Algorithms and Data Structures

COMP261
Tutorial Week 1

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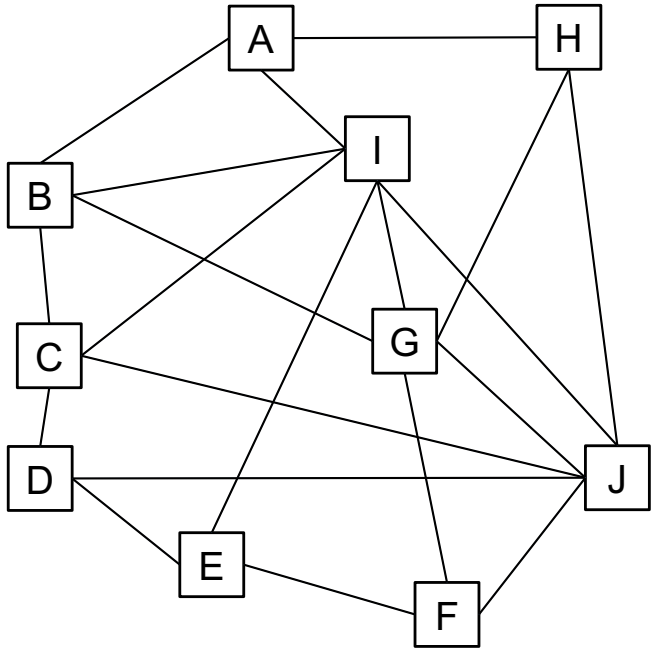
Outline

- Data structures of graph
  - Adjacency matrix
  - Adjacency list

Adjacency Matrix

- Use a 2D matrix to represent the graph
  - Number of rows and columns = number of nodes
  - $M_{ij} = w_{ij}$ is the weight (e.g. length) of the directed edge from *i* to *j*
  - $M_{ij} = \infty$, or leave blank if there is no edge from *i* to *j*.
- Cannot deal with multi-graph.



	A	B	C	D	E	F	G	H	I	J
A		5						5	2	
B	5		3				7		6	
C		3		1					7	9
D			1		3					9
E				3		4			9	
F					4		5			4
G		7				5		6	3	4
H	5						6			7
I	2	6	7		9		3			6
J			9	9		4	4	7	6	

