Lecture 11: Singly Linked Lists

CS 62

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Writing code

- No complex code ever works the first time.
- Neither the "If I just fix this last thing…" attitude.
- Think about testing before you write the code.
- Comment before you write the code.
- Never write more than a method without testing it.
- We will talk about JUnits in lab next week.
- Once satisfied, commit your work.

List ADT

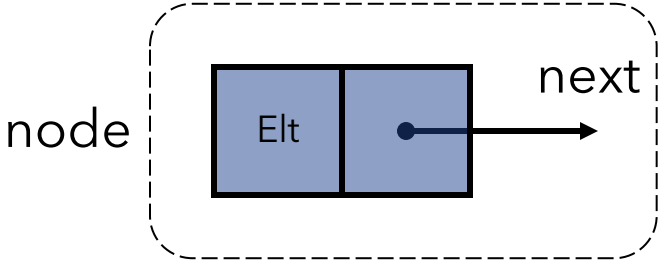
```
public abstract class AbstractList<E>{
    public AbstractList() { }
    public boolean isEmpty() { return size() == 0; }
    public void addFirst(E value) {add(0,value); }
    public void addLast(E value) {add(size(),value);}
    public E getFirst() { return get(0);}
    public E getLast() {return get(size()-1);}
    public E removeFirst() { return remove(0); }
    public E removeLast() { return remove(size()-1); }
    public void add(E value) { addLast(value);}
    public E remove() { return removeLast();}
    public E get() { return getLast(); }
    public boolean contains(E value) {
        return -1 != indexOf(value); }
```

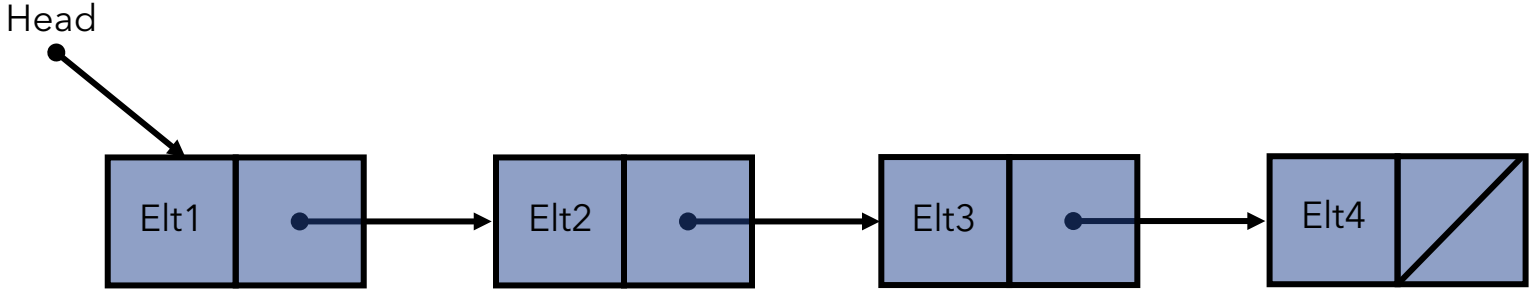
Linked List

- A data structure consisting of a linear sequence of nodes
  - Think of them as snap-lock beads
  - Varying length
- Alternate implementation of an abstract list
  - `Vector` (ArrayList) in `structure5` also extends `AbstractList`
- Trade-offs in complexity:
  - In ArrayList, adding elements is expensive at beginning of list
  - For Linked lists, it is inexpensive to add elements in early positions
  - However, accessing the i-th element is slow

