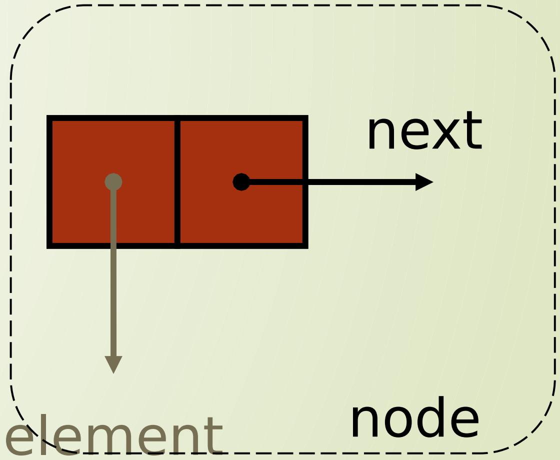
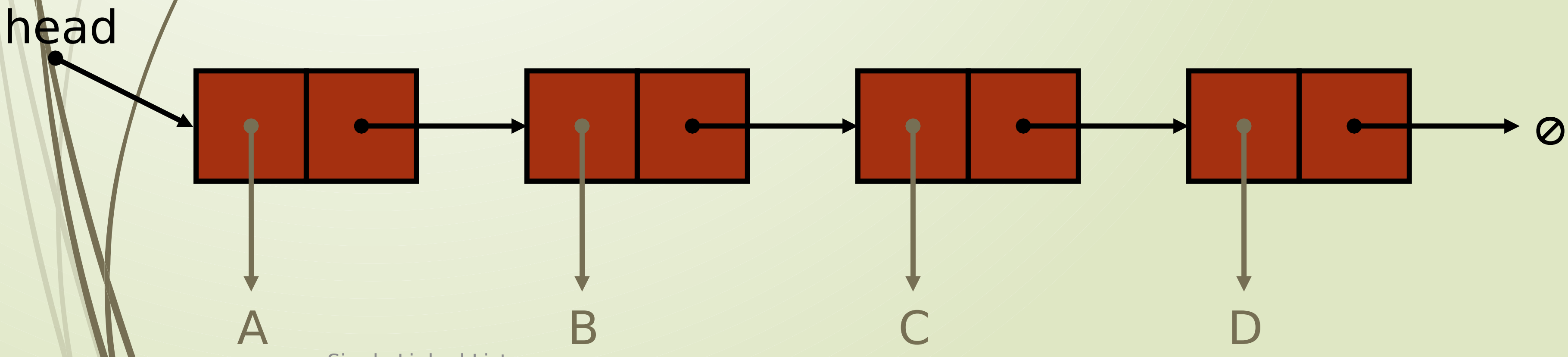
Linked Lists

