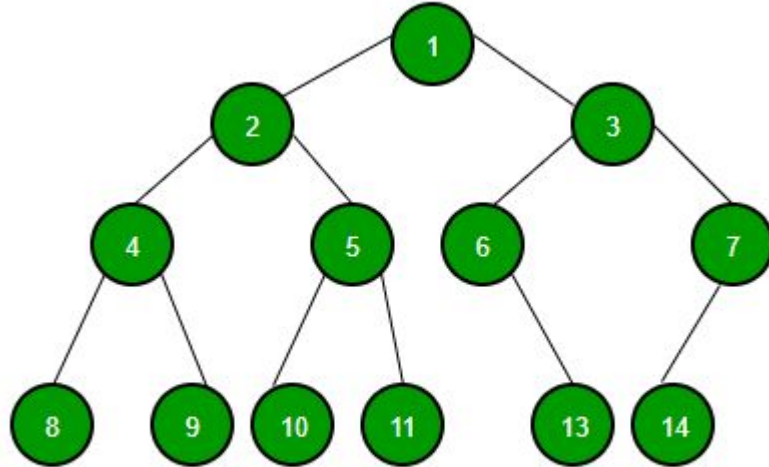# Graphs

Mr. Poole

Binary trees

Unsorted Trees

- **B**readth **F**irst **S**earch
- **D**epth **F**irst **S**earch
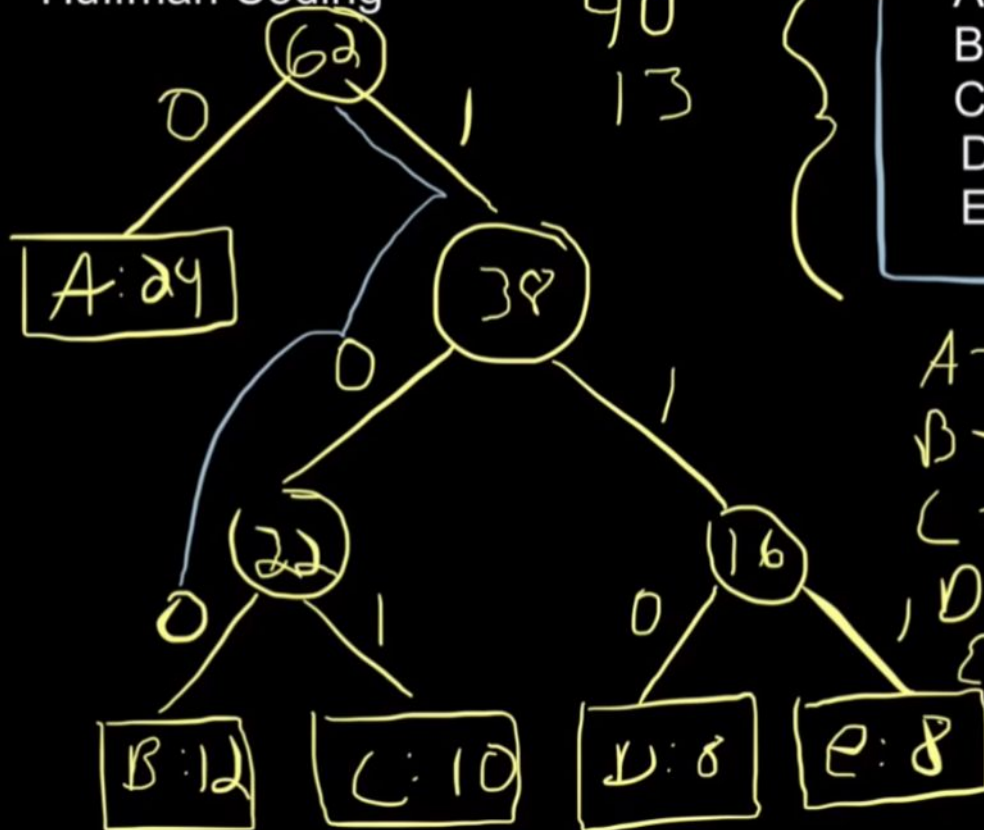
Trees love recursion!

