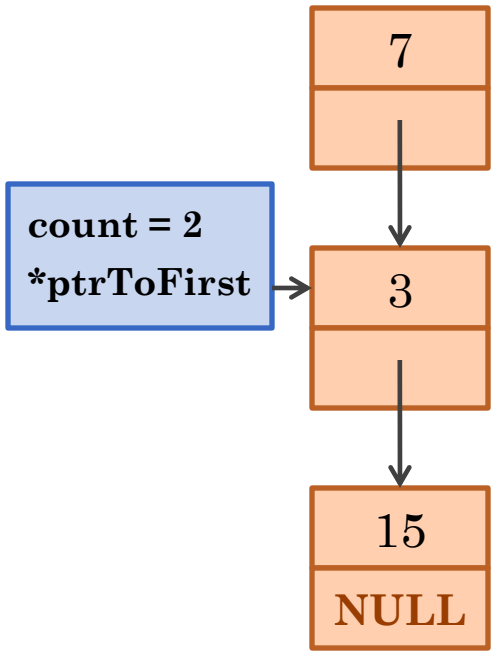
- To **insert a node** to the *front* of the list,
  you need to:
  1. Create a pointer to point to a **new** node
     (this is ***dynamic***)
  2. Create a new node
  3. Store data in the new node
  4. Set **new node's pointer** to point to the **first node**
  5. Make the new node be the "first" node
  6. Increment the count

- **Note:** If the **list** is **empty**
  - Then the new node is the **first** and **only** node.

