Breadth First Search (BFS)

Objective

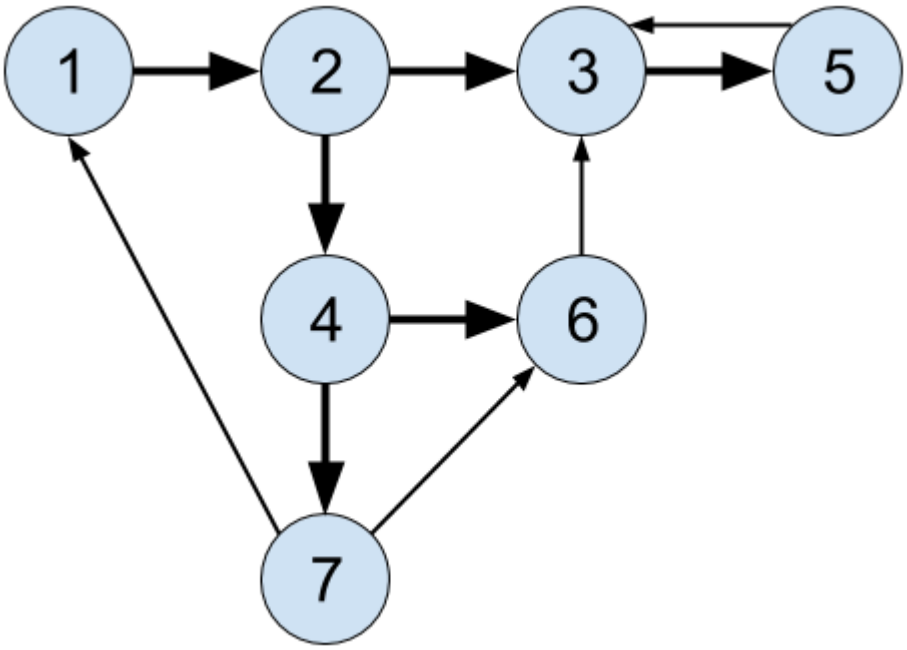
- Learn about one of the more famous graph algorithms
- Learn uses of BFS

Overview

When searching a graph, one of the approaches is called *breadth first search*. This explores the graph outward in rings of ever increasing distance from the starting vertex.

The algorithm never attempts to explore a vert that it either has explored or is exploring.

For example, when starting from the upper left, the numbers on this graph show a vertex visitation order in a BFS:



The bold lines show with edges were followed. (The thin edges were not followed since their destination nodes had already been visited.)

(Of course, the exact order will vary depending on which branches get taken first and which vertex is the starting vertex.)

Uses of BFS

- Pathfinding, Routing
- Find neighbor nodes in a P2P network like Bittorrent
- Web crawlers
- Finding people n connections away on a social site
- Find neighboring locations on graph

- Broadcasting in a network
- Cycle detection in a graph
- Finding Connected Components
- Solving a number of theoretical graph problems

Coloring Vertexes

As the graph is explored, it's useful to color verts as you arrive at them and as you leave them behind as "already searched".

Commonly, unvisited verts are white, verts whose neighbors are being explored are gray, and verts with no unexplored neighbors are black.

Keeping Track of What We Need to Explore

In BFS, it's useful to track which nodes we need to follow up on. For example, in the diagram above, when we get to node 2, we need to explore node 3 and 4 in the future, in order.

We can track that by adding neighbors to a *queue*, and then exploring the verts in the queue.

Pseudocode for BFS

```
BFS(graph, startVert):
  for v of graph.vertexes:
    v.color = white

  startVert.color = gray
  queue.enqueue(startVert)

  while !queue.isEmpty():
    u = queue[0]  // Peek at head of queue, but do not dequeue!

    for v of u.neighbors:
      if v.color == white:
        v.color = gray
        queue.enqueue(v)

    queue.dequeue()
    u.color = black
```

Exercises

- Build a random graph and show a vertex visitation order for BFS.
- One more for good measure.