Sorted Trees

- Binary Search

Examples of Binary Trees

- Text Compression using Huffman Coding (Replaces ASCII)
  - Used for compressing jpeg, zip, mp3 files
- Binary Space Partition
  - Used in almost every 3D video game to determine what needs to be rendered
    - Imagine Minecraft
- Hash Trees (Future lecture)
  - Used in torrents and specialized image-signatures (Used in blockchain ex: Bitcoin)
- Routing Trees
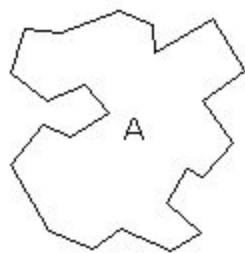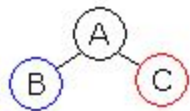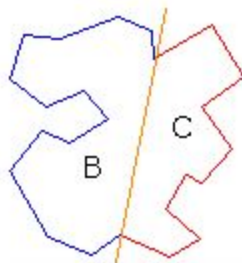 - For network traffic
- Morse Code

Huffman Coding

40
13

A	24
B	12
C	10
D	8
E	8

A → 0 — 8
B → 100 — 8
C → 101 — 8
D → 110 — 8
E → 111 — 8

Binary Space Partition

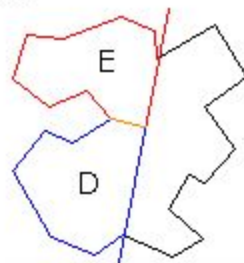# Morse Code
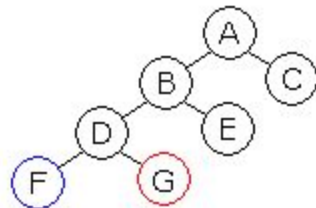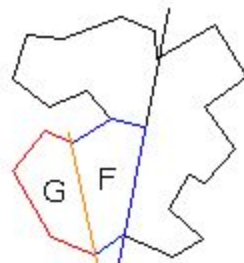
Now onto Graphs!

Now onto Graphs!

Bridges of Königsberg

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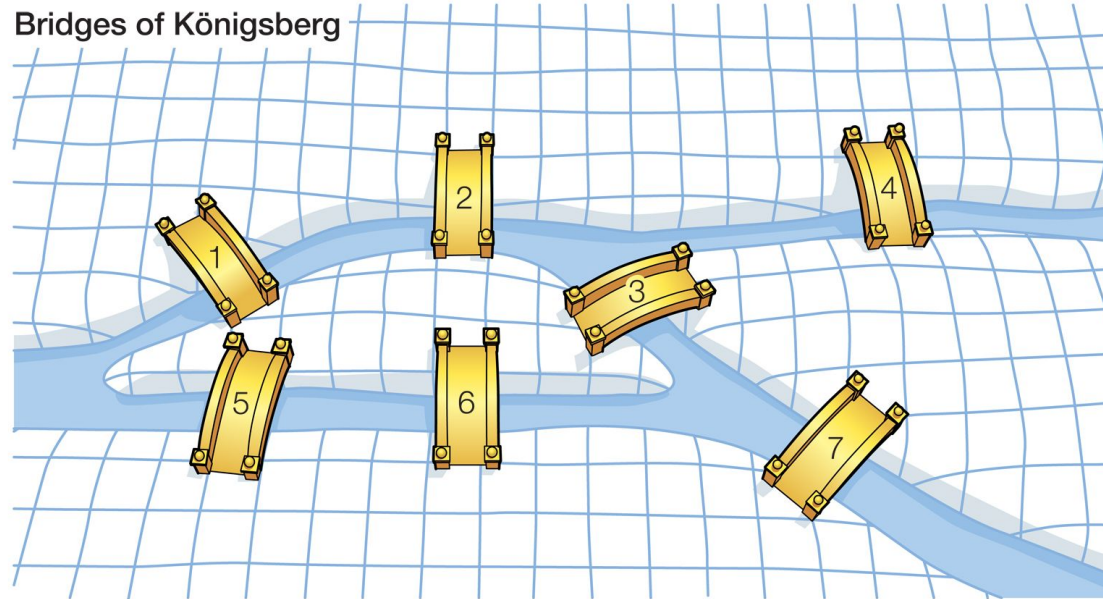
Bridges of Konigsberg
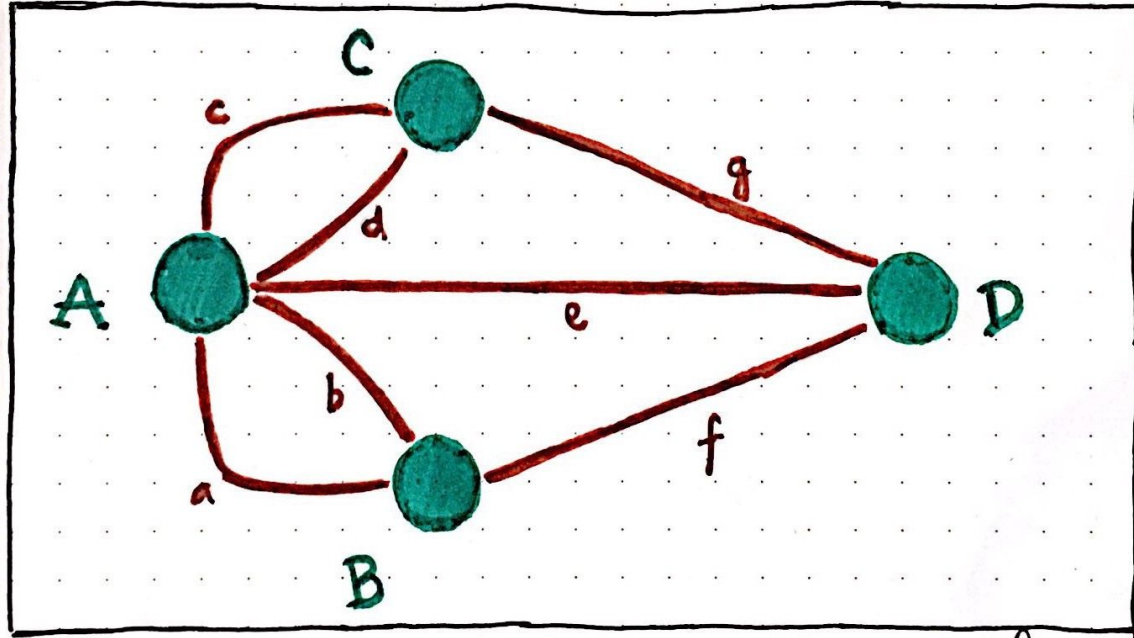
The Seven Bridges of Königsberg — Revisualized

