DATA STRUCTURES AND ALGORITHMS

Lecture 1: Introduction

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RECOMMENDED BOOKS

- Data Structures and Algorithm Analysis in C++ (By Mark Allen Weiss)
- Data Structures and Algorithms (By A. V. Aho, J. E. Hopcroft, J. D. Ullman)
- Data Structures Using C and C++ (By Y. Langsam, M. J. Augenstein, A. M. Tenenbaum)
- Schaum's Outline Series, Theory and problems of Data Structures (By Seymour Lipschutz)

COURSE OUTLINE

- Introduction to Data Structures
- Arrays
- Pointers
- Linked List
- Recursion
- Stack
- Queues
- Sorting Algorithms
- Trees
- Searching
- Graphs

WHAT WE DISCUSS?

- Data
- Structure
- Algorithm

WHAT IS DATA?

- **Data** are values or set of values.
  - E.g.: Ali, 37, H.52.
- **Data item** refers to single unit of values.
  - **Group Item:**
    - Data item that can be sub-divided into sub-item.
    - E.g.: Name can be divided into First Name, Middle Name and Last Name.
  - **Elementary Item:**
    - Data item that can not be sub-divided into sub-item.
    - E.g.: CNIC Number / Roll No. is treated as single-item
- *Collection of data are frequently organized into a hierarchy of fields, records and files.*

WHAT IS ENTITY?

- **Entity:**
  - Something that has certain attributes or properties which may be assigned values.
  - Values may be numeric or non-numeric.
- For Example: Student of a Class.

Attributes:	Name	Age	Gender	Roll No
Values:	Ali	22	Male	1
	Faiza	21	Female	2

WHAT IS ENTITY?

- Entities having same attributes form an ***entity set***.
  - E.g.: all students of a class.
- Each attribute of an entity set has a range of values.
  - The set of possible values that could be assigned to a certain attribute.

- **Information**: Data with given attribute or processed data.

- Organization of data into a hierarchy of fields, records and files:
  - Reflects relationship between attributes, entities and entity set.

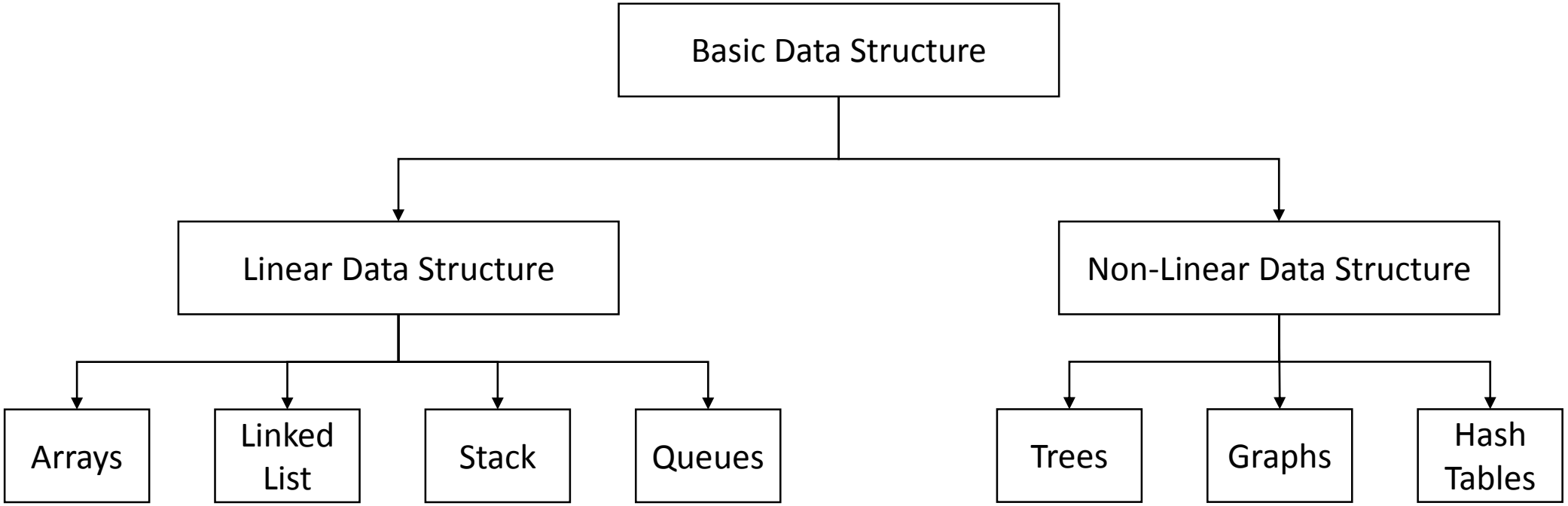
- **Field** is a single elementary unit of information representing an attribute of an entity.
- **Record** is the collection of field values of a given entity.
- **File** is the collection of records of the entities in a given entity set.

