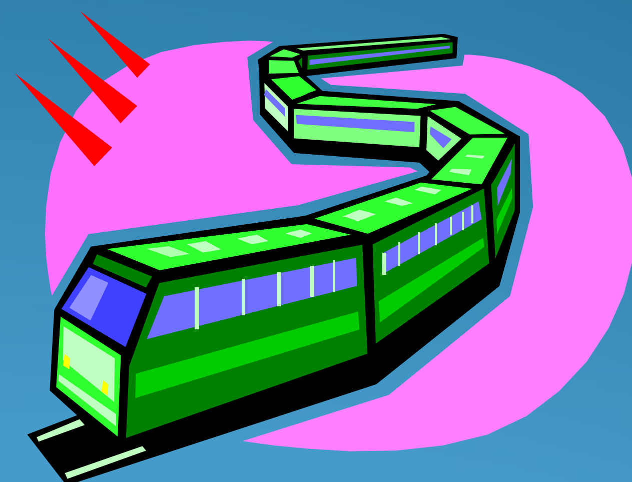
DATA STRUCTURES USING 'C'

Linked Lists



Arrays: pluses and minuses

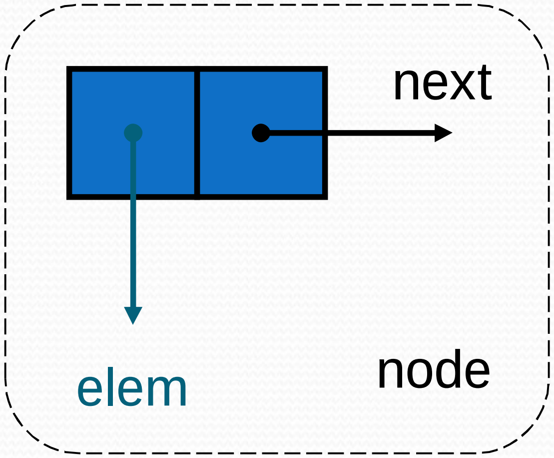
+ Fast element access.

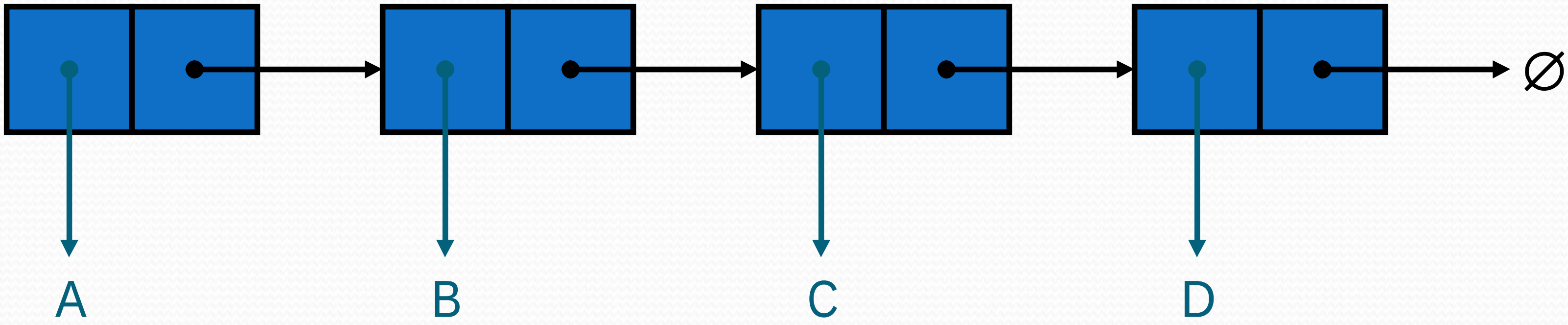
-- Impossible to resize.

- Many applications require resizing!
- Required size not always immediately available.

Singly Linked Lists

- A singly linked list is a concrete data structure consisting of a sequence of nodes
- Each node stores
  - element
  - link to the next node