What is a graph

Graphs are made up of two items

- Vertices
    - Some data value (element)
- Edges
    - Connects vertices by some relation

Adjacency is when two vertices are connected by an edge.

The set for the above would be:

Vertices set = {0,1,2,3,4}

Edge set = {(0,1),(0,4),(1,2),(1,3),(1,4),(2,3),(3,4)}   These are adjacent
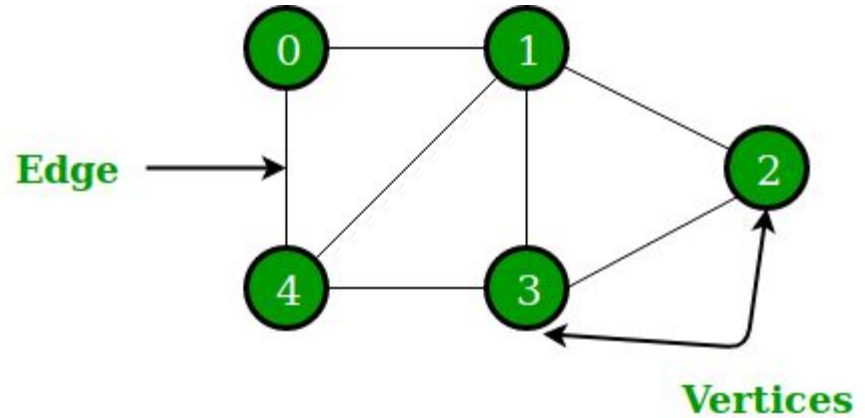
Edge ⟶

Vertices

Types of graphs

- Undirected Graphs
  - In an undirected graph, the order of vertices in the pairs in the Edge set doesn't matter.
  - Usually drawn with straight lines between vertices
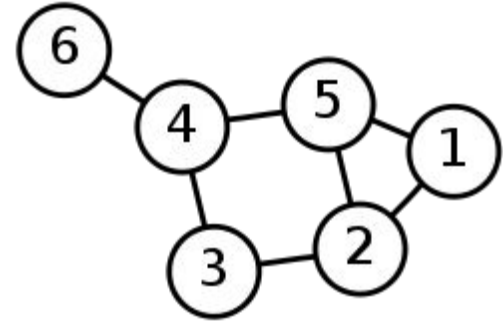
- Directed Graphs
  - The order of vertices in the pairs in the edge set matter
  - An arrow from **u** to **v** is drawn only if (u,v) is the edge set
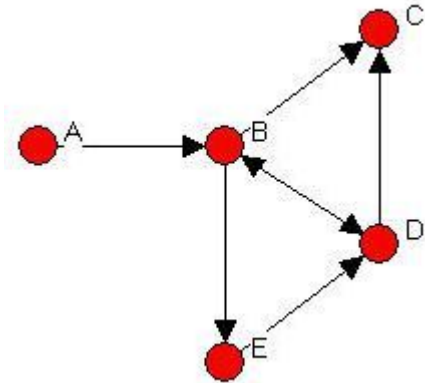
Types of graphs

- **Vertex Labeled Graph**
  - Each vertex is labeled with some data in addition to data that identifies the vertex
  - Vertices set = {(2,Blue),(4,Blue),(5,Red),(7,Green),(6,Red),(3,Yellow)}