Singly Linked List

- A linked list consisting of a sequence of nodes, starting from a head pointer
- Each node stores
  - Element
  - Link to the next node





```java
public class Node<E>{
	protected E data; // value stored in this element
	protected Node<E> nextElement; // ref to next

	public Node(E v, Node<E> next) {
		data = v;
		nextElement = next; // construct the new head of a singly linked list
	}
	public Node(E v) {
		this(v,null); // constructs a new tail of a list with value v
	}
	public Node<E> next() {
		return nextElement; // returns reference to next value in list
	}
	public void setNext(Node<E> next) {
		nextElement = next; // sets reference to new next value
	}
	public E value() {
		return data; // returns value associated with this element
	}
	public void setValue(E value) {
		data = value; // sets value associated with this element
	}
```

SinglyLinkedList

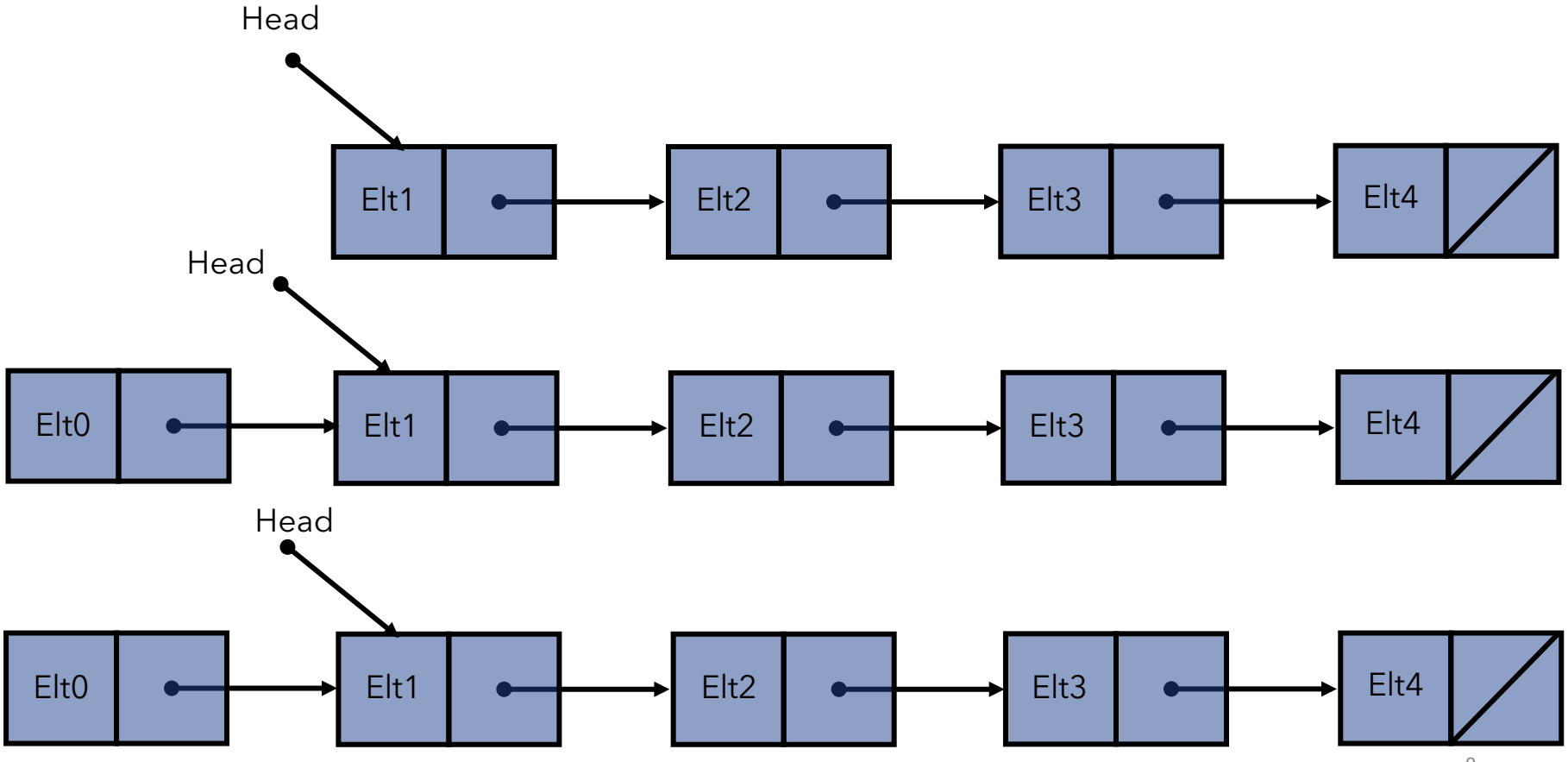
```
public class SinglyLinkedList<E> extends AbstractList<E> {
	protected int count; // list
	protected Node<E> head; // ref. to first element


	//construct an empty list
	public SinglyLinkedList() {
		head = null;
		count = 0;
	 }
	public E getFirst() {
		return head.value(); //returns first value in list
	}
	public int size() {
		return count;
	}
```