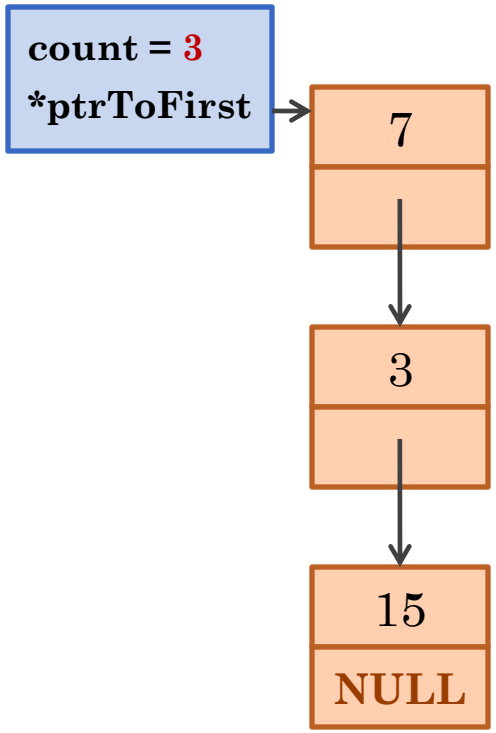
Inserting to the Front of the List



Before insertion

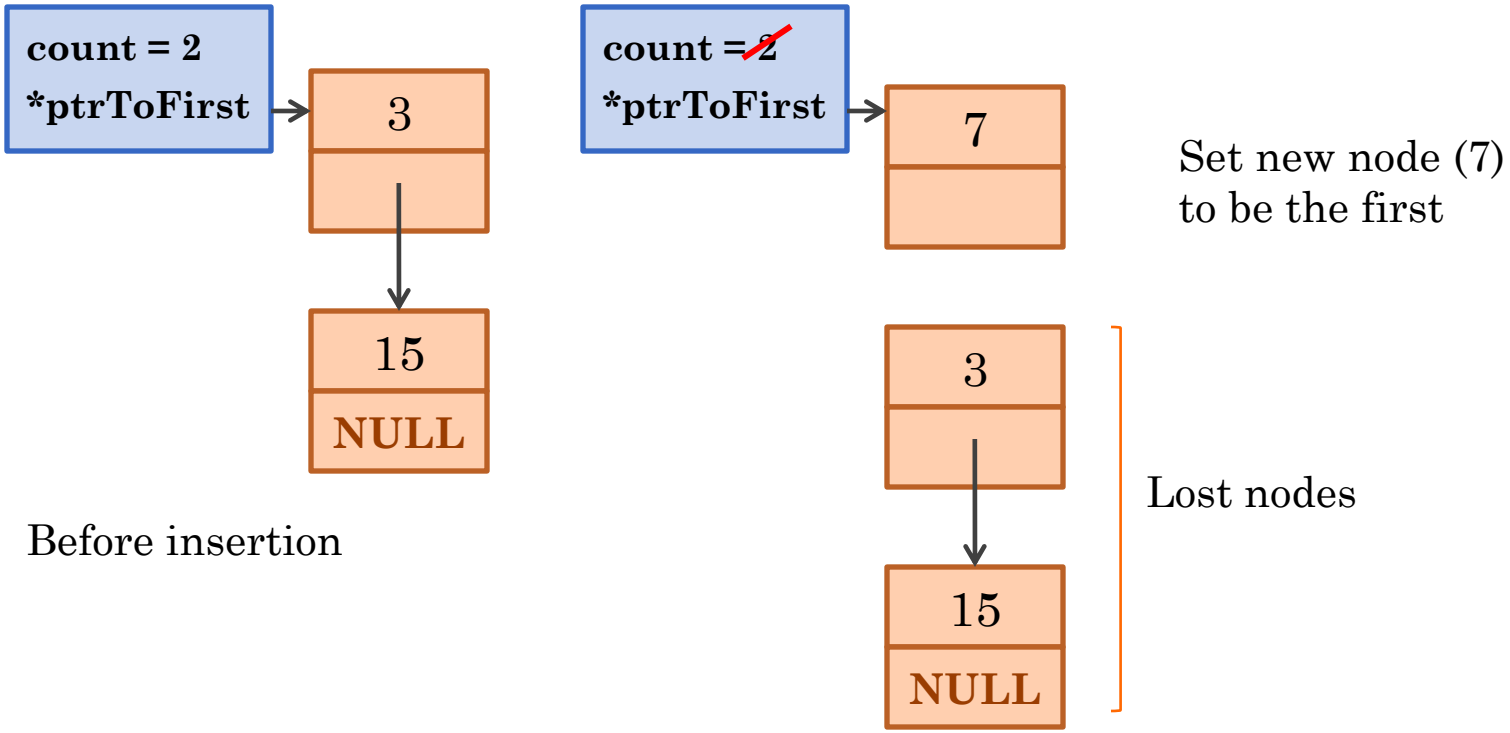


Insert new node (7)



Make ***ptrToFirst*** point to the new node

Pitfall: Lost Nodes



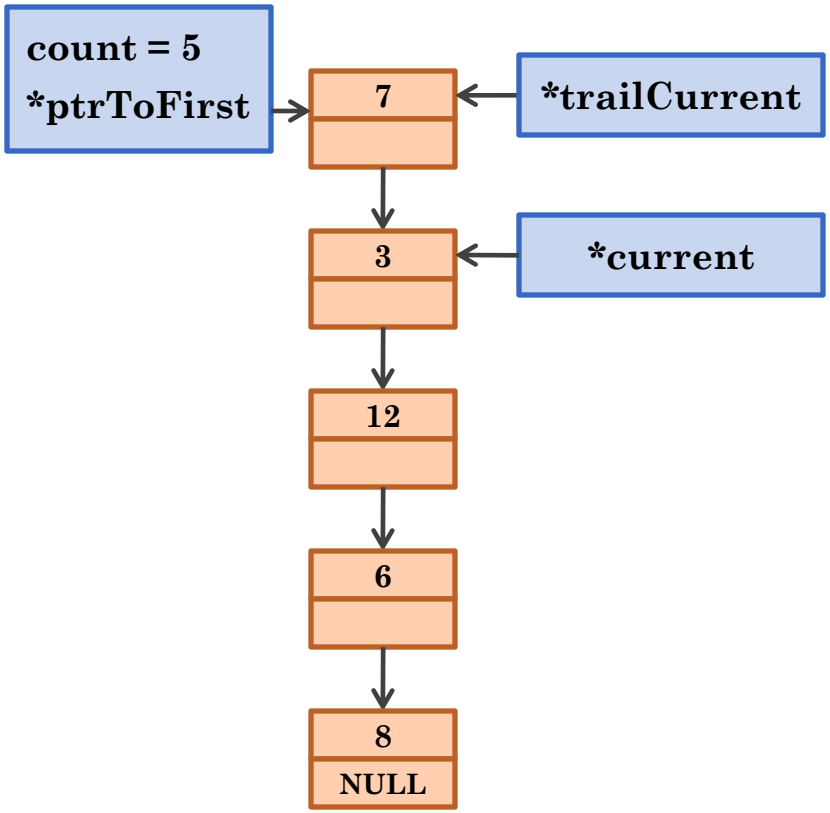
Example

- **Project:** 01_singly_linked_lists
  - Function: **insertFront( )**
  - Inserting to the front of the list

