LINKED LIST

CMPS 148

Specifics of a “list”

- List is a set of ordered elements
  - $A_1, A_2, A_3, A_4, \ldots$
  - Refer to the location of an element by its index (i)
  - A_i always precedes A_{i+1}, etc.
- The size of a list is called N
- List with N = 0 is called an “empty list”

List operations

- A List defines/provides certain operations:
  - insert (at end, at front, before "i", etc)
  - remove (end, front, i)
  - get (i)

There are others too… you'll see more in CMPS 231

Recall our List Container

- Represented as a class / object
- Held a dynamic array as private member to store data
- Could be resized by creating a new sized array and copying over the data
  - **Problem:** This is expensive!

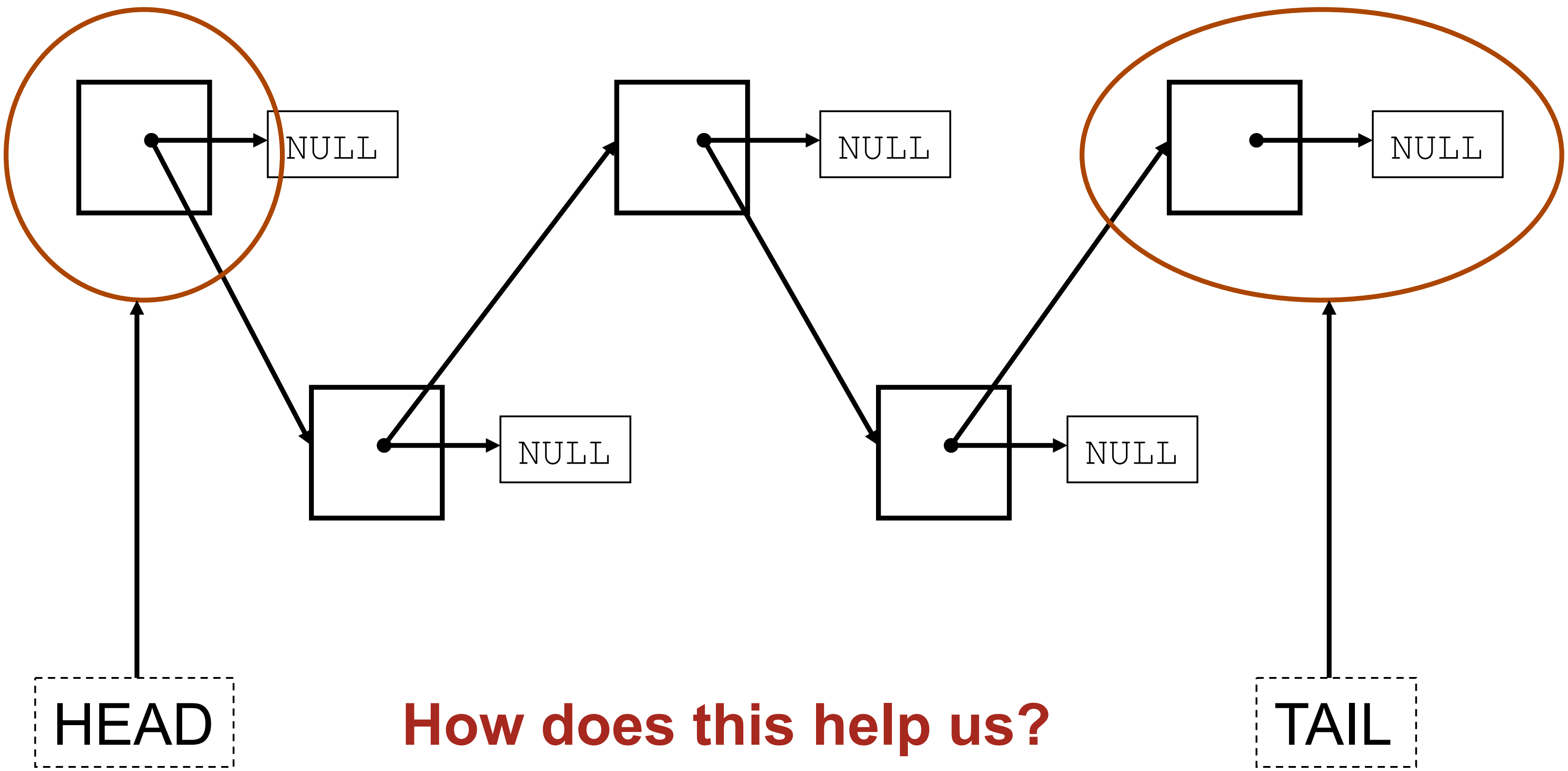
- In addition – inserting at front, in middle forces us to move elements to make room!

