CS350: Data Structures

Doubly Linked Lists

James Moscola
Department of Engineering & Computer Science
York College of Pennsylvania

Doubly Linked Lists

- **Adds an additional pointer to a list node that points to the previous node in the list**

- **Traversable in either the forward or backward direction**

- **Resolves the issue of removing the last node in the linked list**
  - Becomes a O(1) operation as opposed to O(N)

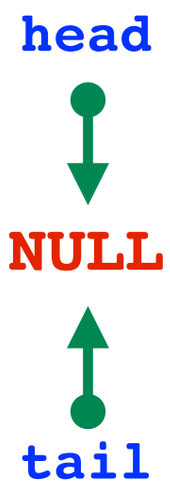
Doubly Linked List Operations

- **Basic operations include:**
  - `insert` / `add`
  - `remove` / `removeFirst` / `removeLast`

- **Additional operations may include:**
  - `getFirst` / `getLast`
  - `find`
  - `isEmpty`
  - `makeEmpty`

Doubly Linked List Implementation

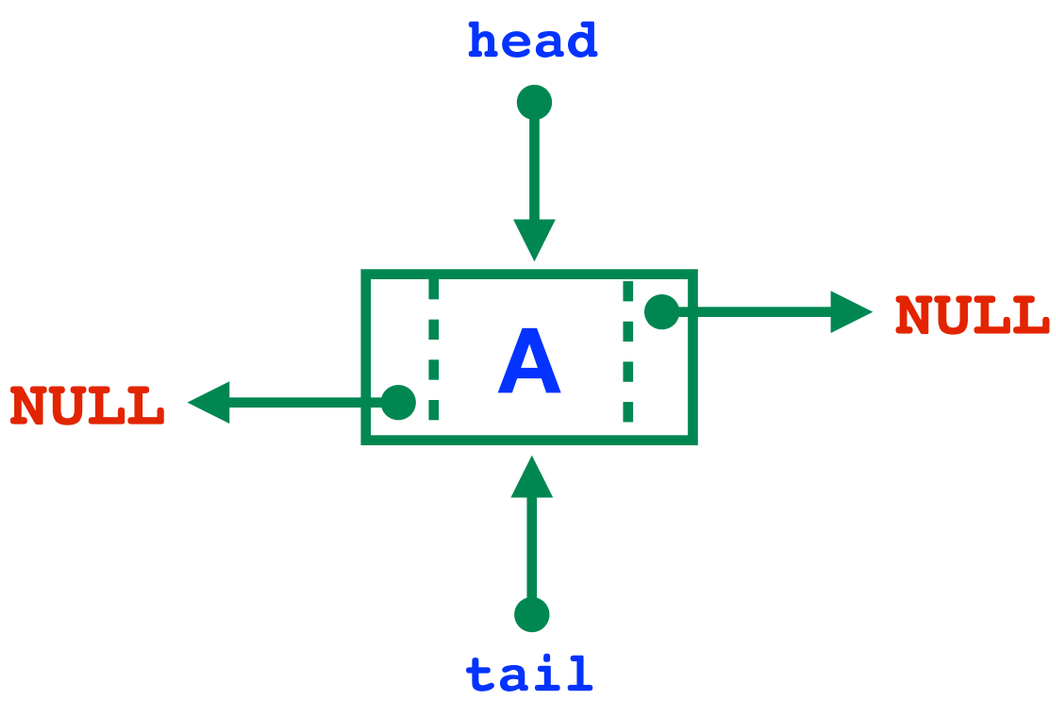
- **Basic implementation uses `head` and `tail` pointers that points to the first node and the last node in the list**
  - Both pointers point to `NULL` upon initialization when no nodes exist in the list



- **Depending on implementation, insertion may take place at the head of the list, at the tail of the list, or at some other specified node**

