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Study Point

Data Structures & Algorithms

"Algorithm, Notations, & Complexity"

(Chapter No. 2)

Presented By:

Sh. Muhammad Aamir
Lecturer
Department of Computer Science
GC University, Faisalabad

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Algorithm

Study Point

- An algorithm is a step-by-step method of solving computational tasks.
- Algorithm = A Precise Sequence of Actions for performing a computational task

(independent from computer languages, i.e. ***pseudo code***).

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Algorithmic Presentation



Study Point

Algorithmic Presentation

Paragraph

- Algorithm Name
- Purpose of Algorithm
- List of variables
- List the input data

Steps

- List of steps to be executed

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Algorithmic Notation ...

Study Point

Name of Algorithm

- Every algorithm is given a name that represents the purpose of the algorithm like "sum" etc.

Steps, Control, Exit

- The algorithm consists of a sequence of **numbered steps**.
- Each step describes **one task** to be performed.
- The instructions in a computer program are written according to these steps.

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Algorithmic Notation

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Algorithmic Notation ...

Study Point

- The steps of an algorithm are executed one after another, beginning with **Step 1** and ending at **Exit** statement is encountered
- The control may be transferred to Step n of the algorithm by the statement "**Go to Step n**"
- If several statements appear in the same step, e.g.
Set $K := 1$, $LOC := 1$ and $MAX := ARR[1]$
Then they are executed from left to right

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Algorithmic Notation ...

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Operators

- Arithmetic Operators (+, -, *, /)
- Relational Operators (<, >, <=, >=, etc)
- Logical Operators (AND, OR, NOT)

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Algorithmic Notation ...

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Comments

- Comments are used to explain the purpose of step or statement. These may be given at the end of each statement or at the beginning of the step.
- Comments are written in [] for an algorithm.

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Algorithmic Notation ...

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Algorithmic Notation ...

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Assignment Statement

- The assignment statement is used to evaluate an expression and assign the calculated value to the variable
- “:=” operator is used to assign a value to the variable with Set keyword
- E.g. Set₁ A:= 5

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Algorithmic Notation ...



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Algorithmic Notation ...

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Input and Output

- Data may be **read / input** by using Read statement
e.g. **Read** : variable names
- Similarly, messages placed in double quotes and data in variables may be output by means of a **Write / Print** statement as
e.g. **Write** : message / variable names

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Algorithmic Notation ...

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Procedures

- The term procedure will be used for independent module/ **sub program** which solves a particular problem.
- The word “Algorithm” will be reserved for the solution of general problems.

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Example-1

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Example-1



Study Point

(ADDITION) This algorithm will find the sum to two variables A, B in C.

Steps:

1. Write: "Enter first value"
2. Read: A
3. Write: "Enter second value"
4. Read: B
5. SET $C := A + B$
6. Write: "The sum is ", C
7. Exit

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Example-2



Example-2



(Temperature) This algorithm will convert the temperature from C (Celsius) to F (Fahrenheit) after reading from user.

Steps:

1. Write: "Enter temperature in Celsius"
2. Read: C
3. $SET F := C * 9 / 5 + 32$
4. Write: "The temperature in Fahrenheit is ", F
5. Exit

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Control Structures



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Control Structures

Study Point

- 1) Sequence Logic, or sequential flow
- 2) Selection Logic, or conditional flow
- 3) Iteration Logic, or repetition flow

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Sequential Logic

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Selection Logic (Conditional Flow)


Study Point

- The structure which implement the selection logic are called **if structures**
- The end of such a structure is presented by the statement **[end of if structure]**

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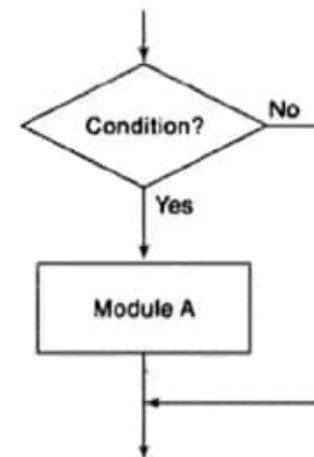
Selection Logic

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Selection Logic (Conditional Flow)...

- **Single Alternative**
 - **If condition, then;**
 - [Module A]
 - [End of If structure]



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Example


Study Point

(EVENODD) This algorithm will find a given number NUM either even or odd.