- Removal at front in middle? Same problem…

Solution

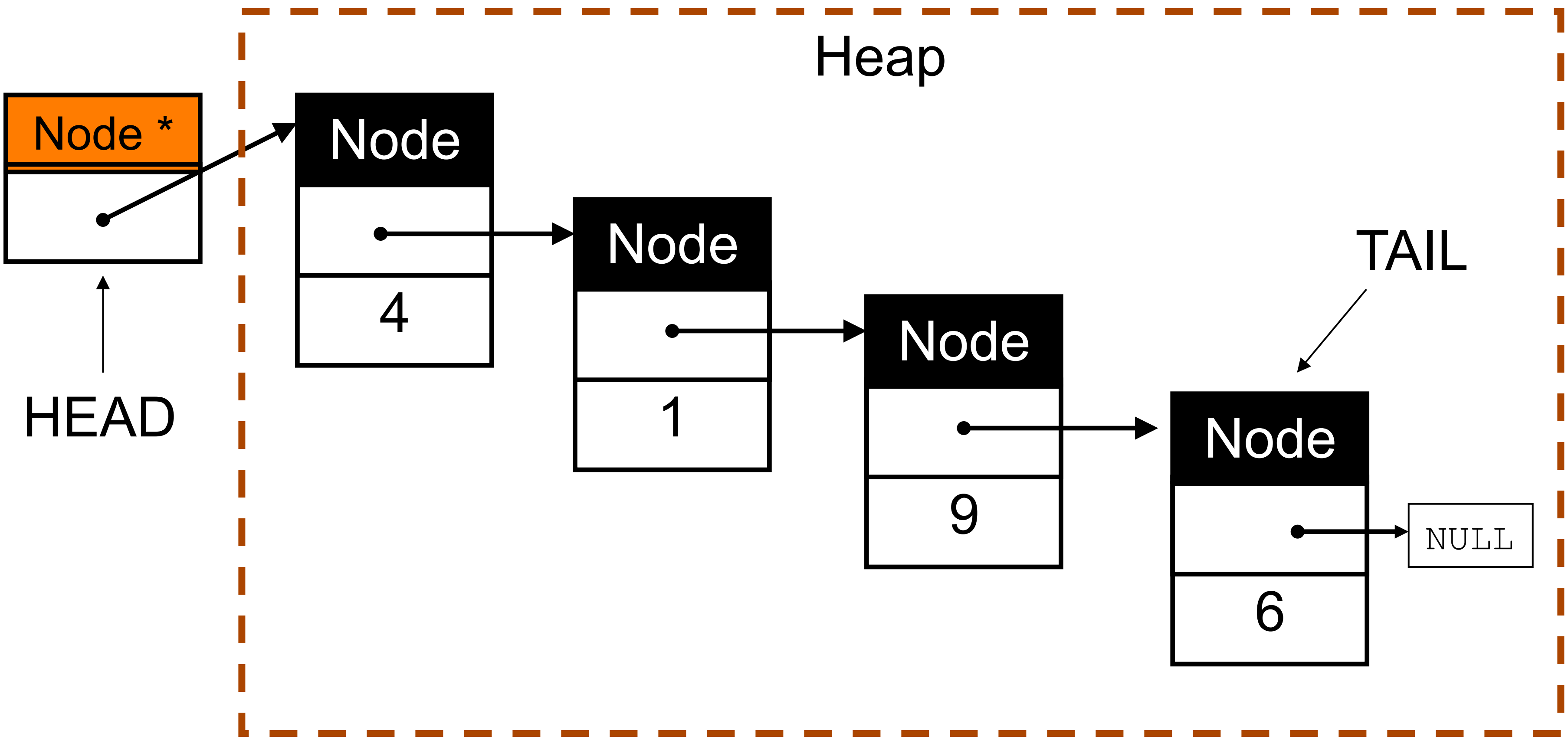
- To solve this problem – we're going to combine two important concepts we've seen this semester:
  - Pointers and Dynamic Allocation
  - Objects
- We'll develop a "container" that:
  - Allocates each element *as needed.*
  - Allows fast insert/remove at front **and** at end

