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 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 \( V[r+1], \ldots, V[n-1] \).
- 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.

- 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.