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## Graphs in real life example

Given article text here The concept of graph theory has a rich history dating back to the 18th century, when mathematicians tackled the Königsberg bridge problem. This seemingly simple puzzle not only revolutionized mathematics but also paved the way for its modern applications in various fields. Graph theory, as we know it today, was born out of Leonhard Euler's solution to the Königsberg bridge problem. In 1736, Euler analyzed the connections between landmasses and bridges, representing them with dots and lines. He realized that no matter how many paths were explored, a solution couldn't be found. Euler's abstraction led him to understand that certain properties of graphs made it impossible to cross all bridges without repeating any. Fast forward to today, graph theory has become an integral part of data science, touching various aspects of our lives. Its applications are diverse and widespread, transforming the way we analyze and interpret complex systems. Graph Theory Emerges from Solving Problems The development of graph theory began with solving problems by abstracting them into geometric relationships. This led to a breakthrough in understanding relationships between objects. Graph theory is an essential tool for tackling various real-world problems by converting them into mathematical equations and solving them using algorithms. One such problem is airline scheduling, which falls under flow problems. In this scenario, flights are represented as vertices, while the connections between them are edges with weights indicating crew requirements. Airline companies use graph theory to optimize their schedules by finding the minimum number of crew members needed for all flights. By adding a source and sink vertex, airlines can calculate the minimum flow that covers all destinations. This approach can also be applied to other areas like supply chain management and public transportation scheduling. Another significant application of graph theory is in navigation systems, which rely on calculating the shortest path between two points. Maps are transformed into graphs by assigning intersections as vertices and streets as edges. Weights are assigned to represent distances or travel times, enabling algorithms to find the most efficient route. Graph theory's ability to model real-world problems has numerous benefits, including optimizing resource allocation, minimizing costs, and improving efficiency. As technology continues to advance, graph theory will play an increasingly vital role in solving complex challenges faced by various industries. However, it is essential to note that not all problems have exact solutions, and sometimes approximations are the best outcome due to their complexity or size. Despite these limitations, graph theory remains a powerful tool for tackling intricate real-world problems. also one-way streets in the city.Now, to give the direction between two points in the map, an algorithm only needs to calculate the path with the lowest sum of edge weights between the two corresponding vertices. This can be trivial for small graphs; however, for graphs created from big cities, this is a hard problem. Fortunately, there are many different algorithms that may not give the perfect solution, but will give a very good approximation, such as the Dijkstra's algorithm or the A\* search algorithm.Finding the shortest or fastest route between two points in the map is definitely one of the most used applications of graph theory. However, there are other applications of the shortest path problem. For example, in social networks, it can be used to study the "six degrees of separation" between people, or in telecommunication networks to obtain the minimum delay time in the network.Solving Sudoku's puzzles (Graph coloring)Sudoku is a popular puzzle with a 9x9 grid that needs to be filled with numbers from 1 to 9. A few numbers are given as a clue and the remaining numbers needed to be filled follow a simple rule: they cannot be repeated in the same row, column or region. This puzzle, despite using numbers, is not a mathematical puzzle, but a combinatorial puzzle that can be solved with the help of graph coloring.One can convert the puzzle to a graph. Here, each position on the grid is represented by a vertex. The vertices are connected if they share the same row, column or region. This graph is an undirected graph, since the relationship between vertices goes both ways. An important feature of the graph is the assignment of a label to each vertex. The label corresponds to the number used in that position. In graph theory, the labels of vertices are called colors.To solve the puzzle, one needs to assign a color to all vertices. The main rule of Sudoku is that each row, column or region cannot have two of the same numbers, thus two vertices that are connected cannot have the same color. This problem is called graph coloring, and, as with other graph theory problems, there are many different algorithms that can be used to solve this problem (Greedy coloring or DSatur algorithm, for example), but their performance depends highly on the graph itself.The coloring problem is used normally for very fundamental problems. However, there are more real-life problems that can be translated to a coloring problem, such as scheduling tasks. For example, scheduling exams in rooms. Each exam is a vertex and there is an edge connecting them if it takes place at the same time. The graph created is called an interval graph, and by solving the minimum coloring problem of the graph, you obtain the minimum number of rooms needed for all the exams. This can be generalized with tasks that use the same resources, such as compilers of programming languages or bandwidth allocation to radio stations.Search Engine Algorithms (PageRank algorithm)Search engines such as Google let us navigate through the World Wide Web without a problem. Once a query is made to search a specific set of words, the engine looks for Here is how search engines and social media platforms rank results to show the most popular ones first: they use graph theory! They create a web graph where websites are connected by directed edges showing hyperlinks. Adding weights to vertices gives priority to more important websites. To classify the most popular, algorithms