A chain of pointers



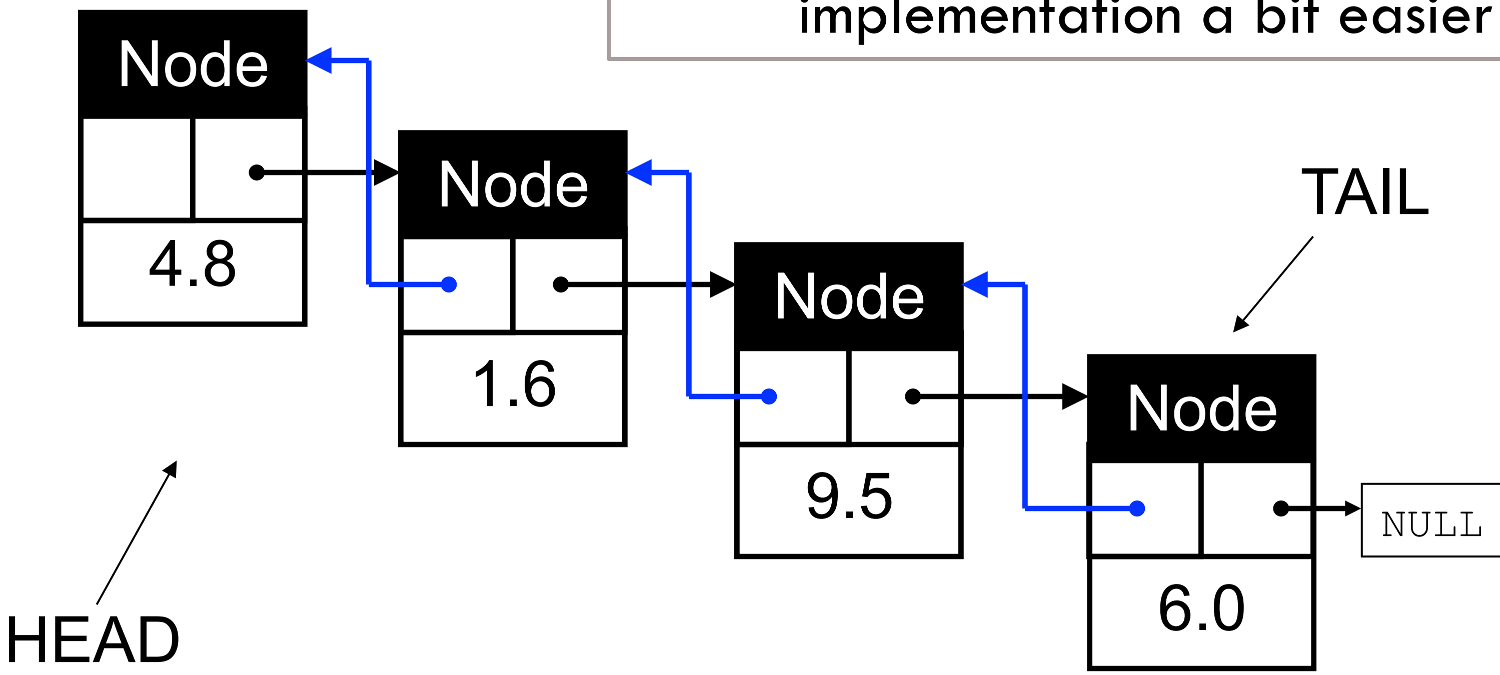
How does this help us?