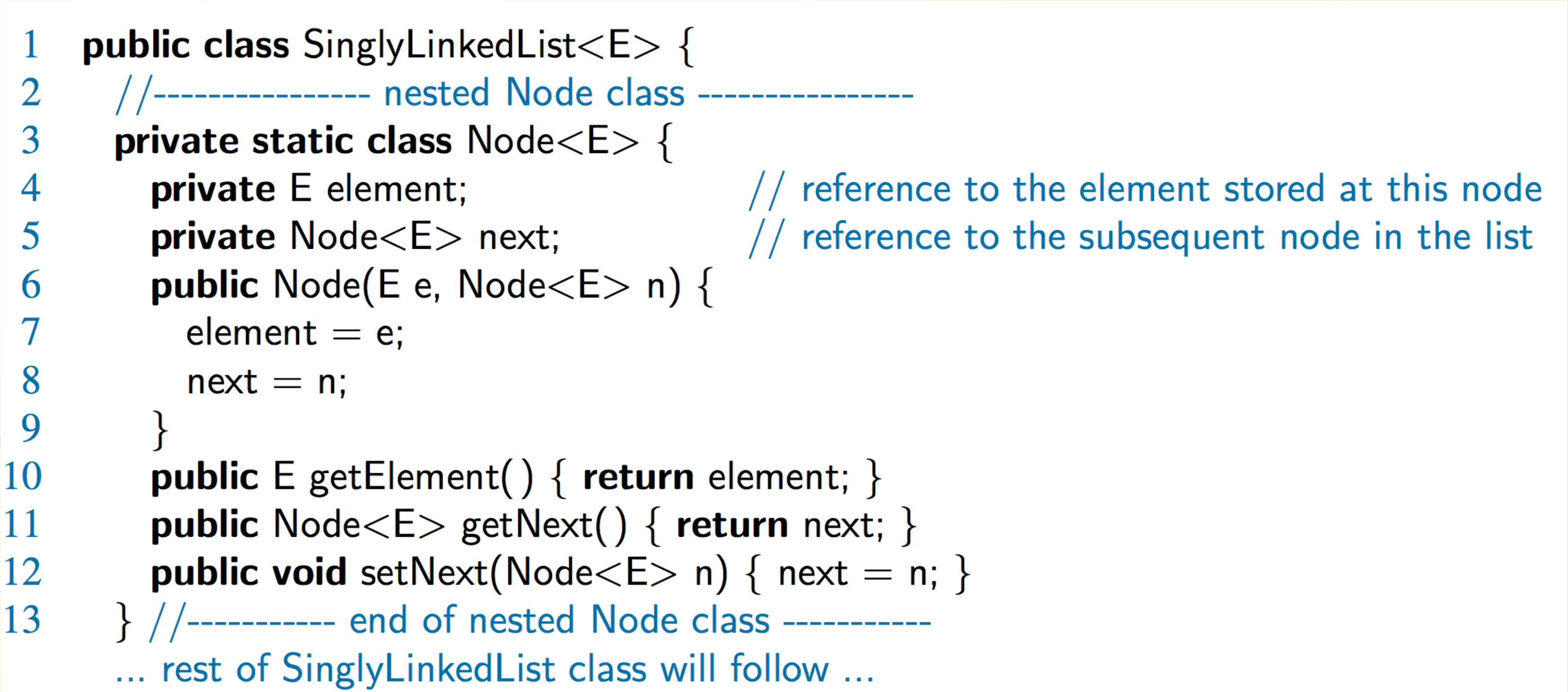
Linked List

- A linked list is a concrete data structure consisting of a sequence of nodes, starting from a head pointer
- Each node stores
  - element
  - link to the next node



