SDSC3001 Tutorial 2

Graph search

2024.09.19

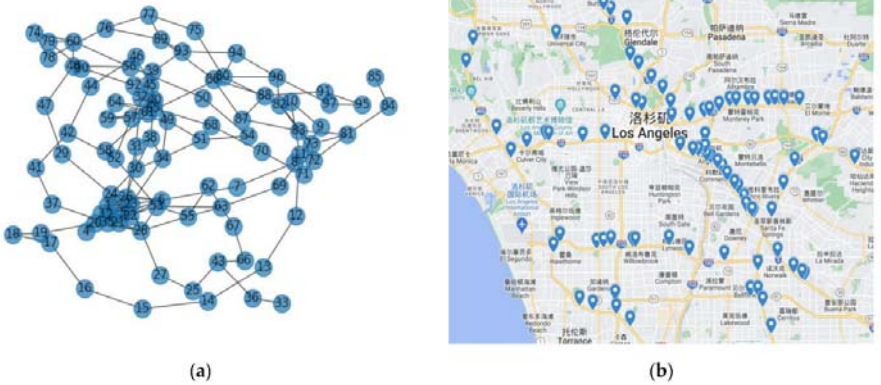
Content

- 1. Examples of Graph Data, And their applications.
- 2. Some basic concepts
- 3. How to describe a Graph in Python?
- 4. Breadth-first/ Depth-first Search
- 5. Game: Painting a Picture.

