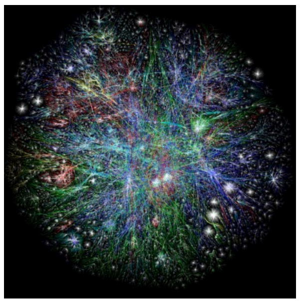
CS 225

Data Structures

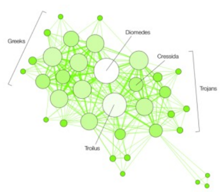
March 30 – Graph Implementation

G Carl Evans

Graphs



HAMLET



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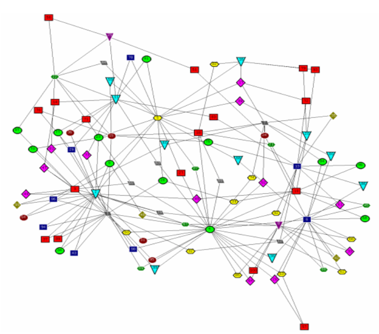
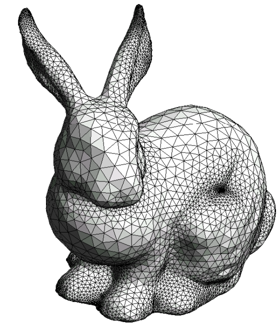
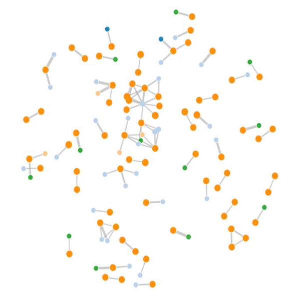
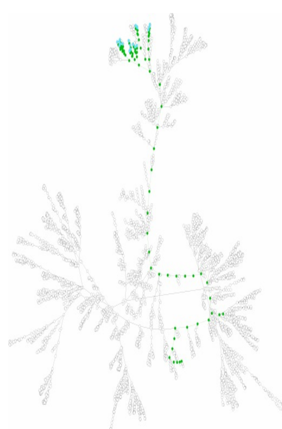


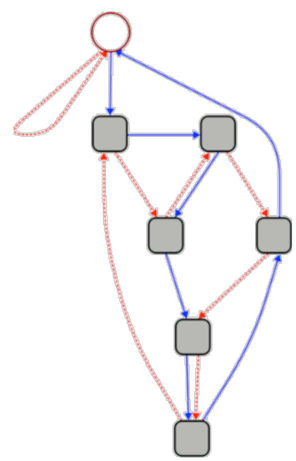


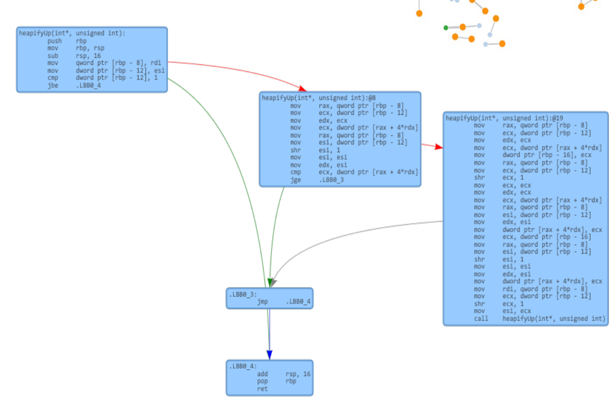
To study all of these structures:

1. A common vocabulary
2. Graph implementations
3. Graph traversals
4. Graph algorithms





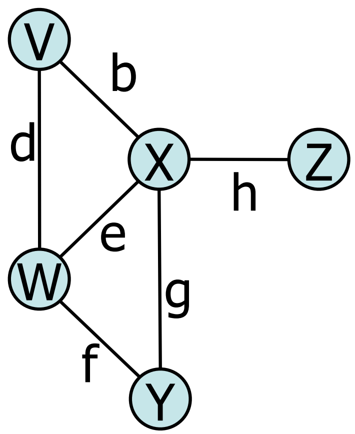




Graph ADT

Data:

- **Vertices**
- **Edges**
- **Some data structure maintaining the structure between vertices and edges.**



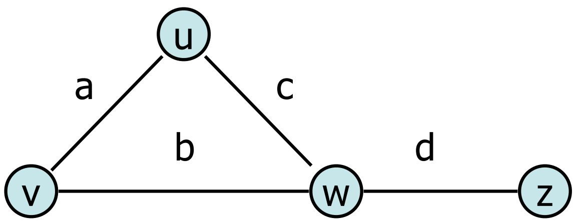
Functions:

- **insertVertex(K key);**
- **insertEdge(Vertex v1, Vertex v2, K key);**

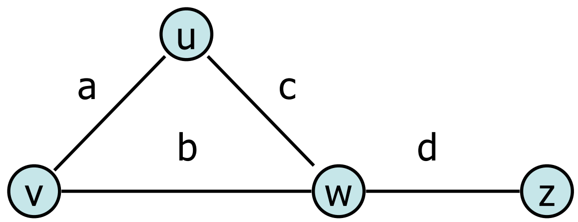
- **removeVertex(Vertex v);**
- **removeEdge(Vertex v1, Vertex v2);**