- **Edge Labeled Graph**
  - Edges are associated with labels
  - Labeled as (u,v,X), X being the label
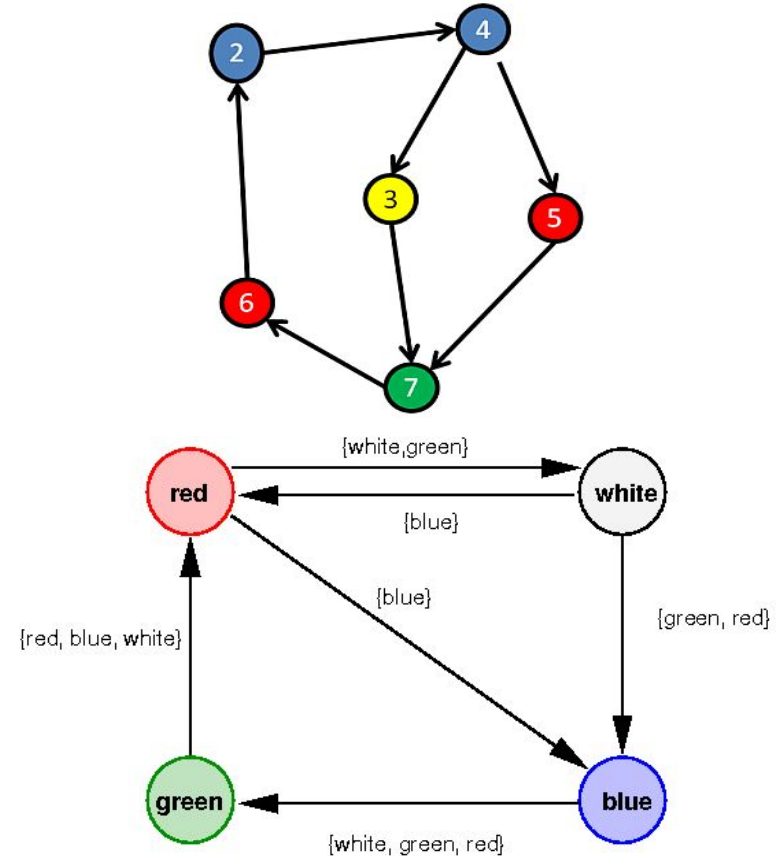
Types of graphs

- ● Cyclic Graphs
  - ○ Directed in one direction with at least one cycle
  - ○ **A cycle is a path along the directed edges from a vertex to itself**

- ● Weighted Graphs
  - ○ An edge labeled graph where labels can be operated on by the usual arithmetic operators, including comparisons.
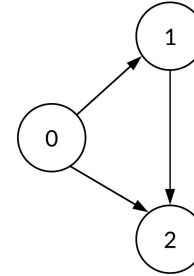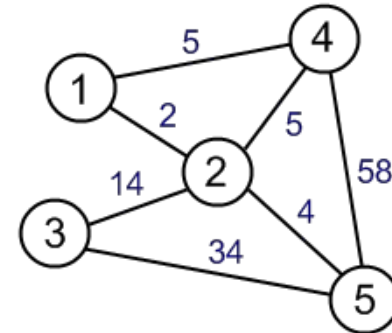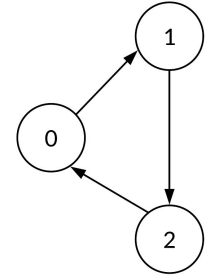 - ○ One of the most common graphs in industry

Acyclic Graph

Cyclic Graph

Traversing Graphs

- Breadth First Search
  - Uses a queue just like Binary Trees!

- Depth First Search
  - Uses stack just like Binary Trees!

Visited :	1	2	3	4	5	6
1	0	0	0	0	0

Queue :

Print : 1

Visited :	1	2	3	4	5	6
1	1	1	0	0	0

Queue : 2 3

Print : 1

After removing 1 from queue and printing it, we enqueue its non-visited adjacent Nodes

Green is unvisited node.
Red is current node.
Orange is the nodes in the recursion stack.
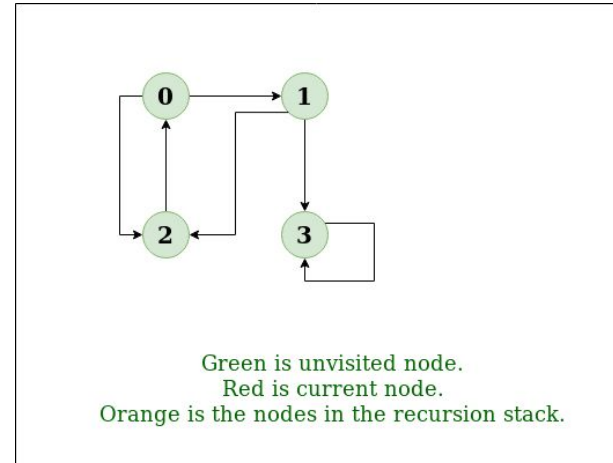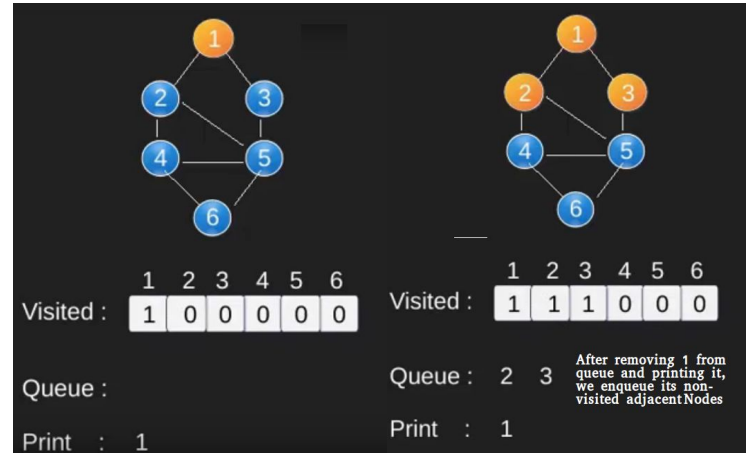
Things you can do on Graphs

