



Introduction to Data Structures

Data Structures – The logical or mathematical model of a particular organization of data is called **Data Structures**.

Data Types vs Data Structures –

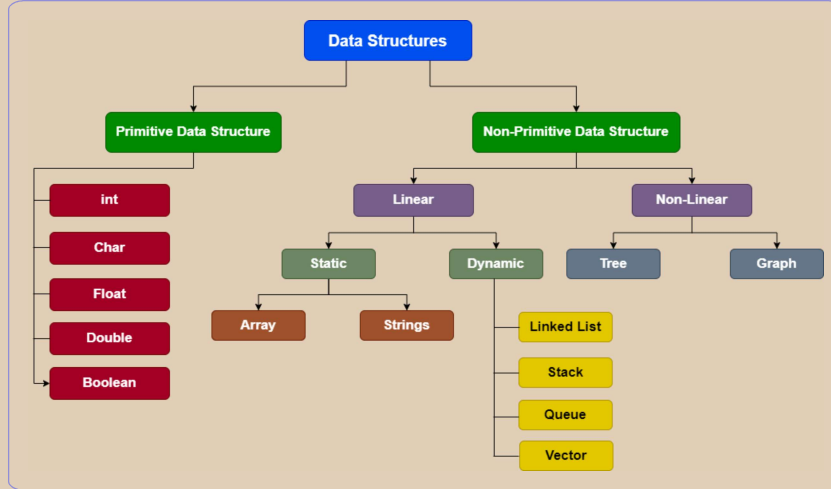
Data Types	Data Structures
Data Type is the kind or form of a variable which is being used throughout the program. It defines that the particular variable will assign the values of the given data type only.	Data Structure is the collection of different kinds of data. That entire data can be represented using an object and can be used throughout the entire program.
Implementation through Data Types is a form of abstract implementation.	Implementation through Data Structures is called concrete implementation.
Can hold values and not data, so it is data less.	Can hold different kind and types of data within one single object.
Values can directly be assigned to the data type variables.	The data is assigned to the data structure object using some set of algorithms and operations like push, pop and so on.
No problem of time complexity.	Time complexity comes into play when working with data structures.
Examples: int, float, double etc.	Examples: stacks, queues, tree etc.

Types of Data Structure –

- Primitive
- Non-Primitive

Primitive Data Structure – Those basic data structures which are pre-defined in standard library. It can store the value of only one data type. It cannot contain null values. ie – int, char, float etc.

Non-Primitive Data Structure – Those data structures which are user-defined (except strings) which can be easily created or modified by user. They can store multiple values and invoke methods to perform certain operations. ie – string, array etc.



[Linear Data Structure](#) – In linear data structure data is organized in sequential order.

Types of linear Data Structure –

- Static
- Dynamic

[Static Data Structure](#) – A static data structure is an organization or collection of data in memory which have a fixed size, that is, it can store a limited amount of elements or data in it. ie – array, string.

[Dynamic Data Structure](#) – A dynamic data structure is an organization or collection of data in memory which do not have a fixed size, that is, its size can be modified during the operations performed on it and can store a variable amount of elements or data in it. ie – linked list, queue, stack etc.

Types of Dynamic Data Structure –

- Linked list
- Stack
- Queue

[Non-linear Data Structure](#) – In non-linear data structure data is organized in random order.

Types of non-linear data structures

- Trees
- Graphs
- Heaps
- Tries
- Maps
- Dictionaries

[Difference between linear and non-linear data structure](#) –

Linear Data Structure	Non-Linear Data Structure

In a linear data structure, data elements are arranged in a linear order where each and every element is attached to its previous and next adjacent.	In a non-linear data structure, data elements are attached in hierarchically manner.
In linear data structure, single level is involved.	Whereas in non-linear data structure, multiple levels are involved.
Its implementation is easy in comparison to non- linear data structure.	While its implementation is complex in comparison to linear data structure.
In linear data structure, data elements can be traversed in a single run only.	While in non-linear data structure, data elements can't be traversed in a single run only.
In a linear data structure, memory is not utilized in an efficient way.	While in a non-linear data structure, memory is utilized in an efficient way.
Applications of linear data structures are mainly in application software development.	Applications of non-linear data structures are in Artificial Intelligence and image processing.
ie – array, stack, queue, linked list, etc.	ie – trees, graphs, heaps, dictionaries, tries, maps etc.