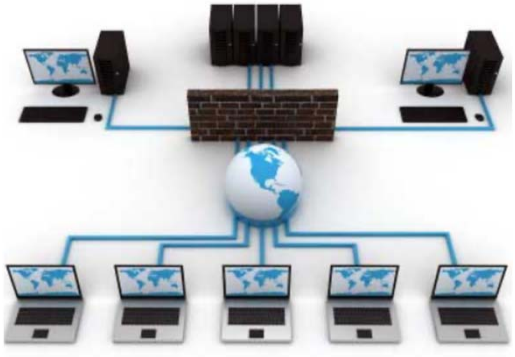
Graph Data

Graph: Nodes and edges

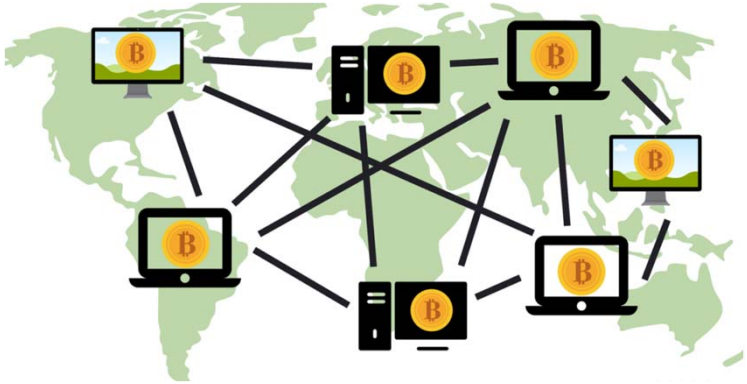
Social network



Traffic network



Computer network

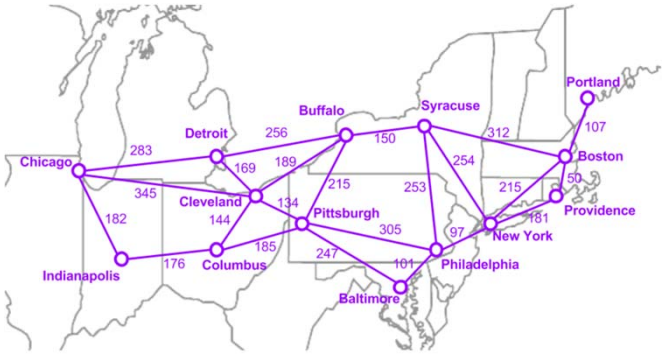


Bitcoin network

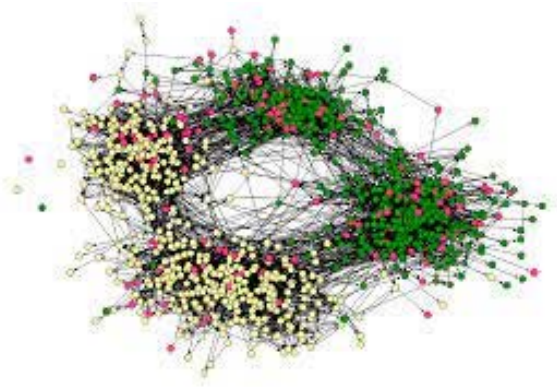
Graph Data Applications

Problems on Graph

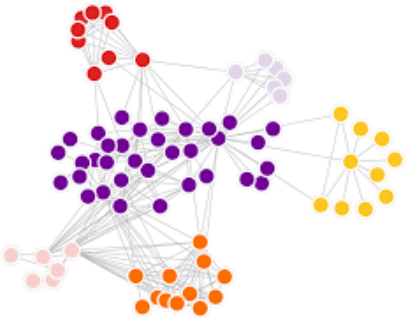
- **Graph Search: Given a source node and a destination node, find a path between them.**
- **Dense Subgraph Mining: Find dense subgraph in a graph.**
- **Graph Clustering: Find similar nodes in a group.**
- **Graph Representation Learning: Learn representations for node/edge/subgraph.**



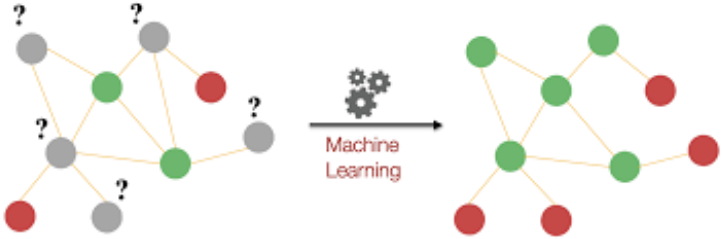
(a)



(b)



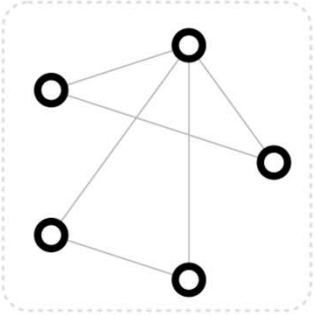
(c)



(d)

Some concepts in Graph

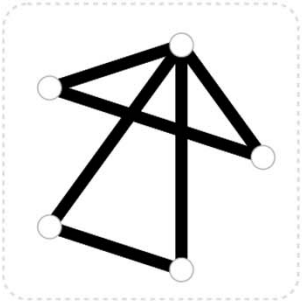
Definition: A graph represents the relations (*edges*) between a collection of entities (*nodes*).



V Vertex (or node) attributes
e.g., node identity, number of neighbors

E Edge (or link) attributes and directions
e.g., edge identity, edge weight

U Global (or master node) attributes
e.g., number of nodes, longest path



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Same meaning:
- Vertex, Node, Entity
- Edge, Link

Distill

A Gentle Introduction to Graph Neural Networks

Neural networks have been adapted to leverage the structure and properties of graphs. We explore the components needed for building a graph neural network - and motivate the design choices behind them.

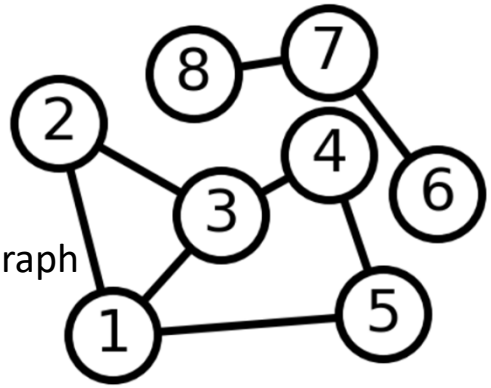
https://distill.pub/2021/gnn-intro/

How to define a Graph in practice?

1. Array (adjacency matrix)

Most of the elements are zero
Sparse matrix

Undirected Graph



symmetric matrix

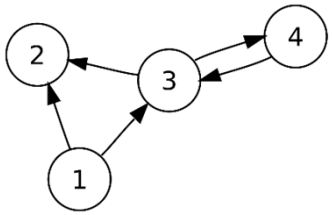
$A_{8,8}$

	1	2	3	4	5	6	7	8
1	0	1	1	0	1	0	0	0
2	1	0	1	0	0	0	0	0
3	1	1	0	1	0	0	0	0
4	0	0	1	0	1	0	0	0
5	1	0	0	1	0	0	0	0
6	0	0	0	0	0	0	1	0
7	0	0	0	0	0	1	0	1
8	0	0	0	0	0	0	1	0