Possible operations

A node can be added/removed:

- At the beginning of the list
- At the end of the list
- Between nodes
- In an empty list (addition only)

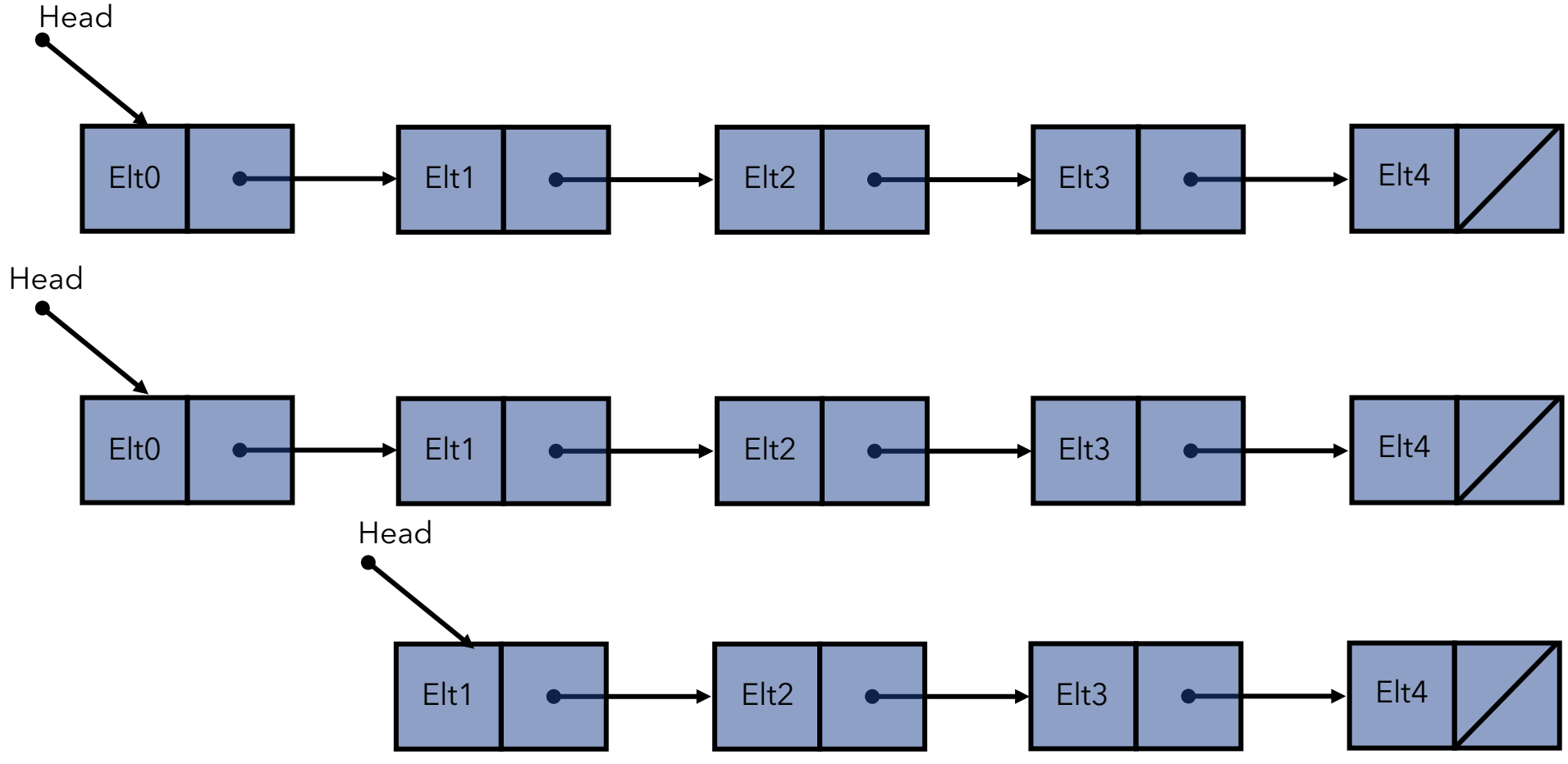
Adding at the head



Adding at the head is $O(1)$

```
public void addFirst(E value){
    // note order that things happen:
    // head is parameter, then assigned
    head = new Node<E>(value, head);
    count++;
}
```

