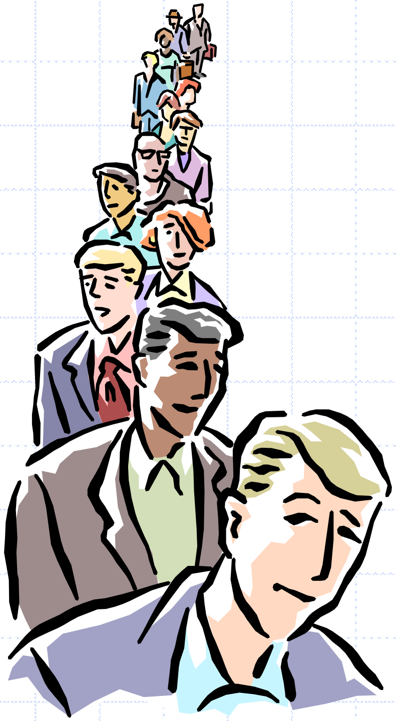
Iterators and Sequences



Containers and Iterators

- An iterator abstracts the process of scanning through a collection of elements
- A container is an abstract data structure that supports element access through iterators
    - begin(): returns an iterator to the first element
    - end(): return an iterator to an imaginary position just after the last element
- An iterator behaves like a pointer to an element
    - *p: returns the element referenced by this iterator
    - ++p: advances to the next element
- Extends the concept of position by adding a traversal capability

Containers

- Data structures that support iterators are called containers
- Examples include Stack, Queue, Vector, List
- Various notions of iterator:
    - (standard) iterator: allows read-write access to elements
    - const iterator: provides read-only access to elements
    - bidirectional iterator: supports both ++p and –p
    - random-access iterator: supports both p+i and p-i

Iterating through a Container

- Let C be a container and p be an iterator for C

```
for (p = C.begin(); p != C.end(); ++p)
        loop_body
```

- Example: (with an STL vector)

```
typedef vector<int>::iterator Iterator;
int sum = 0;
for (Iterator p = V.begin(); p != V.end(); ++p)
sum += *p;
return sum;
```

Implementing Iterators

- Array-based
  - array A of the n elements
  - index i that keeps track of the cursor
  - begin() = 0
  - end() = n (index following the last element)
- Linked list-based
  - doubly-linked list L storing the elements, with sentinels for header and trailer
  - pointer to node containing the current element
  - begin() = front node
  - end() = trailer node (just after last node)

STL Iterators in C++

- Each STL container type C supports iterators:
  - C::iterator – read/write iterator type
  - C::const_iterator – read-only iterator type
  - C.begin(), C.end() – return start/end iterators
- This iterator-based operators and methods:
  - *p: access current element
  - ++p, --p: advance to next/previous element
  - C.assign(p, q): replace C with contents referenced by the iterator range [p, q) (from p up to, but not including, q)
  - insert(p, e): insert e prior to position p
  - erase(p): remove element at position p
  - erase(p, q): remove elements in the iterator range [p, q)

Sequence ADT

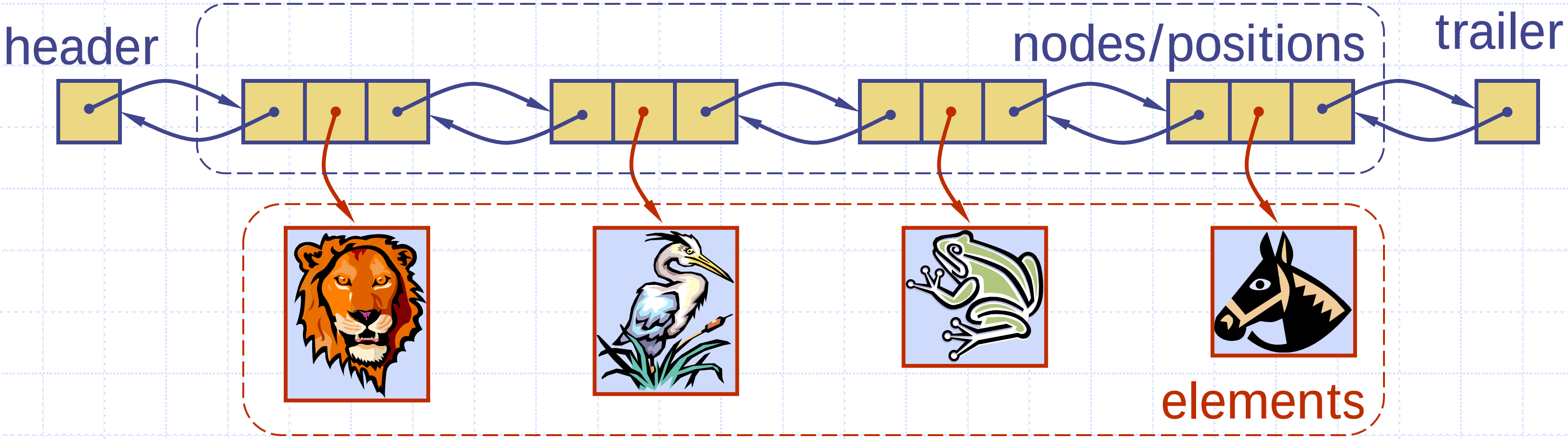
- The Sequence ADT is the union of the Array List and Node List ADTs
- Elements accessed by
  - Index, or
  - Position
- Generic methods:
  - size(), empty()
- ArrayList-based methods:
  - at(i), set(i, o), insert(i, o), erase(i)
- List-based methods:
  - begin(), end()
  - insertFront(o), insertBack(o)
  - eraseFront(), eraseBack()
  - insert (p, o), erase(p)
- Bridge methods:
  - atIndex(i), indexOf(p)

