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Week7 /S4/ Lecture #: DSOOPS-33

Topics Covered

- Data Structure Types: Linear vs Non-linear
- Operation Types: Static vs Dynamic Data Structures
- Practice Problems (2 Easy, 1 Medium, 1 Hard – Conceptual)

Data Structure Types: Linear vs Non-linear

Linear Data Structures

- Data elements are arranged sequentially or in a linear order.
- Each element is connected to its previous and next element (except first and last).
- Traversal and processing occur in a single run or sequence.
- Examples include:
    - Array: Fixed-size collection stored contiguously in memory.
    - Linked List: Nodes connected linearly via pointers.
    - Stack: Last-In-First-Out (LIFO) structure.
    - Queue: First-In-First-Out (FIFO) structure.

Key Characteristics:

- Single-level data organization.
- Easier to implement and use.
- Efficient for simple sequential tasks.

Non-linear Data Structures

- Data elements are arranged hierarchically or graphically, not in a strict sequence.
- Elements can be connected to multiple other elements; multiple paths exist.
- Traversal may require multiple passes through different branches.
- Examples include:
    - Trees: Hierarchical data structure with a root and child nodes.

- Graphs: Nodes connected by edges, representing complex relationships.

Key Characteristics:

- Multi-level, hierarchical organization.
- More complex but suitable for modeling complex data relationships.
- Efficient memory usage for certain applications.

Comparison Table: Linear vs Non-linear Data Structures

Feature	**Linear Data Structures**	**Non-linear Data Structures**
Arrangement	Sequential, one after another	Hierarchical or interconnected
Structure levels	Single level	Multiple levels
Element connections	Each element connected to next one	Elements can connect to multiple others
Traversal	Single run through sequence	Multiple traversals may be needed
Examples	Array, Stack, Queue, Linked List	Tree, Graph
Use cases	Simple lists, sequential data processing	Complex relationships, hierarchies, networks

Implementation complexity	Relatively simpler	More complex

Operation Types: Static vs Dynamic Data Structures

Static Data Structures

- The size and structure are fixed at compile time.
- Memory allocation is usually fixed and contiguous.
- Examples: Arrays, structures with fixed size.
- Advantages:
    - Fast access due to fixed layout.
    - Simple memory management.
- Disadvantages:
    - Waste of memory if unused space exists.
    - Cannot easily grow or shrink during runtime.

Dynamic Data Structures

- Size and structure can change during program execution.
- Use pointers to allocate memory on the fly (dynamic memory allocation).
- Examples: Linked lists, trees, graphs implemented with dynamic nodes.
- Advantages:
    - Efficient memory use; grows and shrinks as needed.
    - Flexible for varying data sizes.
- Disadvantages:
    - Slightly slower access (due to pointer traversal).
    - Requires careful memory management to avoid leaks.

Summary Table: Static vs Dynamic Data Structures

Feature	**Static Data Structures**	**Dynamic Data Structures**
Size	Fixed at compile time	Can grow/shrink at runtime
Memory Allocation	Static (contiguous)	Dynamic (heap allocation)
Flexibility	Less flexible	Highly flexible
Memory Efficiency	May waste unused space	Generally more efficient
Implementation Complexity	Simpler	Requires pointer management
Examples	Arrays	Linked Lists, Trees, Graphs

Practice Problems and Activities (Conceptual/Non-Programming)

Easy 1

Question:
List two examples each of linear and non-linear data structures from everyday life and explain why they fit those categories.

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Easy 2

Question:
Explain in your own words the difference between static and dynamic data structures. Why might a dynamic data structure be preferred when the size of data is unknown?

Medium

Question:
Suppose you need to store a collection of books for a library system where books may be categorized by genre and sub-genre. Would a linear or non-linear data structure be more suitable? Justify your answer.

Hard

Activity:
An online social network contains millions of users and their connections.

- Identify which type of data structure (linear or non-linear) would be appropriate to represent user connections and relationships.
- Discuss why (think about scalability and complexity).
- Also, explain whether the data structure should be static or dynamic and why.

Wrap-Up & Key Takeaways

- Linear data structures organize data sequentially; they are simpler and suitable for straightforward, ordered data.
- Non-linear data structures handle hierarchical or complex relationships and are essential for many real-world models.
- Static structures have fixed size, while dynamic structures can change size during execution offering flexibility.
- Choice of data structure impacts efficiency, memory use, and program complexity.