8×8 matrix

$a_{ij} = 1$, *if node* i, j *are connected*
$a_{ij} = 0$, *otherwise*

Directed Graph

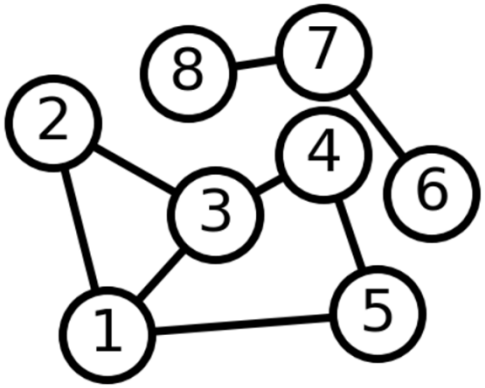


Q: What is $a_{ii} = 1$?

In graph theory, a **loop** (also called a **self-loop** or a *buckle*) is an edge that connects a vertex to itself.

Represent Graph in Python

2. Neighbor Dictionary (adjacency table)

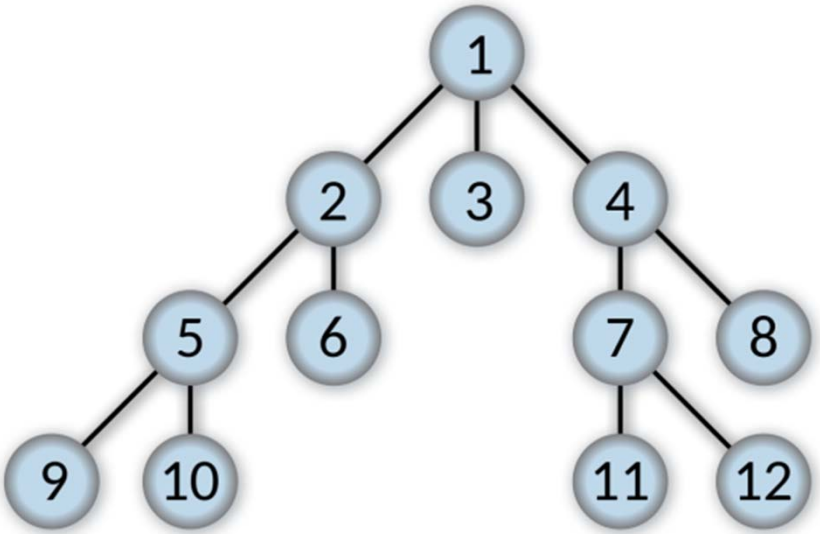


Graph=

```
{1: [2, 3, 5],
 2: [1, 3],
 3: [1, 4],
 4: [3, 5],
 5: [1, 4],
 6: [7],
 7: [6, 8],
 8: [7]}
```

BFS: Breadth-First Search (See Jupyter)

Running example



Initial	
Waiting List	[1]
Visited List	[ ]

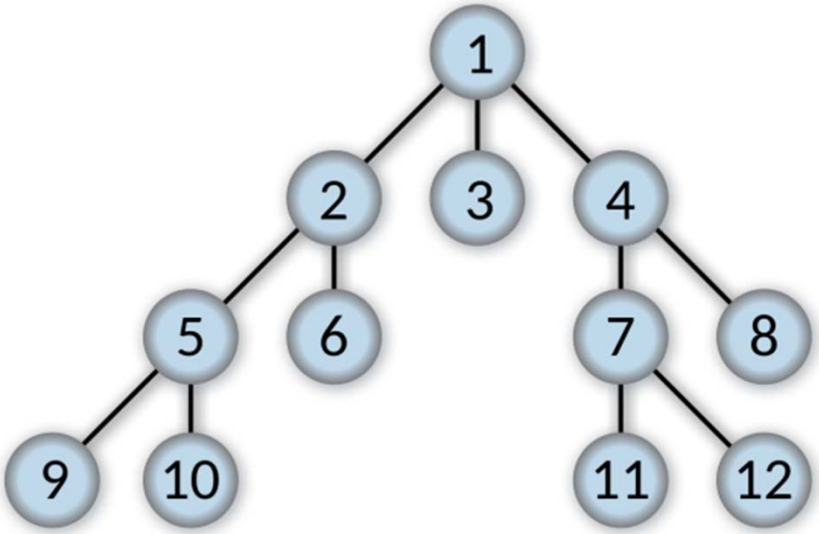
Deal with 1	
Waiting List	[2 3 4]
Visited List	[1]

