### Comparison of Linked Lists and Dynamic Arrays

#### Time Complexity

\*\*Linked Lists:\*\*

- \*\*Insert at index\*\*: O(n) (traversal required to reach the index)

- \*\*Delete at index\*\*: O(n) (traversal required to reach the index)

- \*\*Get size\*\*: O(n) (if not maintaining a size variable)

- \*\*Is empty\*\*: O(1)

- \*\*Rotate right\*\*: O(n)

- \*\*Reverse\*\*: O(n)

- \*\*Append\*\*: O(n) (if not maintaining a tail pointer), O(1) (if tail pointer is maintained)

- \*\*Prepend\*\*: O(1)

- \*\*Merge\*\*: O(n) (depends on the length of both lists)

- \*\*Interleave\*\*: O(n + m) (n and m are sizes of the two lists)

- \*\*Get middle\*\*: O(n)

- \*\*Index of\*\*: O(n)

- \*\*Split at index\*\*: O(n)

\*\*Dynamic Arrays:\*\*

- \*\*Insert at index\*\*: O(n) (shifting elements required)

- \*\*Delete at index\*\*: O(n) (shifting elements required)

- \*\*Get size\*\*: O(1)

- \*\*Is empty\*\*: O(1)

- \*\*Rotate right\*\*: O(n)

- \*\*Reverse\*\*: O(n)

- \*\*Append\*\*: Amortized O(1)

- \*\*Prepend\*\*: O(n) (shifting elements required)

- \*\*Merge\*\*: O(n + m) (n and m are sizes of the two arrays)

- \*\*Interleave\*\*: O(n + m) (n and m are sizes of the two arrays)

- \*\*Get middle\*\*: O(1)

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- \*\*Split at index\*\*: O(n)

#### Space Complexity

\*\*Linked Lists:\*\*

- Each node requires additional space for the storage of a pointer/reference.

- O(n) for n elements plus O(n) for pointers.

\*\*Dynamic Arrays:\*\*

- Requires a contiguous block of memory.

- O(n) for n elements.

- Additional space for resizing: can be up to O(n) (usually, the array doubles in size when capacity is reached).

#### Advantages and Disadvantages

\*\*Linked Lists:\*\*

\*\*Advantages:\*\*

- \*\*Dynamic Size\*\*: Can easily grow and shrink in size by adding or removing nodes without any need to allocate or deallocate a large block of memory.

- \*\*Efficient Insertions/Deletions\*\*: Insertions and deletions at the beginning or middle (once the position is known) are more efficient as no shifting of elements is required.

- \*\*Memory Utilization\*\*: More efficient in memory usage if there are many insertions and deletions because no resizing is required.

\*\*Disadvantages:\*\*

- \*\*Memory Overhead\*\*: Requires extra memory for storing pointers/references.

- \*\*Sequential Access\*\*: Accessing elements is slower (O(n)) as it requires traversal from the head to the desired node.

- \*\*Cache Locality\*\*: Poor cache performance due to scattered memory locations.

\*\*Dynamic Arrays:\*\*

\*\*Advantages:\*\*

- \*\*Random Access\*\*: Provides O(1) time complexity for accessing elements.

- \*\*Memory Utilization\*\*: Efficient for scenarios where the size of the array is stable or grows gradually.

- \*\*Compact Memory\*\*: Stores elements in contiguous memory locations, improving cache performance.

\*\*Disadvantages:\*\*

- \*\*Fixed Size\*\*: Initially requires allocation of a fixed size. Resizing (when the array grows beyond its capacity) can be expensive (O(n)).

- \*\*Insertions/Deletions\*\*: Insertions and deletions, especially in the middle, require shifting of elements, leading to O(n) time complexity.

- \*\*Wasted Space\*\*: Can have unused allocated memory, leading to potential wasted space.

### Report on Comparison

\*\*Introduction:\*\*

Both linked lists and dynamic arrays are fundamental data structures used in computer science for storing collections of elements. They each have their own strengths and weaknesses, making them suitable for different types of applications. This report compares these two data structures in terms of their time complexity, space complexity, and practical advantages and disadvantages.

\*\*Time Complexity:\*\*

Linked lists offer efficient insertion and deletion operations, especially at the beginning of the list, with O(1) complexity. However, accessing elements in a linked list requires O(n) time due to sequential traversal. In contrast, dynamic arrays provide O(1) access time but suffer from O(n) complexity for insertions and deletions due to the need to shift elements.

\*\*Space Complexity:\*\*

Linked lists require additional space for pointers, leading to an overall space complexity of O(n) plus O(n) for pointers. Dynamic arrays have a space complexity of O(n) but may have additional overhead during resizing operations.

\*\*Advantages and Disadvantages:\*\*

Linked lists are advantageous for applications requiring frequent insertions and deletions at known positions but suffer from poor cache performance and higher memory overhead. Dynamic arrays excel in scenarios requiring fast access to elements and better cache locality but face challenges with resizing and inefficient insertions and deletions.

\*\*Conclusion:\*\*

The choice between linked lists and dynamic arrays depends on the specific requirements of the application. Linked lists are suitable for applications with frequent insertions and deletions, while dynamic arrays are better for scenarios needing fast access and stable size. Understanding these trade-offs helps in selecting the appropriate data structure for optimal performance.

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