Removing a Node

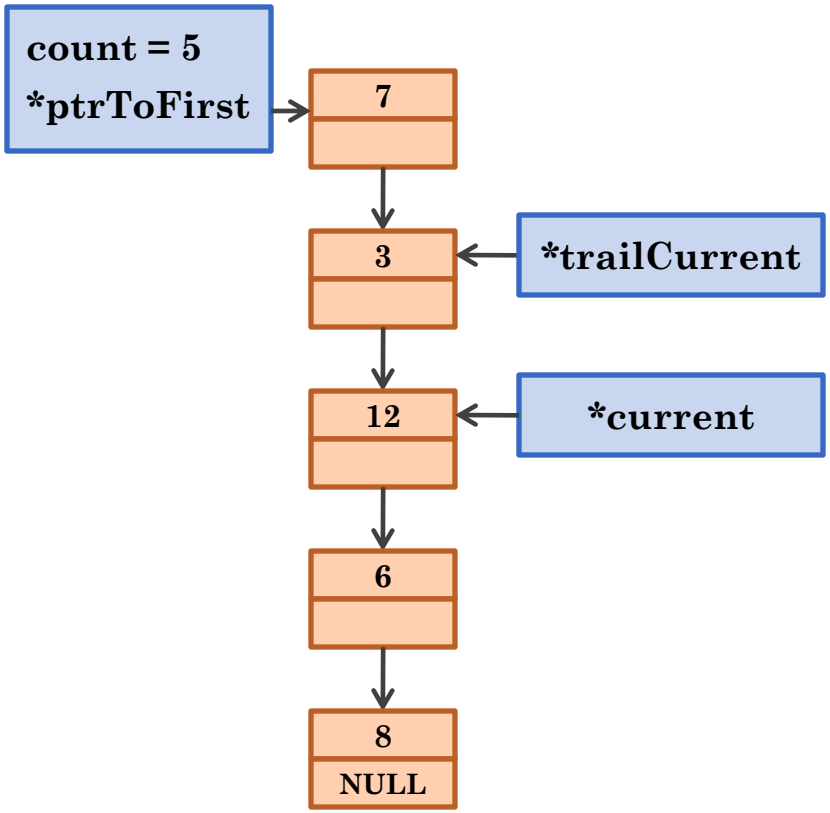
- We want to delete a node that has a given information. What do we need?
  - Create a **pointer** to
    - traverse the list → `current`
    - be right behind `current`→ `trailCurrent`
  - Set a **boolean** value to keep track of whether the item is found or not
- Need to consider ***all*** cases:
  - List is empty → output message
  - Node to be deleted is first
  - Item was not found

Deleting a Node



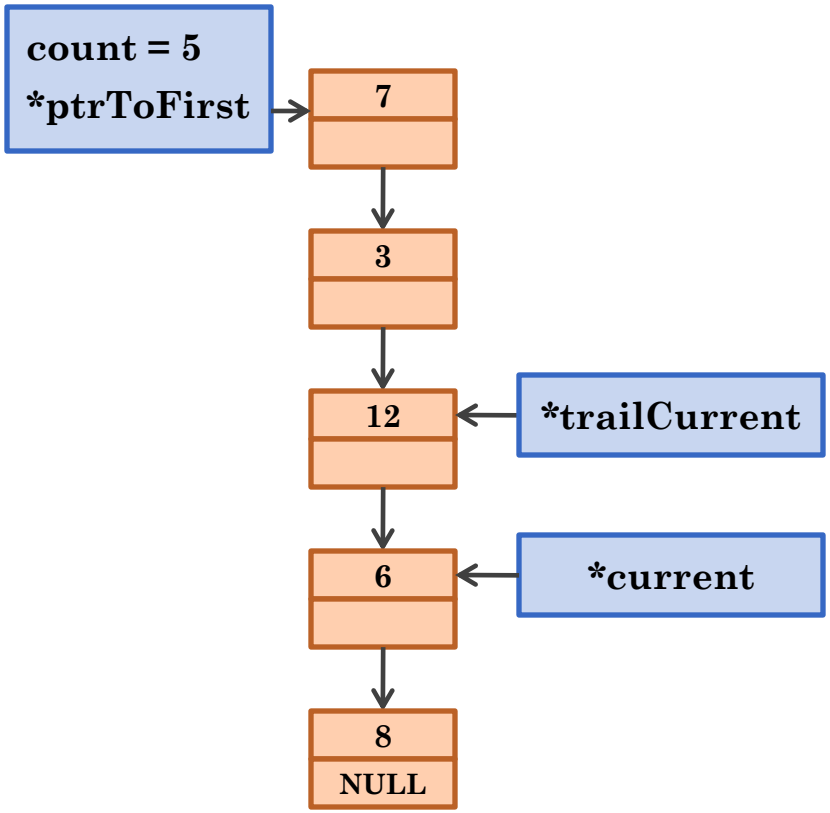
Looking for (6)

Deleting a Node (cont.)



