Topic 2: Arrays and Lists

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Data Structures

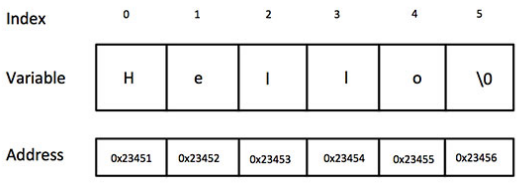
- For the next three weeks, we'll study different ways to store and organize data.
- We learn about different data structures, because each has its advantages and disadvantages.

Our first "data structure": arrays

Sequence of elements $a_1, a_2, \ldots, a_n$ is called an array and usually denoted by something like
`A[1],A[2],···,A[n]`
or
`A[1...n]`
They're in consecutive memory cells, but we (usually) don't care where exactly.

All array elements are of the same type, e.g., integer. Can declare as `integer A[1...n]`

Arrays



Arrays

- How do we find the *i*th element. How long does it take?
- What if we want to erase an element
- The size of an array is fixed when we declare it. How big should we make it?

Linked Lists

- A list is made up of nodes. Each node stores an element (a piece of data) plus a pointer or "link" to another node.
- The first node is called the head.
- The last node, called the tail points to null.
- The nodes may be scattered all over the memory.

Implementing a list

Assume that for list `L` we have pointers to the first as well as the last node of list:

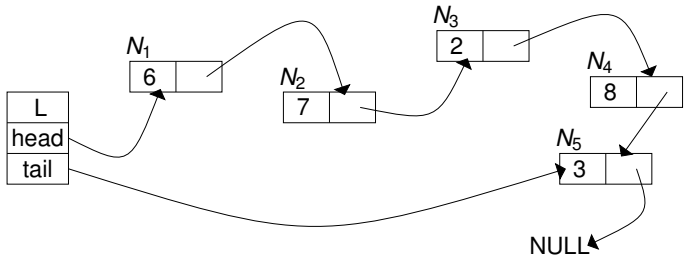
- `L.head`
- `L.tail`
- (and possibly also we have `L.size`)

May refer to node `N` using:

- `N.data`, the element
- `N.next`, the link, the next node in the list (may be `NULL`)

`NULL` means “there’s nothing there”, i.e., last element has no successor.

A linked list



Implementing a list

We would like `L.find(i)` to find the *i*th piece of data in a list? How can we do this? How long will it take?

Finding the *i*th item

Input: list L

Output: *i*th item in L

How can we alter the list? Anything that inserts or removes must fix all references to (predecessors and) successors.

Deletion of the head

Input: list L

Output: L with head deleted

Insertion of v after N

Input: list L, data v, node N

Output: L with v inserted after N

Arrays versus lists

	Array	Linked List
Data Access		
Insertion, Deletion		

Doubly Linked Lists

- A node in a doubly linked list stores two references:
  - a next link, which points to the next node in the list
  - a prev link, which points to the previous node in the list
- To simplify, we add two dummy or sentinel nodes at the ends of the doubly linked list:
  - the header has a valid next reference but a null prev reference
  - the trailer has a valid prev reference but a null next reference

A doubly linked list needs to store references to the two sentinel nodes and a size counter keeping track of the number of nodes in the list (not counting sentinels).

An empty list would have the two sentinel nodes pointing to each other.

Circularly Linked Lists

- A circularly linked list has the same kind of nodes as a singly linked list. That is, each node has a next pointer and a reference to an element.
- The circularly linked list has no beginning or end. You can think of it as a singly linked list, where the last nodes next pointer, instead of being `NULL`, points back to the first node.
- Instead of references to the head and the tail, we mark a node of the circularly linked list as the cursor. The cursor is the starting node when we traverse the list.

Deletion from doubly linked list

Input: list L, node N

Output: L with N removed

```
Input: n numbers in array A[0],. . .,A[n-1]
Output: ?
  for i=0 to n-2 do
      e = A[i]
      p = i
      for j=i+1 to n-1 do
          if A[j]<e then
              e = A[j]
              p= j
          end if
      end for
      swap A[i] and A[p]
  end for
  return A
```

What is the output and how it is obtained. How long does this procedure take (that is, say, how many times do we make the comparison of $A[j]$ and e in the condition of the **if** statement)?