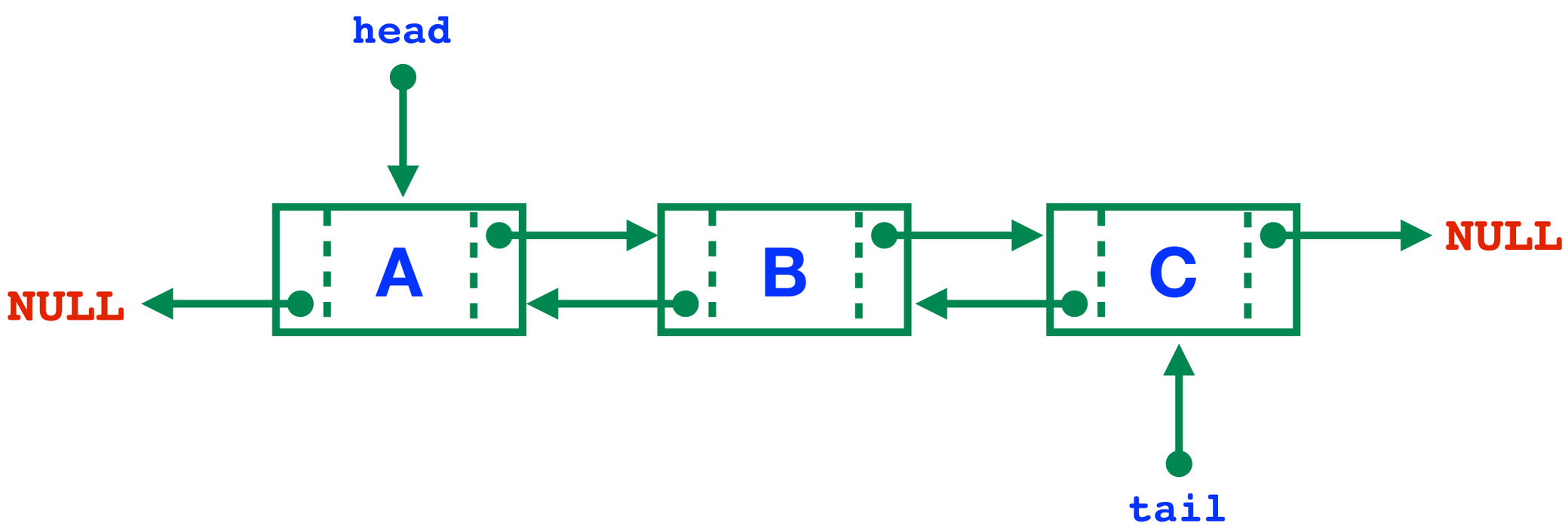
After Inserting a Node

- **In this illustration, nodes are inserted at the tail end (nodes can be inserted at either the head or the tail)**
  - After inserting the first node, A
  - The **`head`** and the **`tail`** pointers are reassigned to point to the first node



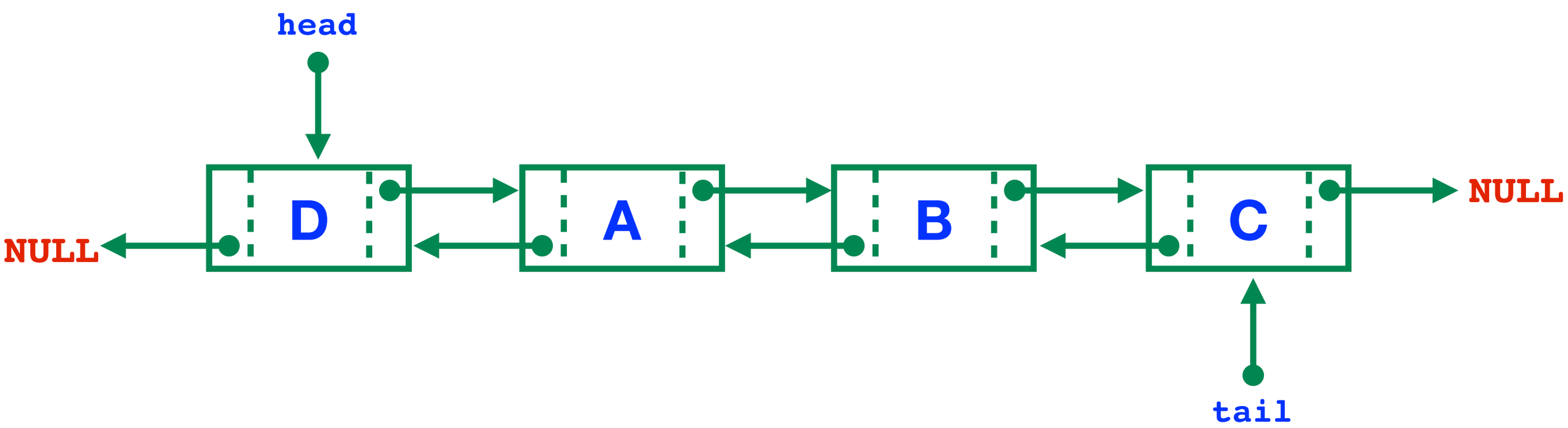
After Inserting Additional Nodes

- **In this illustration, nodes are inserted at the tail end (nodes can be inserted at either the head or the tail)**
  - After inserting nodes in the sequence A, B, C
  - The **`tail`** pointer advances with each insertion at the **`tail`** end



