

Vectors

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Outline and Reading

- ◆ The Vector ADT (§2.2.1)
- ◆ Array-based implementation (§2.2.1)

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The Vector ADT

- ◆ The **Vector** ADT extends the notion of array by storing a sequence of arbitrary objects
- ◆ An element can be accessed, inserted or removed by specifying its rank (number of elements preceding it)
- ◆ An exception is thrown if an incorrect rank is specified (e.g., a negative rank)

Main vector operations:

- object **elemAtRank**(integer r): returns the element at rank r without removing it
- object **replaceAtRank**(integer r , object o): replace the element at rank with o and return the old element
- **insertAtRank**(integer r , object o): insert a new element o to have rank r
- object **removeAtRank**(integer r): removes and returns the element at rank r

◆ Additional operations **size()** and **isEmpty()**

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Applications of Vectors

- ◆ Direct applications
 - Sorted collection of objects (elementary database)
- ◆ Indirect applications
 - Auxiliary data structure for algorithms
 - Component of other data structures

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Array-based Vector

- ◆ Use an array V of size N
- ◆ A variable n keeps track of the size of the vector (number of elements stored)
- ◆ Operation **elemAtRank**(r) is implemented in $O(1)$ time by returning $V[r]$

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Insertion

- ◆ In operation **insertAtRank**(r, o), we need to make room for the new element by shifting forward the $n - r$ elements $V[r], \dots, V[n - 1]$
- ◆ In the worst case ($r = 0$), this takes $O(n)$ time

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Deletion

- ◆ In operation **removeAtRank**(r), we need to fill the hole left by the removed element by shifting backward the $n - r - 1$ elements $V[r + 1], \dots, V[n - 1]$
- ◆ In the worst case ($r = 0$), this takes $O(n)$ time

The diagram shows three stages of the deletion process in a vector V of size n. The first stage shows an element being removed at index r, leaving a gap. The second stage shows elements from index r+1 to n-1 being shifted one position to the left. The third stage shows the vector compacted, with the last element now at index n-1.

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Performance

- ◆ In the array based implementation of a Vector
 - The space used by the data structure is $O(n)$
 - **size**, **isEmpty**, **elemAtRank** and **replaceAtRank** run in $O(1)$ time
 - **insertAtRank** and **removeAtRank** run in $O(n)$ time
- ◆ If we use the array in a circular fashion, **insertAtRank**(0) and **removeAtRank**(0) run in $O(1)$ time
- ◆ In an **insertAtRank** operation, when the array is full, instead of throwing an exception, we can replace the array with a larger one

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