Deal with 2	
Waiting List	[3 4 5 6]
Visited List	[1 2]

Deal with 3	
Waiting List	[4 5 6]
Visited List	[1 2 3]

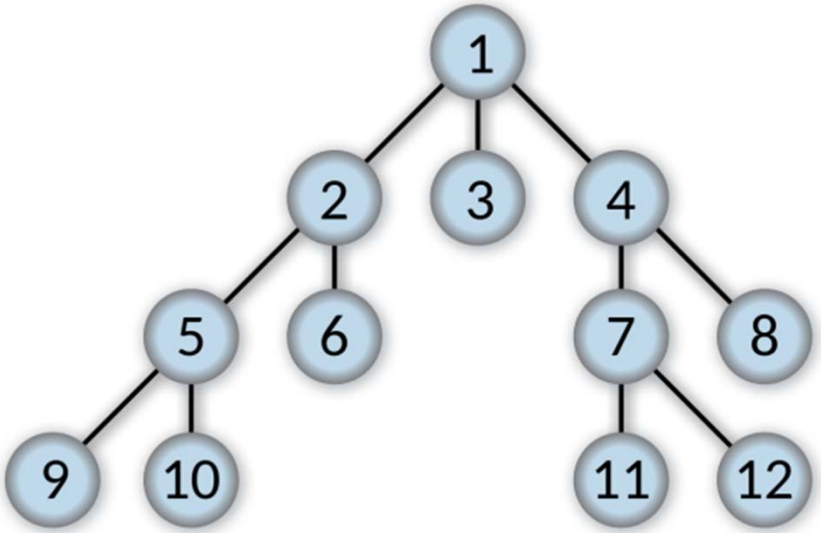
BFS: Breadth-First Search

Running example



BFS: Breadth-First Search

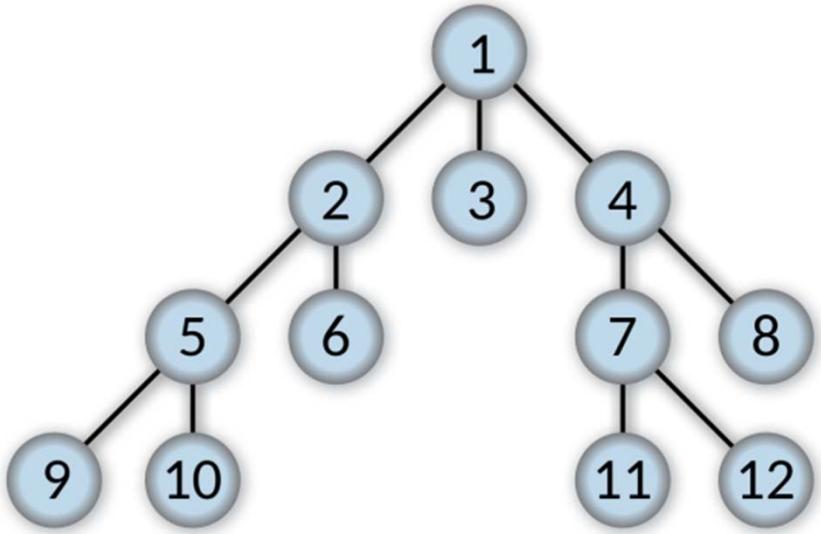
Running example



BFS: [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12]

DFS: Depth-First Search

Running example



Initial	
Waiting List	[1]
Visited List	[ ]

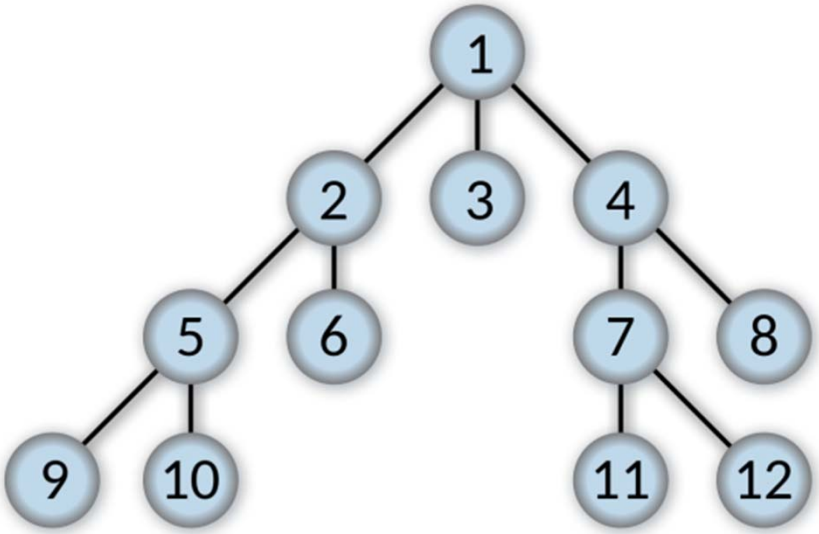
Deal with 1	
Waiting List	[2 3 4]
Visited List	[1]