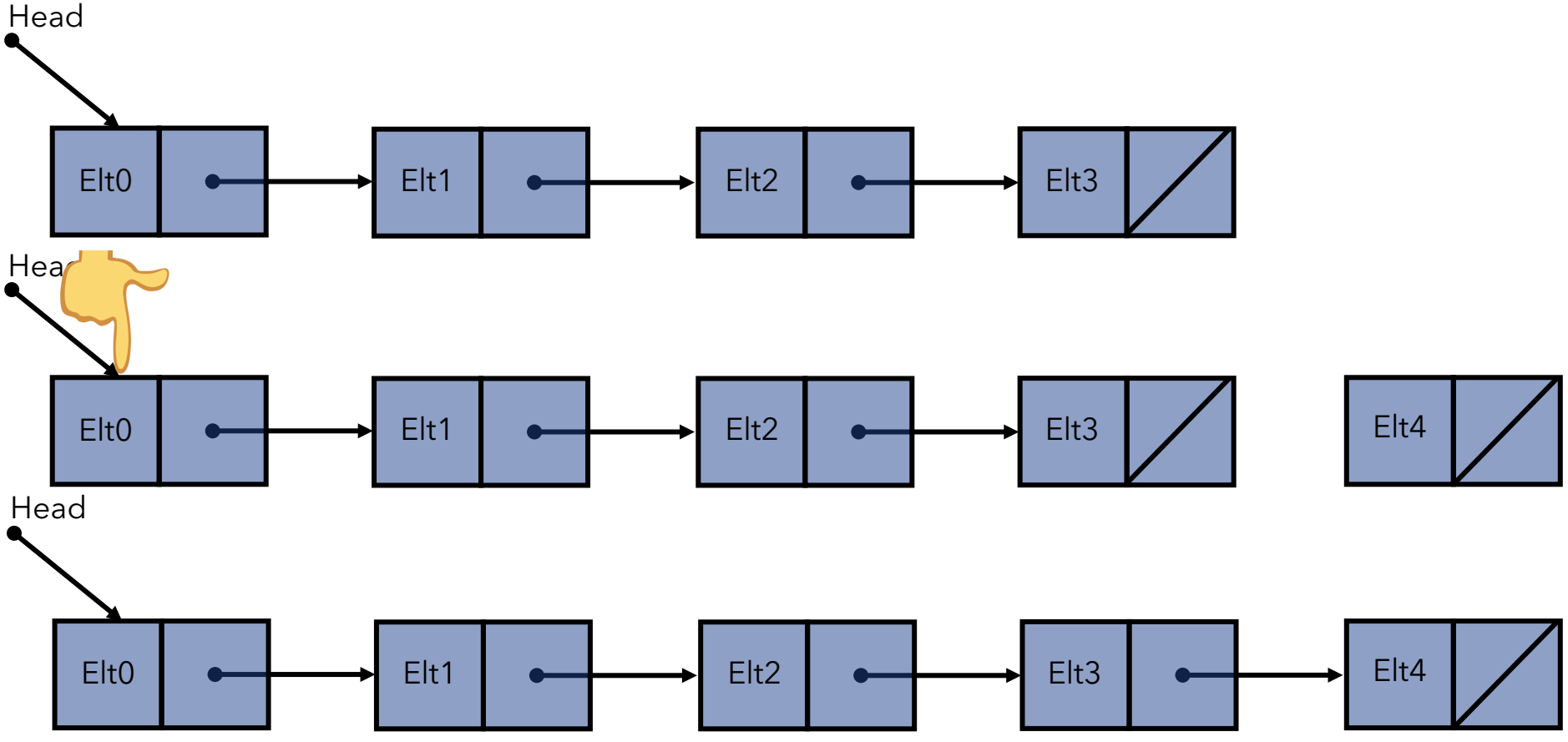
Removing at the head



Removing at the head is $O(1)$

```
public E removeFirst(){
     Node<E> temp = head;
     head = head.next(); // move head down list
     count--;
     return temp.value();
}
```