Looking for (6)

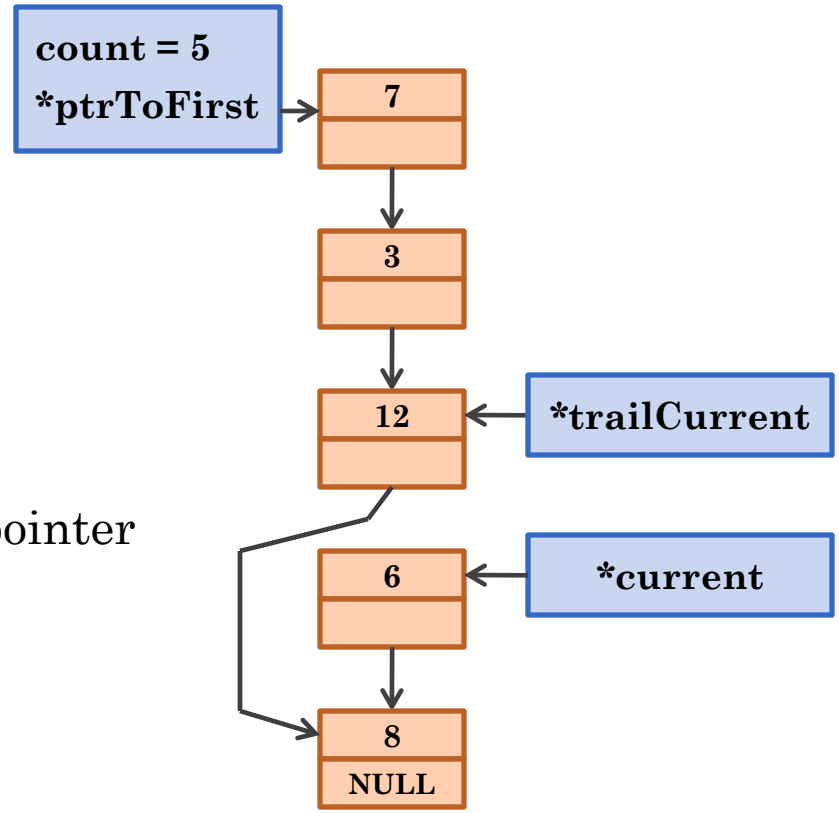
Deleting a Node (cont.)



Looking for (6)

Found!

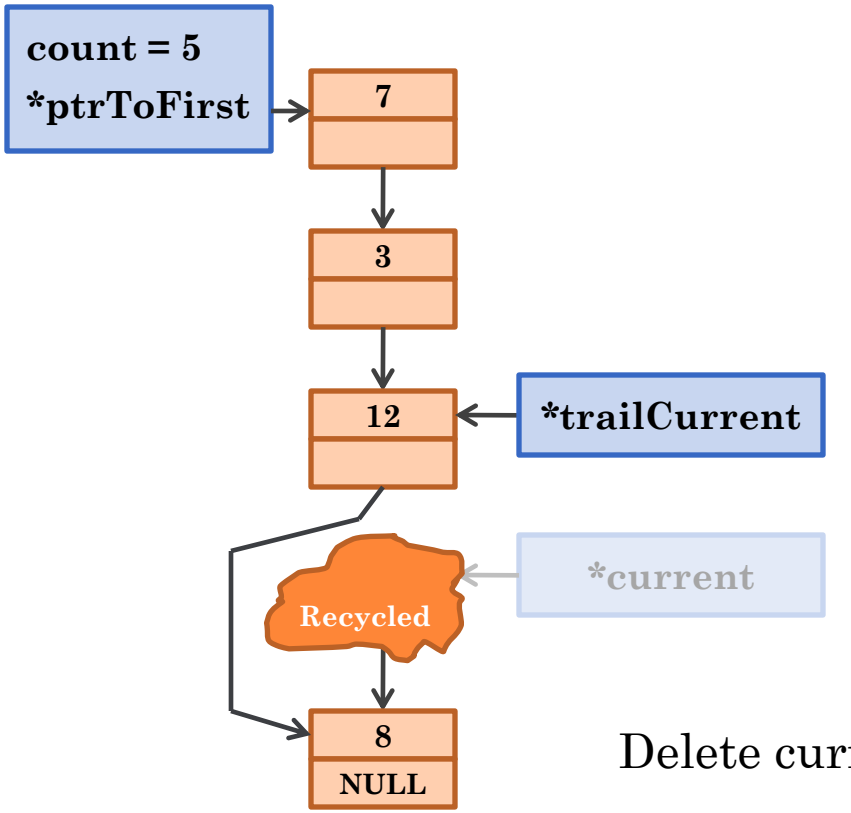
Deleting a Node (cont.)