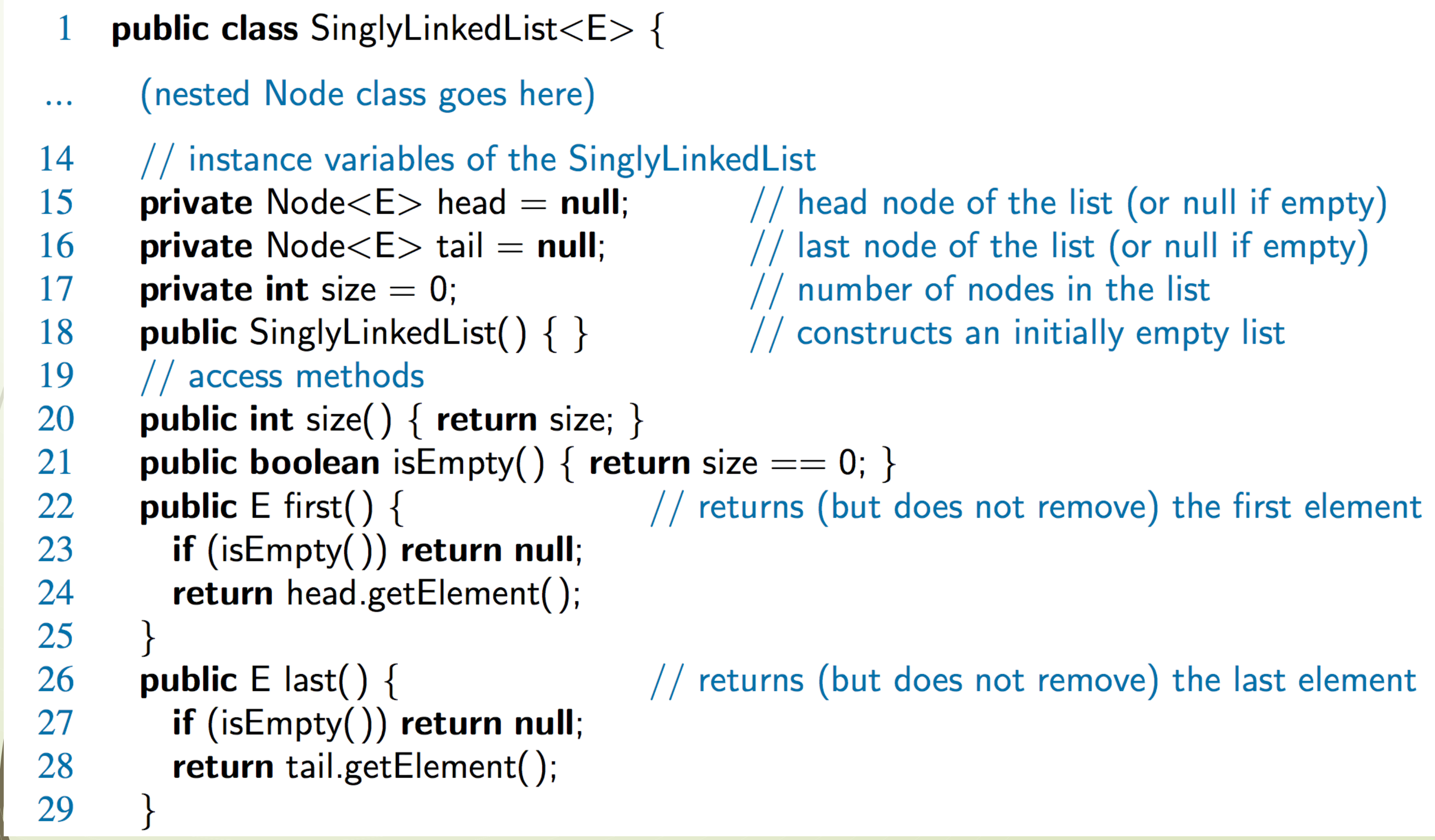


A Nested Node Class



```
public class SinglyLinkedList<E> {
  //---------------- nested Node class ----------------
  private static class Node<E> {
    private E element;                // reference to the element stored at this node
    private Node<E> next;             // reference to the subsequent node in the list
    public Node(E e, Node<E> n) {
      element = e;
      next = n;
    }
    public E getElement( ) { return element; }
    public Node<E> getNext( ) { return next; }
    public void setNext(Node<E> n) { next = n; }
  } //----------- end of nested Node class -----------
  ... rest of SinglyLinkedList class will follow ...
```

