Applications of Graph Algorithms

Introduction

Graphs, as a data structure given rise by the mathematical concept have become ubiquitous in technology today. Graphs have found some unique applications, and this brief report aims to explore some of them. Over time, graphs have become the data structure of choice, and along with graph algorithms now form the backbone of technology today.

Applications

Internet Traffic Routing

Graph algorithms, particularly shortest path algorithms (example: Dijkstra's algorithm), are used to route internet traffic. With millions of search, access, and other functions being performed per second, efficiency is key in order to keep up speed and quality of service. Using the shortest path algorithm ensures minimal time and hops between the end-user and the actual web-server to return the requested resource via the DNS server and ISP routers.

Google Maps and Navigation

Some of the most critical applications we rely on make use of graphs. Navigation apps such as Google Maps are basically extremely large graphs with locations as individual nodes and roads/paths between them edges. When providing navigation from one point to another, Google Maps essentially uses shortest path search algorithms like Dijkstra's algorithm to find the shortest route between point A and point B based on the constraints provided (no tolls, no highways, etc.). However, it is important to note that while the shortest path between two points is always a straight line, this is not always true in real-life as two places may not be directly connected. This makes navigation more challenging. By encompassing other locations (nodes) within this graph search, Google Maps makes calculations more viable. An example of this is as follows: when calculating the shortest path between the east coast and the west coast, Google does not show a straight line - instead, it takes into consideration cities and towns in between that get you closer and closer to your end destination in the shortest distance and time. The resulting shortest paths are those that are shown on one's screen. One would think such computations would take an incredibly long time. However, Google is able to accomplish this fairly quickly though high-performance computing clusters and extremely efficient servers, and many, many data centers to power all the searches it processes.

Uber, and Sharing Services

Uber/Eats/other sharing services such as DoorDash and Grubhub are based on the same premise, utilizing shortest path algorithms to ensure efficient and quick service. Behind the scenes of these services' highly intuitive mobile applications, there is a lot of computation at work. Since Uber also makes extensive use of maps and navigation, much of what was said in the previous section is applicable here. In addition to maps and navigation, Uber extensively uses graphs coupled with AI for real time data visualization which enables teams at Uber to make immediate decisions regarding current supply and demand. Another interesting place where Uber uses graphs is to determine hotspots, and use such information for geosurge (more commonly known as surge pricing). Additionally, UberEats uses graphs and artificial intelligence to make recommendations for both places to order from and dishes to try. Uber Engineering has an extremely detailed article about how Eats uses graph learning to power recommendations (if you wish to read it, it can be found here). Essentially, Eats' data is structured as graphs, where various properties are encoded. Machine Learning is then applied on these nodes for specific properties and learning from the patterns/representations obtained. Recommendation "carousels" are created both for restaurants to try, and for dishes similar to those you have tried before and may like. This graph learning system also constantly improves itself by using your latest choices to improve recommendations.

Facebook, LinkedIn, Social Networks, and Streaming Services

Social networks are basically graphs with people as nodes. When Facebook, LinkedIn, or any similar social network suggests new people to add to your network, it is using breadth-first search to find potential new connections based on existing connections. Influencers and cliques in social networks are also based on the premise of graphs, where platforms use influencers and follower nodes to direct targeted advertisements, and find similar nodes using graph search (bfs) to form cliques. Similarly, streaming services like Netflix use breadth-first and depth-first search to make recommendations in different genres/within the same genre respectively. Similar to UberEats above, Netflix also maintains a recommendation carousel, and similarly uses a structure of knowledge graphs to search for related content and build recommendations.