Abstract Data Types - Lists
Arrays implementation
Linked-lists implementation

Lecture 15

Jérôme Waldispühl

School of Computer Science

McGill University

Slides by Mathieu Blanchette

Abstract data types (ADT)

- Definition: Model of a data structure that specifies:
  - The type of data stored
  - The operations supported on that data
- An ADT specifies what can be done with the data, but not how it is done
- It is the the implementation of the ADT that specifies how operations are performed
- The user of an ADT does not need to know anything about the implementation.

List ADT

Data stored: a ordered set of objects of any kind

[1, 1, 2, 3, 5, 8]

[ln(), sin(), f(), exp()]

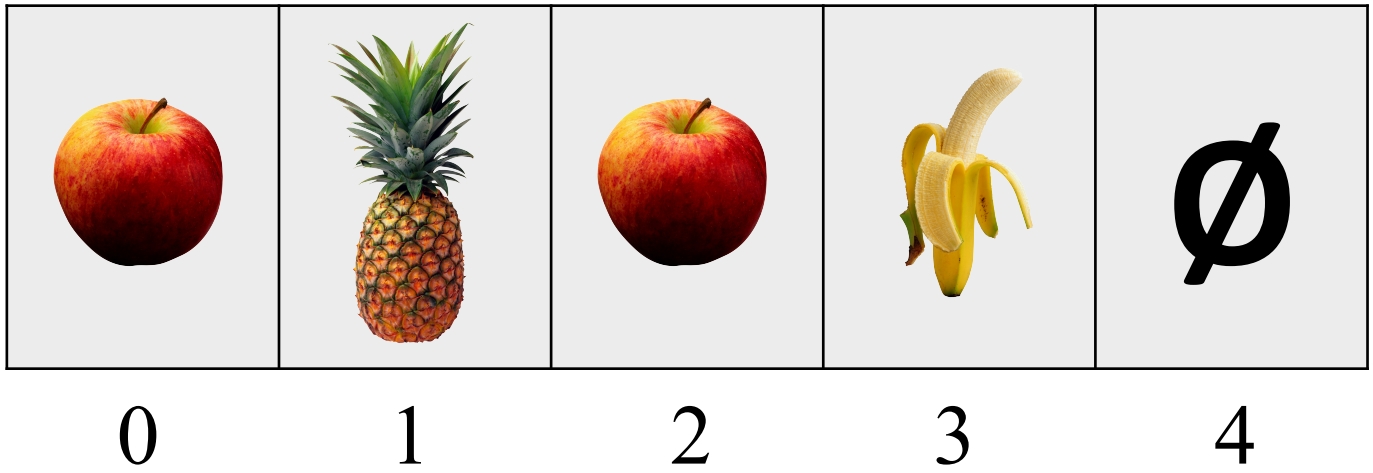
[ ,  ,  , ]

Operations on list ADT

- getFirst() : returns the first object of the list
- getLast() : returns the last of object of the list
- getNth(n): returns the n-th object of the list
- insertFirst(Object o) : adds o at the beginning of the list
- insertLast(Object o): adds o the end of the list
- insertNth(n, o): adds the n-th object of the list by o
- removeFirst(): removes the first object of the list
- removeLast(): removes the last object of the list
- removeNth(n): removes the n-th object of the list
- getSize(): returns the number of objects in the list
- concatenate(List l): appends List l to the end of this list

Implementation of the list ADT With an Array

- An 1D array L to store the elements of the list
- An integer size to record the number of objects stored.