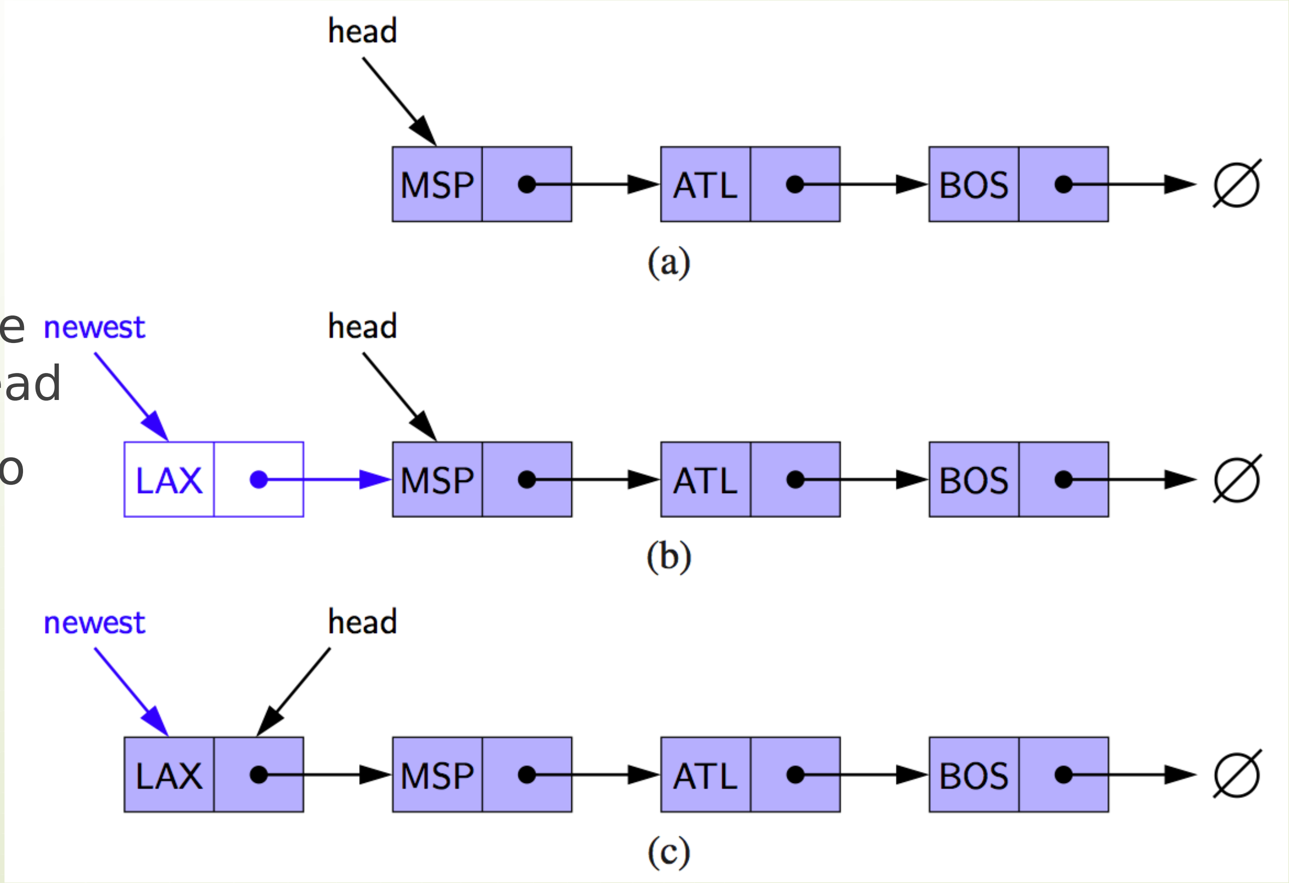
Accessor Methods



```
public class SinglyLinkedList<E> {
   (nested Node class goes here)
   // instance variables of the SinglyLinkedList
   private Node<E> head = null;               // head node of the list (or null if empty)
   private Node<E> tail = null;               // last node of the list (or null if empty)
   private int size = 0;                      // number of nodes in the list
   public SinglyLinkedList( ) { }             // constructs an initially empty list
   // access methods
   public int size( ) { return size; }
   public boolean isEmpty( ) { return size == 0; }
   public E first( ) {                     // returns (but does not remove) the first element
     if (isEmpty( )) return null;
     return head.getElement( );
   }
   public E last( ) {                      // returns (but does not remove) the last element
     if (isEmpty( )) return null;
     return tail.getElement( );
   }
```