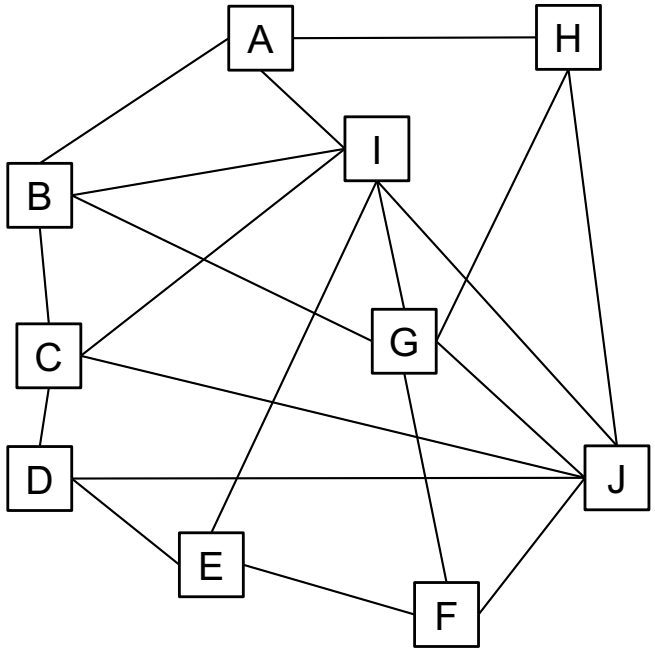
Adjacency Matrix

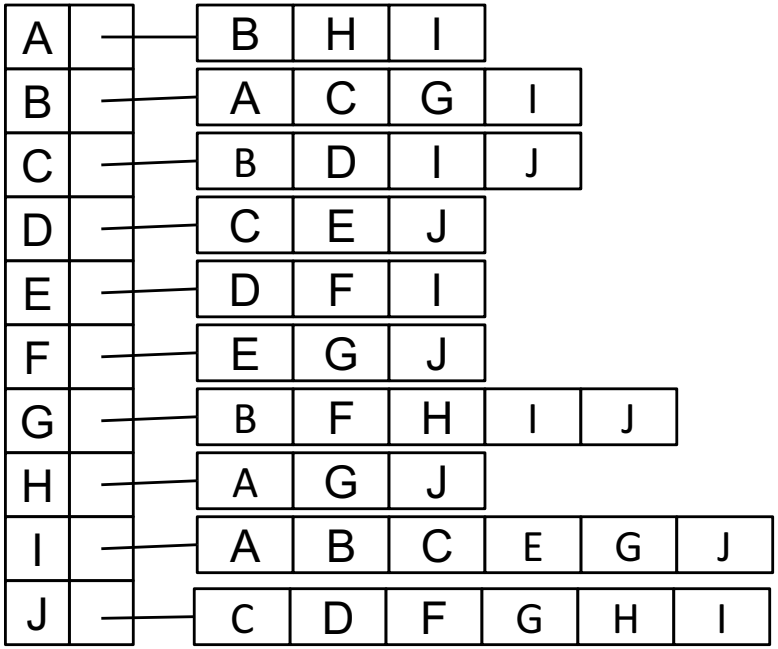
- Use a 2D matrix to represent the graph
  - Number of rows and columns = number of nodes
  - M_{ij} is a list of edge objects
- An edge object is unique for each edge

```
Class Edge {
    Node fromNode;
    Node toNode;
}

Edge e1 = new Edge(A, B);
Edge e2 = new Edge(A, B);

System.out.println(e1.equals(e2));
```

Adjacency List

- For each node, store
  - A list of outgoing edge objects
  - A list of incoming edge objects
- Need to store a list of edge objects to store edge information, e.g. edge length





Complexity Comparison

- Assume simple graph: at most one edge between each pair of nodes, with N nodes and M directed edges
- Max Degree of the graph: $\Delta_{in} = \Delta_{out} = \Delta$
  - **Adjacency matrix**: each entry stores an edge object
  - **Adjacency list**: each node has two lists, one for outgoing edge objects, and the other for incoming edge objects

	Adjacency Matrix	Adjacency List
Find all nodes	$O(N)$	$O(N)$
Find all edges	$O(N^2)$	$O(M)$
Find all outgoing edges of a node	$O(N)$	$O(\Delta)$
Find all incoming edges of a node	$O(N)$	$O(\Delta)$
Find all outgoing node neighbours of a node	$O(N)$	$O(\Delta)$
Find all incoming node neighbours of a node	$O(N)$	$O(\Delta)$
Check if there is an edge from u to v	$O(1)$	$O(\Delta)$

- Adjacency list has better complexity overall

Example in Assignment 1

Roads (roadID-roadInfo.tab)

roadid	type	name	city	1way	sp	rc	!car	!ped	!bic
16060	6	cowley st	waterview	0	2	0	0	0	0
16473	6	walmer rd	point chevalier	0	2	0	0	0	0
16501	4	carrington rd	point chevalier	0	2	2	0	0	0

Nodes (nodeID-lat-lon.tab)