New Data Structure: Node



Double Linked Lists

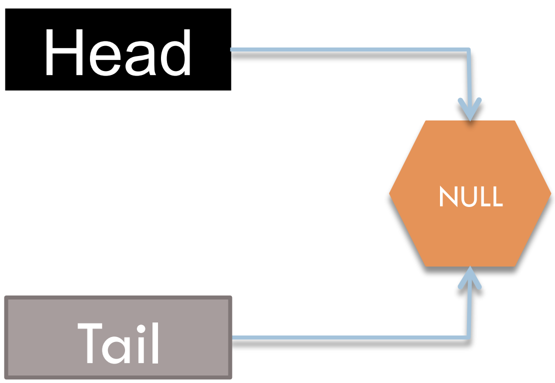
Seems more complicated – but makes implementation a bit easier



There are some downsides to this though…

Initial State

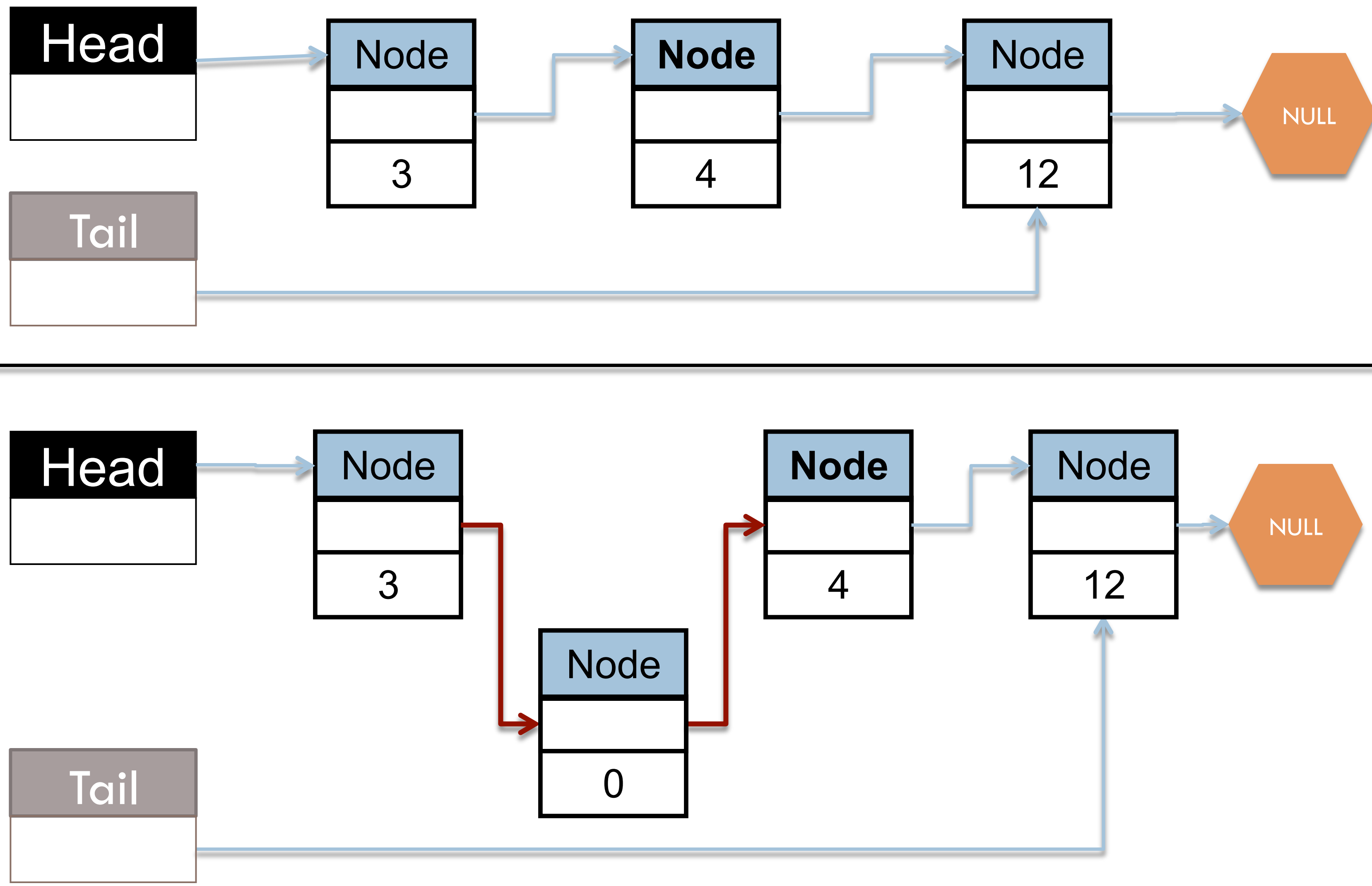
- Lets write the constructor to ensure the list is empty



