

Applications of Graph Theory in Various Areas

Varsha Gupta

Department of Applied Science

Maharishi Arvind Institute of Engineering and Technology

Corresponding Author's email id: *jain.kusum81@gmail.com*

Abstract

Graphs can be used to model many types of relations and processes in physical, biological, social and information systems. Many practical problems can be represented by graphs. The field of mathematics plays an important role in various fields. One of the important areas in mathematics is graph theory which is used in structural models. This structural arrangements of various objects or technologies lead to new inventions and modifications in the existing environment for enhancement in those fields. In recent years, graph theory has established itself as an important mathematical tool in a wide variety of subjects, ranging from operational research and chemistry to genetics. Graphs are used to represent networks of communication, data organization, computational devices, the flow of computation, etc. For instance, the link structure of a website can be represented by a directed graph, in which the vertices represent web pages and directed edges represent links from one page to another. A similar approach can be taken to problems in social media, travel, biology, computer chip design, mapping the progression of neuro-degenerative diseases, and many other fields. The development of algorithms to handle graphs is therefore of major interest in computer science. The transformation of graphs is often formalized and represented by graph rewrite systems. This paper gives an overview of the applications of graph theory in the field of computer science which uses graph in many theoretical concepts. Various papers based on graph theory have been studied related to scheduling concepts, computer science applications and an overview has been presented here.

Keywords: *Graphs, connectivity, constraints, graph coloring, graph drawing*

I. INTRODUCTION

In mathematics and computer science, graph theory is the study of graphs, which are mathematical structures used to model pairwise relations between objects. A "graph" in this context is made up of "vertices" or "nodes" and lines called edges that connect them. A graph may be undirected, meaning that there is no distinction between the two vertices associated with each edge, or its edges may be directed from one vertex to another; see graph (mathematics) for more detailed definitions and for other variations in the types of graph that are commonly considered. Graph theory is a branch of discrete mathematics. In mathematics and computer science, graph theory is the study of graphs which are mathematical structures used to model pair wise relations between objects. There is wide use of graphs in providing problem solving techniques, because it gives a manner prior for presenting formal definition. This paper has been divided into two sections. First section gives the historical background of graph theory and Second section gives the application of graph theory in various fields.

Part-A:

History of Graph theory:

The origin of graph theory started with the problem of Koinsberg Bridge, in 1735. This problem lead to the concept of Eulerian Graph. Euler studied the problem of Koinsberg bridge and constructed a structure to solve the problem called Eulerian graph. In 1840, A.F Mobius gave the idea of complete graph and bipartite graph and Kuratowski proved that they are planar by means of recreational problems. The concept of tree, (a connected graph without cycles) was implemented by Gustav Kirchhoff in 1845, and he employed graph theoretical ideas in the calculation of currents in electrical networks or circuits. In 1852, Thomas Gutherie found the famous four color problem. Then in 1856, Thomas. P. Kirkman and William Hamilton studied cycles on polyhydra and invented the concept called Hamiltonian graph by studying trips that visited certain sites exactly once. In 1913, H.Dudeney mentioned a puzzle problem. Eventhough the four color problem was invented it was solved only after a century by Kenneth Appel and Wolfgang

Haken. This time is considered as the birth of Graph Theory.

Part: B

Applications of Graph theory:

1. Computer Network Security:

A team of computer scientists led by Eric Filiol at the Virology and Cryptology Lab, ESAT, and the French Navy, ESCANSIC, have recently used the vertex cover algorithm to simulate the propagation of stealth worms on large computer networks and design optimal strategies for protecting the network.