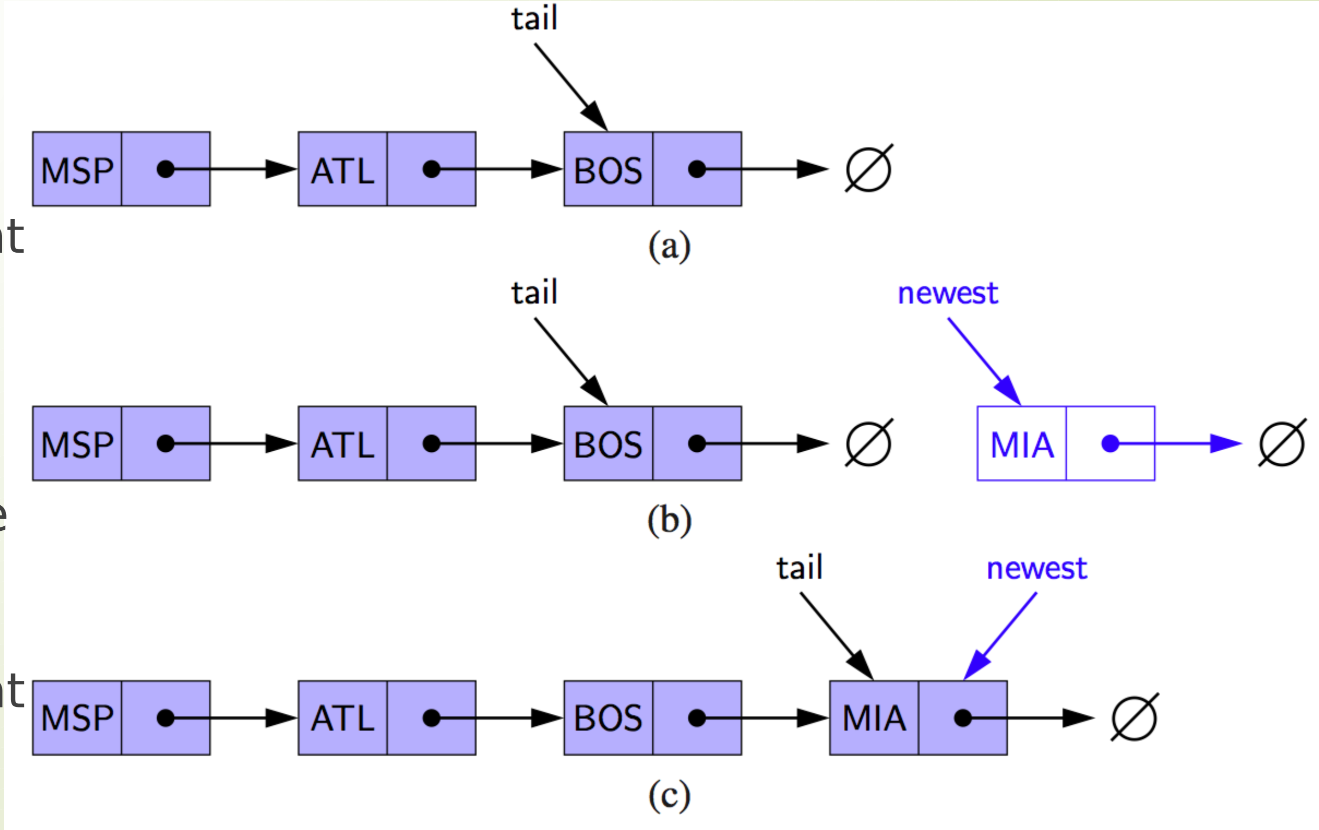
Inserting at the Head

- Allocate new node
- Insert new element
- Have new node point to old head
- Update head to point to new node