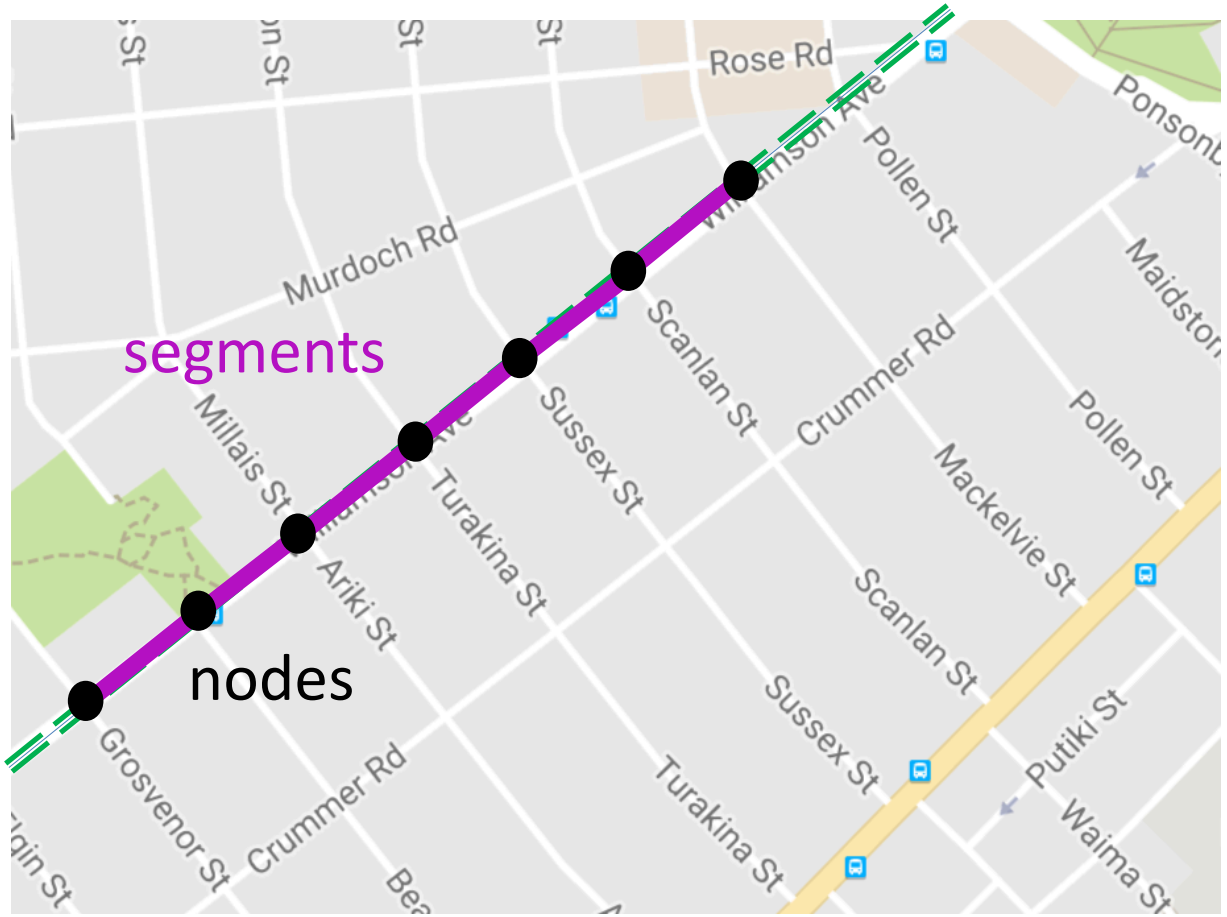
10526	-36.871900	174.693080
10518	-36.871780	174.693510
10845	-36.872000	174.699370

Road segments (roadSeg-roadID-length-nodeID-nodeID-coords.tab)

roadID	length	nodeID1	nodeID2	coords			
16060	0.223	12420	12556	-36.88853	174.72218	-36.88954	174.72361
16501	0.243	13612	13689	-36.88977	174.73364	-36.88765	174.73431
100	0.020	16931	16956	-36.85512	174.76492	-36.85529	174.76501

Example in Assignment 1

- **Roads** vs **road segments**
  - A **road** can have many intersections (e.g. Williamson Ave)
  - A **road segment** has no intersection in the middle
- **node = intersection, edge = segment**



Example in Assignment 1

- Use adjacency list
  - Each node has two lists, one for outgoing edges, the other for incoming edges
- Graph
  - A set of nodes (intersections)
  - A set of edges (segments)
- Node class: outgoing edges, incoming edges, id, location, …
- Edge class: fromNode, toNode, id, length, …

Example in Assignment 1

- Graph
  - Map<Integer, Node> nodes; // key is node id
  - Collection segments;
- Node
  - int id;
  - List outSegs;
  - List inSegs;
  - …
- Segment
  - int id;
  - Road road;
  - Node fromNode;
  - Node toNode;
  - …