- **incidentEdges(Vertex v);**
- **areAdjacent(Vertex v1, Vertex v2);**

Graph Implementation Idea



Graph Implementation: Edge List



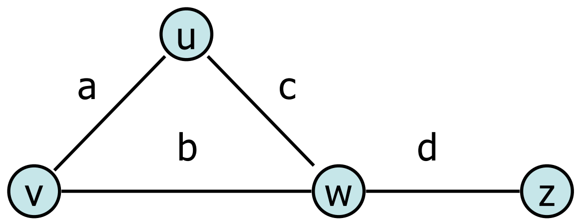
Vertex Collection:

u
v
w
z

Edge Collection:

u	v	a
v	w	b
u	w	c
w	z	d

Graph Implementation: Edge List



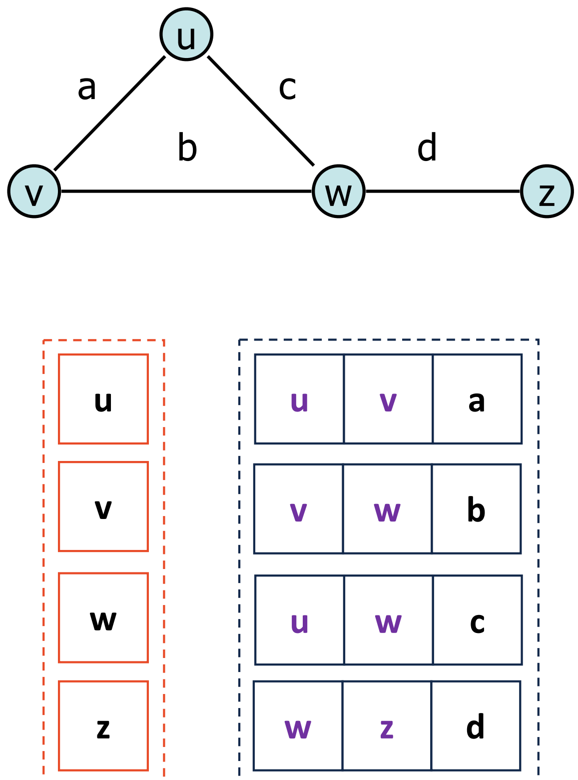
u
v
w
z

u	v	a
v	w	b
u	w	c
w	z	d

insertVertex(K key):

removeVertex(Vertex v):

Graph Implementation: Edge List

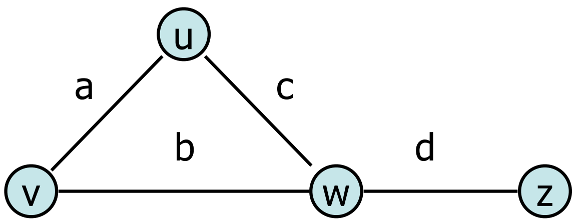


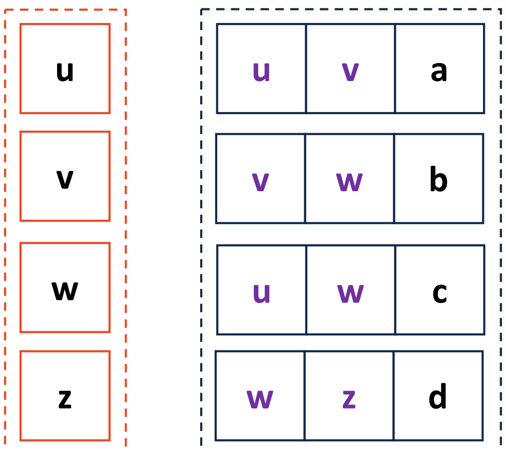
incidentEdges(Vertex v):

areAdjacent(Vertex v1, Vertex v2):

```
G.incidentEdges(v1).contains(v2)
```

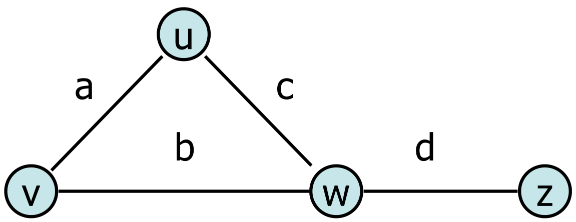
Graph Implementation: Edge List





insertEdge(Vertex v1, Vertex v2, K key):

