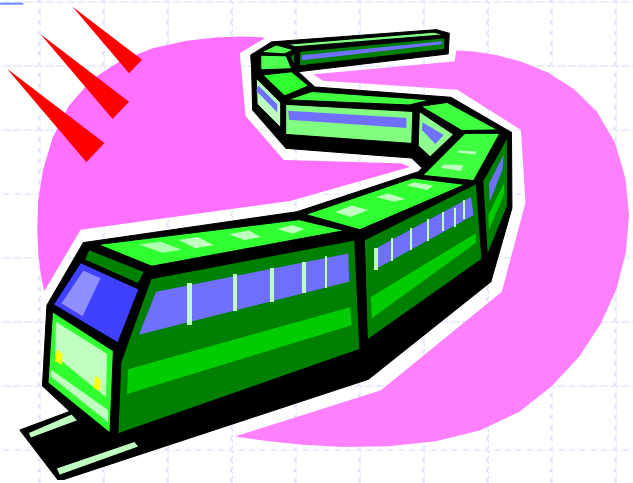
Lists



Position ADT

- The Position ADT models the notion of place within a data structure where a single object is stored
- It gives a unified view of diverse ways of storing data, such as
  - **a cell of an array**
  - **a node of a linked list**
- Just one method:
  - object element(): returns the element stored at the position

Node List ADT

- The Node List ADT models a sequence of positions storing arbitrary objects
- It establishes a before/after relation between positions
- Generic methods:
  - size(), isEmpty()

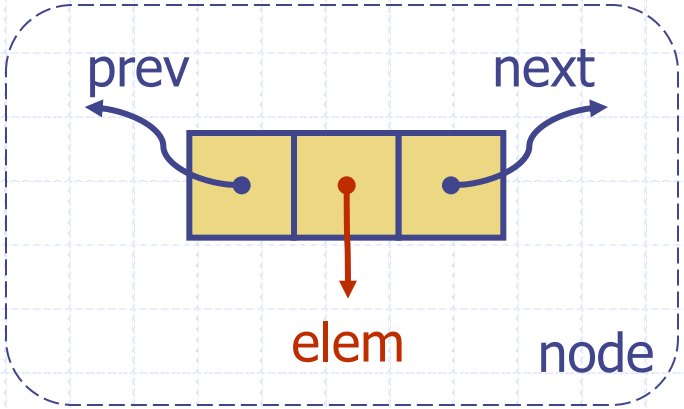
Accessor methods:

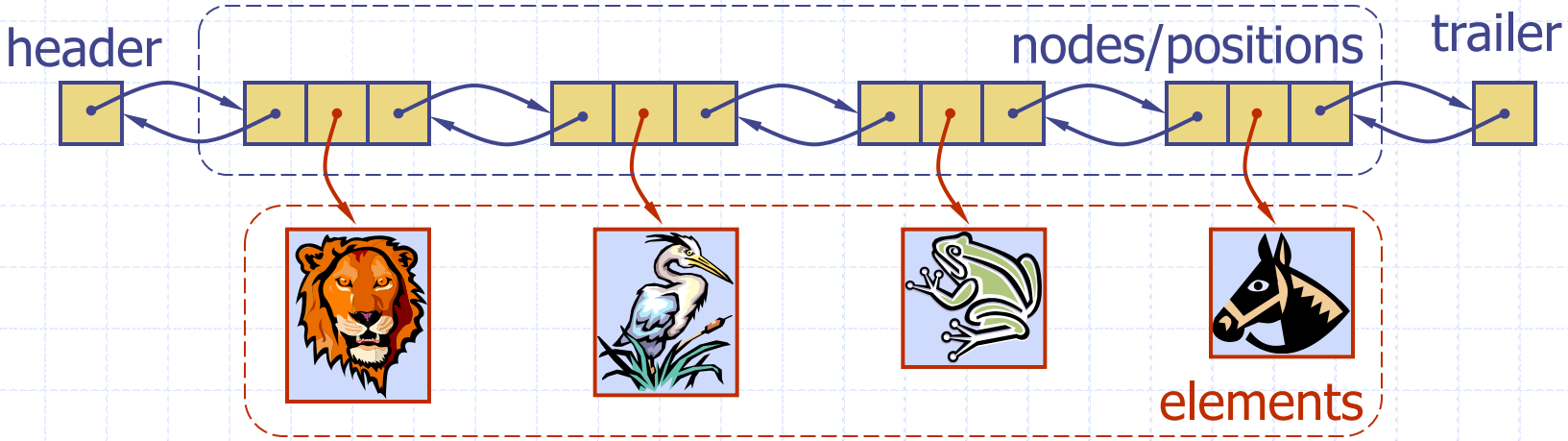
- first(), last()
- prev(p), next(p)