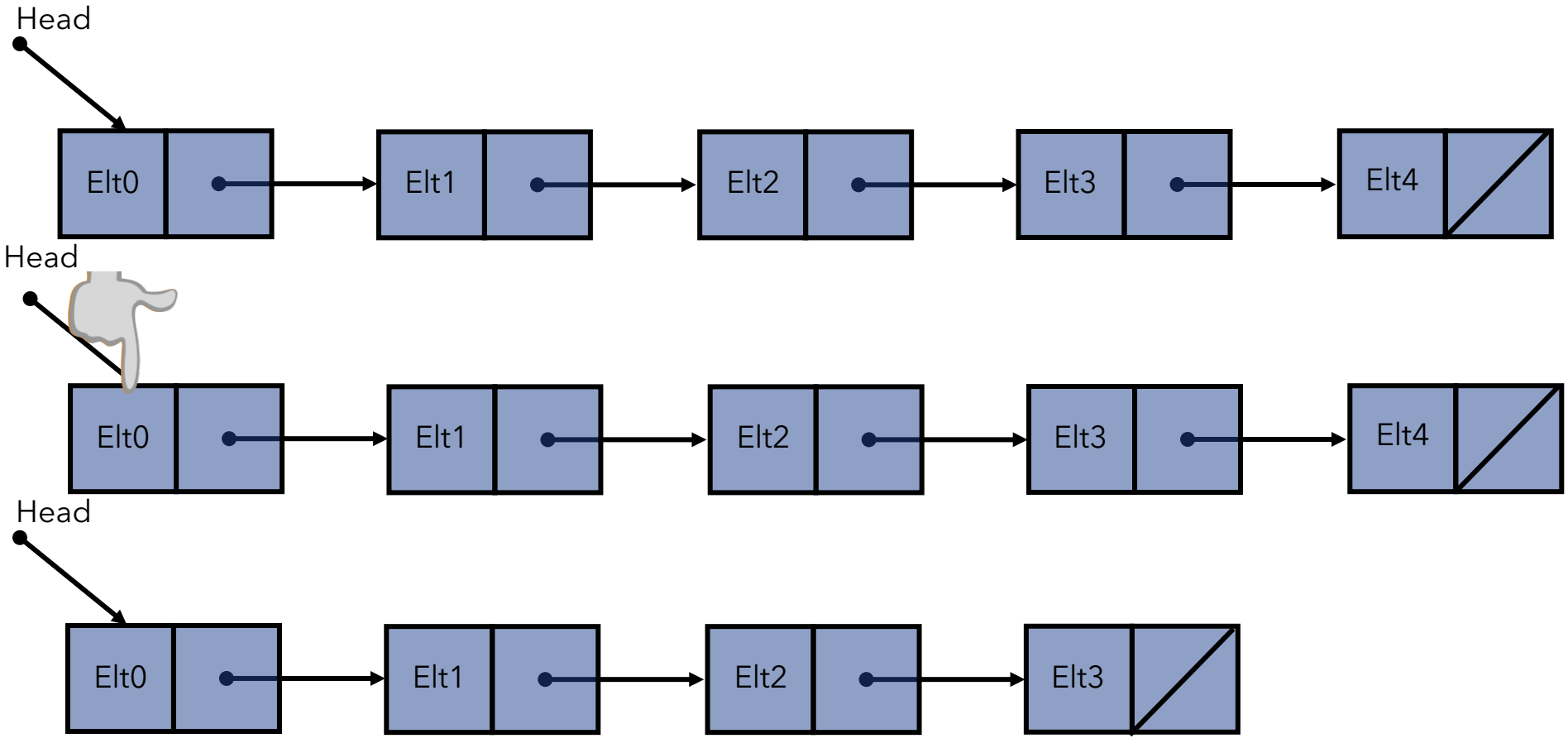
Adding at the end



Adding at the end is $O(n)$

```
public void addLast(E value) {
      // location for new value
      Node<E> temp = new Node<E>(value,null);
      if (head != null) {
            // pointer to possible tail
            Node<E> finger = head;
            while (finger.next() != null) {
                  finger = finger.next();
            }
           finger.setNext(temp);
      }
      else head = temp; //empty list
      count++;
}
```