like PageRank can be used. It assigns probabilities to click on links and orders the list based on this distribution. However, this algorithm has flaws that can be exploited, so newer algorithms consider sponsored ads too. In 2022, Facebook had over 2.9 billion active users, mostly from advertising. To target specific audiences, graph theory can create a social network graph where vertices represent people connected by relationships like friendships. This undirected graph appears chaotic at first but patterns emerge. By decomposing the graph into smaller sub-graphs using algorithms like hierarchical clustering or minimum cut methods, communities of highly connected people are found. These communities share common interests and are more likely to buy similar products or follow same artists. This community detection can be used for advertising purposes, as well as security controls. If a group or vertex behaves strangely compared to peers, it may indicate intrusion, which can be detected to prevent malicious activities in networks of computers or programs. Graph theory is a powerful tool used to model pairwise relations between objects, and its applications span various domains including computer science, biology, transportation, and social networks. By abstracting problems and removing non-important parts, graph theory can help identify strange connections that improve network security, plan the best route on a road trip, or understand how diseases spread in a community. The study of graphs consists of directed and undirected graphs, where connections between points have direction or not, respectively. Additionally, weighted and unweighted graphs differ in the presence of values or weights representing measures like distance, cost, or time. Graph theory has diverse applications, including social networks where user connections are simulated using graph algorithms to analyze network structures, identify influential users, and predict trends or behavior. Graph theory is a fundamental concept in various fields such as transportation networks, internet and computer systems, epidemiology, supply chain management, and biology. Graphs are crucial in depicting relationships between different components like cities connected by roads or websites linked by hyperlinks. Algorithms based on graph theory can be used to determine the shortest paths between nodes, optimize routes for faster travel times or reduced distances, and manage traffic flow efficiently. In internet-related tasks such as search engine optimization, web structure analysis, intrusion detection systems, and network routing protocol optimization, graph algorithms play a vital role. Similarly, in epidemiology, graph theory is essential for modeling the spread of diseases among populations by identifying nodes (people) and edges (contacts or interactions). This helps develop strategies for disease management and containment measures. Graphs are also used extensively in supply chain optimization to represent different manufacturing phases as nodes and commodity movement between them as edges. Graph algorithms aid in controlling inventory levels, reducing costs, increasing efficiency, and ensuring timely product delivery. In biology and bioinformatics, graphs depict complex biological systems such as protein interactions, metabolic processes, genetic linkages, and molecular structures. Graph algorithms help understand the underlying causes of diseases like cancer and genetic disorders, analyze DNA sequences, predict protein structures, and determine functional links between different components. Graph theory's versatility extends to various applications beyond these fields, underscoring its significance in analyzing and understanding complex relationships within systems. Graphs are a powerful tool with numerous applications in various fields, enabling the analysis and interpretation of complex data. Originating as a recreational math puzzle in the 18th century, Graph Theory has expanded to become a branch of mathematics with real-life applications in transportation planning, computing, search engines, and biology. Graph theory has numerous applications across various fields, including biology, linguistics, epidemiology, computer science, cybersecurity, and cancer treatment. In biology, graph theory helps understand gene regulation, transcriptional control, and expression levels by modeling biological processes. Linguists apply graph theory to model language structures, sentences, and words as formal systems. Epidemiologists use graphs to track disease spread, identify high-risk individuals, and suggest control measures. In computer science, graph theory is used for internet routing algorithms, ensuring data traffic flow despite faults or congestion points. Cybersecurity experts employ graph theory to analyze network vulnerabilities, monitor malicious activities, and map social media relationships. Graph theory also helps model cancer cell growth and metastasis, enabling targeted treatments with reduced side effects. Additionally, graph theory can be applied to social networks to determine node importance based on connections made. This can lead to increased online traffic for more influential individuals. Overall, graph theory is crucial in modeling and studying many real-world phenomena. Graph theory is a branch of mathematics that focuses on studying graphs, networks, and their properties. It provides insights into understanding relationships within personal or professional networks, enabling individuals to explore and measure connections between nodes. By applying graph theory, one can identify influential nodes in a network by examining their interactions with other nodes. Graph theory has been employed for decades to solve complex problems in various fields, including scientific research, computer science, and engineering. Its applications extend beyond problem-solving to include designing communications networks, navigation systems, and transportation systems. Moreover, graph theory is utilized in networking to create efficient networks and facilitate information access. Additionally, it can be used to represent molecular structures and flow patterns within cells or the circulatory system, making it an essential tool for rethinking technological and economic systems.

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