Graph Implementation: Adjacency Matrix

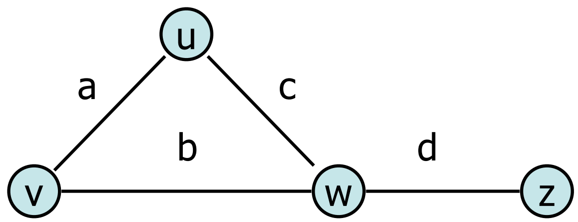


u
v
w
z

u	v	a
v	w	b
u	w	c
w	z	d

	u	v	w	z
u				
v				
w				
z				

Graph Implementation: Adjacency Matrix

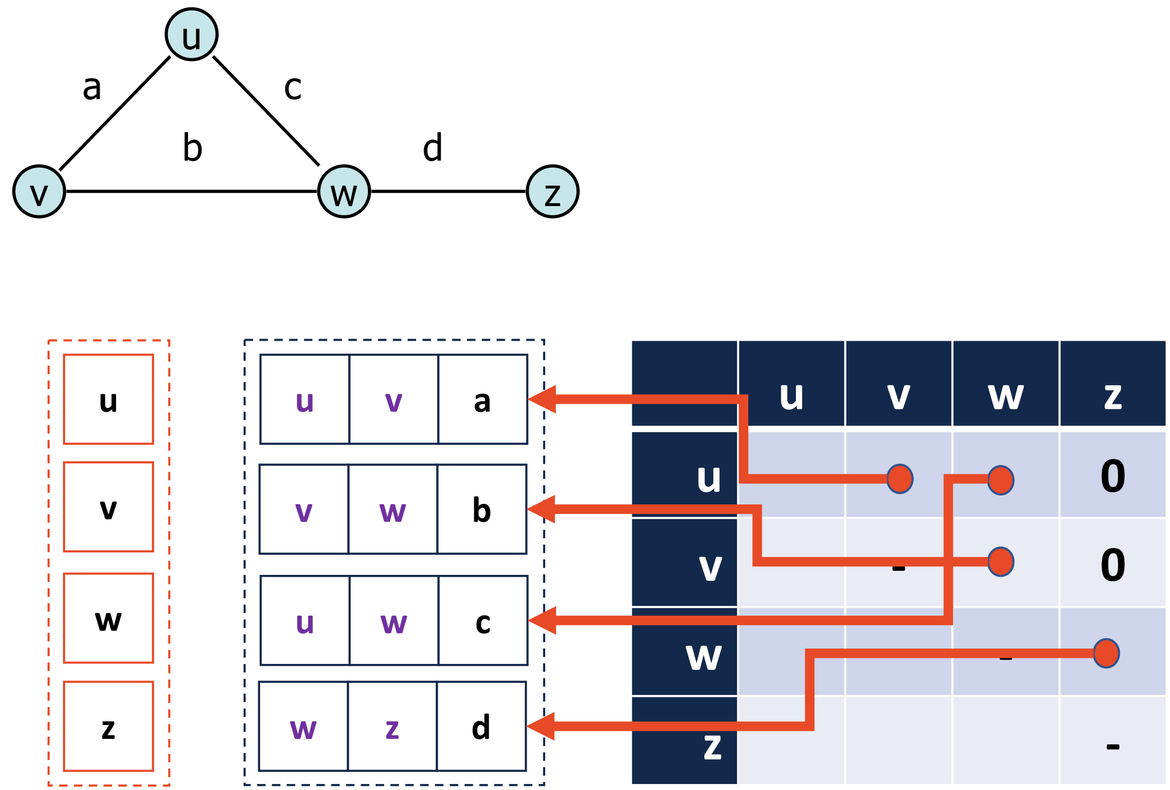


u
v
w
z

u	v	a
v	w	b
u	w	c
w	z	d

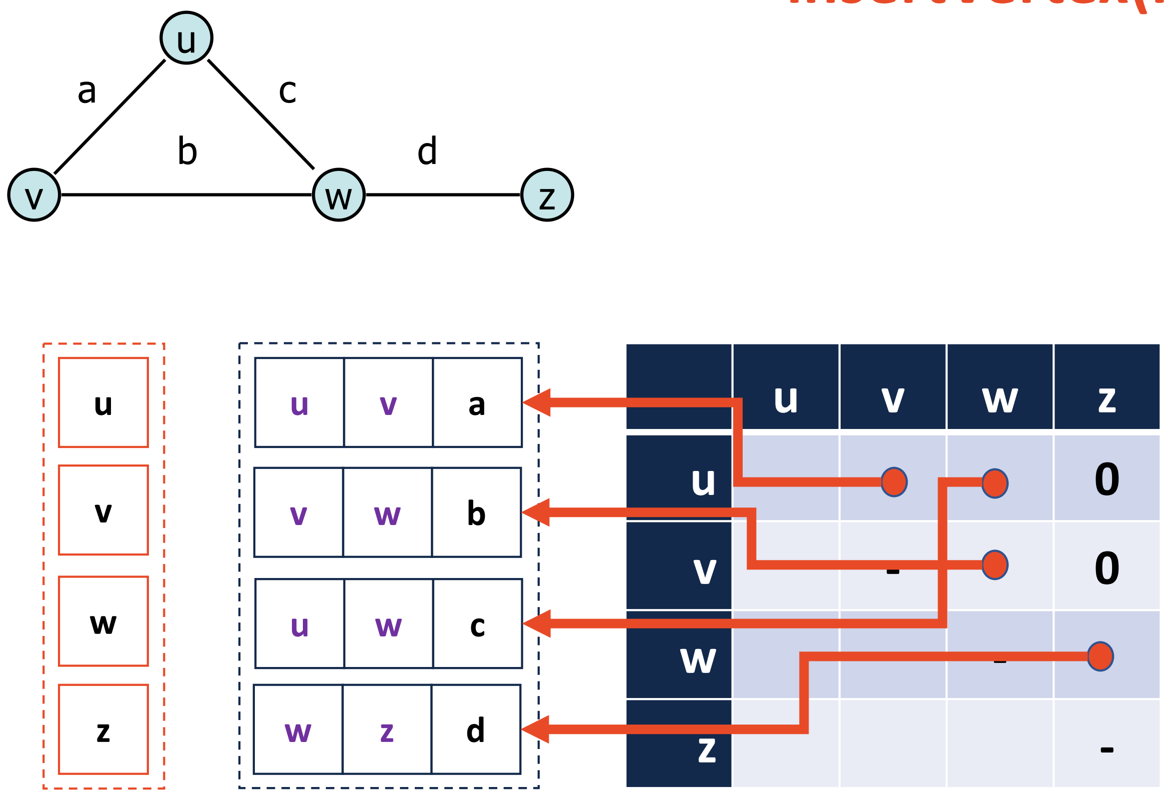
	u	v	w	z
u	-	1	1	0
v		-	1	0
w			-	1
z				-