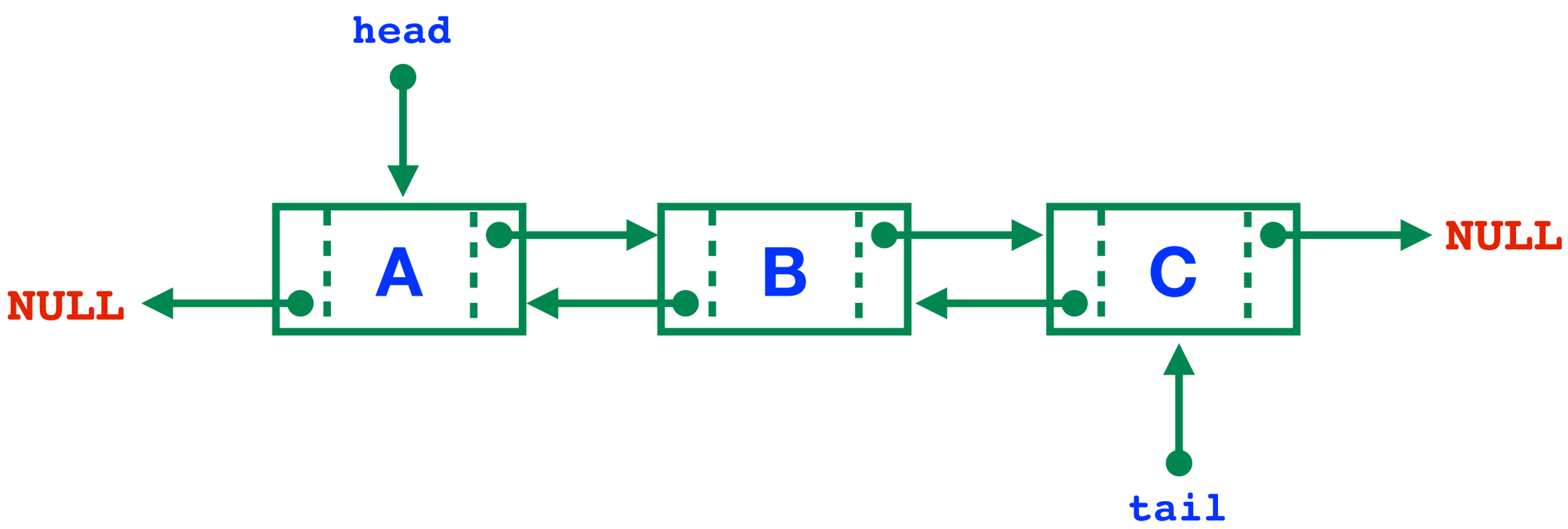
After Inserting Additional Nodes

- **In this illustration, nodes are inserted at the head**
  - After inserting the node D
  - The **`head`** pointer retreats with each insertion at the **`head`**