- Search for vertices or edges
- Check connectivity
- Find cycles through the graph
- Find the shortest path through all elements
- [Much more](#) [more](#)

Bridges of Königsberg
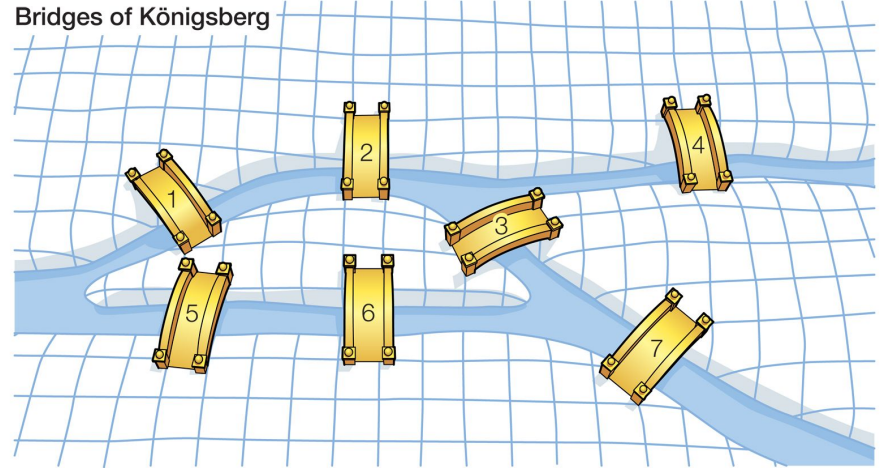
© 2010 Encyclopædia Britannica, Inc.