Application of Data Structures –

Arrays –

- Used for storing fixed number of items that need fast access time at any point during program execution.
- Storing list of data elements belonging to same data type.
- Auxiliary storage for other data structures.
- Storage of binary tree elements of fixed count.
- Storage of matrices.
- Arrangement of the leader-board of a game can be done simply through arrays to store the score and arrange them in descending order to clearly make out the rank of each player in the game.
- A simple question Paper is an array of numbered questions with each of them assigned some marks.
- 2D arrays, commonly known as, matrices, are used in image processing.
- It is also used in speech processing, in which each speech signal is an array.
- Your viewing screen is also a multidimensional array of pixels.
- Book titles in a Library Management Systems.
- Online ticket booking.
- Contacts on a cell phone.
- For CPU scheduling in computer.
- To store the possible moves of chess on a chessboard.
- To store images of a specific size on an android or laptop.

Strings –

- Spam email detection.
- Plagiarism detection.
- Search engine.
- Digital forensic and information retrieval system.

- Spell checkers.
- In the database to check valid information of the user.

Linked list –

- Implementing stacks, queues, binary trees and graphs of predefined size.
- Implement dynamic memory management functions of the operating system.
- Polynomial implementation for mathematical operations
- Circular linked list is used to implement OS or application functions that require round robin execution of task
- Images are linked with each other. So, image viewer software uses a linked list to view the previous and the next images using the previous and next buttons.
- Web pages can be accessed using the previous and the next URL links which are linked using a linked list.
- The music players also use the same technique to switch between music.
- To keep the track of turns in a multiplayer game, a circular linked list is used.
- MS-Paint drawings and shapes are connected via a linked list on canvas.
- Escalators — Circular linked List.
- Each of the lines of code in an IDE internally is a record on a doubly-linked list.
- Left/Right swipe on Tinder uses a doubly-linked list.
- Social media content "feeds".
- Used for symbol table management in a designing compiler.
- Used in switching between applications and programs (Alt + Tab) in the Operating system (implemented using Circular Linked List).
- Train coaches are connected to one another in a doubly-linked list fashion.
- It can be used to implement Stacks, Queues, Graphs, and Trees.
- To perform an undo operation.
- Back button.[LIFO]
- Syntax in the coding editor.

Stack –

- Temporary storage structure for recursive operations.
- Auxiliary storage structure for nested operations, function calls, deferred/postponed functions.
- Manage function calls.
- Evaluation of arithmetic expressions in various programming languages.
- Conversion of infix expressions into postfix expressions (polish notation).
- Checking syntax of expressions in a programming environment.
- Matching of parentheses.
- String reversal.
- In all the problems solutions are based on backtracking.
- Used in depth first search in graph and tree traversal.
- Operating System functions
- UNDO and REDO functions in an editor.

Queue –

- It is used in breadth search operations in graphs.
- Job scheduler operations of OS like a print buffer queue, keyboard buffer queue to store the keys pressed by users.

- Job scheduling, CPU scheduling, Disk Scheduling.
- Priority queues are used in file downloading operations in a browser.
- Data transfer between peripheral devices and CPU.
- Interrupts generated by the user applications for CPU.
- Calls handled by the customers in BPO.

Trees –

- Implementing the hierarchical structures in computer systems like directory and file system.
- Implementing the navigation structure of a website.
- Code generation like Huffman's code.
- Decision making in gaming applications.
- Implementation of priority queues for priority based OS scheduling functions.
- Parsing of expressions and statements in programming language compilers.
- For storing data keys for DBMS for indexing.
- Spanning trees for routing decisions in computer and communications networks.
- Hash trees.
- path-finding algorithm to implement in AI, robotics and video games applications.

Graphs –

- Representing networks and routes in communication, transportation and travel applications.
- Routes in GPS.
- Interconnections in social networks and other network based applications.
- Mapping applications.
- Ecommerce applications to present user preferences.
- Utility networks to identify the problems posed to municipal or local corporations.
- Resource utilization and availability in an organization.
- Document link map of a website to display connectivity between pages through hyperlinks.
- Robotic motion and neural networks.

Matrix –

- In geology, matrices are used for making seismic surveys.
- Used for plotting graphs, and statistics and also to do scientific studies and research in almost different fields.
- Matrices are also used in representing real-world data like the population of people, infant mortality rate, etc.
- They are the best representation methods for plotting surveys.
- For refraction and reflection in science optics.
- Electronic circuits and quantum physics.
- Media player.
- Mailing list.
- Symbol table creation.