Graph in Real Life

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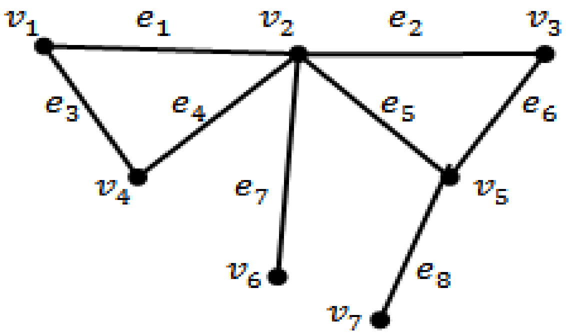
Abstract:
In mathematics, **graph theory** is the study of graphs, which are mathematical structures used to model pairwise relations between objects. A graph in this context is made up of vertices which are connected by edges. A distinction is made between **undirected graphs**, where edges link two vertices symmetrically, and **directed graphs**, where edges link two vertices asymmetrically.[10] The field graph theory started its journey from the problem of Konigsberg Bridge in 1735. This paper gives an overview of the applications of graph theory in heterogeneous fields to some extent but mainly focuses on Internet, Computer Science, Physics, Chemistry, Air distance, Work distribution problems and some more applications of Graph theory that uses graph theoretical concepts.

Key Words: Graph theory, Internet, Computer Science, Physics and Chemistry, Bipartite Graph, Air distance, Work distribution.

Introduction:
Graph theoretical ideas are highly utilized by computer science applications. Also paths, walks and circuits in graph theory are used in tremendous applications say traveling salesman problem, timetable problem, job scheduling problems, database design concepts, resource networking.
Every day we are surrounded by countless connections and networks for example roads and rail tracks, phone lines and the internet, electronic circuits and even molecular bonds. There are also social networks between friends and families. All these systems consist of certain points, called vertices, connected by lines, called edges. In mathematics, all these networks are called **graphs**.
1.1 Definition: A graph – usually denoted $G(V,E)$ or $G=(V,E)$ – consists of set of vertices V together with a set of edges E. The number of vertices in a graph is usually denoted n while the number of edges is usually denoted m.
1.2 Example: consider the Graph G,



Here $V=\{v_1,v_2,v_3,v_4,v_5,v_6,v_7\}$ is vertex set and $E=\{e_1,e_2,e_3,e_4,e_5,e_6,e_7,e_8\}$ is edge set.
1.3 Definition: Edges are also known as lines and (in social networks) as ties or links. An edge $e=(u,v)$ is defined by the unordered pair of vertices that serve as its end points.
1.4 Definition: Two vertices u and v are adjacent if there exists an edge $e=(u,v)$ that connects them.
1.5 Definition: An edge (u,v) is said to be incident upon nodes u and v.
1.6 Definition: An edge $e=(u,u)$ that links a vertex to itself is known as a self-loop.
Graph Theory, due to its intrinsic simplicity, has a lot of applications in Computer Science, Computer Networks, Engineering Science, Social Science, Mathematics, Physics, Chemistry, Biology, Genetics, Economics, Logistics, Sociological Structures, Data Structures, Artificial Intelligence, Pattern Recognition, Cybernetics, Computer Fault Diagnosis and many other fields. Graph theory applications continue to grow.

Internet :
The Internet, for example, is a vast, virtual graph. Every vertex is an individual webpage, and every edge means that there is a hyperlink between two pages. Note that links only go one way, so this graph is directed, and that this graph is very, very, large.

Volume: I, Date-30/04/2023
ISBN: 978-93-94819-26-9

E-websites, like Wikipedia or Facebook, have lots of incoming links, while many smaller websites may have very few incoming links. This is the underlying concept which Google uses to sort search results.

The Internet is the largest network created by mankind. While websites and hyperlinks form a virtual graph, there is also the physical network of computers, servers, routers, phone lines and cables.