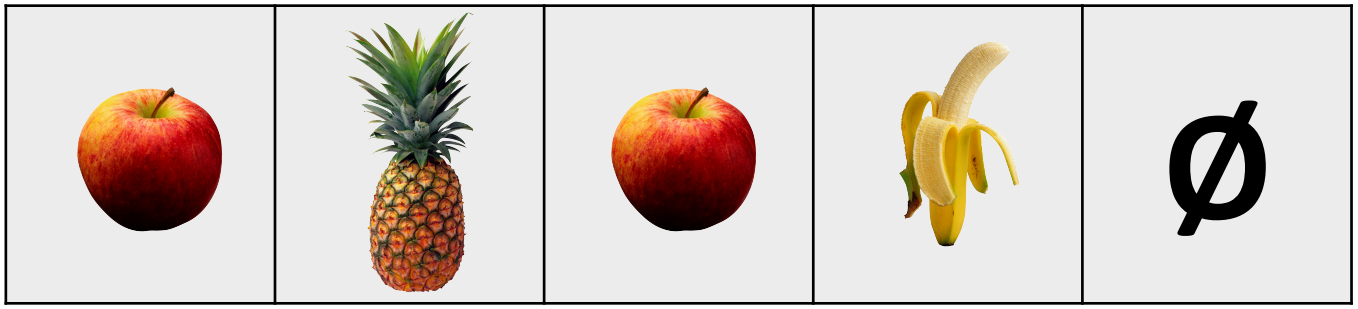


size = 4

Implementation of the list ADT With an Array

```
getFirst() { return L[0] }
getLast() { return L[size-1] }
getNth(n) { return L[n] }
```

L



size = 4

Implementation of the list ADT With an Array

insertLast() [ ,  , ]

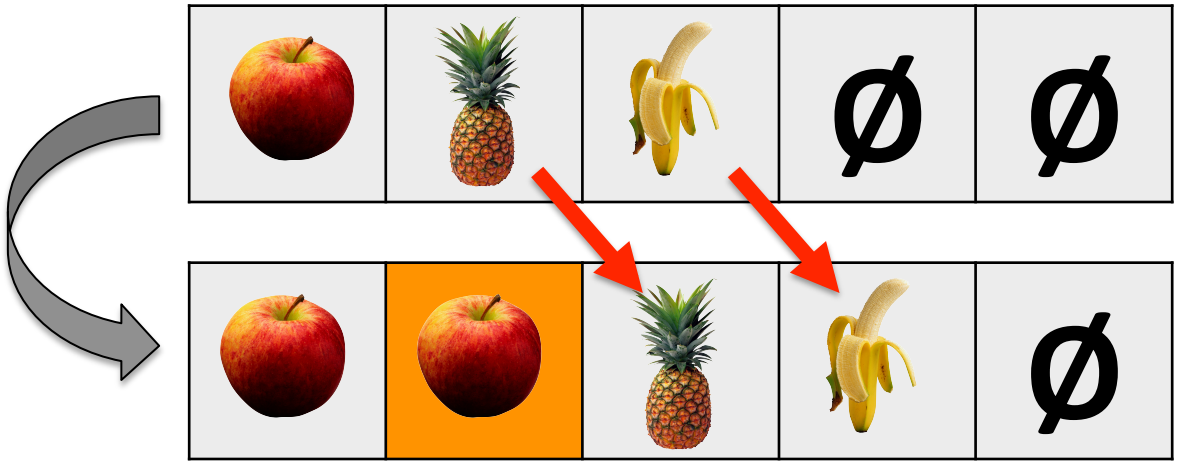
Size = 3

Size = 4

insertLast(Object o) { L[size] ← o; size ← size +1 }

Implementation of the list ADT With an Array

insertNth(1, )




```
insertNth(into n, Object o) {
        for i  ← size downto n {
                L[i] ← L[i-1]; }
        L[n] ← o;
        size  ← size +1 }
```

```
insertFirst(Object o) {
        insertNth(0,o)
}
```

