Weighted graphs and their implementations in C++

Q: How does a weighted graph differ from an ordinary graph?

A: In a weighted graph each edge *(x,y)* has associated with it a weight *w((x,y))*, which is a number.

Common interpretations of weights

- graph represents a road map and nodes are locations or intersections on the map: *w((x,y))* can be the distance from *x* to *y* or the time required to get from x to y

- graph represents a project and the nodes are different tasks in the project: *w((x,y))* is the time it takes to complete the task *x*

- graph represents a pipe network under construction and the nodes represent junctions in the pipe network: *w((x,y))* can be the cost of constructing the pipe from *x* to *y*

Common use

- find the shortest/fastest/cheapest path from some node to some other node

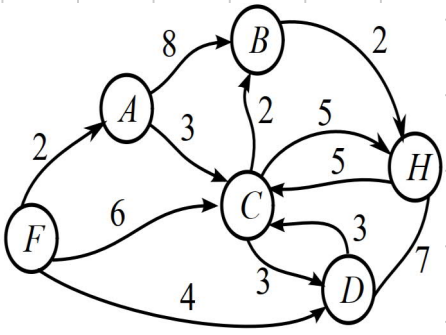
- BFS assumes *w((x,y))* = 1 for all edges

Example

Goal: shortest path from *F* to *H*.

One BFS solution: <*F, D, H* >

True solution: <*F, A, C, B, H* >



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Implementation 1

For each node *y* adjacent to *x*, store pair <*y, w((x,y))* >

```
struct Node
{
    // All the data stored in the node
    int id;
    std::string name;
    // ...

    std::vector<std::pair<Node*,Cost>> to_neighbours;
};
```

Suitable when

- only need to move forward along edges
- edges added or deleted infrequently
- only data associated with edge is cost (weight)

Implementation 2

```
struct Node
{
    // All the data stored in the node
    int id;
    std::string name;
    // ...

    // ...map, not set!
    std::unordered_map<Node*,Cost> to_neighbours;
};
```

Suitable when

- only need to move forward along edges
- edges added or deleted frequently
- only data associated with edge is cost (weight)

Implementation 3

```
struct Edge
{
    int cost;
    string name;
    // ...
};

struct Node
{
    // All the data stored in the node
    int id;
    std::string name;
    // ...

    // ...map, not set!
    std::unordered_map<Node*,Edge> to_neighbours;
};
```

Suitable when

- only need to move forward along edges
- edges added or deleted frequently
- there is much data associated with edge

Implementation 4

```
// In undirected graphs, egde data can be shared between directions
struct Edge
{
    int cost;
    string name;
    Hugedata data;
    // ... too much data or changing data
};

struct Node
{
    // All the data stored in the node
    int id;
    std::string name;
    // ...

    // ...map, not set!
    std::unordered_map<Node*,std::shared_ptr<Edge>> to_neighbours;
};
```

Suitable when

- only need to move forward along edges
- edges added or deleted frequently
- there is much data associated with edge
- the graph is undirected and we do not wish to keep two copies of the same edge