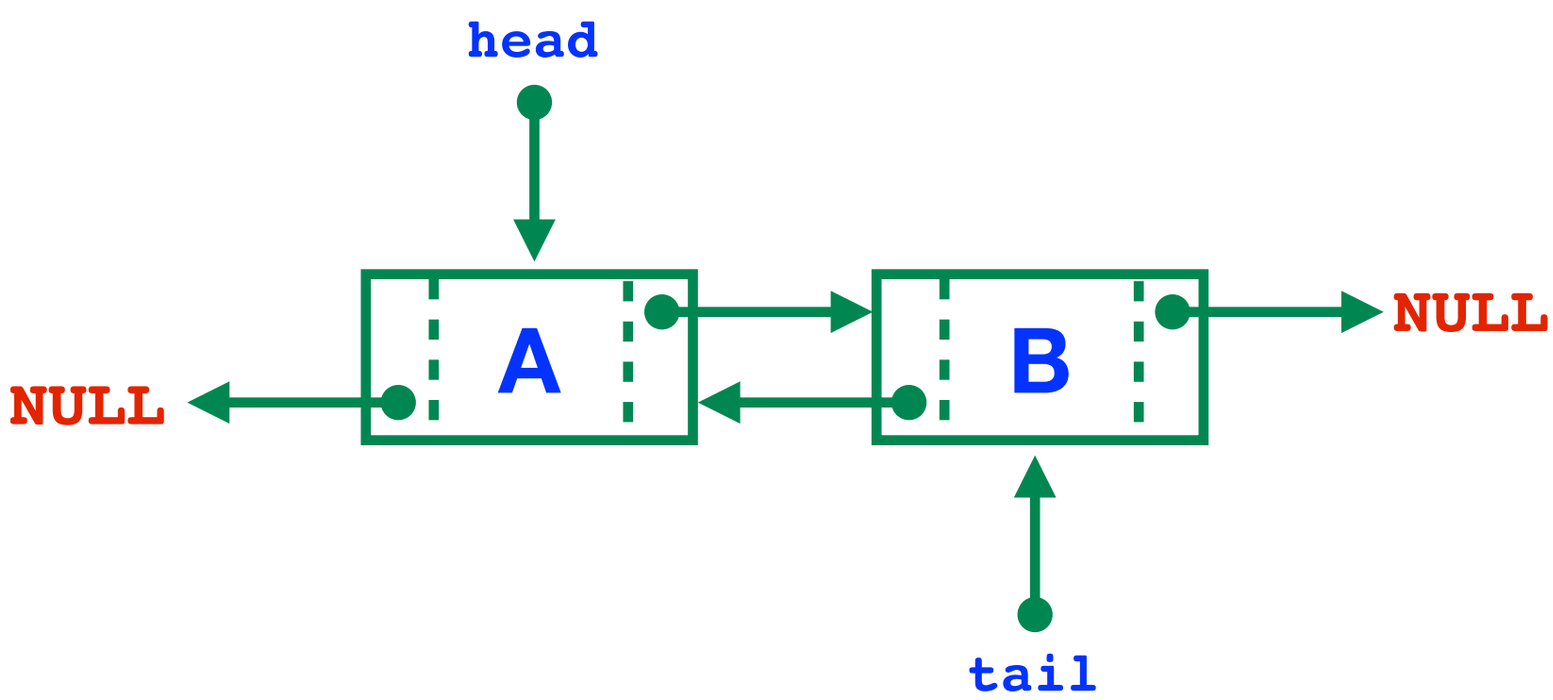
After Removing the First Node

- **Nodes can be removed from the `head` of the list or the `tail`**
  - After removing a single node from the **`head`** of the list
  - The **`head`** pointer advances with a removal from the **`head`** of the list



After Removing the Last Node

- **Nodes can be removed from the `head` of the list or the `tail`**
  - After removing a single node from the `tail` of the list
  - The `tail` pointer retreats with a removal from the `tail` of the list



Doubly Linked List Implementation

```
public class DLinkedListNode<E> {
   public E data;
   public DLinkedListNode<E> next;
   public DLinkedListNode<E> prev;
}
```

Doubly Linked List Implementation

```
// Inserts at the tail of the list

public void append (E data) {
   DLinkedListNode<E> newNode = new DLinkedListNode<E>();
   newNode.data = data;  // assign data to newNode
   newNode.prev = tail;
   tail.next = newNode;
   tail = newNode;
}
```

This method is oversimplified, what happens if this is called when the list is empty?

Doubly Linked List Implementation

Fixed `append` method

```
// Inserts at the tail of the list

public void append (E data) {
   DLinkedListNode<E> newNode = new DLinkedListNode<E>();
   newNode.data = data;  // assign data to newNode
   if (isEmpty()) {
      head = tail = newNode;
   } else {
      newNode.prev = tail;
      tail.next = newNode;
      tail = newNode;
   }
}
```

Doubly Linked List Implementation

```
// Inserts at the head of the list

public void prepend (E data) {
   DLinkedListNode<E> newNode = new DLinkedListNode<E>();
   newNode.data = data;  // assign data to newNode
   newNode.next = head;
   head.prev = newNode;
   head = newNode;
}
```

This method is oversimplified, what happens if this is called when the list is empty?