Implementation of the list ADT With an Array

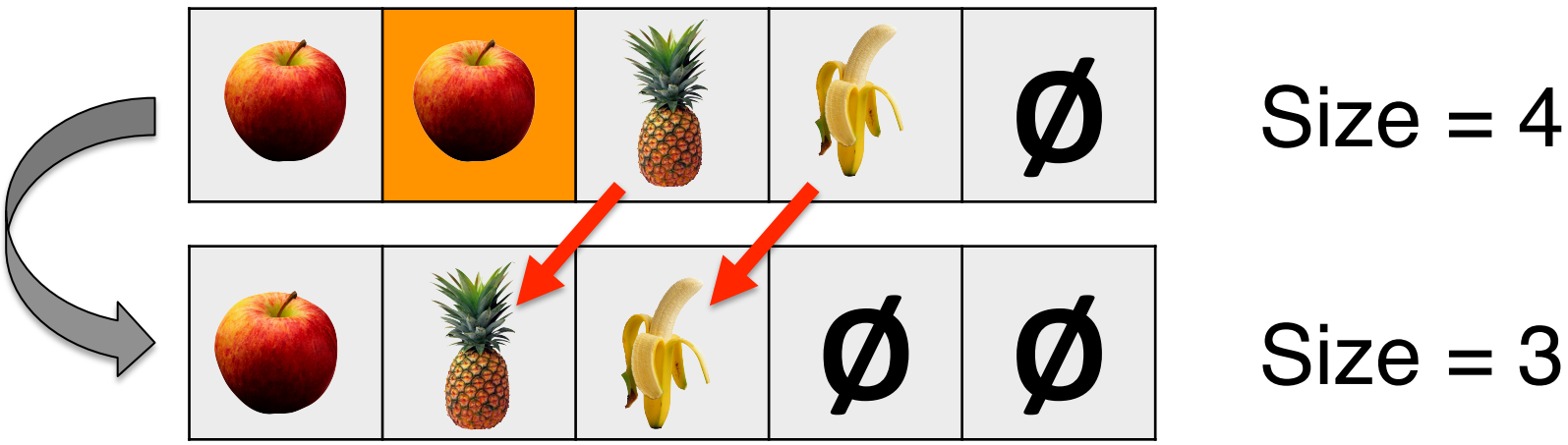
removeLast(): size ← size -1

removeNth(n)

for i ← n **to** size-1 **do** L[i] ← L[i+1]

size ← size -1

removeFirst(): removeNth(0)



Limitations of arrays

- In some situations, an array is not a good way to implement a list, because:
  - Size has to be known in advance
  - Memory required may be much larger than the number of elements actually used
  - Inserting or deleting an element can take time up to O(n)

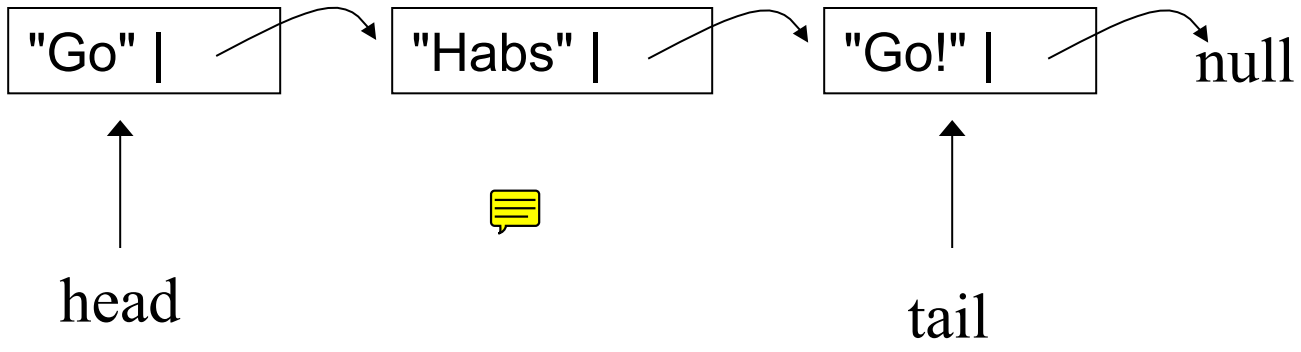
- An array implementation is bad when:
  - the number of objects to be stored in not known in advance
  - the user will need to do a lot of insertions or removals

Linked-list implementation

- Linked-list: Sequence of nodes. Each node stores some data and knows the next node in the list.
- A linked-list is a recursive data structure!

