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# INDEX

# GRAPH THEORY AND COMPUTER SCIENCE

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***Abstract:***

*The use of mathematics in quite visible in every area of Computer Science. Graph theory is an important area in mathematics. Graph theory is used in structural models in Computer Science. They arise in all sorts of applications, including scheduling, optimization, communications, and the design and analysis of algorithms. This paper gives an overview of the applications of graph theory in the field of Computer Science.*

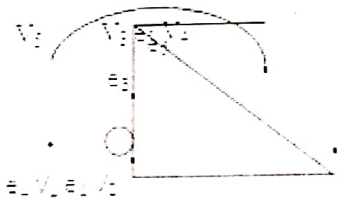
***Keywords**: Digraph, Prograph, Adjacency matrix, Incidence matrix, web design.*

## Introduction:

Graph theory is an applied branch of mathematics which deals the problems with the help of graphs. Different kinds of graphs and their applications in computer science is proposed here.

### *Graph:*

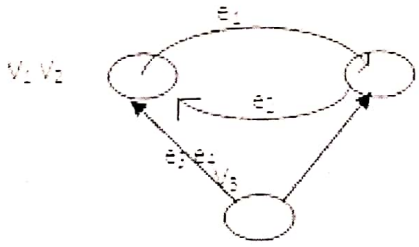
A graph G = (V,E) Consists of a set of objects V = {$V_1$,$V_2$----} called vertices and another set E = {$e_1$,$e_2$--------} whose elements are called edges, such that each edge $e_k$ is identified with an unordered pair(Vi,Vj) of vertices. The vertices Vi,Vj, associated with edge $e_k$ are called the end vertices of $e_k$. An edge having the same vertex as both its end vertices is called a self loop. Simply we say that a graph is a diagram in which the vertices are represented as points and each edge as a line segment joining its end vertices.



(Fig 1: Graph with five vertices and six edges)

### *Directed graph:*

A directed graph (or diagraph) G consists of a set of vertices V = { $V_1V_2$, ----------}, a set of edges E = {$e_1$, $e_2$, ---------}, and a mapping 'Ψ' that maps every edge onto some ordered pair of vertices ($V_1$,$V_j$)



(Fig2: A diagraph with three vertices and four edges)

Directed graphs are employed in abstract representations of computer programs, where the Vertices stand for the program instructions and the edges specify the execution sequence.

**Simple graph:** A graph without any self loop or parallel edge is called a simple graph The diagraph in Fig 2 is a simple graph.

**Complete graph:** A graph is said to be complete graph if all the vertices in the graph are adjacent to each other.

**Sub graph:** A graph g = (V', E') is said to be sub graph of a graph G = (V,E) iff E' ∈ E and V' ∈ V. Similarly E' and v' are said subset of E and V respectively.

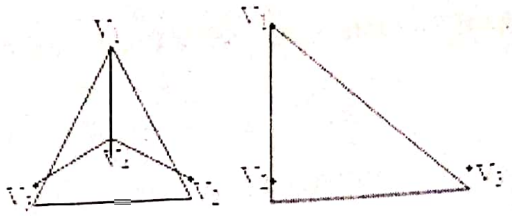


Fig 3

### *Computer Representation of Graph:*

A matrix is a convenient and useful way of representing a graph to a computer. A graph is generally presented to and is stored in a digital computer in one of the following five forms.

1. Adjacency matrix
2. Incidence matrix
3. Edge listing
4. Two linear arrays
5. Successor listing.

### *Adjacency matrix:*

The adjacency matrix of a graph G with n vertices and no parallel edges is an n by n symmetric binary matrix $X = [x_{ij}]$ defined over the ring of integers such that.

$[x_{ij}] = 1$, if there is an edge between $i^{th}$ & $j^{th}$ vertices, and

= O, if there is no edge between them.

The most accepted practice that feeds a graph / digraph G having n vertices to a computer is adjacency matrix. The adjacency matrix requires $n^2$ bits of computer memory. Bits can be packed into words. Let w be the word length (i.e the number of bits in a computer word) and n be the number of vertices in the graph. Then each row of the adjacency matrix may be written as a sequence of n bits in $[n/w]$ machine words. ([x] denotes the smallest integer not less than x. ). The number of words required to store the adjacency matrix is, therefore n $[(n/w)]$ . Due to symmetric in nature, adjacency matrix of an undirected graph with n vertices need $n(n-1)/2$ bits storage only.

### *Incidence matrix:*

Let G be a graph with n vertices, e edges, and no self – loops. Define an n by e matrix $A = [a_{ij}]$, whose n rows correspond to the n vertices and the e columns correspond to the edges as follows,

The matrix element

$A_{ij} = 1$, if $j^{th}$ edge ej is incident on $i^{th}$ vertex $v_i$, and

= 0, otherwise

Matrix A is called incidence matrix, it is written as A (G).