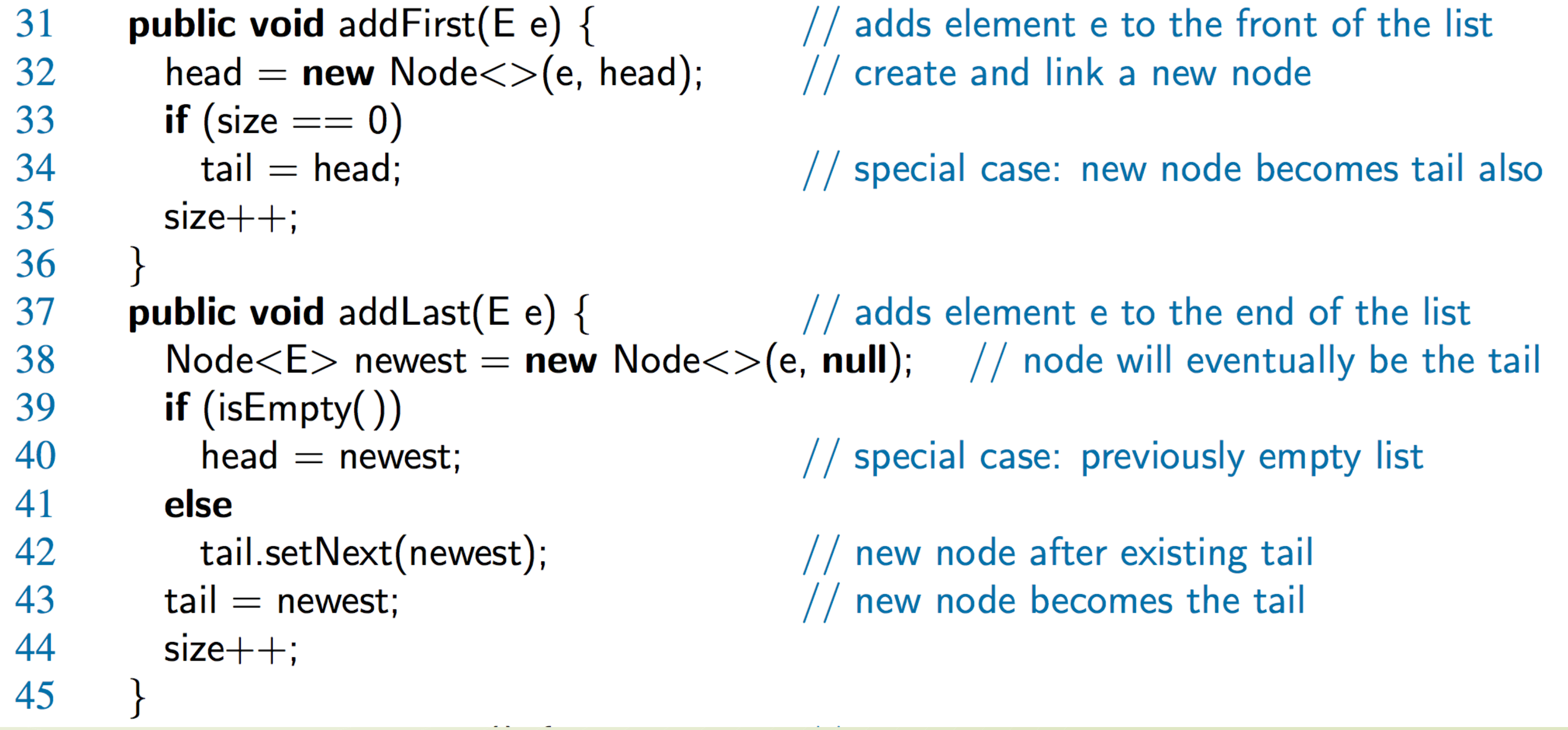


Inserting at the Tail

- Allocate a new node
- Insert new element
- Have new node point to null
- Have old last node point to new node
- Update tail to point to new node