Looking for (6)

Move pointer

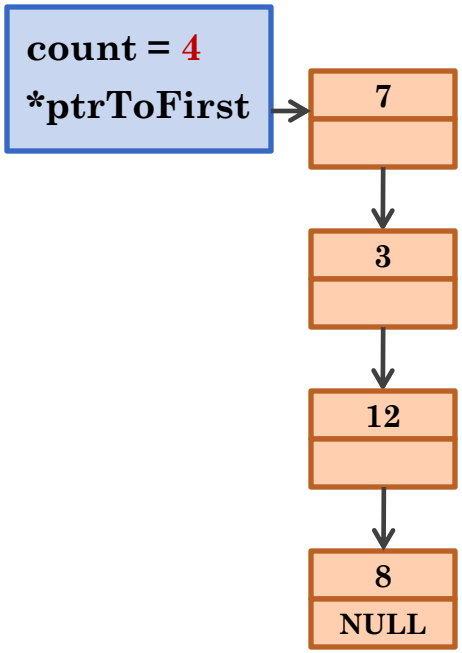
Deleting a Node (cont.)



Looking for (6)

Delete current

Deleting a Node (cont.)



Null both current and trailCurrent pointers

Example

- **Project:** 01_singly_linked_lists
  - Function: **deleteNode()**
  - Deleting a node
    - Need to consider all cases
      - List is empty
      - Node to be deleted is the first
      - Continue searching for node in the list
      - Node is found
      - Node is not found

Printing the List

- How do you **print** the list?
  1. Create a **pointer** to traverse the list → **`current`**
  2. Set the **`current`** pointer to point to the **`first`** node
  3. While the **`current`** pointer does not point to **`NULL`**

     (that is, has not reached the end of the list)
     a) Output the data the **`current`** pointer is pointing to
     b) Move the **`current`** pointer forward

Example

- **Project:** 01_singly_linked_lists
  - Function: **print()**

List Destructor

- The **destructor** will call a function ***destroyList( )*** to perform all necessary operations to free memory

1. Create a pointer **temp** to traverse the list
2. Use a **while loop** to delete all nodes in the list
3. Reset **count** to 0

Useful Syntax

- You have several nodes (*n1*, *n2*, *n3*…)
  - *n1* is the **first** node
- You want to…
  - … Get the data stored in node *n1*

```
ptrToFirst->getData();
```

  - … Make a new node be the be first and point to *n1*

    (assume you already created **ptrToNewNode**)

```
ptrToNewNode->setPtrToNext(ptrToFirst); //point to n1
ptrToFirst = ptrToNewNode; //the new node is now
                           // the first node
```

  - … Know if the list is empty

```
if (ptrToFirst == NULL)
```

Common Errors

- Forgetting to add
  - `#include <string>` in the **`AnyList.h`** file
    - Needed for **`NULL`**
- Confusing nodes and pointers
- Forgetting to reset the pointer that points to the first node in the list, ***ptrToFirst***

IMPORTANT !

- **Before executing** your program (F5) ***always*** do the following:
  - Click on **Build** → **Rebuild Solution**

Important → Common Identifiers

- We have named the pointer that points to the first node **ptrToFirstNode**
  - BUT, common identifiers are: **first**, **head**
- We have named the pointer that points to the next node **ptrToNextNode**
  - BUT, common identifiers are: **link**, **next**
- We have named the pointer that points to a new node **ptrToNewNode**
  - BUT, most common identifier is: **newNode**

Important → Common Identifiers

- We have named the pointer that points to the first node **ptrToFirstNode**
  - BUT, common identifiers are: **first**, **head**
- We have named the pointer that points to **ptrToNextNode**
  - BUT, common identifiers are: **link**, **next**
- We have named the pointer that points to a new node **ptrToNewNode**
  - BUT, most common identifier is: **newNode**

Class projects may use any identifier.

End Singly-linked Lists