Name	Age	Gender	Roll No.	Hometown
Ali	22	Male	1	Chakwal
Faiza	21	Female	2	Rawalpindi
Hassan	21	Male	3	Islamabad
Musa	23	Male	4	D. G. Khan
Falak	22	Female	5	Islamabad
Hussain	22	Male	6	Lahore
Nida	23	Female	7	Gujranwala

WHAT IS DATA STRUCTURES?

- In general, any representation that is used for storing information is a data structure.
- More typically, a data structure provides a way of organization for a collection of data items
- A data structure is a way to store and organize data in order to facilitate the access and modifications.
- Data structure is the logical or mathematical model of a particular organization of data
  - Example: An integer, structures, classes, linked lists, etc.

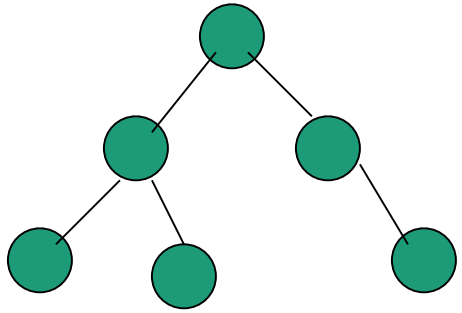
BASIC DATA STRUCTURES



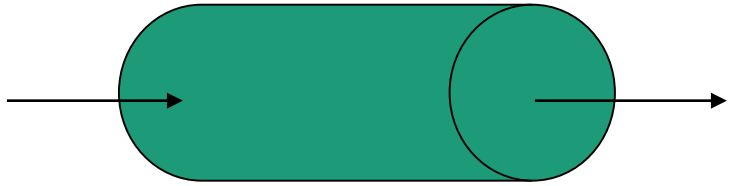
BASIC DATA STRUCTURES

Array

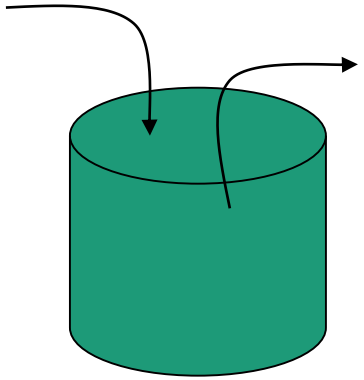
Linked List



Tree



Queue



Stack

WHERE DATA STRUCTURE IS HELPFUL?

- The choice of efficient data structure makes the difference between a program running in a few seconds or many days.
- The choice of particular data model depends on two consideration:
  - It must be rich enough in structure to represent the relationship between data elements.
  - The structure should be simple enough that one can effectively process the data when necessary.

DATA STRUCTURE EFFICIENCY

- A solution is said to be *efficient* if it solves the problem within its *resource constraints*.
  - Space
  - Time
- The cost of a solution is the amount of resources that the solution consumes.

COSTS AND BENEFITS

- Each data structure has costs and benefits.
- It is very difficult to find a data structure that is better than others in all situations.
- A data structure requires:
  - space for each data item it stores,
  - time to perform each basic operation,
  - programming effort.

TYPES OF DATA STRUCTURE

- **Linear**: In Linear data structure, values are arrange in linear fashion.
  - ***Array***: Fixed-size
  - ***Linked-list***: Variable-size programming effort.
  - ***Stack***: Add to top and remove from top
  - ***Queue***: Add to back and remove from front
  - ***Priority queue***: Add anywhere, remove the highest priority

TYPES OF DATA STRUCTURE

- **Non-Linear**: In Non-linear data structure, data values are not arranged in order.
  - ***Hash tables***: Unordered lists which use a ‘hash function’ to insert and search
  - ***Tree***: Data is organized in branches.
  - ***Graph***: A more general branching structure, with less strict connection conditions than for a tree

TYPES OF DATA STRUCTURE

- **Homogenous**: In this type of data structures, values of the same types of data are stored.
  - Array
- **Non-Homogenous**: In this type of data structures, data values of different types are grouped and stored.
  - Structures
  - Classes