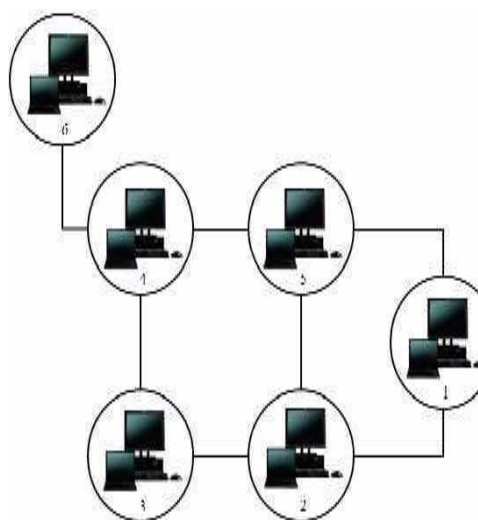


Figure: 1

The simulation was carried out on a large internet-like virtual network and showed that the combinatorial topology of routing may have a huge impact on the worm propagation and thus some servers play a more essential and significant role

than others. The real-time capability to identify them is essential to greatly hinder worm propagation. The idea is to find a minimum vertex cover in the graph whose vertices are the routing servers and whose edges are the (possibly dynamic) connections between routing servers. This is an optimal solution for worm propagation and an optimal solution for designing the network defense strategy. Figure 5.1 above shows a simple computer network and a corresponding minimum vertex cover $\{2, 4, 5\}$.

2. GRAPHS IN CHEMISTRY:

Graphs are used in the field of chemistry to model chemical compounds. In computational biochemistry some sequences of cell samples have to be excluded to resolve the conflicts between two sequences. This is modeled in the form of graph where the vertices represent the sequences in the sample. An edge will be drawn between two vertices if and only if there is a conflict between the corresponding sequences. The aim is to remove possible vertices, (sequences) to eliminate all conflicts. In brief, graph theory has its unique impact in various fields and is growing large now a days. The subsequent section analyses the applications of graph theory especially in computer science.

3. GRAPH THEORY AND ITS APPLICATIONS IN WIRELESS NETWORKS:

Wireless multi-hop networks, in various forms, e.g. wireless sensor networks, underwater sensor networks, and vehicular networks, mesh networks and UAV (Unmanned Aerial Vehicle) formations, and under various names, e.g. ad-hoc networks, hybrid networks, delay tolerant networks and intermittently connected networks, are being increasingly used in military and civilian applications. Graph theory, particularly a recently developed branch of graph theory, i.e. random geometric graphs, is well suited to studying these problems. These include but not limited to: cooperative communications; opportunistic routing; geographic routing; statistical characterization (e.g. connectivity, capacity and delay) of multi-hop wireless networks; geometric constraints among connected nodes and their use in autonomous parameter estimation without manual calibration. This research will investigate the use of graph theory to solve problems in the above broad areas. Research outcomes will benefit almost all areas in wireless multi-hop networks, including routing, scheduling, mobility management, dimensioning, interference

control, energy management and localization.

4. DATA MINING:

Graph mining is the main application area of graph theory in data mining. Graph mining represents the relational aspect of data. There are five theoretical based approaches of graph based data mining. They are sub graph categories, sub graph isomorphism, graph invariants, mining measures and solution methods.

5. OPERATING SYSTEM:

A graph is a data structure of finite set of pairs, called edges or vertices. Many practical problems can be solved with the help of graph in the field of operating system such as job scheduling and resource allocation problems. For example graph coloring concept can be applied in job scheduling problems of CPU, jobs are assumed as vertices of the graph and there will be an edge between two jobs that cannot be executed simultaneously and there will be one to one relationship between feasible scheduling of graphs

6. MAP COLORING AND GSM MOBILE PHONE NETWORKS:

Groups Special Mobile (GSM) is a mobile phone network where the

geographical area of this network is divided into hexagonal regions or cells. Each cell has a communication tower which connects with mobile phones within the cell. All mobile phones connect to the GSM network by searching for cells in the neighbours. Since GSM operate only in four different frequency ranges, it is clear by the concept of graph theory that only four colors can be used to color the cellular regions. These four different colors are used for proper coloring of the regions.

Therefore, the vertex coloring algorithm may be used to assign at most four different frequencies for any GSM mobile phone network.

CONCLUSION

The main aim of this paper is to present the importance of graph theoretical ideas in various areas for researches that they can use graph theoretical concepts for the research. An overview is presented especially to project the idea of graph theory. So, the graph theory section of each paper is given importance than to the other sections. Researches may get some information related to graph theory and its applications in various field and can get some ideas related to their field of research.

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1