Recursive Node Class

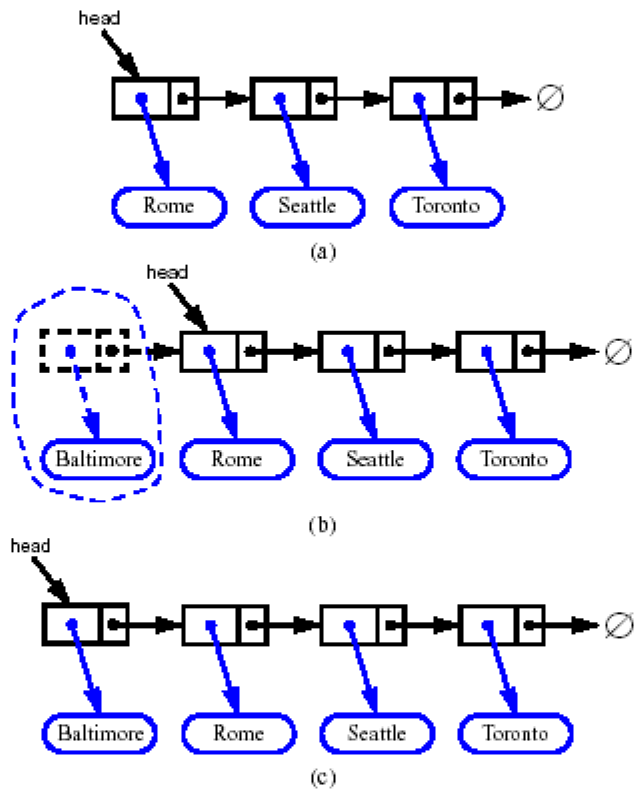
```
public class Node {
    // Instance variables:
    private Object element;
    private Node next;
    /** Creates a node with null references to its element and next node. */
    public Node() {
      this(null, null);
    }
    /** Creates a node with the given element and next node. */
    public Node(Object e, Node n) {
        element = e;
        next = n;
    }
    // Accessor methods:
    public Object getElement() {
      return element;
    }
    public Node getNext() {
      return next;
    }
    // Modifier methods:
    public void setElement(Object newElem) {
        element = newElem;
    }
    public void setNext(Node newNext) {
        next = newNext;
    }
}
```

Singly linked list

```
public class SLinkedList {
    protected Node head; // head node of the list
    /** Default constructor that creates an empty list */
    public SLinkedList() {
            head = null;
    }
    // ... update and search methods would go here ...
}
```

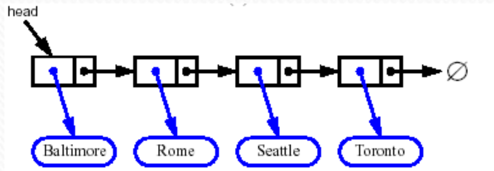
Inserting at the Head

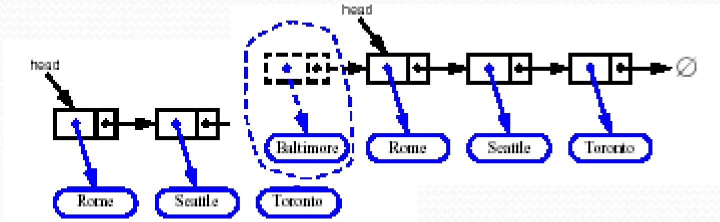
1. Allocate a new node
2. Insert new element
3. Make new node point to old head
4. Update head to point to new node



Removing at the Head

1. Update head to point to next node in the list
2. Allow garbage collector to reclaim the former first node



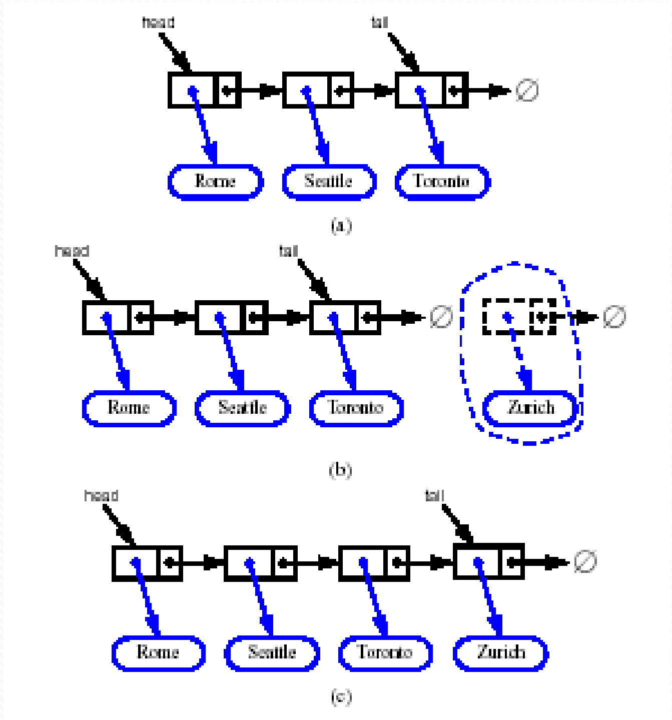


Singly linked list with ‘tail’ sentinel

```
public class SLinkedListWithTail {
    protected Node head; // head node of the list
    protected Node tail; // tail node of the list
    /** Default constructor that creates an empty list */
    public SLinkedListWithTail() {
            head = null;
            tail = null;
    }
    // ... update and search methods would go here ...
}
```