Applications of Sequences

- The Sequence ADT is a basic, general-purpose, data structure for storing an ordered collection of elements
- Direct applications:
  - Generic replacement for stack, queue, vector, or list
  - small database (e.g., address book)
- Indirect applications:
  - Building block of more complex data structures

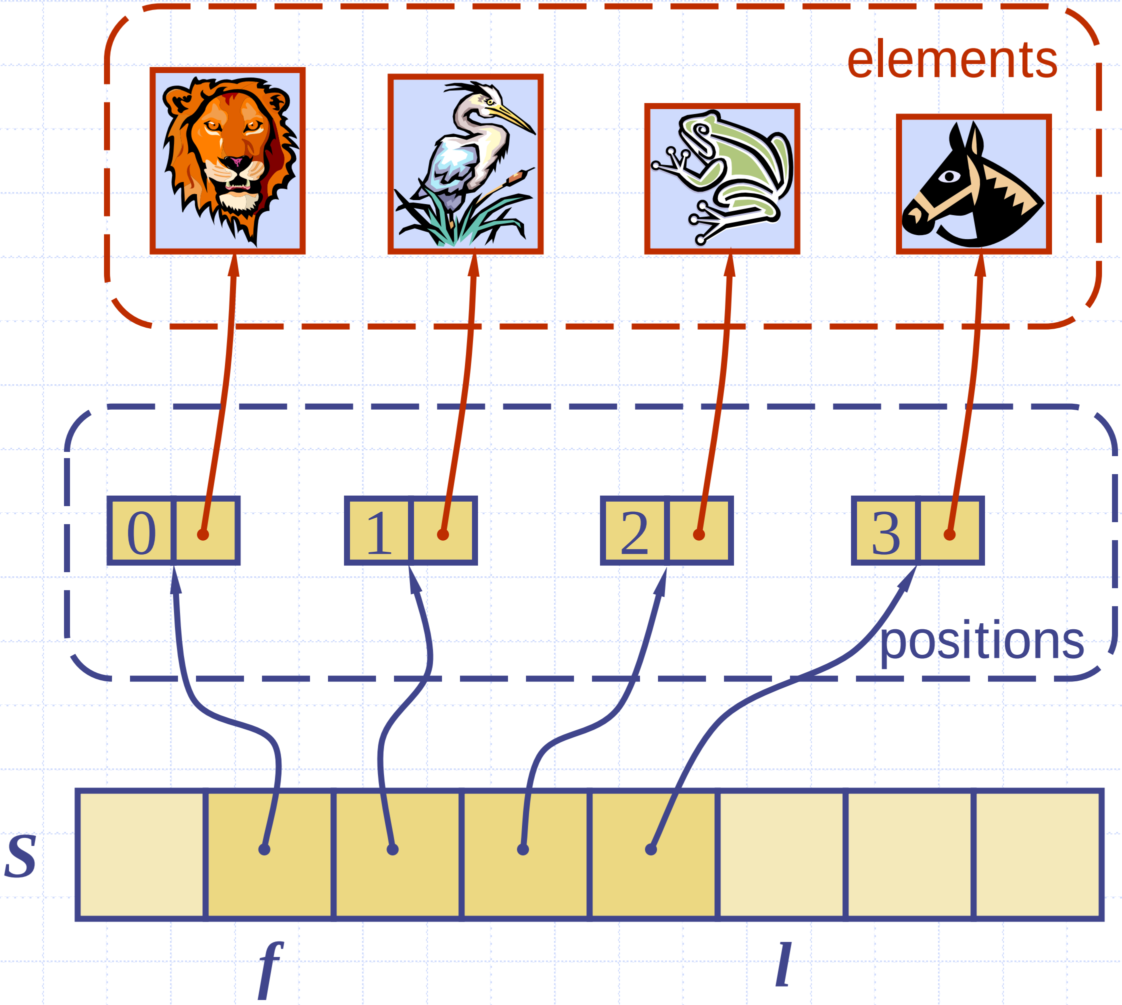
Linked List Implementation

- A doubly linked list provides a reasonable implementation of the Sequence ADT
- Nodes implement Position and store:
  - element
  - link to the previous node
  - link to the next node
- Special trailer and header nodes
- Position-based methods run in constant time
- Index-based methods require searching from header or trailer while keeping track of indices; hence, run in linear time



Array-based Implementation

- We use a circular array storing positions
- A position object stores:
  - Element
  - Index
- Indices *f* and *l* keep track of first and last positions



Comparing Sequence Implementations

Operation	Array	List
size, empty	1	1
atIndex, indexOf, at	1	***n***
begin, end	1	1
set(p,e)	1	1
set(i,e)	1	***n***
insert(i,e), erase(i)	***n***	***n***
insertBack, eraseBack	1	1
insertFront, eraseFront	***n***	1
insert(p,e), erase(p)	***n***	1