An incidence matrix requires n.e. bits of storage, which might be more than the $n^2$ bits needed for an adjacency matrix, because the number of edges e is usually greater than the number of vertices n. Incidence matrices are particularly favored for electrical network and switching networks.

For a graph whose adjacency matrix is sparse (A matrix that contains many zero elements is called a sparse matrix), edge listing is a more efficient method of storing the graph.

Two linear arrays was used in the algorithm for storing weighted graphs. The successor or neighbor listing form is extremely concvenient for path) finding algorithms.

### *Why Graphs:*

Graphs are extremely important in computer science mainly for the reasons.

- Without graphs, representation of many problems in computer science become abstract.
- The solution to a problem as a graph may derive new approach directly.
- Many problems involve representing relationships between objects, places or concepts.

### *Algorithms and Graph theory:*

The major role of graph theory in computer applications is the development of graph algorithms. These algorithms are used to solve the graph theoretical concepts which used to solve the computer science application problems. Various

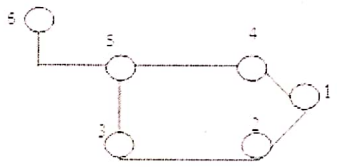
computer science languages are used to support the graph theory concepts. The main goal of such languages is to enable the user to formulate operations on graphs in a compact and natural manner. Some graph theoretic languages are.

- GTPL-Graph – Theoretic Language
- GASP– Graph Algorithm Software Package
- HINT– Extension of the listing processing language LISP
- GRASPE - Extension of LISP
- IGTS- Interactive Graph Theory System (Extension of FORTRAN)
- GEA – Graphic Extended ALGOL
- AMBIT/G – For manipulation of diagraphs
- GIRL - Graph Information Retrieval Language.
- FGRAAL – FORTRAN Extended Graph Algorithmic Language.

### *Application of Graphs In Computers Science*

**Graph in Computer Network:** A set of devices (Computers) connected through communication links (wires) forms computer network. In this case graphs are utilized in defining, representing, classifying the physical layout of a network with optimal cost which varies with wire length. It is also used in categorizing the network in Local Area Network, Metropolitan Area Network and Wide Area Network to determine its size. In all the cases simple graphs are used.

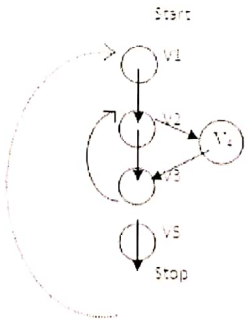
**Graphs in Computer Network Security:** The vertex cover algorithm is used to simulate the propagation of stealth worms on large computer networks and proposed optimal strategies to protect the network against virus attacks in real time. The main idea here is to find a minimum vertex cover in the graph whose vertices are the routing servers and the edges are the connections between the routing servers. Then an optimal solution is found for worm propagation and a network dense strategy is defined. The sample computer network with corresponding minimum vertex cover is shown below.



(Fig 4: Minimum Vertex Cover Set { 2,4,5} of the computer network)

**Graphs in coding theory:** Gray codes ; A code which requires the changing of only one bit at a time is called the Gray Code, the reflected binary code, circuit code, or cyclic code. These codes are important in analog – to – digital conversion of information. An m – bit Gray code corresponds to a circuit in an m – cube having $2^m$ vertices at most. When all these vertices are used by m – bit code, then it is called computer code. When 4 – bit words are used to represent decimal digits, use only 10 out of 16 vertices.

**Graphs in Computer Programming:** Analysis of a given computer program has been an important problem from the early days of computer programming. The purpose of such an analysis could be to estimate the running time or storage requirement of a program to subdivide a large program into a number of subprograms, to detect certain types of structural errors in the program, to document a program or simply to understand a program written by someone else. For all these purposes it is very convenient to represent a program as a diagraph. The graph this obtained might be formed as program digraph (prograph) Each vertex $v_i$ of the prograph is a program block – each having one entry and one exit point. Each edge $(v_i,v_j)$ represents flow of control from the exit point of $v_i$ to the entry point of $v_j$.




(Fig 5: A typical prograph of n nodes.)

A program digraph can also be thought of as an abstraction of a flow chart in which the boxes are shrunk to vertices and arrows become the edges.

***Graphs in Web design:***

The link structure of a website could be represented by a directed graph: the vertices are the available web pages and the link from page A to B is the directed edge. A similar approach can also be taken to problems computer chip design.

## Conclusion:

Graph theoretical ideas are highly utilized by computer science applications. Especially in research areas of computer science. The main aim of this paper is to present the importance of graph theoretical ideas in various areas of computer applications.

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