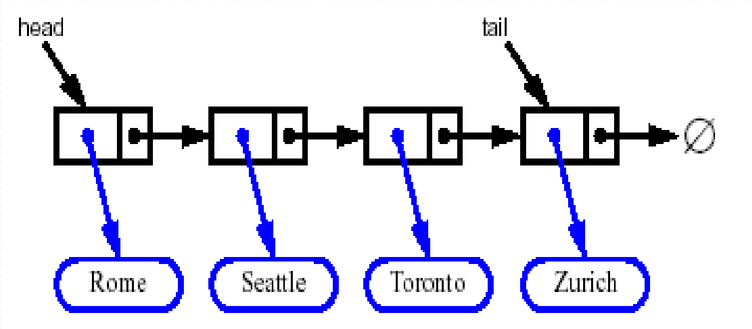
Inserting at the Tail

1. Allocate a new node
2. Insert new element
3. Have new node point to null
4. Have old last node point to new node
5. Update tail to point to new node



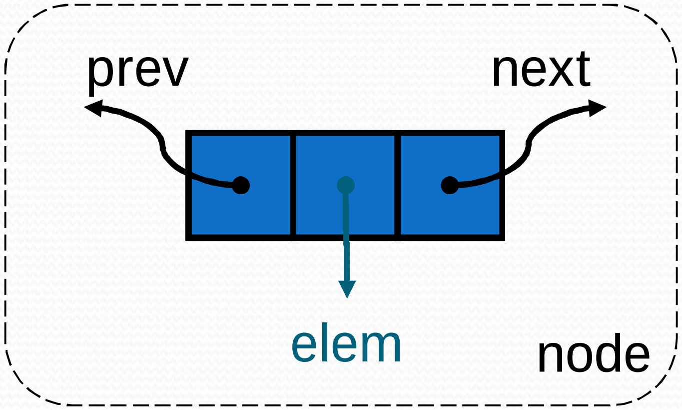
Removing at the Tail

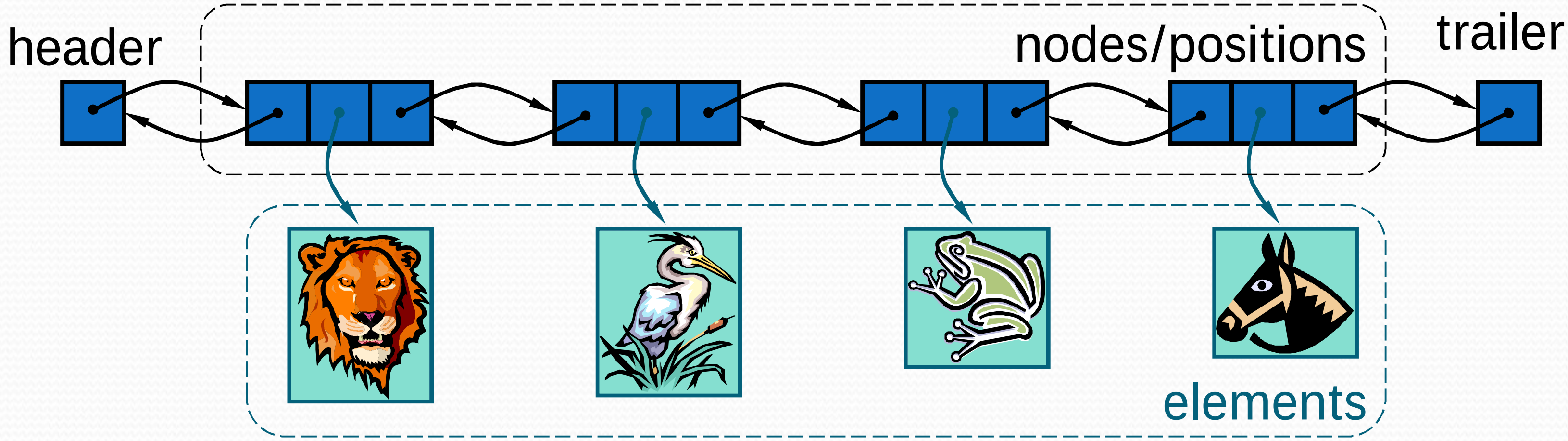
- Removing at the tail of a singly linked list cannot be efficient!
- There is no constant-time way to update the tail to point to the previous node



