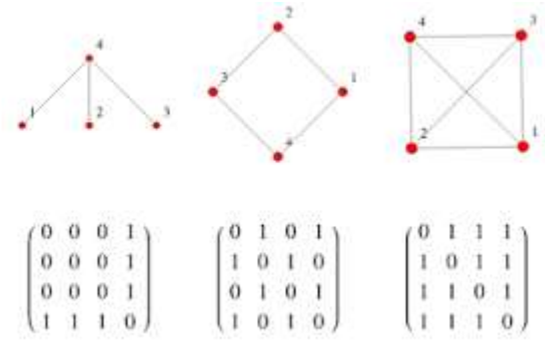
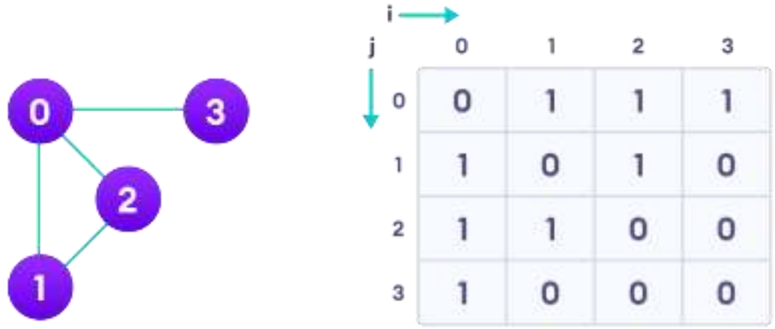
How graphs can be represented in a data structure

In terms of representing graphs in a data structure, there are three ways that are possible, adjacency matrix, adjacency list and adjacency set.



$$\begin{pmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 1 & 1 & 1 & 0 \end{pmatrix} \quad \begin{pmatrix} 0 & 1 & 0 & 1 \\ 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ 1 & 0 & 1 & 0 \end{pmatrix} \quad \begin{pmatrix} 0 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 \end{pmatrix}$$

Figure 1

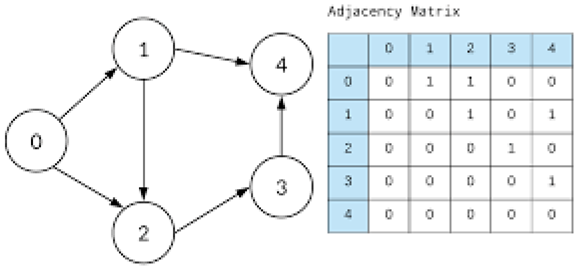


	0	1	2	3
0	0	1	1	1
1	1	0	1	0
2	1	1	0	0
3	1	0	0	0

Figure 2

Adjacency matrix: an adjacency matrix is a table with rows and columns where each label from the row and columns represents a node. In figure 1, we can see that the number of rows, columns and nodes are the same. The zeros and ones represent whether there is a path to each node. For example, vertices 4 in the diagram on the left has three paths to vertices 1, 2 and 3, which means their value is represented as a one, whereas vertices 1 only has a path to vertices 4, leaving vertices 2 and 3 to have values of zero. We can also see this in figure 2, where vertices 0 has three paths to vertices 1, 2 and 3, but vertices 3 only has one path to vertices 0.

In figure 3, this is known as a directed graph, whereas figures 1 and 2 were undirected. This means that the connection is specified by the direction of the edge. This is shown in the graph for vertices 1 which links to vertice 2 and 4, but vertices 2 isn't connected to vertices 1.



Adjacency Matrix

	0	1	2	3	4
0	0	1	1	0	0
1	0	0	1	0	1
2	0	0	0	1	0
3	0	0	0	0	1
4	0	0	0	0	0

Figure 3

Adjacency list: An adjacency list represents the graph as an array in a linked list. The list created is unordered and once a data node is added to the array, the previous node gets pushed down the list. Figure 4 shows an example of an adjacency list where node 1 is linked to node 0 and node 2. In terms of saving storage space, this is an effective data structure because the values of edges are stored. The downside to an adjacency list is that it takes longer to look up a node value than an adjacency matrix because you have to check which node is connected to what to find the value you are looking for.

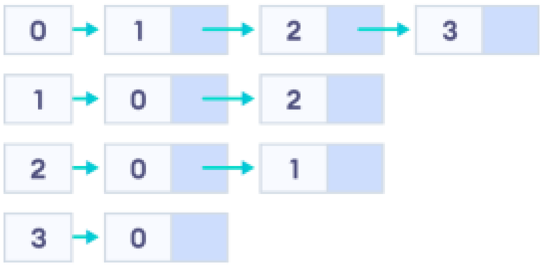


Figure 4

Adjacency set: An adjacency set is similar to an adjacency list, but the difference is that the data isn't sorted into a linked list. This is shown in the diagram figure 5.

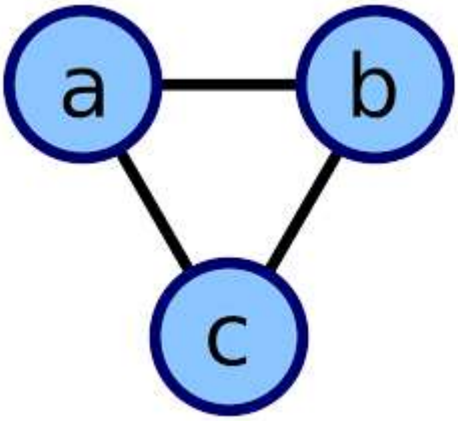


Figure 5

Sources:

https://www.mygreatlearning.com/blog/representing-graphs-in-data-structures

https://www.programiz.com/dsa/graph-adjacency-list

https://cs.stackexchange.com/questions/146553/why-are-graphs-represented-as-adjacency-lists-instead-of-adjacency-sets

Images:

https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcTPNYpwGseAdIk3Heqbo03_fOhipB78T_Xq9lM8uOO87WTJl_m59U2PLrjLeL5e2vk6XbQ&usqp=CAU

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https://www.google.com/url?sa=i&url=https%3A%2F%2Fmathworld.wolfram.com%2FAdjacencyMatrix.html&psig=AOvVaw31MYEtYStBTX1SO6KoIkmr&ust=1652031560470000&source=images&cd=vfe&ved=0CA0QjhxqFwoTCJi28qz3zfcCFQAAAAAdAAAAABAD

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