Graph Implementation: Adjacency Matrix



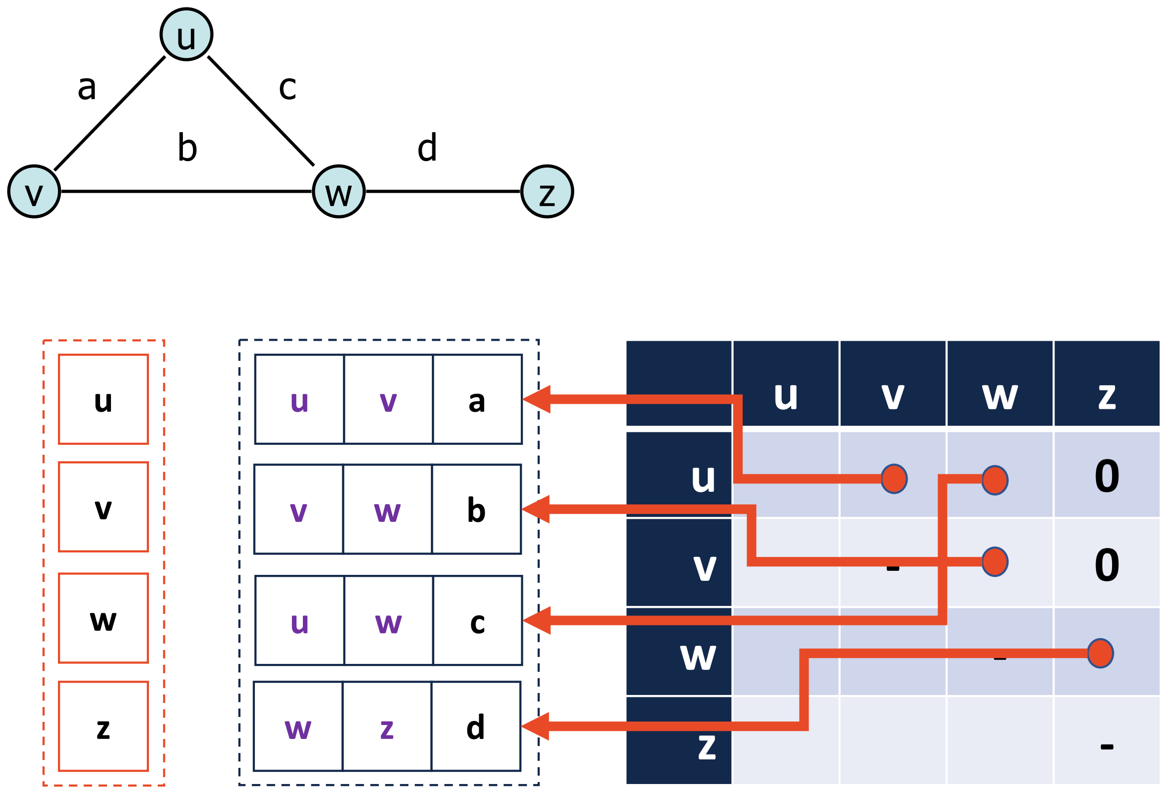
Graph Implementation: Adjacency Matrix

insertVertex(K key):



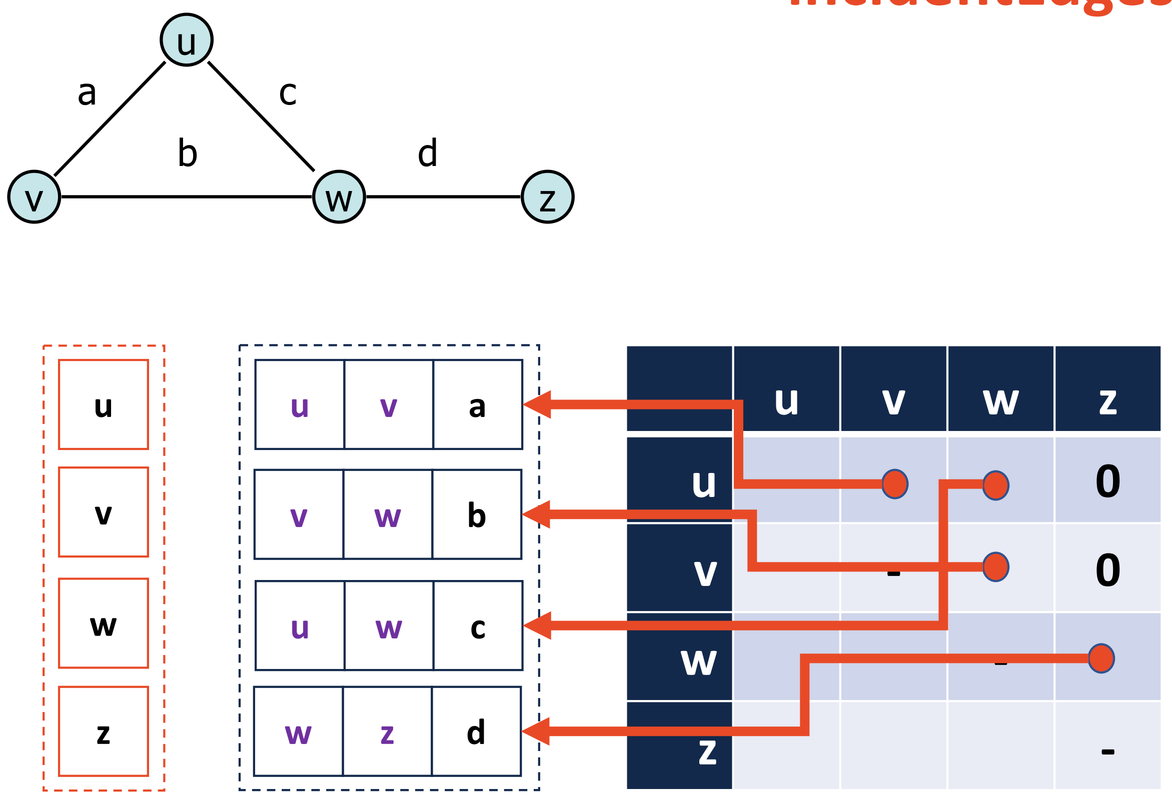
Graph Implementation: Adjacency Matrix

removeVertex(Vertex v):