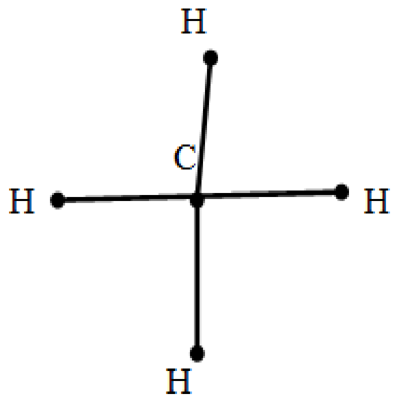
Every time you make a phone call or load a website, network operators have to find a way to connect sender and receiver, without exceeding the capacity of any individual cable or connection. Graph theory and probability make it possible to guarantee a reliable service, for example by finding diversions when a particular connection is busy.

Computer science:

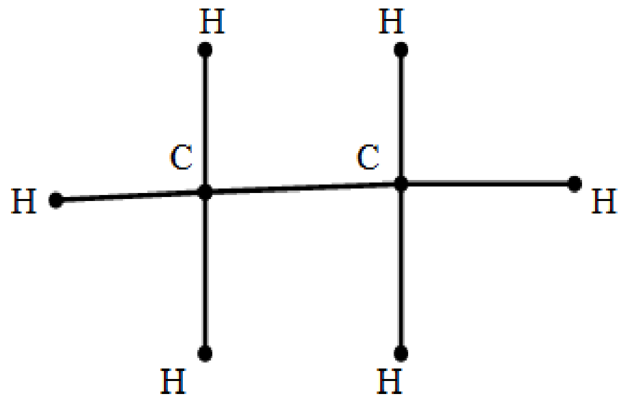
The branch of computer science known as data structure uses graphs to represent networks of communication, data organization, computational devices, the flow of computation, etc. For instance, the link structure of a website can be represented by a directed graph, in which the vertices represent web pages and directed edges represent links from one page to another. A similar approach can be taken to problems in travel, biology, computer chip design, mapping the progression of neuro-degenerative diseases,[7,8] and many other fields.

Physics and chemistry:

Graph theory is also used to study molecules in chemistry and physics. In condensed matter physics, the three-dimensional structure of complicated simulated atomic structures can be studied quantitatively by gathering statistics on graph-theoretic properties related to the topology of the atoms. In chemistry a graph makes a natural model for a molecule, where vertices represent atoms and edges bonds. In statistical physics graphs can represent local connections between interacting parts of a system, as well as the dynamics of a physical process on such systems. Similarly, in computational neuroscience graphs can be used to represent functional connections between brain areas that interact to give rise to various cognitive processes, where the vertices represent different areas of the brain and the edges represent the connections between those areas. Graph theory plays an important role in electrical modelling of electrical networks, here, weights are associated with resistance of the wire segments to obtain electrical properties of network structures.[9] Chemical graph theory uses the molecular graph as a means to model molecules. Graphs are used in the field of chemistry to model chemical compounds. Graph provides a natural mathematical model of molecules.



Structure of Methane



Structure of Ethane

Air Distance between Cities:

Graphs also plays an important role in transportation and navigation. All flight, train and subway networks form graphs, which can be used when creating efficient schedules.

Consider the table of approximate airlines distance in miles between four of the largest cities in the world, London, New York, Paris and Tokyo.

Cities	London	New York	Paris	Tokyo
London	–	3469	214	5959
New York	3469	–	3636	6757
Paris	214	3636	–	6053
Tokyo	5959	6757	6053	–