EXAMPLE

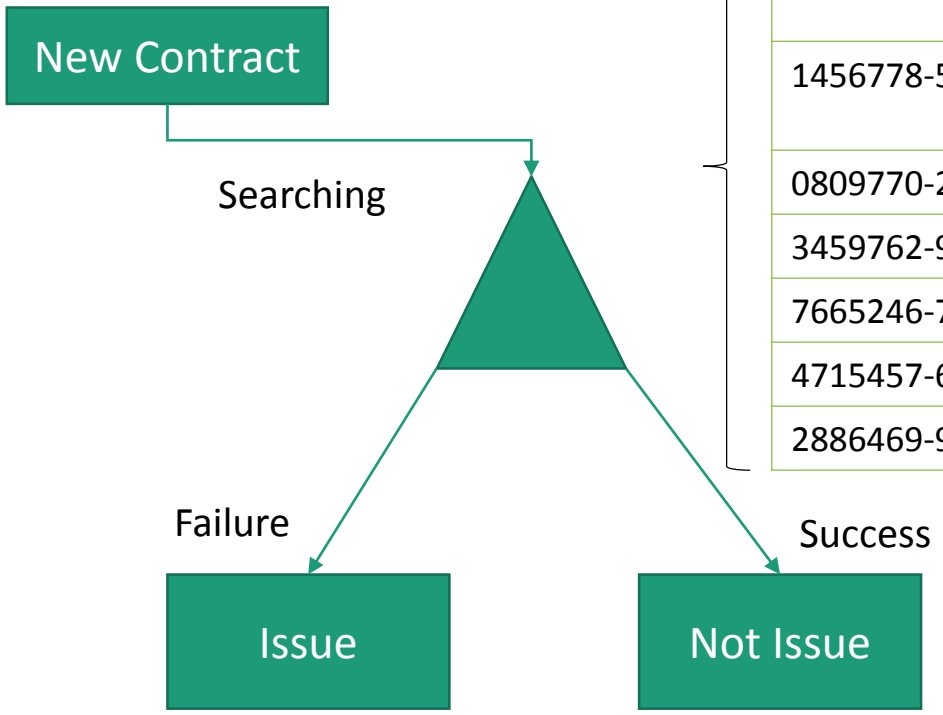
- A cellular service company provides contracts to its 10 million users.
- Due to new security enforcements, the company wants to *prevent issuing of multiple contracts to users.*
- Method of Detecting Multiple Contracts
  - Before issuing a new contract to user
  - First search the id of user in existing contracts database
  - In case of failure, issue a new contract
  - In case of success, do not issue a new contract to user

EXAMPLE

NIC#	Name	Address
4437621-9	Ali Ahmed	House No 3 Gulshan Bahar Sec 16, Karachi
1456778-5	Muhammad Fawad	D-17 Shams Plaza Block-B N. Nazimabad, Karachi
0809770-2	Shahzad Khan	H No 106 Hazara Colony, Quetta
3459762-9	Zameer Ahmed	Street 3 Gulshanabad Rawalpindi
7665246-7	Sameer Qayyum	Post Office Jahaniyan, Khanewal
4715457-6	Zahid Ahmed	H.No. 425, Sector G-8/4, Islamabad
2886469-9	Syed Yasir Rizvi	People's Colony Sector 2, Faisalabad

- Linear Array (with 10 million entries)
  - 3 arrays (NIC, name, address)
  - structure array
  - class's object array

EXAMPLE



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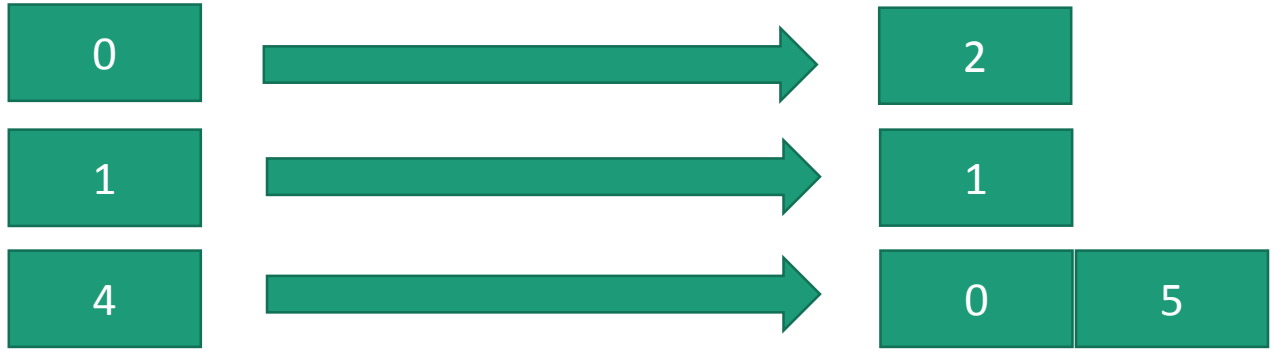
- Any disadvantage of Linear Array?
- How to improve?

EXAMPLE

- Improved Data Structure
  - Create a dictionary data structure
  - Group all those records together that start with similar NIC (first digit) numbers, and add a dictionary entry for each distinct digit (0-9)
  - Example: 4437621-9, 7665246-7, 4715457-6.
    - 4 and 7 are dictionary entries
  - In case of searching, first search the dictionary entry, and then proceed to searching contracts

EXAMPLE



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CONCLUSION

- In this lecture we have studied:
  - Data, entity and entity set
  - Organization of data
  - Definition of data structures
  - Benefits of data structures
  - Types of data structures

Question?