Vectors

Algorithms & Data Structures
ITCS 6114/8114

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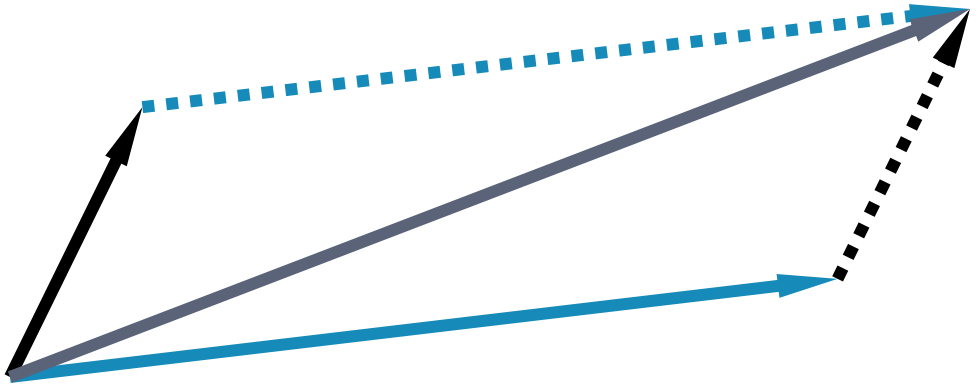
Vectors



Outline and Reading

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

The Vector ADT

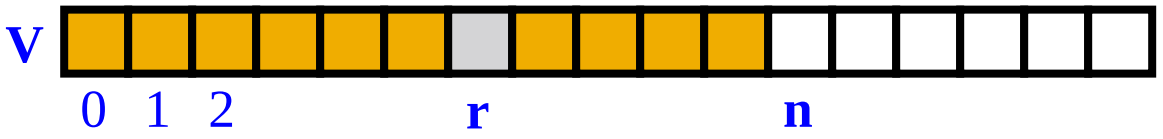
- The Vector ADT extends the notion of array by storing a sequence of arbitrary objects
- An element can be accessed, inserted or removed by specifying its rank (number of elements preceding it)
- An exception is thrown if an incorrect rank is specified (e.g., a negative rank)
- Main vector operations:
  - object elemAtRank(integer r): returns the element at rank r without removing it
  - object replaceAtRank(integer r, object o): replace the element at rank r 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()

Applications of Vectors

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

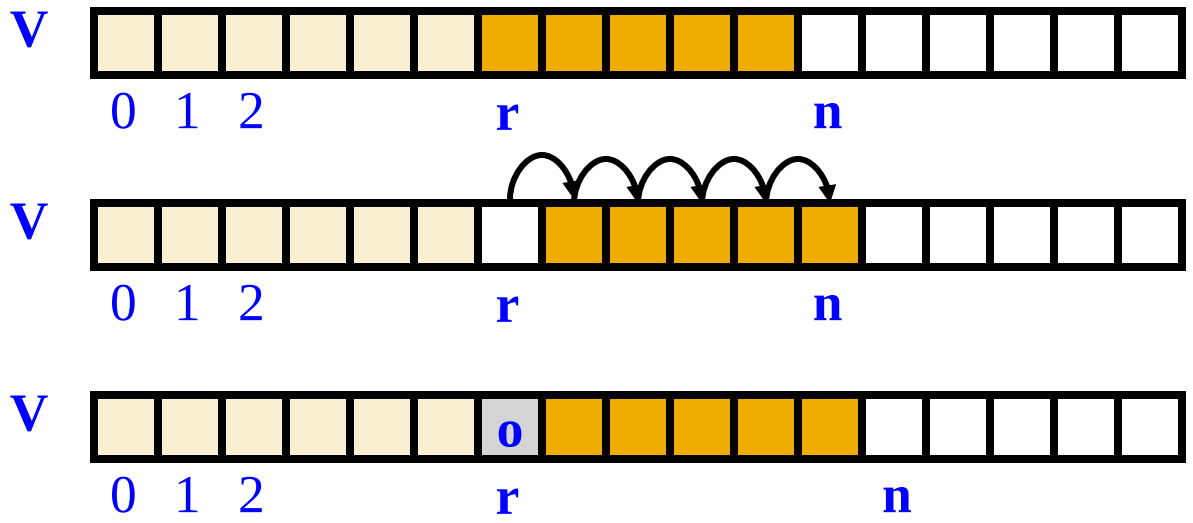
Array-based Vector

- 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**]



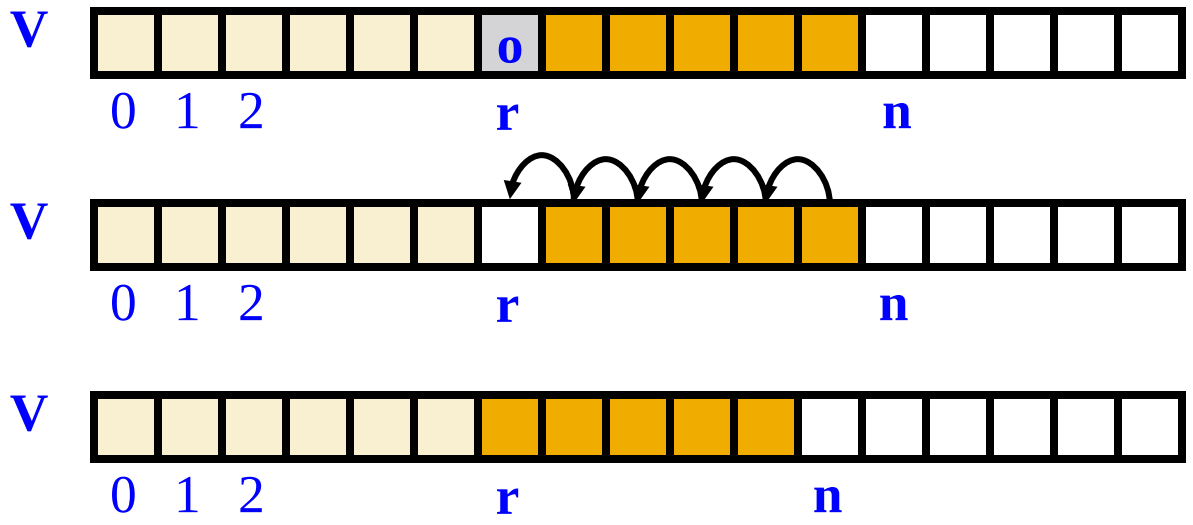
Insertion

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



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], …, **V**[**n** - 1]
- In the worst case (**r** = 0), this takes **O**(**n**) time



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

- In an **insertAtRank** operation, when the array is full, instead of throwing an exception, we can replace the array with a larger one

Reference

- Algorithm Design: Foundations, Analysis, and Internet Examples. Michael T. Goodrich and Roberto Tamassia. John Wiley & Sons.
- Introduction to Algorithms. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein.

Thank you!