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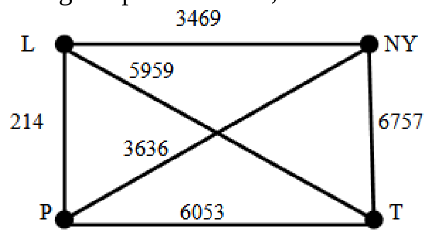
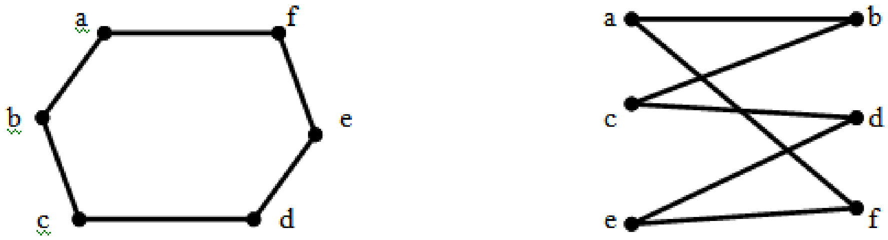
The above information can be shown using Graph as follows,



Bipartite Graph:

A Simple Graph G is called bipartite if its vertex set can be partitioned into two disjoint subsets such that each edge connects a vertex from one subset to the vertex of the other subset.

e.g. In the following Graph G, Two disjoint subsets are { a, c, e } and { b, d, f }.



Graph G   Bipartite form of G

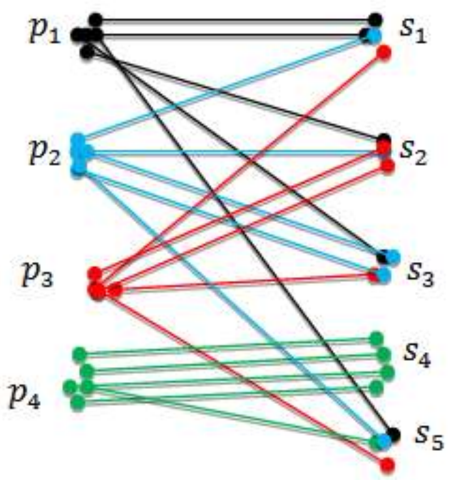
Work Distribution Problem:

Allocation of subjects to the professors is one of the major issues if the constraints are complex. Graph theory plays an important role in this problem. For m professors with n subjects, this is done as follows. A bipartite graph G where the vertices are the number of professors say $p_1, p_2, p_3, p_4, \dots \dots, p_k$ and m number of subjects say $s_1, s_2, s_3, s_4, \dots \dots, s_m$ such that the vertices are connected by u_i edges, where u_i is the number of unit allotted to professors of different subjects.

For example, Consider there are 4 professors namely p_1, p_2, p_3, p_4 and 5 subjects say s_1, s_2, s_3, s_4, s_5 to be taught. Each subject having 4 units. The teaching requirement matrix $A = [a_{ij}]$ is given below.

P	s_1	s_2	s_3	s_4	s_5
p_1	2	1	1	0	1
p_2	1	1	2	0	1
p_3	1	2	1	0	1
p_4	0	0	0	4	1

The bipartite graph is constructed as follows



Complete Graph :

A complete graph is a simple undirected graph in which every pair of distinct vertices is connected by a unique edge.

An example of complete graph is shown below,

Handshakes and Dating :

You have been invited to a wonderful birthday party with your friends. Including yourself and the host, there are 5 people present in the evening, as the guests get ready to leave, everyone shakes hands with everyone else. How many handshakes are there in total?

We can represent the handshakes using a graph: every person is a vertex, and every handshake is an edge.

Now it is easy to count the number of edges in the graph. We find that with 5 people, there are 10 handshakes.

Rather than counting all the edges in large graphs, we could also try to find a simple formula that tells us the result for any number of guests.

Each of the 5 people shakes hands with 4 others. That makes $5 \times 4 = 20$ handshakes in total. For n people, the number of handshakes would be $n(n-1)$.

In fact, we have counted every handshake twice, once for each of the two people involved. This means that the correct number of handshakes for 5 guests is $\frac{5 \times 4}{2} = 10$.

Conclusion:

The main aim of this paper is to present the importance of graph theoretical ideas in various areas of Internet, Air distance, Work distribution problems, handshaking, Traveling salesman problems 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 Internet, Air distance, Work distribution problems, handshaking and can get some ideas related to their field of research.

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