Dijkstra's Shortest Path Algorithm

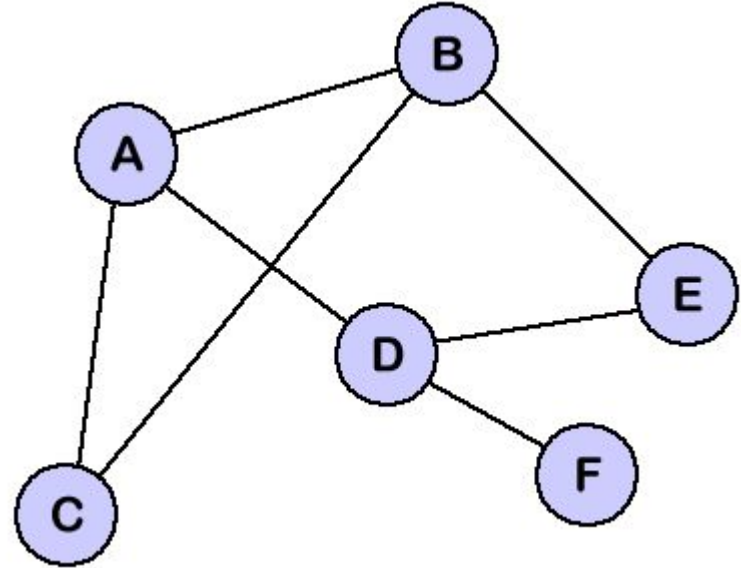- Given a graph and a source vertex in the graph, find the shortest path from the source to all vertices in the given graph.
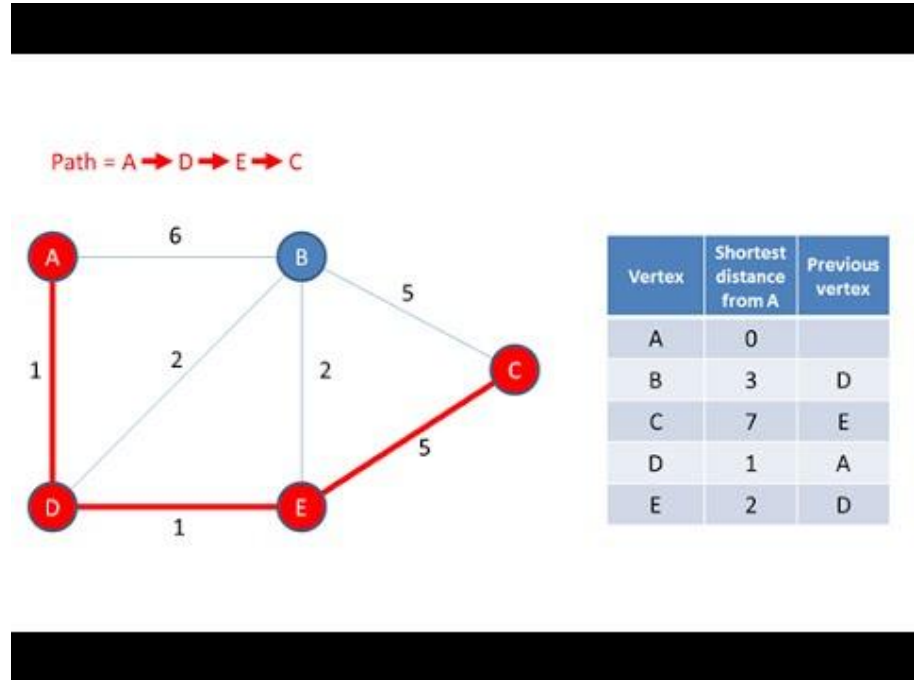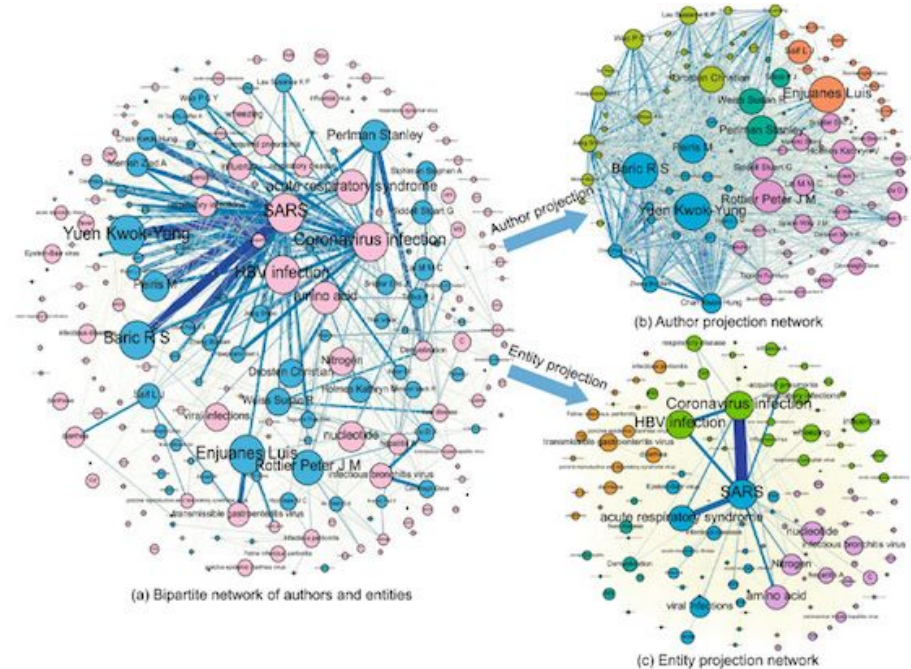
Dijkstra's Shortest Path Algorithm

- Given a graph and a source vertex in the graph, find the shortest path from the source to all vertices in the given graph.