Deal with 2	
Waiting List	[2 3 7 8]
Visited List	[1 4]

Deal with 3	
Waiting List	[2 3 7]
Visited List	[1 4 8]

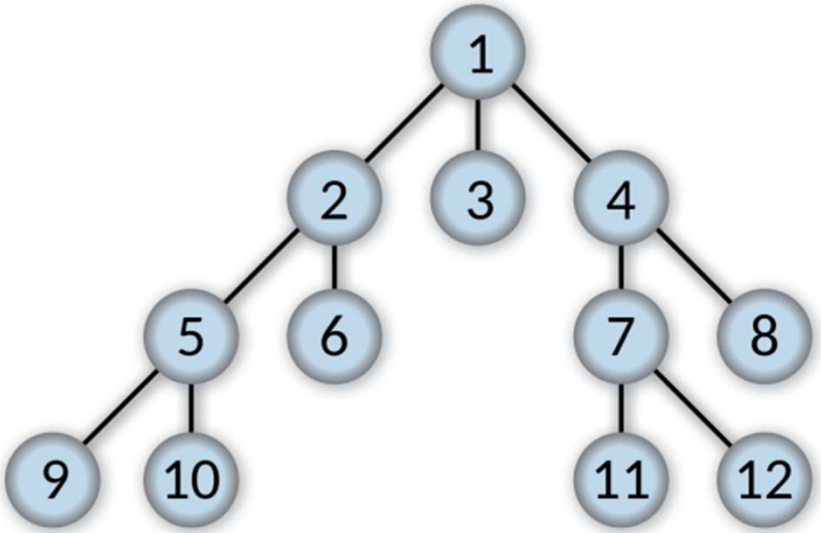
DFS: Depth-First Search

Running example



DFS: Depth-First Search

Running example



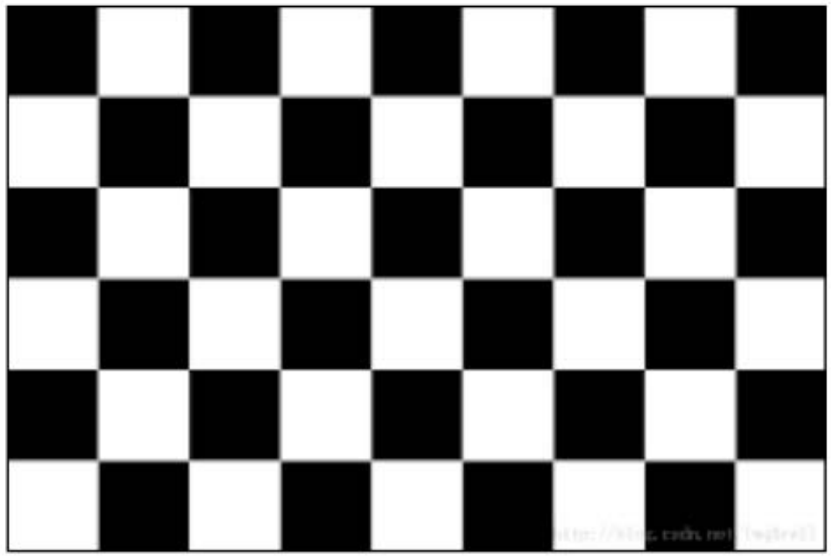
DFS: [1, 4, 8, 7, 12, 11, 3, 2, 6, 5, 10, 9]

Now, let's do some arts!

Draw a picture by graph search

Basic logic

- A pixel is a node.
- The neighbors of a pixel is the node near it.
- We can color a node and then spread the color to its neighbor nodes.
- It just like a flood!
- https://observablehq.com/@mbostock/randomized-flood-fill



Thank you!