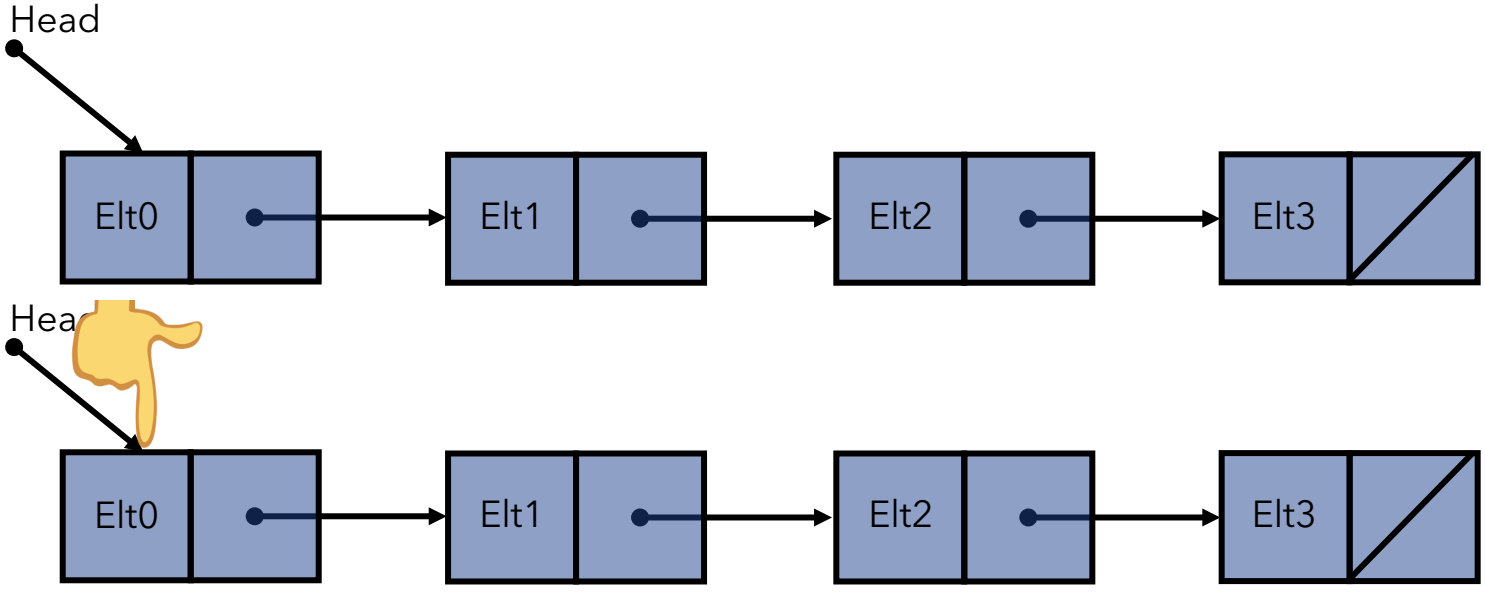
Removing from the end



Removing from the end is $O(n)$

```
public E removeLast() {
	Node<E> finger = head;
	Node<E> previous = null;
	//throw an exception if list is empty
	while (finger.next() != null)
	{
		previous = finger;	// find end of list
		finger = finger.next();
	}
	// finger is null, or points to end of list
	if (previous == null) {
		head = null;	// has exactly one element
	} else{
		previous.setNext(null); // pointer to last element is reset
	}
	count--;
	return finger.value();
}
```