Path = A ➔ D ➔ E ➔ C

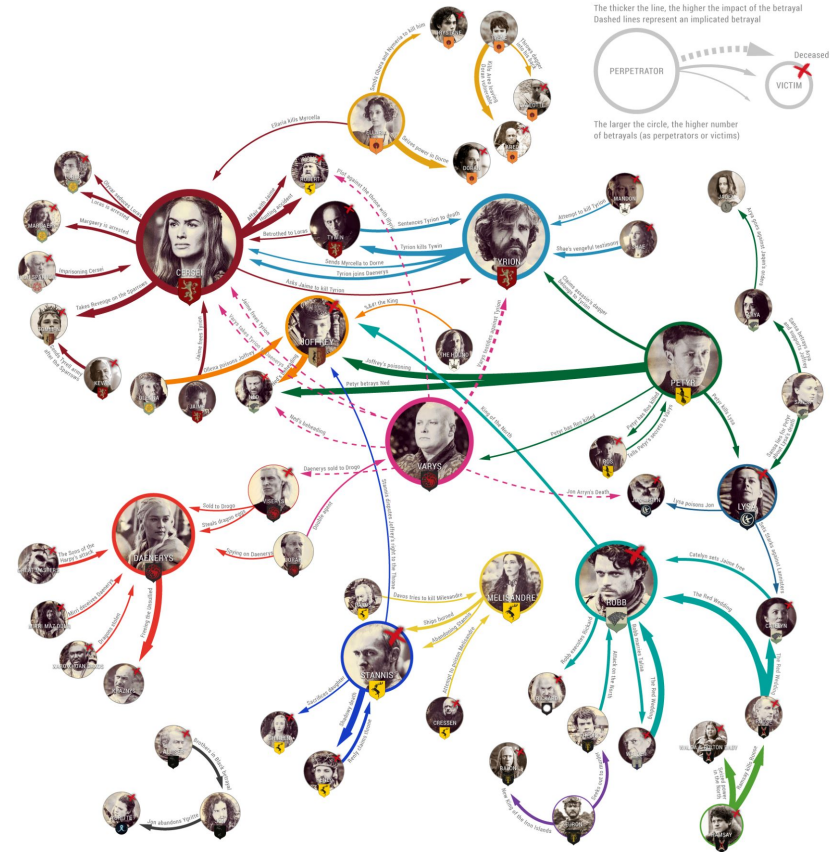| Vertex	Shortest distance from A	Previous vertex
A	0	
B	3	D
C	7	E
D	1	A
E	2	D

Examples of Graphs

- Social Networks
- Web Graphs
- Biological Networks
- Knowledge Graphs
- Product Recommendations
- Neural Networks
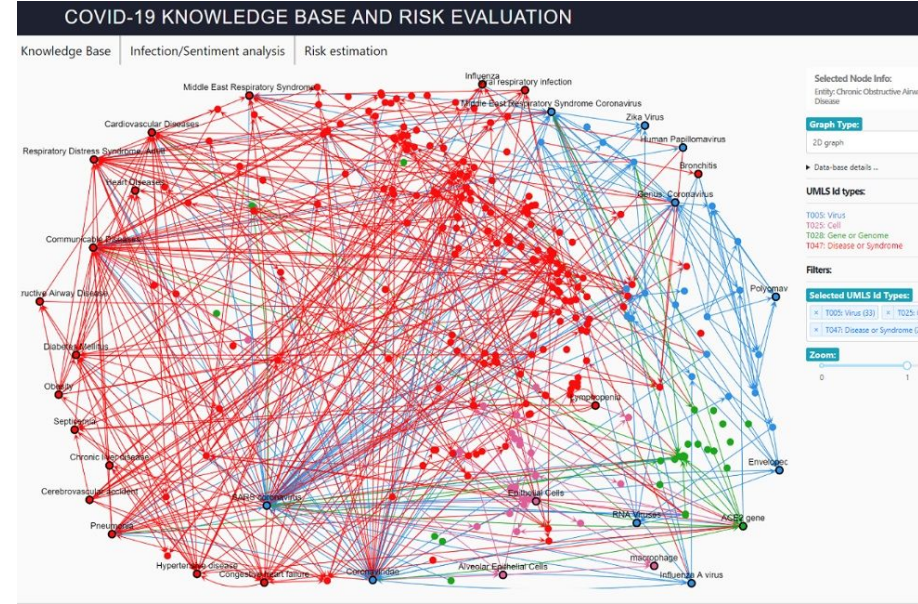- Road Networks
- Blockchain
- Bitcoin Transaction Graphs

(a) Bipartite network of authors and entities

(b) Author projection network

(c) Entity projection network

Examples of Graphs

● Social [Networks](#)

Game of Thrones Web of Betrayals

The thicker the line, the higher the impact of the betrayal
Dashed lines represent an implicated betrayal

The larger the circle, the higher number
of betrayals (as perpetrators or victims)

