

MCA PART III
Paper-XX: Design and Analysis of Algorithm
Topic: Analysis of Algorithms

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Efficiency of an algorithm can be analyzed at two different stages, before implementation and after implementation. They are the following –

- **A *Priori* Analysis** – Efficiency of an algorithm is measured by assuming that all other factors, for example, processor speed, are constant and have no effect on the implementation.
- **A *Posterior* Analysis** – The selected algorithm is implemented using programming language. This is then executed on target computer machine. In this analysis, actual statistics like running time and space required, are collected.

We shall learn about *a priori* algorithm analysis. Algorithm analysis deals with the execution or running time of various operations involved. The running time of an operation can be defined as the number of computer instructions executed per operation.

Complexity of an Algorithm

Suppose **X** is an algorithm and **n** is the size of input data, the time and space used by the algorithm X are the two main factors, which decide the efficiency of X.

- **Time Factor** – Time is measured by counting the number of key operations such as comparisons in the sorting algorithm.
- **Space Factor** – Space is measured by counting the maximum memory space required by the algorithm.

The complexity of an algorithm **f(n)** gives the running time and/or the storage space required by the algorithm in terms of **n** as the size of input data.

Space Complexity

Space complexity of an algorithm represents the amount of memory space required by the algorithm in its life cycle. The space required by an algorithm is equal to the sum of the following two components –

- A fixed part that is a space required to store certain data and variables, that are independent of the size of the problem. For example, simple variables and constants used, program size, etc.
- A variable part is a space required by variables, whose size depends on the size of the problem. For example, dynamic memory allocation, recursion stack space, etc.

Space complexity $S(P)$ of any algorithm P is $S(P) = C + SP(I)$, where C is the fixed part and $S(I)$ is the variable part of the algorithm, which depends on instance characteristic I . Following is a simple example that tries to explain the concept –

Algorithm: SUM(A, B)

Step 1 - START

Step 2 - $C \leftarrow A + B + 10$

Step 3 - Stop

Here we have three variables A , B , and C and one constant. Hence $S(P) = 1 + 3$. Now, space depends on data types of given variables and constant types and it will be multiplied accordingly.

Time Complexity

Time complexity of an algorithm represents the amount of time required by the algorithm to run to completion. Time requirements can be defined as a numerical function $T(n)$, where $T(n)$ can be measured as the number of steps, provided each step consumes constant time.

For example, addition of two n -bit integers takes n steps. Consequently, the total computational time is $T(n) = c * n$, where c is the time taken for the addition of two bits. Here, we observe that $T(n)$ grows linearly as the input size increases.