Might be a good idea to have a public function to determine if list is empty

- Lets write figure out how to add *the first item*
  - Lets test it by ensuring isEmpty now returns false too..

Insertion – the general case



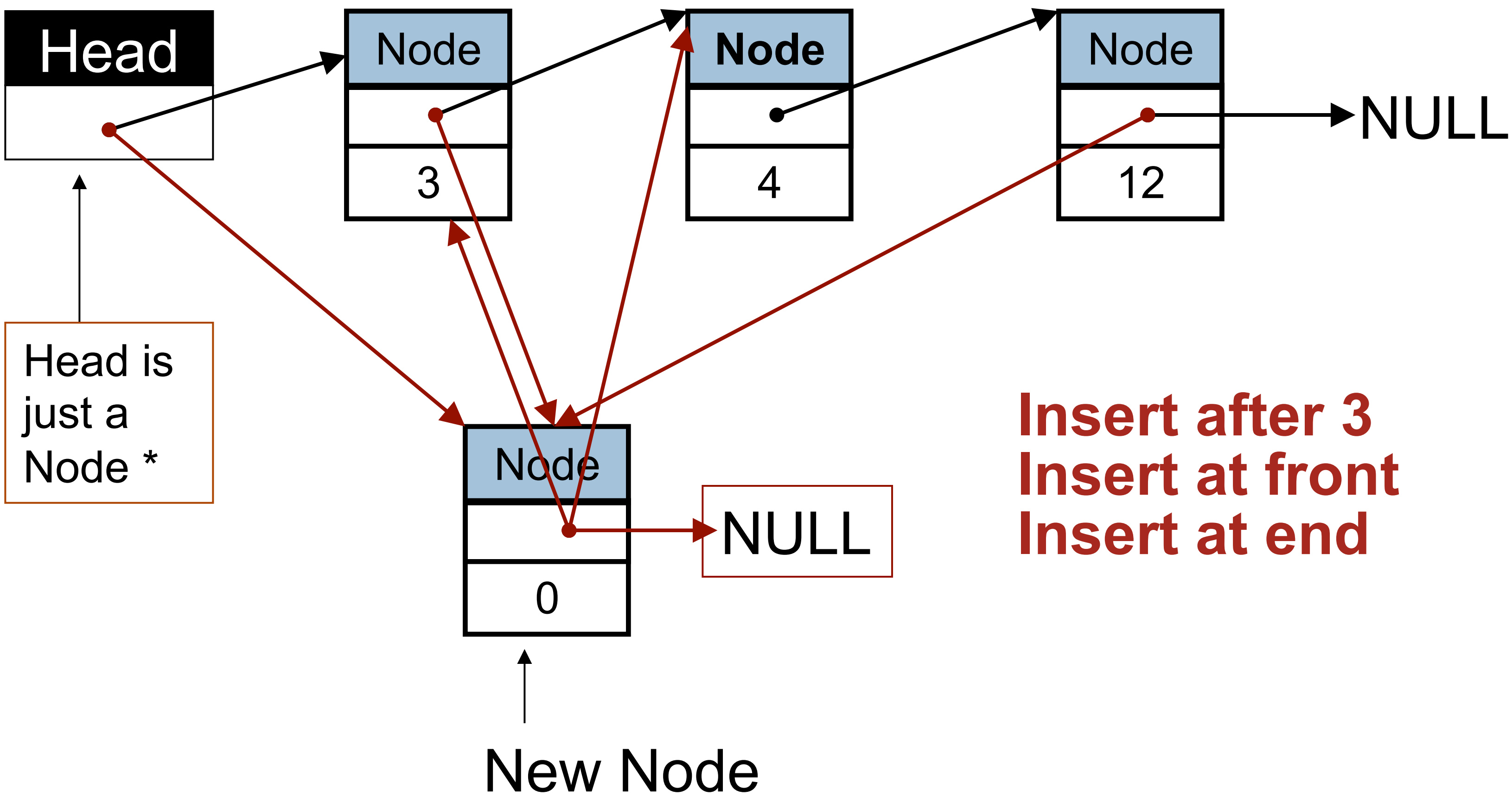
Insertion – the special cases