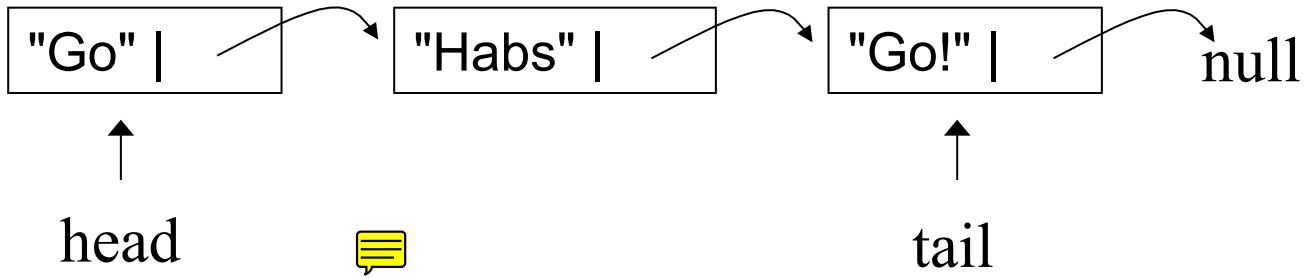
- Node:

- List:



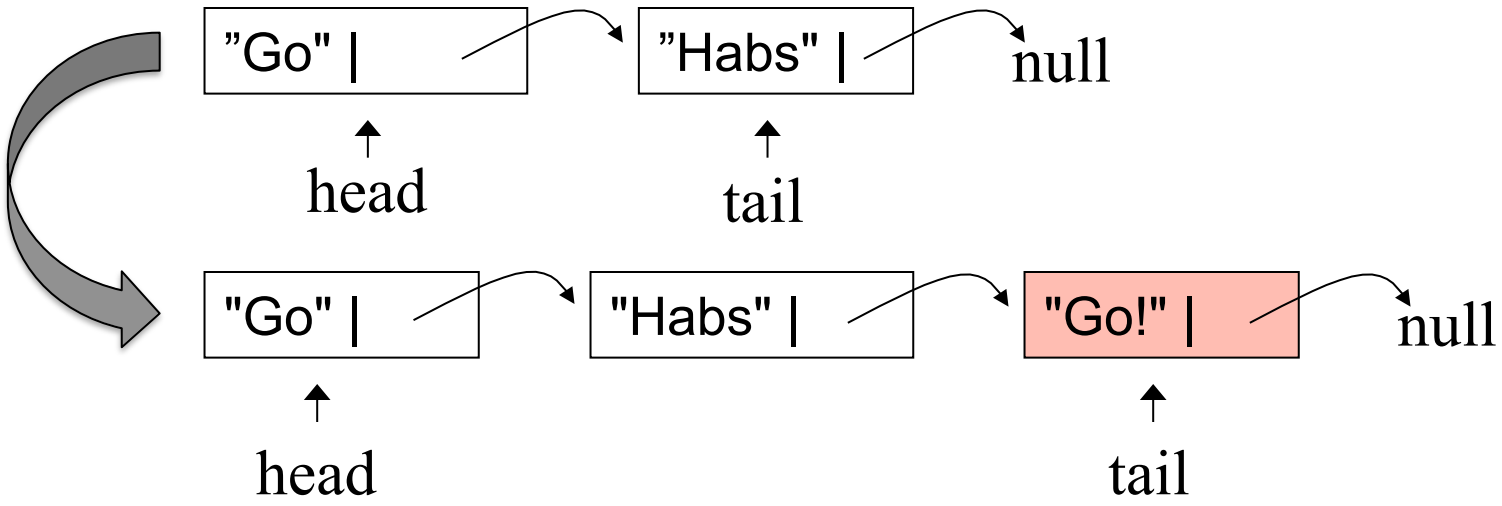
```
public class node {

    private Object value;
    private node next;

    // constructor
    public node(Object x, node n) {
          value = x;
          next = n;
    }

    public node getNext() {              return next;          }

    public Object getValue() {           return value;         }

    public void setValue(Object x) {  value = x;               }

    public void setNext(node n) {      next = n;               }
}
```

```
class linkedList {

  node head, tail;

   // default constructor, builds an empty list
   list() {
       head = null;
       tail = null;
   }

   getFirst() { return head.getValue();      }
   getLast() { return tail.getValue();       }

   getNth()  { /* we will do later */ }
  ...
```