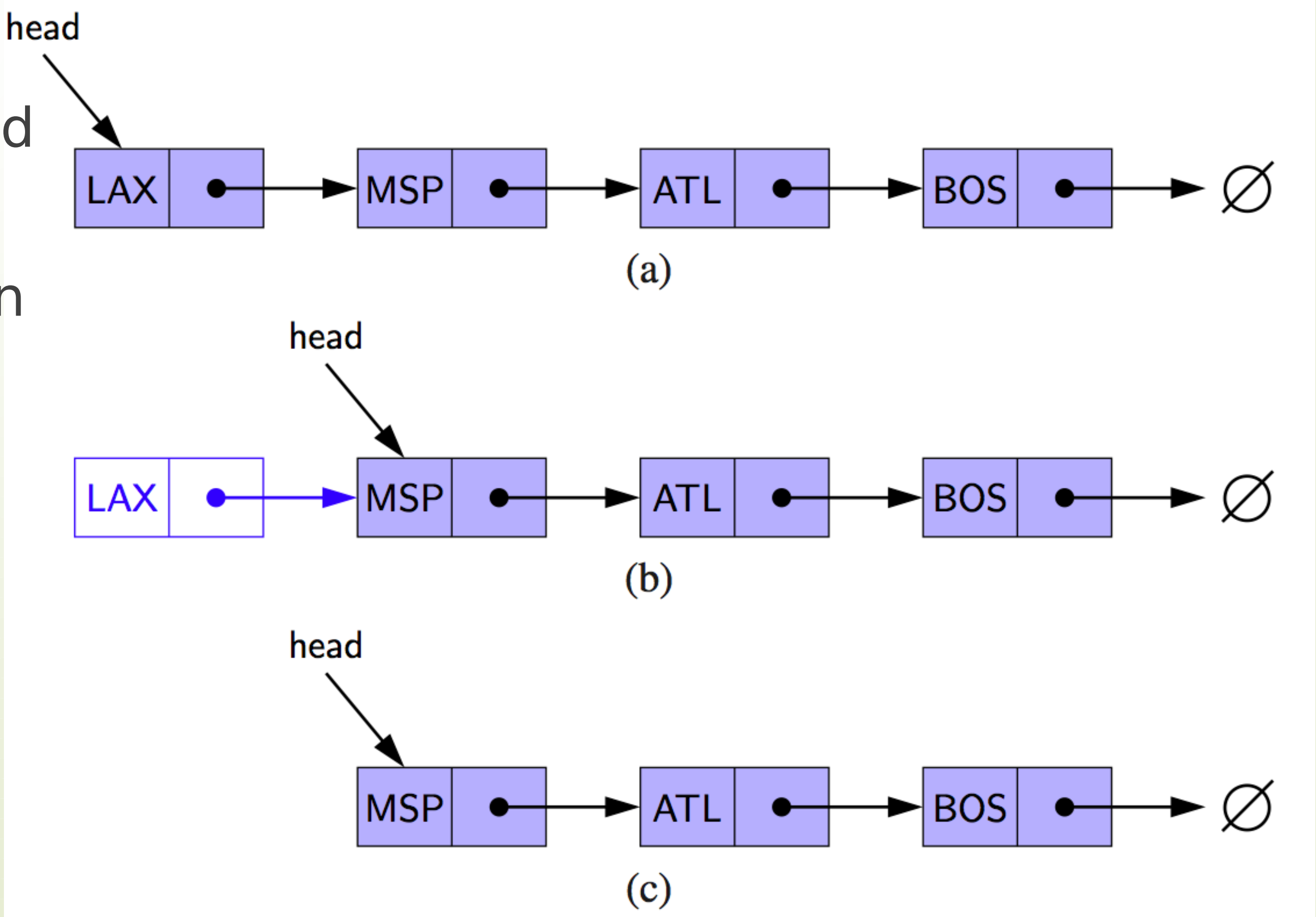
Java Methods



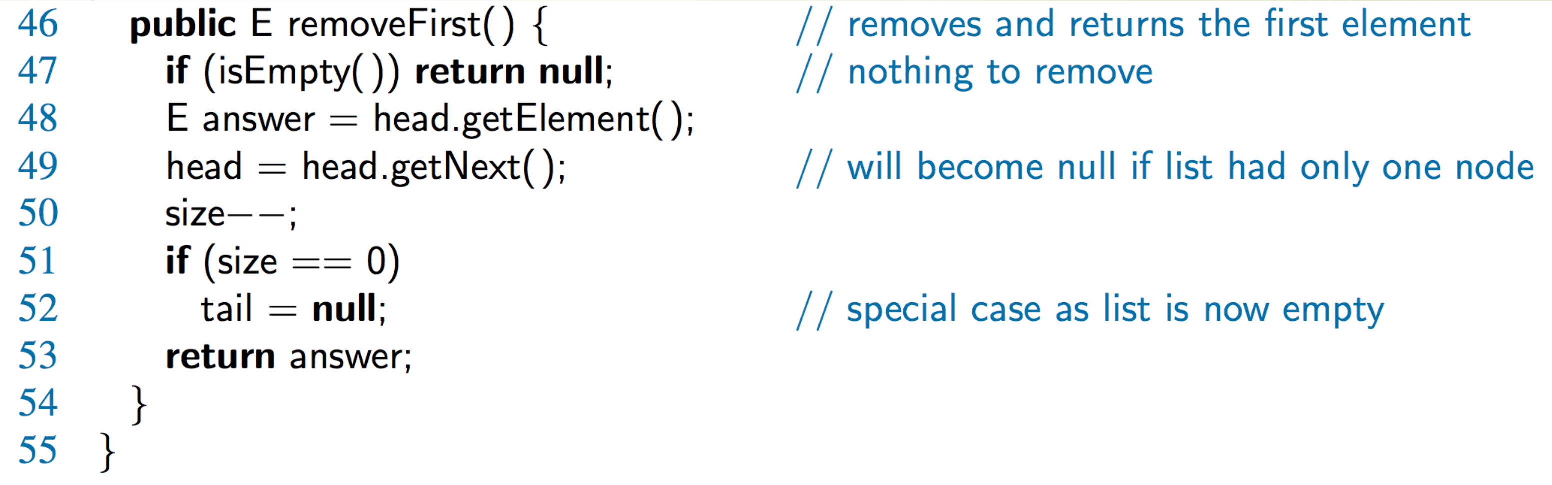
```
public void addFirst(E e) {                  // adds element e to the front of the list
  head = new Node<>(e, head);                // create and link a new node
  if (size == 0)
    tail = head;                             // special case: new node becomes tail also
  size++;
}
public void addLast(E e) {                   // adds element e to the end of the list
  Node<E> newest = new Node<>(e, null);      // node will eventually be the tail
  if (isEmpty())
    head = newest;                           // special case: previously empty list
  else
    tail.setNext(newest);                    // new node after existing tail
  tail = newest;                             // new node becomes the tail
  size++;