- Update methods:
  - set(p, e)
  - addBefore(p, e), addAfter(p, e),
  - addFirst(e), addLast(e)
  - remove(p)

Doubly Linked List

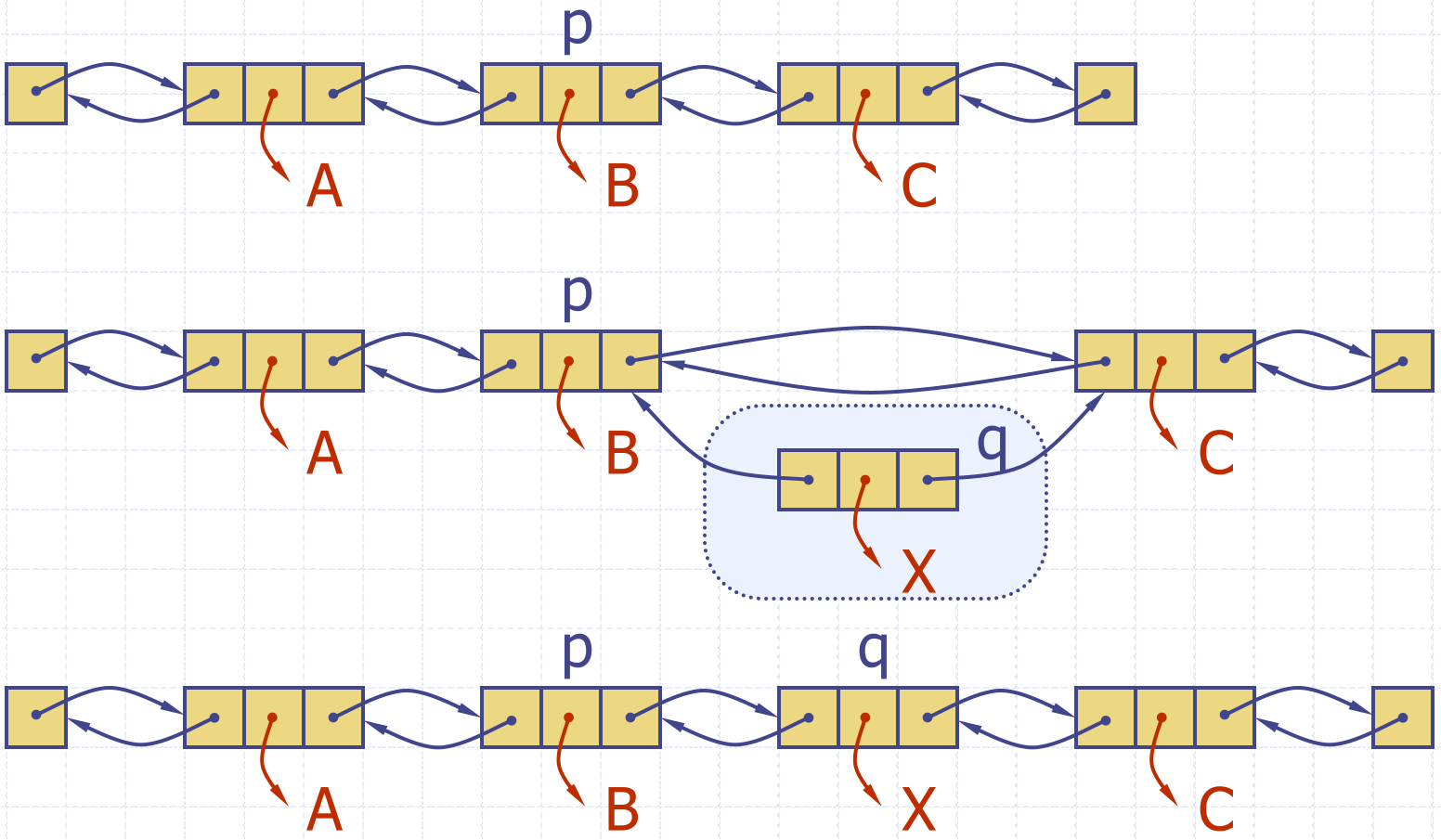
- A doubly linked list provides a natural implementation of the Node List ADT
- Nodes implement Position and store:
  - element
  - link to the previous node
  - link to the next node
- Special trailer and header nodes