Steps:

1. Write: "Enter any number"
2. Read: NUM
3. SET $R := \text{NUM} \bmod 2$
4. If $R = 0$, then
Write: "The given number is even"
Else:
Write: "The given number is odd"
[End of If structure]
5. Exit

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Selection Logic (Conditional Flow)...



- **Multiple Alternative**
 - **If condition(1), then:**
[Module A1]
 - Else if condition (2), then:**
[Module A2]
 - Else:**
[Module B]
 - [End of If structure]**

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Example



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Example



Study Point

- The solution for quadratic equation $ax^2+bx+c=0$ where $a \neq 0$, are given by quadratic formula

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

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Algorithm: (Quadratic Equation) This algorithm input the coefficients A, B, C of quadratic equation



Algorithm: (Quadratic Equation) This algorithm input the coefficients A, B, C of quadratic equation and output the real solutions, if any.



Study Point

Step 1 Read: A, B, C.
Step 2 Set $D := B^2 - 4AC$.
Step 3 If $D > 0$, Then
 (a) Set $X_1 := (-B + \sqrt{D}) / 2A$
 Set $X_2 := (-B - \sqrt{D}) / 2A$
 (b) Write : X_1, X_2
Else If $D = 0$, Then
 (a) Set $X_1 := (-B) / 2A$
 (b) Write : X_1
Else:
 Write : 'No real value solution'
[End of If structure]
Step 4 Exit.

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Iteration Logic



Iteration Logic (Repetitive Flow)



- Repetitive flow begins with **Repeat** statement and is followed by a module (called the *body of the loop*)
- End of this structure is presented by **[End of loop]**
- The *repeat-for loop* uses the index variable, such as K, to control the loop
- The format of a loop is as

Repeat for K = R to S by T:
[Module]

[End of loop]

Here R is an initial value, S is last value and T is increment. Loop will terminate when $K > S$

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Iteration Logic



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Iteration Logic (Repetitive Flow)...

Study Point

- The **repeat-while loop** uses the condition to control the loop.
- The format of this loop is as
Repeat while condition:
[Module]
[End of loop]

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Example:

Algorithm: (Largest Element in Array) Given a non-empty array DATA with N values, this algorithm finds the location LOC and value MAX of the largest

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Example:

Algorithm: (Largest Element in Array) Given a non-empty array DATA with N values, this algorithm finds the location LOC and value MAX of the largest element of DATA

 Study Point

1. [Initialize] Set $K := 1$, $LOC := 1$, and $MAX := DATA[1]$
2. Repeat Step 3 and step 4 while $K \leq N$:
3. If $MAX < DATA[K]$, Then:
Set $MAX := DATA[K]$ and $LOC := K$
[End of If structure]
4. Set $K := K + 1$
[End of Step 2 loop]
5. Write LOC, MAX
6. Exit

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Powerful Word Processor

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Why we need algorithm analysis?

Study Point

- As computers get faster and problem sizes get bigger, analysis will become *more* important.
- Why? The difference between good and bad algorithms will get bigger.

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Powerful Word Processor

Complexity of Algorithm

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 Study Point

- Must have some criteria for measuring the efficiency of Algorithm
- **Time and Space** used by an Algorithm are two main measuring factors for efficiency
- The time is measured by counting the **number of key operations** (e.g. number of comparisons)
- The space is measured by counting the **maximum of memory needed** by the algorithm.

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Complexity of Algorithm...

Study Point

- The *complexity* of an algorithm M is the *function* $f(n)$ which gives **the running time and/or storage space** requirement of the algorithm in terms of the **size n of the input data**.

Example

- Suppose we are given an English short story **TEXT**, and suppose we want to search through TEXT for the first occurrence of a given 3-letter word W . If W is the 3-letter word "the" then it is likely that W occurs near the beginning of TEXT, so **$f(n)$ will be small**.
- On the other hand, if W is the 3-letter word "zoo," then W may not appear in TEXT at all, so **$f(n)$ will be large**.

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Worst Case

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- the maximum value of $f(n)$ for any possible input

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Average Case

Study Point

- The analysis of the average case assumes a certain **probabilistic distribution for the input data**; one such **assumption** might be that all possible permutations of an input data set are **equally likely**.
- The average case also uses the following concept in probability theory.
- Suppose the numbers occur with respective probabilities P_1, P_2, \dots, P_k .
- Then the *expectation* or **average value E** is given by
$$E = n_1P_1 + n_2P_2 + \dots + n_kP_k$$

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Linear Search

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