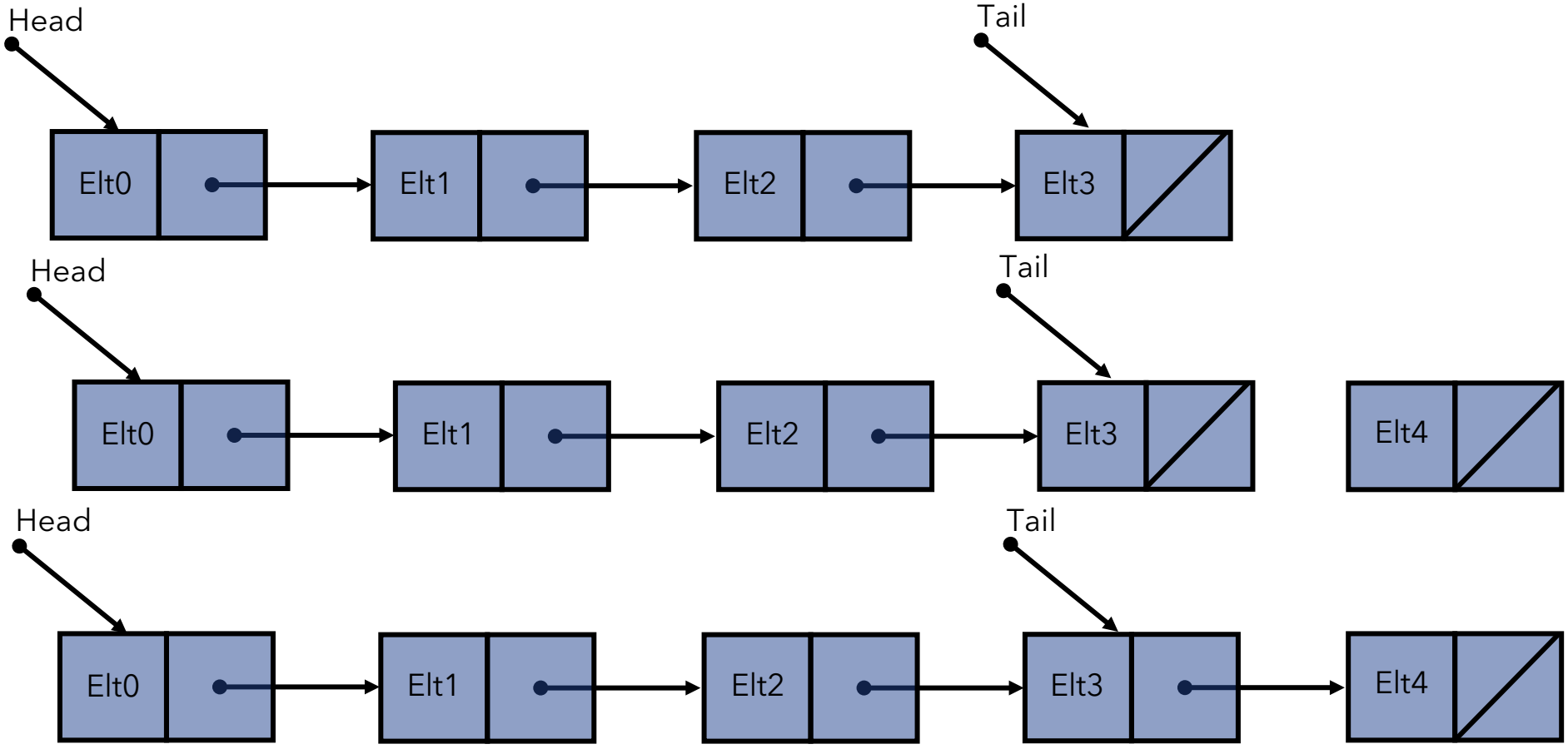
Getting the last element



Getting the last element is $O(n)$

```
public E getLast() {
      Node<E> finger = head;
      //throw exception if list is empty
      while (finger != null && finger.next() != null)
      {
            finger = finger.next();
      }
      return finger.value();
}
```