Doubly Linked List

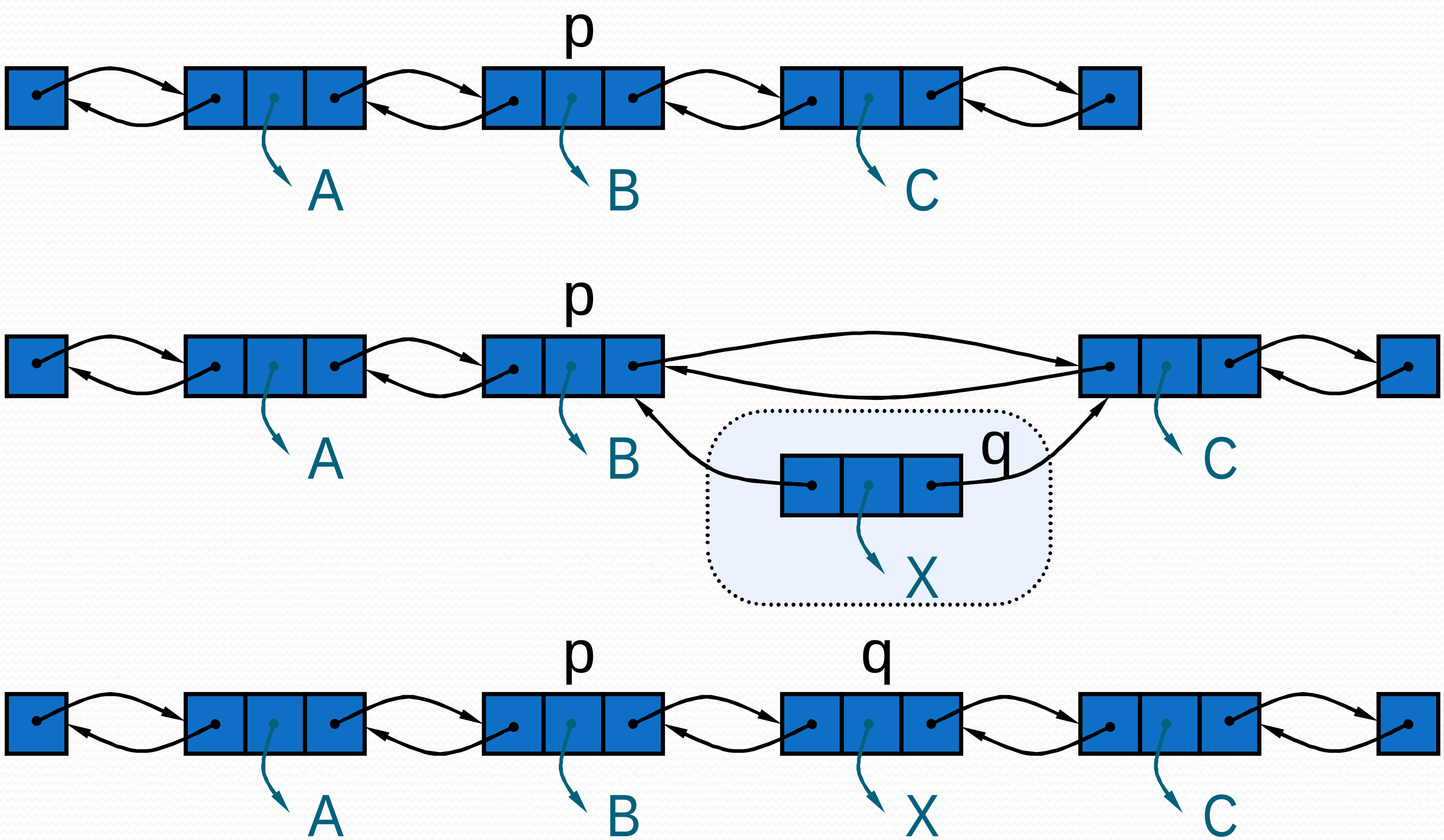
- A doubly linked list is often more convenient!
- Nodes store:
  - element
  - link to the previous node
  - link to the next node
- Special trailer and header nodes