}
```

Removing at the Head

- Update head to point to next node in the list
- Allow garbage collector to reclaim the former first node



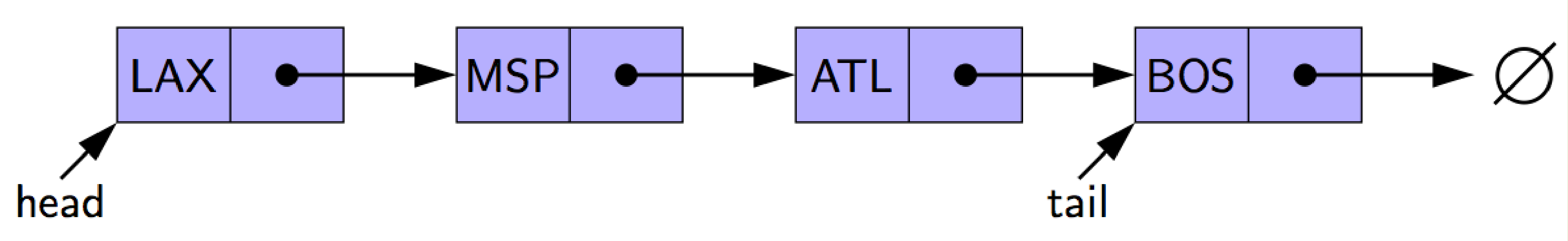
Java Method



```
  public E removeFirst( ) {                  // removes and returns the first element
    if (isEmpty( )) return null;             // nothing to remove
    E answer = head.getElement( );
    head = head.getNext( );                  // will become null if list had only one node
    size−−;
    if (size == 0)
      tail = null;                           // special case as list is now empty
    return answer;
  }
}
```

Removing at the Tail

- Removing at the tail of a singly linked list is not efficient!
- There is no constant-time way to update the tail to point to the previous node


LAX
MSP
ATL
BOS
∅
head
tail