Intro to Graphs

What exactly are graphs?

- We’ve actually been working with graphs since day 1!
  - linked lists
  - all types of trees
- A graph is simply a group of connected nodes
- Unlike linked lists and trees, the graphs we are talking about come in all sorts of different shapes and can be represented in a number of ways.
  - For example, cyclic graphs
- Almost no restrictions

Ways to represent Graphs and Terminology

- You may hear people referring to nodes and pointers as vertices and edges respectively instead. These are pretty much synonymous.
- Graphs can be directed or undirected, referring to whether edges point one way or both ways
- Edges and vertices have a relationship that helps us better understand their Big O complexities:
  - $E \leq V^2$, where E = edges and V = vertices
- Ways to represent graphs:
  - Matrix
  - Adjacency Matrix
  - Adjacency List

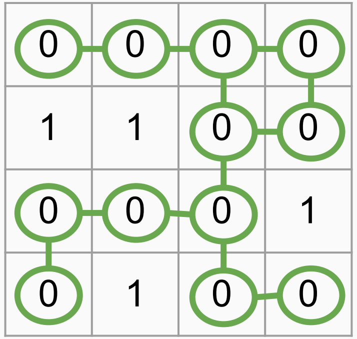
Matrices

- Graphs represented as a 2D array
- Typically an 4-directional undirected graph
- Coordinates represented with row and column indices
  - We can find values by using grid[row][col]
  - Some also use x and y, but I recommend against this because I've seen many people get confused during mock interviews.
- Commonly used for path representation

```
grid = [  [0, 0, 0, 0],
          [1, 1, 0, 0],
          [0, 0, 0, 1]
          [0, 1, 0, 0]  ]
```

0 = free

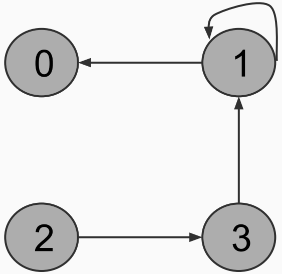
1 = blocked



Adjacency Matrices

- The cells of a adjacency matrix are NOT nodes
- Instead, the indices represent vertices, and the values in the cells represent edges between vertices
- Always a square since both sides represent vertices
- Examples
  - adjMatrix[1][2] == 1
    - An edge exists from vertex 1 to vertex 2
  - adjMatrix[2][1] == 1
    - An edge exists from vertex 2 to vertex 1
    - Order matters!!
  - adjMatrix[0][1] == 0
    - No edge exists from vertex 0 to vertex 1
  - adjMatrix[1][1] == 1
    - There exists a self looping edge at vertex 1
- Rare because it is space inefficient. Complexity is $O(V^2)$

```
adjMatrix=[ [0, 0, 0, 0],
            [1, 1, 0, 0],
            [0, 0, 0, 1],
            [0, 1, 0, 0]  ]
```



	0	1	2	3
0	0	0	0	0
1	1	1	0	0
2	0	0	0	1
3	0	1	0	0

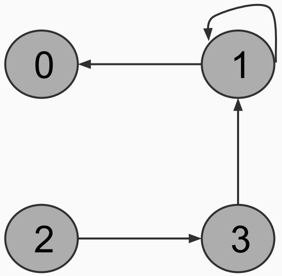
Adjacency Lists

- Very common way to represent a graph
- Uses nodes, similar to linked lists or trees
- Unlike linked lists or trees, there is no predefined number of connected neighbors
- We can represent neighbors in an array or set
- Much more space efficient than adjacency matrix since we only represent nodes that actually exist.
- Sometimes may have to build the adjacency list ourselves

```
class GraphNode :
        def __init__(val) :
                self.val = val
                self.neighbors = []
```

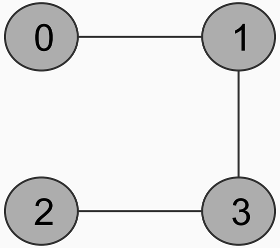
directed graph:

```
graph = {
        0: [],
        1: [0,1],
        2: [3],
        3: [1]
}
```



undirected graph:

```
graph = {
        0: [1],
        1: [0,3],
        2: [3],
        3: [1,2]
}
```



Adjacency Matrix vs List

- Analogy: If you had to store 6oz of water, would you do so with a 5 gallon container, or an 8oz cup?
- If the majority of your matrix is empty, then why use it? Just list each value instead. However, if your list is really long, why not just use a matrix to condense it?
- The decision is arbitrary, but generally a Adjacency Matrix would have an advantage when the graph is dense with edges.

Questions?