NOTE ABOUT DATA STRACTURE

**Chap-01**

**Data Stricture Basic**

Data Structures are the programmatic way of storing data so that data can be used efficiently. Almost every enterprise application uses various types of data structures in one or the other way.

Data Structure is a systematic way to organize data in order to use it efficiently.

**Why to Learn Data Structure and Algorithms?**

As applications are getting complex and data rich, there are three common problems that applications face now-a-days.

* **Data Search** − Consider an inventory of 1 million(106) items of a store. If the application is to search an item, it has to search an item in 1 million(106) items every time slowing down the search. As data grows, search will become slower.
* **Processor speed** − Processor speed although being very high, falls limited if the data grows to billion records.
* **Multiple requests** − As thousands of users can search data simultaneously on a web server, even the fast server fails while searching the data.

To solve the above-mentioned problems, data structures come to rescue. Data can be organized in a data structure in such a way that all items may not be required to be searched, and the required data can be searched almost instantly.

**Applications of Data Structure and Algorithms**

Algorithm is a step-by-step procedure, which defines a set of instructions to be executed in a certain order to get the desired output. Algorithms are generally created independent of underlying languages, i.e. an algorithm can be implemented in more than one programming language.

From the data structure point of view, following are some important categories of algorithms −

* **Search** − Algorithm to search an item in a data structure.
* **Sort** − Algorithm to sort items in a certain order.
* **Insert** − Algorithm to insert item in a data structure.
* **Update** − Algorithm to update an existing item in a data structure.
* **Delete** − Algorithm to delete an existing item from a data structure.

The following computer problems can be solved using Data Structures −

* Fibonacci number series
* Knapsack problem
* Tower of Hanoi
* All pair shortest path by Floyd-Warshall
* Shortest path by Dijkstra
* Project scheduling

**Characteristics of a Data Structure**

* **Correctness** − Data structure implementation should implement its interface correctly.
* **Time Complexity** − Running time or the execution time of operations of data structure must be as small as possible.
* **Space Complexity** − Memory usage of a data structure operation should be as little as possible.

**Execution Time Cases**

There are three cases which are usually used to compare various data structure's execution time in a relative manner.

* **Worst Case** − This is the scenario where a particular data structure operation takes maximum time it can take. If an operation's worst case time is ƒ(n) then this operation will not take more than ƒ(n) time where ƒ(n) represents function of n.
* **Average Case** − This is the scenario depicting the average execution time of an operation of a data structure. If an operation takes ƒ(n) time in execution, then m operations will take mƒ(n) time.
* **Best Case** − This is the scenario depicting the least possible execution time of an operation of a data structure. If an operation takes ƒ(n) time in execution, then the actual operation may take time as the random number which would be maximum as ƒ(n).

**Basic Terminology**

* Data − Data are values or set of values.
* Data Item − Data item refers to single unit of values.
* Group Items − Data items that are divided into sub items are called as Group Items.
* Elementary Items − Data items that cannot be divided are called as Elementary Items.
* Attribute and Entity − An entity is that which contains certain attributes or properties, which may be assigned values.
* Entity Set − Entities of similar attributes form an entity set.
* Field − Field is a single elementary unit of information representing an attribute of an entity.
* Record − Record is a collection of field values of a given entity.
* File − File is a collection of records of the entities in a given entity set.

**Data Definition**

Data Definition defines a particular data with the following characteristics.

* Atomic − Definition should define a single concept.
* Traceable − Definition should be able to be mapped to some data element.
* Accurate − Definition should be unambiguous.
* Clear and Concise − Definition should be understandable.

**Data Object**

Data Object represents an object having a data.

**Data Type**

Data type is a way to classify various types of data such as integer, string, etc. which determines the values that can be used with the corresponding type of data, the type of operations that can be performed on the corresponding type of data. There are two data types −

* Built-in Data Type
* Derived Data Type

**Built-in Data Type**

Those data types for which a language has built-in support are known as Built-in Data types. For example, most of the languages provide the following built-in data types.

* Integers
* Boolean (true, false)
* Floating (Decimal numbers)
* Character and Strings

**Derived Data Type**

Those data types which are implementation independent as they can be implemented in one or the other way are known as derived data types. These data types are normally built by the combination of primary or built-in data types and associated operations on them. For example −

* List
* Array
* Stack
* Queue

**Basic Operations**

The data in the data structures are processed by certain operations. The particular data structure chosen largely depends on the frequency of the operation that needs to be performed on the data structure.

* Traversing
* Searching
* Insertion
* Deletion
* Sorting
* Merging

**Chap-02**

**Array**

Array is a container which can hold a fix number of items and these items should be of the same type. Most of the data structures make use of arrays to implement their algorithms. Following are the important terms to understand the concept of Array.

* **Element** − Each item stored in an array is called an element.
* **Index** − Each location of an element in an array has a numerical index, which is used to identify the element.

**Array Representation**

Arrays can be declared in various ways in different languages. For illustration, let's take C array declaration.





As per the above illustration, following are the important points to be considered.

* Index starts with 0.
* Array length is 10 which means it can store 10 elements.
* Each element can be accessed via its index. For example, we can fetch an element at index 6 as 9.

**Basic Operations**

Following are the basic operations supported by an array.

* **Traverse** − print all the array elements one by one.
* **Insertion** − Adds an element at the given index.
* **Deletion** − Deletes an element at the given index.
* **Search** − Searches an element using the given index or by the value.
* **Update** − Updates an element at the given index.