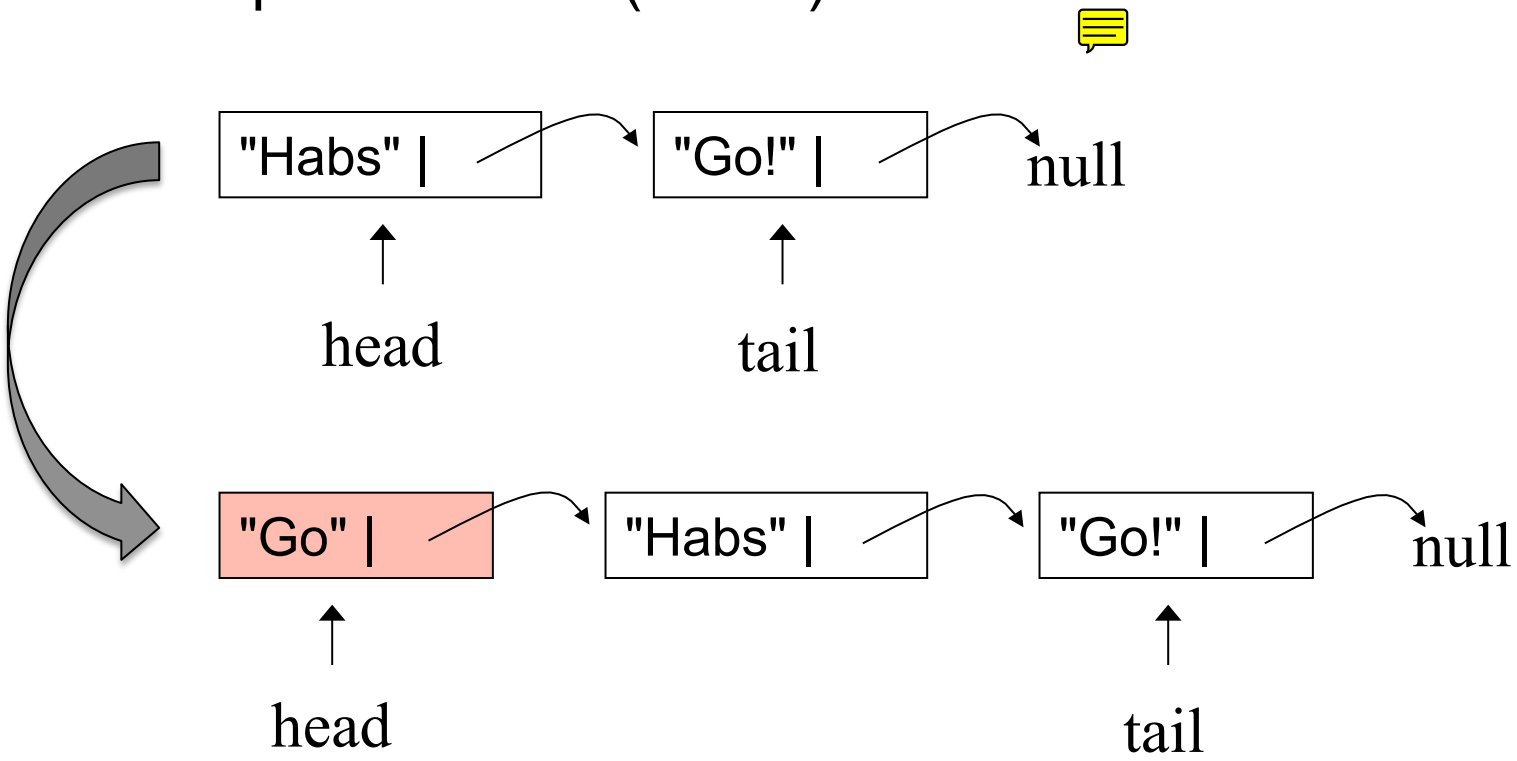
```
/* Add an object at the tail of the list */
    void addLast(Object x) {
        if ( tail == null ) {    // list is empty
            tail = head = new node(x, null);
          }
        else {
            tail.setNext( new node(x,null) );
            tail = tail.getNext();
        } }
```

Example: addLast(“Go!”)



```
/* Add an object at the head of the list */
    void addFirst(Object x) {
        head = new node(x, head);
        if (tail == null) tail = head;
     }
```

Example: addFirst(“Go”)



insertNth(n,Object x) is more complicated…

Why? How to code it?

We will come back on that a bit later…

Example: insertNth(1,“Habs”)