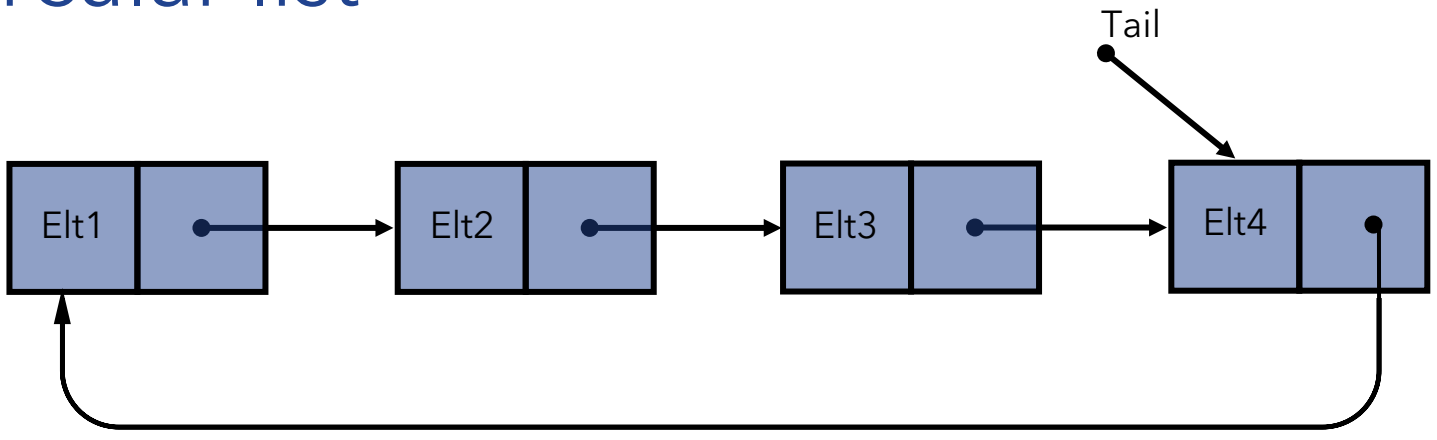
Adding when having a tail pointer is $O(1)$



Removing at the tail is $O(n)$

- We still have to traverse the whole linked list – not efficient!

Circular list



- Accessing/modifying the head or the tail is $O(1)$.
- Circular lists are as space-efficient as singly linked lists but tail-related operations are less costly.