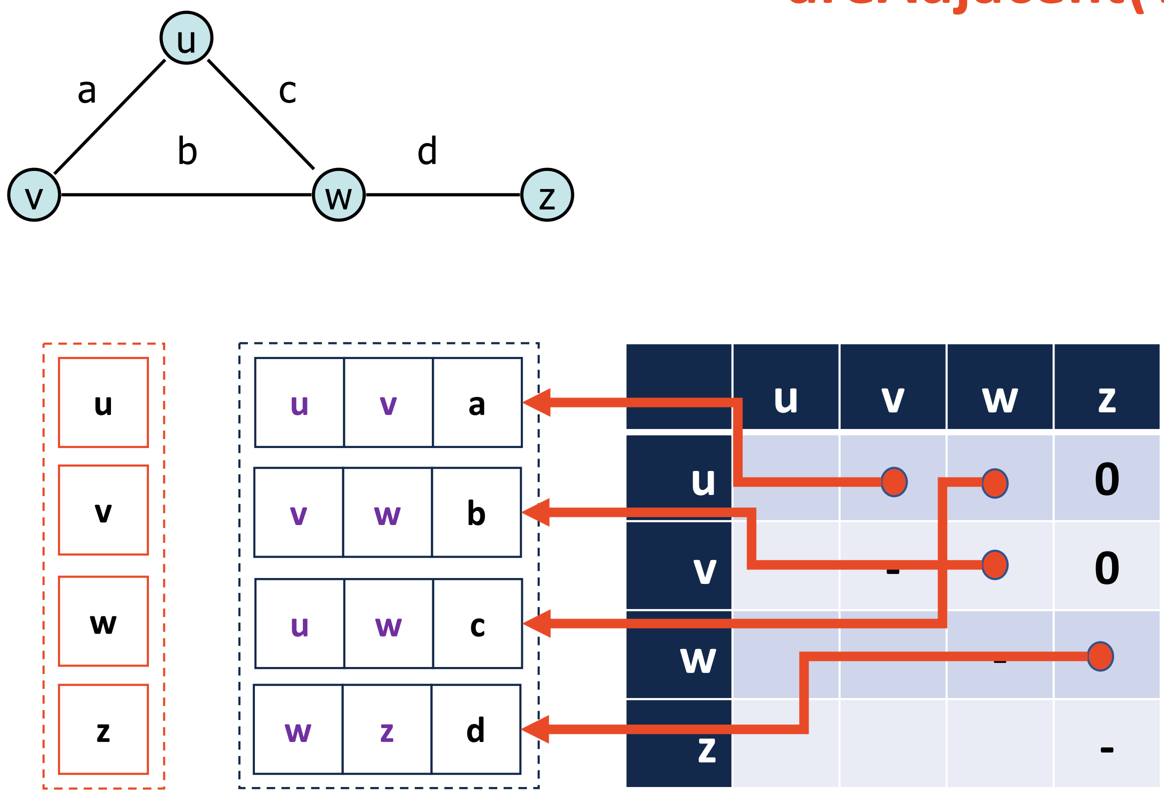
Graph Implementation: Adjacency Matrix

incidentEdges(Vertex v):



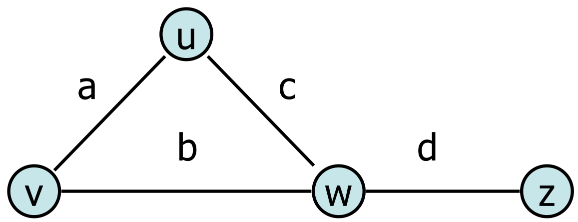
Graph Implementation: Adjacency Matrix

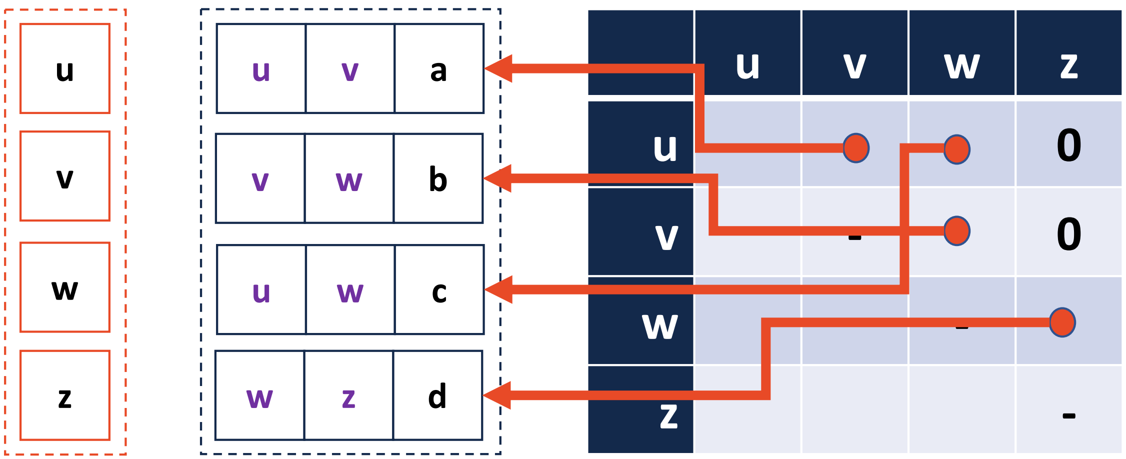
areAdjacent(Vertex v1, Vertex v2):