- Pointer are great… until they aren't ☺
  - What happens when we insert into the front of a list?
  - What happens when we insert into the end of a list?

Hope is not a plan… you **must think** about special cases!

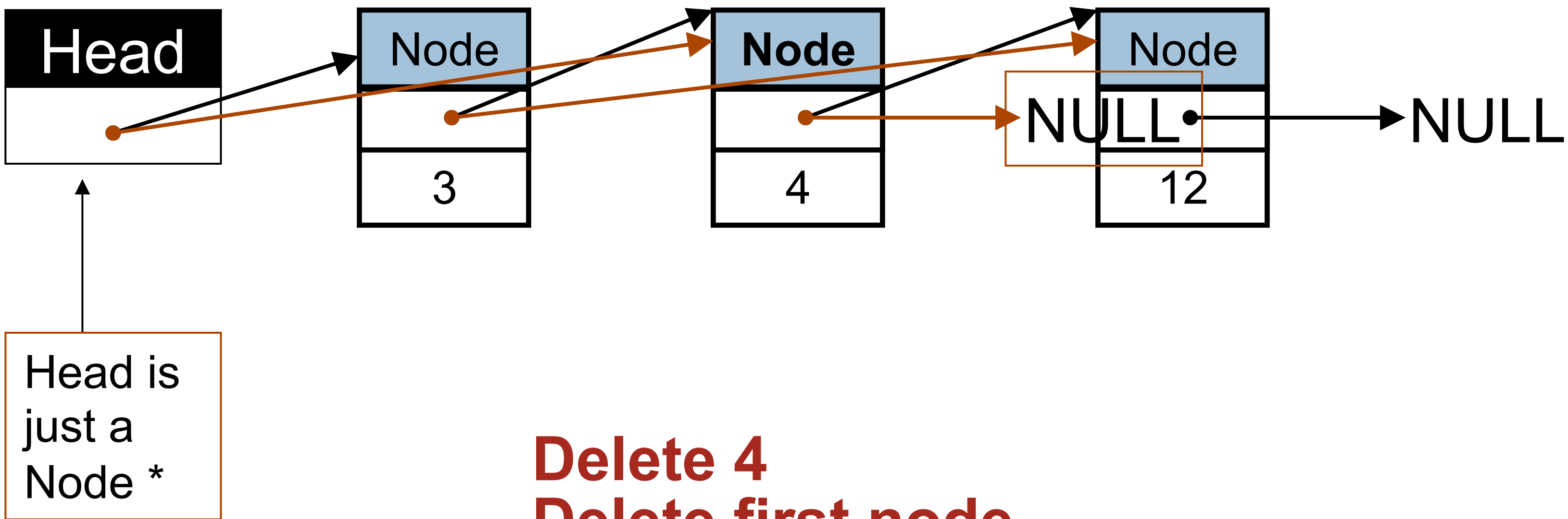
Sometimes they work out without special code
… sometimes they don't