Insertion

- We visualize operation insertAfter(p, X), which returns position q

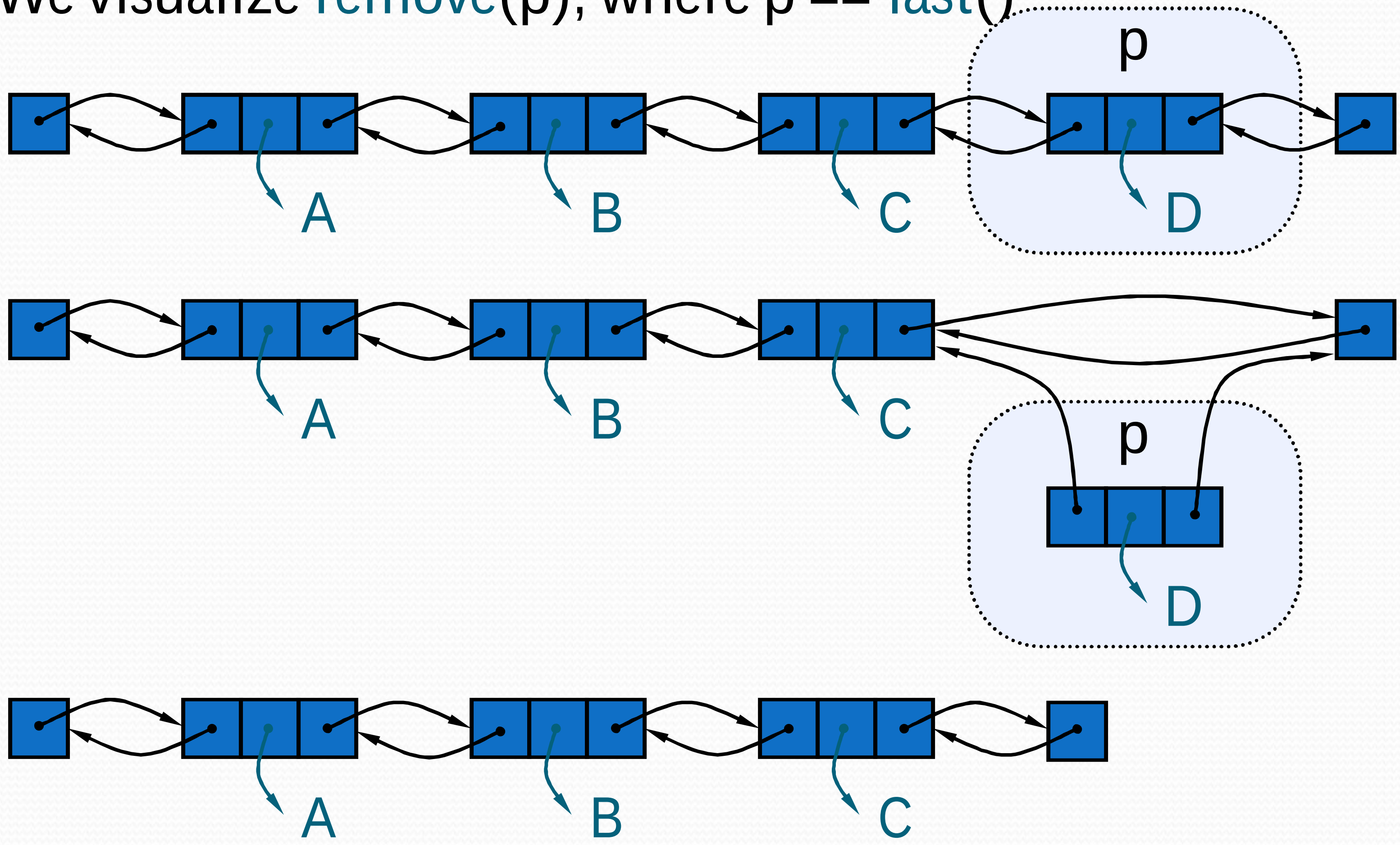


Insertion Algorithm

Algorithm insertAfter(*p*,*e*):
  Create a new node *v*
  v.setElement(*e*)
  v.setPrev(*p*) {link *v* to its predecessor}
  v.setNext(*p*.getNext()) {link *v* to its successor}
  (*p*.getNext()).setPrev(*v*) {link *p*’s old successor to *v*}
  p.setNext(*v*) {link *p* to its new successor, *v*}
  return *v* {the position for the element *e*}

Deletion

- We visualize remove(p), where p == last()



Deletion Algorithm

Algorithm remove(*p*):
    t = *p*.element {a temporary variable to hold the return value}
    (*p*.getPrev()).setNext(*p*.getNext()) {linking out *p*}
    (*p*.getNext()).setPrev(*p*.getPrev())
    p.setPrev(**null**) {invalidating the position *p*}
    p.setNext(**null**)
    return *t*

Worst-cast running time

- In a doubly linked list

  + insertion at head or tail is in O(1)

  + deletion at either end is on O(1)

  -- element access is still in O(n)