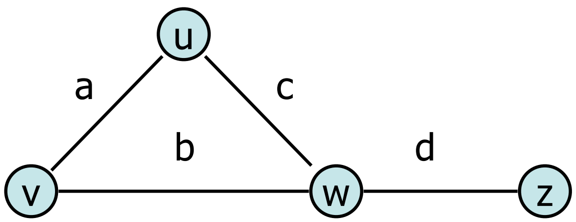
Graph Implementation: Adjacency Matrix

insertEdge(Vertex v1, Vertex v2, K key):





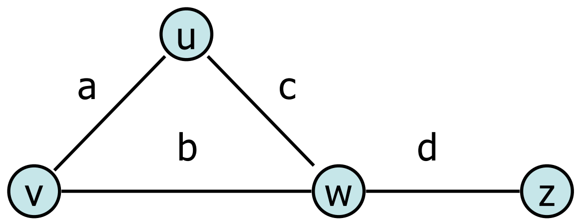
Graph Implementation: Edge List

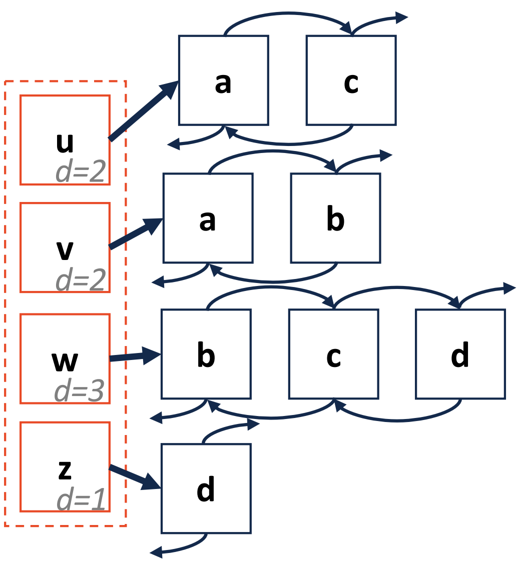


u
v
w
z