Insertion



Insert after 3
Insert at front
Insert at end

Deletion

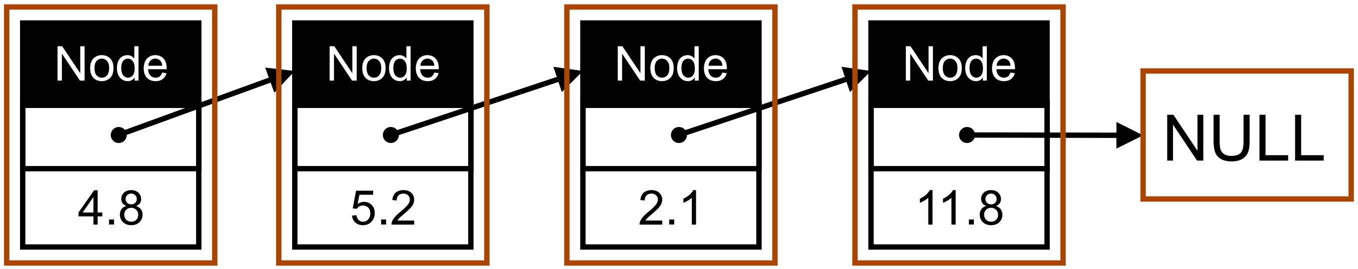


Delete 4
Delete first node
Delete last node

Testing

- We don't know if our code works yet..
  - Print the nodes
  - Implement get(index) to see if things are where we thing they are…
  - Both operations require *traversal*

List Traversal




```
Node * current = this->head;
while ( current != NULL ) {
      cout << current->getData();
      current = current->getNext();
}
return;
```

console: 4.8 5.2 2.1 11.8

Removal

- We should implement removal code:
  - Remove at front
  - Remove at end
  - Remove at a specified index

Same overall principals
Special Case: Remove from list with 1 element?

Linked List

- Linked List:
  - Group of Nodes
  - Each Node contains three things:
    - Data!
    - a pointer to the *next* Node
    - A pointer to the *previous* Node
- LinkedList supports
  - insert (at end, at front, before "i", etc)
  - remove (end, front, i)
  - print()
  - get (i)

Memory Management

- Often you'll want to "clear" the list
  - makeEmpty()

- If a list provides a "makeEmpty" operation, there is no guarantee that the programmer will call it.
- Inserting items causes Nodes to be allocated by heap
- Must provide way to automatically call "makeEmpty"

Destructor

- C++ provides special syntax for this:

```
~LinkedList() {
    this->makeEmpty();
}
```

- The destructor is automatically called when the object goes out of scope.
- Also called when delete operator is used.
- Destructor should delete any heap allocated memory within the object.
- Always write a destructor!

Next time…

- This seems like a useful class… but it's a lot of work
  - It would be helpful if we didn't have to rewrite the entire thing to hold lists of doubles, characters, strings, circles…..
  - Templates.