Doubly Linked List Implementation

```
// Removes node from head of list and returns its value

public E removeFirst() {
   if (head != null) {
      E nodeData = head.data;
      head.next.prev = null;
      head = head.next;
      return nodeData;
   } else {
      return null;
   }
}
```

Considerations for Linked List Implementation

- **Implementation as previously shown requires error checking in the insertion and removal methods to check for edge cases (i.e. checking for an empty list)**

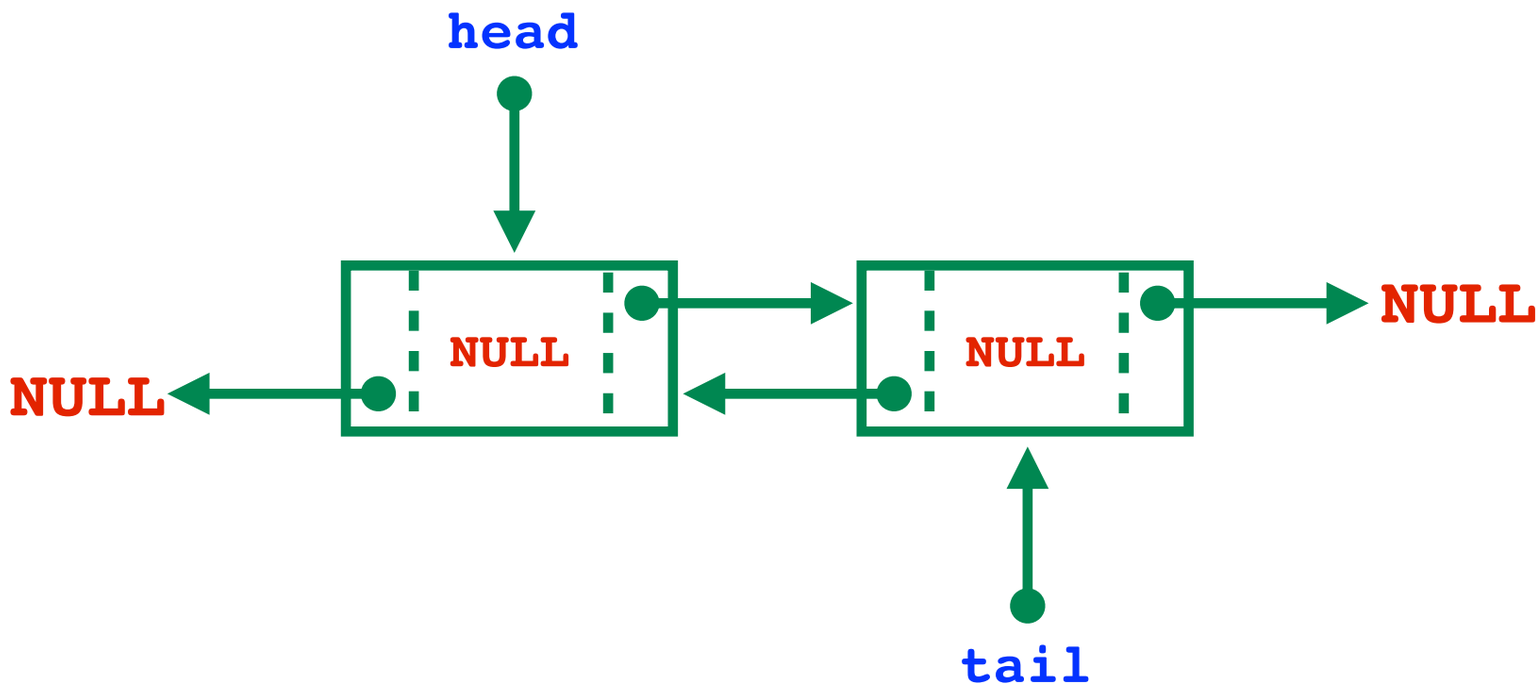
- **To improve the speed of operations, it is possible to remove these tests**
  - Tradeoff: speedup comes at the expense of one/two additional ‘dummy’ nodes in the Linked List

- **Idea: create one or two dummy nodes (sentinel nodes) that exists in the linked list at ALL times**
  - Eliminates the need to always check for `NULL`
  - Generalized the insertion and removal methods