u	v	a
v	w	b
u	w	c
w	z	d

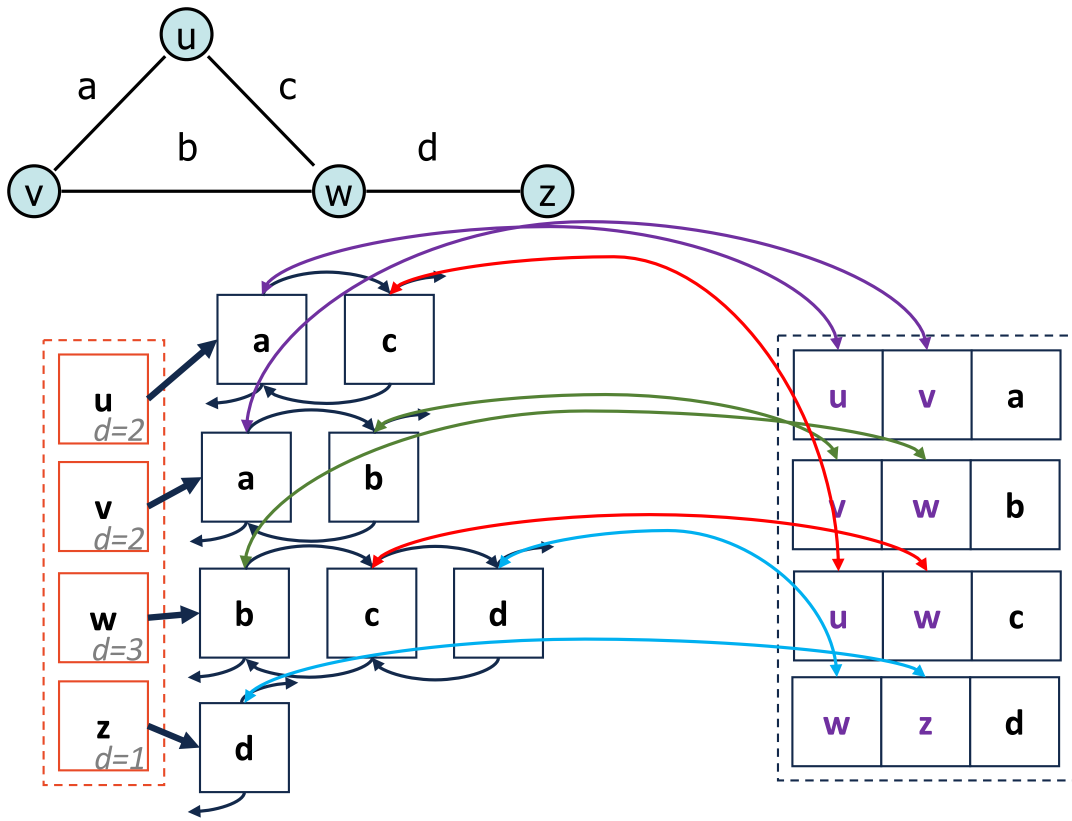
Adjacency List





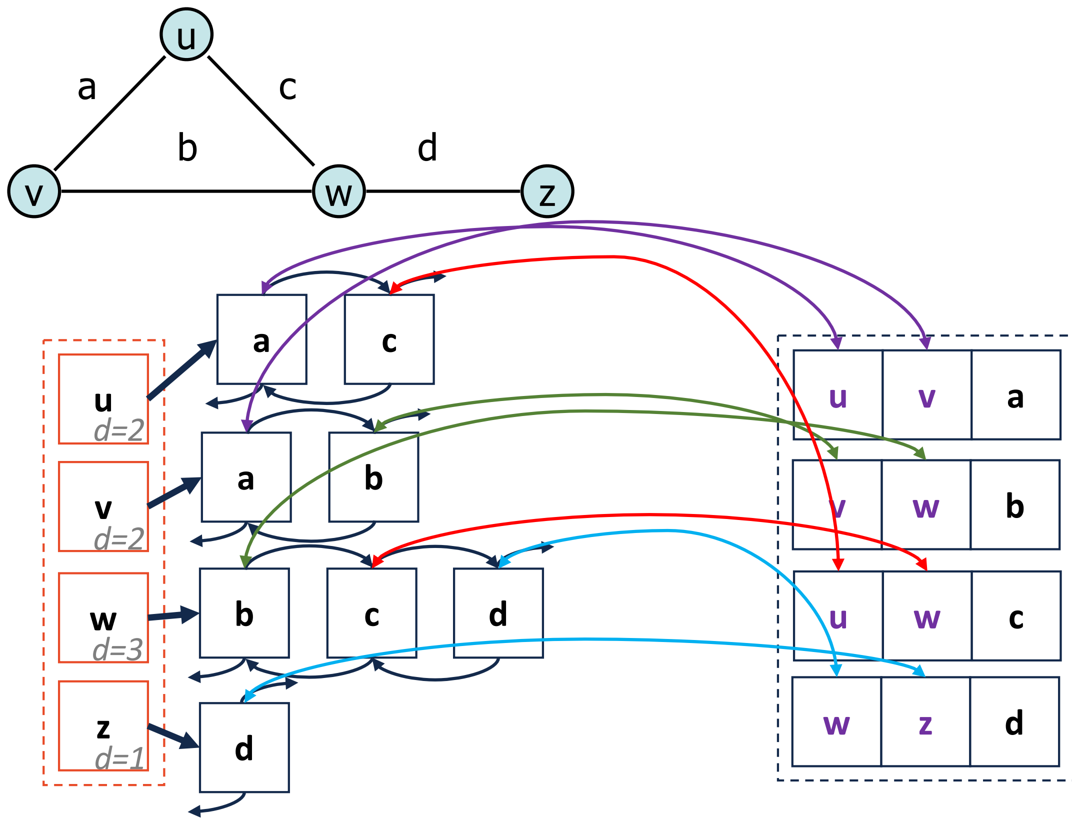
u	v	a
v	w	b
u	w	c
w	z	d

Adjacency List



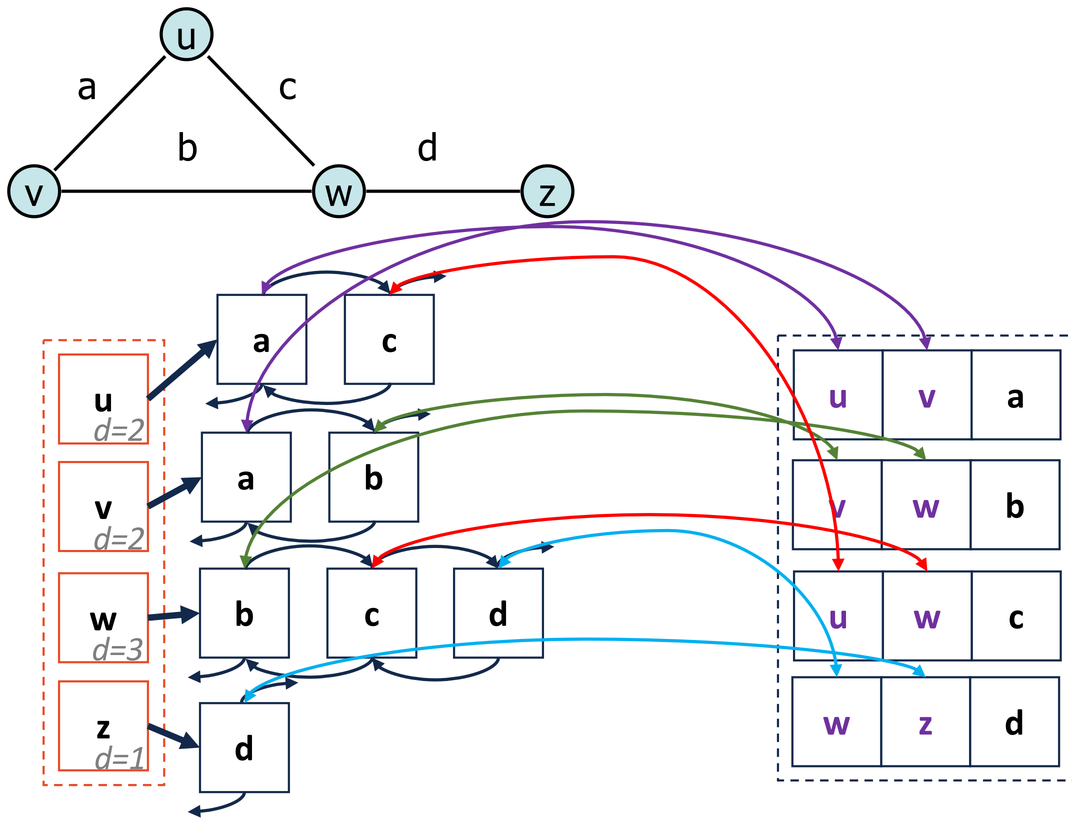
Adjacency List

insertVertex(K key):