Source: HBO, Game of Thrones. Updated 06/2017

Examples of Graphs

- ## Knowledge [Graphs](#)
- A sample screenshot of the COVID-19 knowledge base dashboard under development. The screen shows four types of COVID-19 related entities, virus (blue), cell (pink), gene or genome (green), and disease or syndrome (red), and their relationships. All entities are Unified Medical Language System (UMLS) compatible for convenient knowledge sharing. The systems support 75 types of UMLS entities
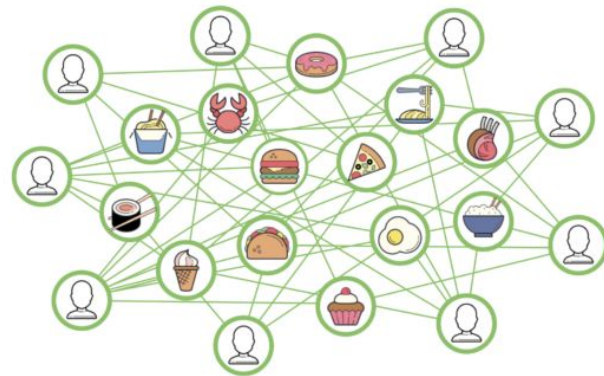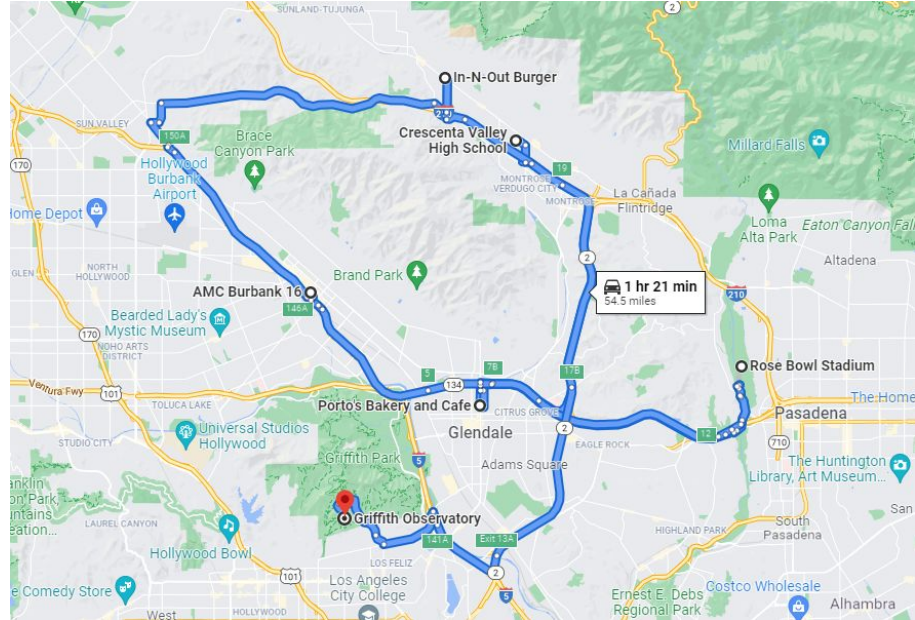
Examples of Graphs

- Product Recommendations
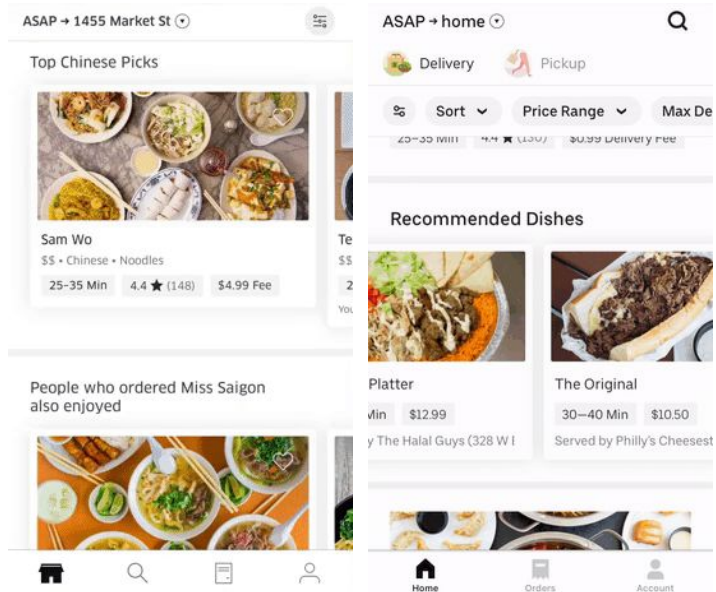
Food Discovery with Uber Eats: Using Graph Learning to Power Recommendations
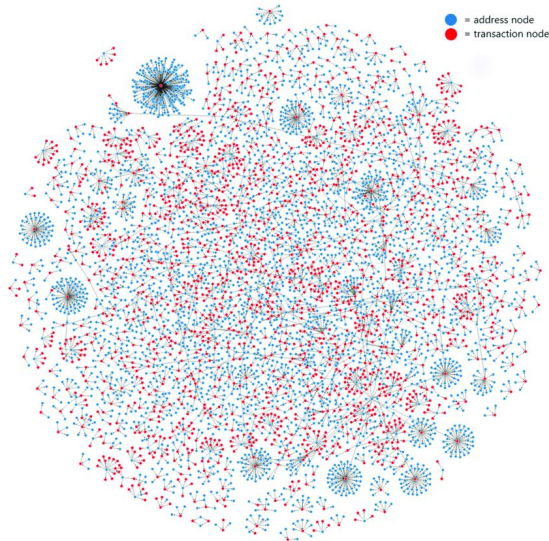
Examples of Graphs

- Road Networks

Examples of Graphs

- Road Networks

Examples of Graphs

- Blockchain
- Bitcoin Transaction Graphs