Doubly Linked List with Two Sentinel Nodes

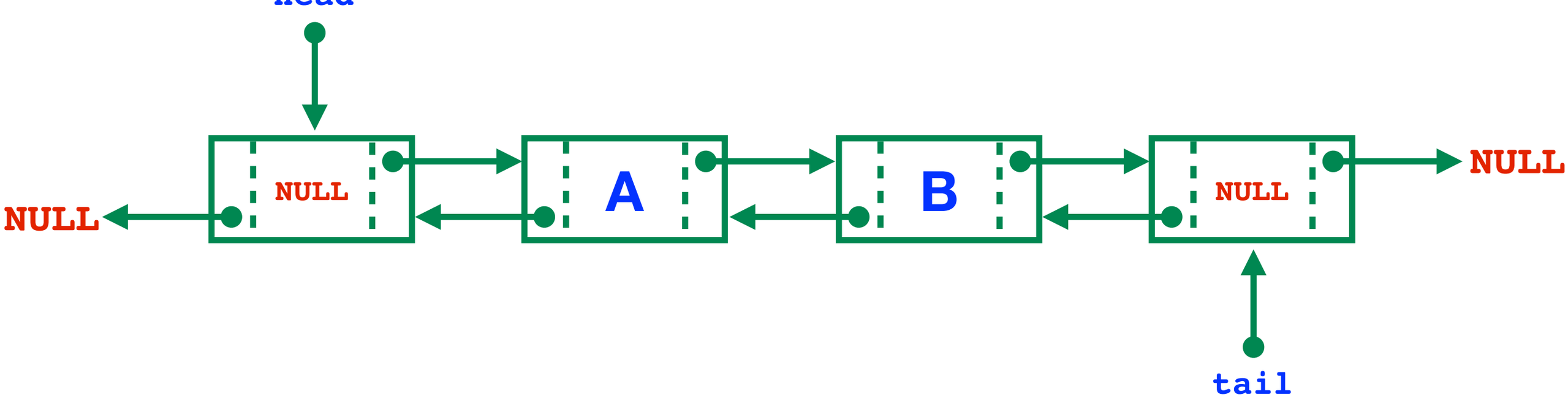
- **To check for empty:** `(head.next == tail);`
- **When traversing the list check to see if current position points to either the `head` or the `tail` to determine if at the end of the list**

Empty list



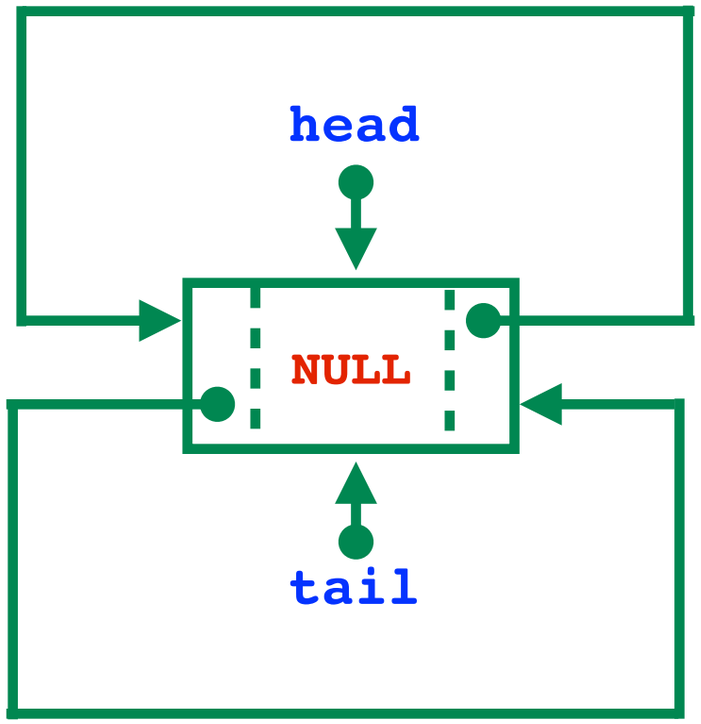
Doubly Linked List with Two Sentinel Nodes

List with two nodes



Circular Doubly Linked List with a Sentinel Node

Empty list



How should `isEmpty( )` be implemented?

Circular Doubly Linked List with a Sentinel Node

List with two nodes