Insertion

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



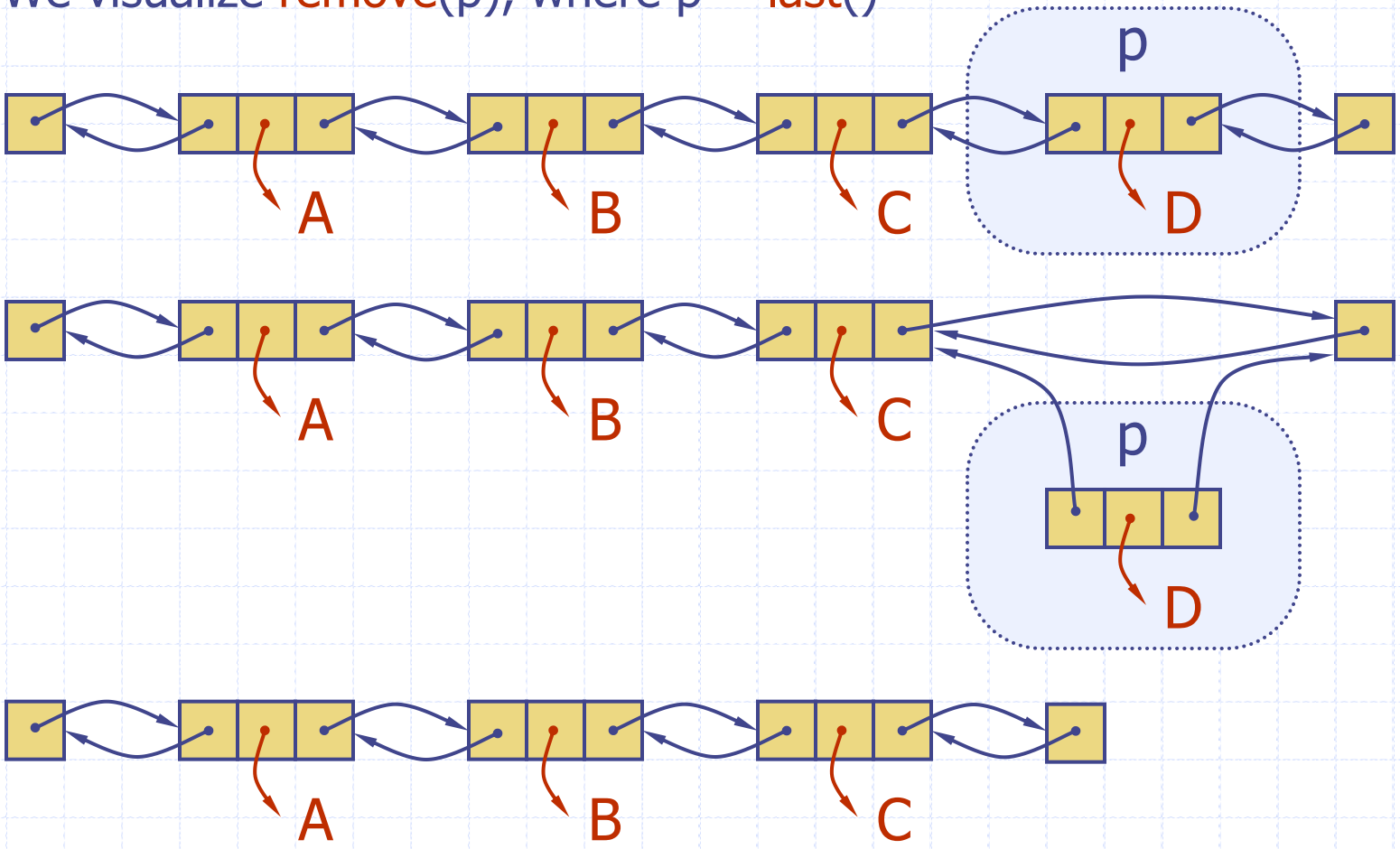
Insertion Algorithm

Algorithm addAfter(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
```

Performance

- In the implementation of the List ADT by means of a doubly linked list
  - The space used by a list with n elements is $O(n)$
  - The space used by each position of the list is $O(1)$
  - All the operations of the List ADT run in $O(1)$ time (assuming positions are used, not indices)
  - Operation element() of the Position ADT runs in $O(1)$ time

Applications

- Implementing a Stack
- http://www.cs.usfca.edu/~galles/visualization/StackLL.html

- Implementing a Queue
- http://www.cs.usfca.edu/~galles/visualization/QueueLL.html