In C, when an array is initialized with size, then it assigns defaults values to its elements in following order.

|  |  |
| --- | --- |
| **Data Type** | **Default Value** |
| bool | false |
| char | 0 |
| int | 0 |
| float | 0.0 |
| double | 0.0f |
| void |  |
| wchar\_t | 0 |

**Traverse Operation**

This operation is to traverse through the elements of an array.

**Example**

Following program traverses and prints the elements of an array:

#include <stdio.h>

main() {

int LA[] = {1,3,5,7,8};

int item = 10, k = 3, n = 5;

int i = 0, j = n;

printf("The original array elements are :\n");

for(i = 0; i<n; i++) {

printf("LA[%d] = %d \n", i, LA[i]);

}

}

When we compile and execute the above program, it produces the following result −

**Output**

The original array elements are :

LA[0] = 1

LA[1] = 3

LA[2] = 5

LA[3] = 7

LA[4] = 8

**Insertion Operation**

Insert operation is to insert one or more data elements into an array. Based on the requirement, a new element can be added at the beginning, end, or any given index of array.

Here, we see a practical implementation of insertion operation, where we add data at the end of the array −

**Example**

Following is the implementation of the above algorithm −

#include <stdio.h>

main() {

int LA[] = {1,3,5,7,8};

int item = 10, k = 3, n = 5;

int i = 0, j = n;

printf("The original array elements are :\n");

for(i = 0; i<n; i++) {

printf("LA[%d] = %d \n", i, LA[i]);

}

n = n + 1;

while( j >= k) {

LA[j+1] = LA[j];

j = j - 1;

}

LA[k] = item;

printf("The array elements after insertion :\n");

for(i = 0; i<n; i++) {

printf("LA[%d] = %d \n", i, LA[i]);

}

}

When we compile and execute the above program, it produces the following result −

**Output**

The original array elements are :

LA[0] = 1

LA[1] = 3

LA[2] = 5

LA[3] = 7

LA[4] = 8

The array elements after insertion :

LA[0] = 1

LA[1] = 3

LA[2] = 5

LA[3] = 10

LA[4] = 7

LA[5] = 8

**Deletion Operation**

Deletion refers to removing an existing element from the array and re-organizing all elements of an array.

**Algorithm**

Consider **LA** is a linear array with **N** elements and **K** is a positive integer such that **K<=N**. Following is the algorithm to delete an element available at the Kth position of LA.

1. Start

2. Set J = K

3. Repeat steps 4 and 5 while J < N

4. Set LA[J] = LA[J + 1]

5. Set J = J+1

6. Set N = N-1

7. Stop

**Example**

#include <stdio.h>

void main() {

int LA[] = {1,3,5,7,8};

int k = 3, n = 5;

int i, j;

printf("The original array elements are :\n");

for(i = 0; i<n; i++) {

printf("LA[%d] = %d \n", i, LA[i]);

}

j = k;

while( j < n) {

LA[j-1] = LA[j];

j = j + 1;

}

n = n -1;

printf("The array elements after deletion :\n");

for(i = 0; i<n; i++) {

printf("LA[%d] = %d \n", i, LA[i]);

}

}

When we compile and execute the above program, it produces the following result −

**Output**

The original array elements are :

LA[0] = 1

LA[1] = 3

LA[2] = 5

LA[3] = 7

LA[4] = 8

The array elements after deletion :

LA[0] = 1

LA[1] = 3

LA[2] = 7

LA[3] = 8

**Search Operation**

You can perform a search for an array element based on its value or its index.

**Algorithm**

Consider **LA** is a linear array with **N** elements and **K** is a positive integer such that **K<=N**. Following is the algorithm to find an element with a value of ITEM using sequential search.

1. Start

2. Set J = 0

3. Repeat steps 4 and 5 while J < N

4. IF LA[J] is equal ITEM THEN GOTO STEP 6

5. Set J = J +1

6. PRINT J, ITEM

7. Stop

**Example**

Following is the implementation of the above algorithm −

#include <stdio.h>

void main() {

int LA[] = {1,3,5,7,8};

int item = 5, n = 5;

int i = 0, j = 0;

printf("The original array elements are :\n");

for(i = 0; i<n; i++) {

printf("LA[%d] = %d \n", i, LA[i]);

}

while( j < n){

if( LA[j] == item ) {

break;

}

j = j + 1;

}

printf("Found element %d at position %d\n", item, j+1);

}

When we compile and execute the above program, it produces the following result −

**Output**

The original array elements are :

LA[0] = 1

LA[1] = 3

LA[2] = 5

LA[3] = 7

LA[4] = 8

Found element 5 at position 3

**Update Operation**

Update operation refers to updating an existing element from the array at a given index.

**Algorithm**

Consider **LA** is a linear array with **N** elements and **K** is a positive integer such that **K<=N**. Following is the algorithm to update an element available at the Kth position of LA.

1. Start

2. Set LA[K-1] = ITEM

3. Stop

**Example**

Following is the implementation of the above algorithm −

#include <stdio.h>

void main() {

int LA[] = {1,3,5,7,8};

int k = 3, n = 5, item = 10;

int i, j;

printf("The original array elements are :\n");

for(i = 0; i<n; i++) {

printf("LA[%d] = %d \n", i, LA[i]);

}

LA[k-1] = item;

printf("The array elements after updation :\n");

for(i = 0; i<n; i++) {

printf("LA[%d] = %d \n", i, LA[i]);

}

}

When we compile and execute the above program, it produces the following result −

**Output**

The original array elements are :

LA[0] = 1

LA[1] = 3

LA[2] = 5

LA[3] = 7

LA[4] = 8

The array elements after updation :

LA[0] = 1

LA[1] = 3

LA[2] = 10

LA[3] = 7

LA[4] = 8