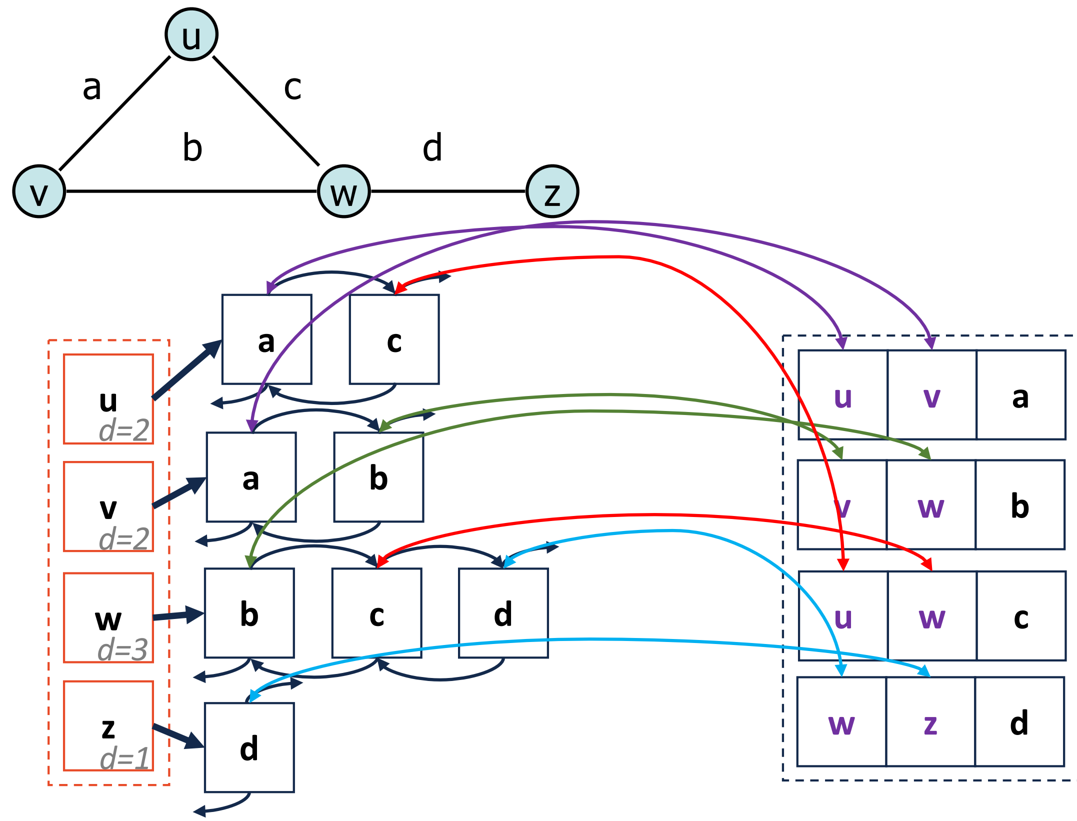
Adjacency List

removeVertex(Vertex v):



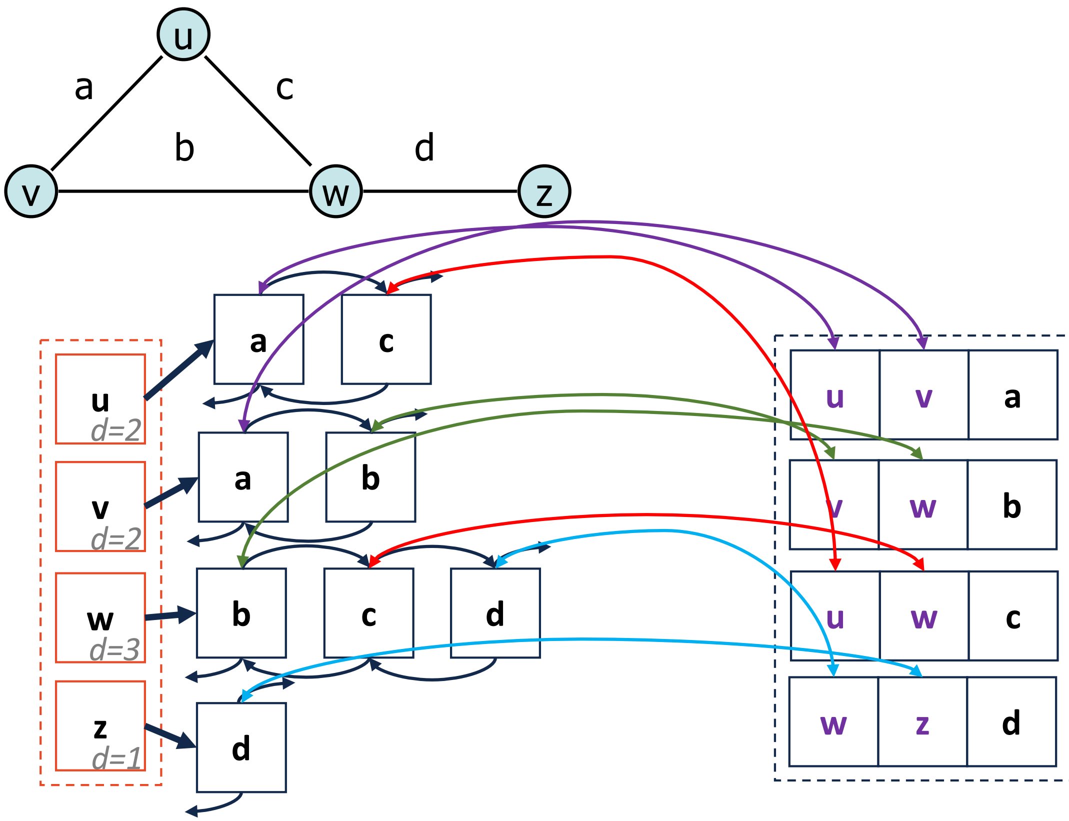
Adjacency List

incidentEdges(Vertex v):



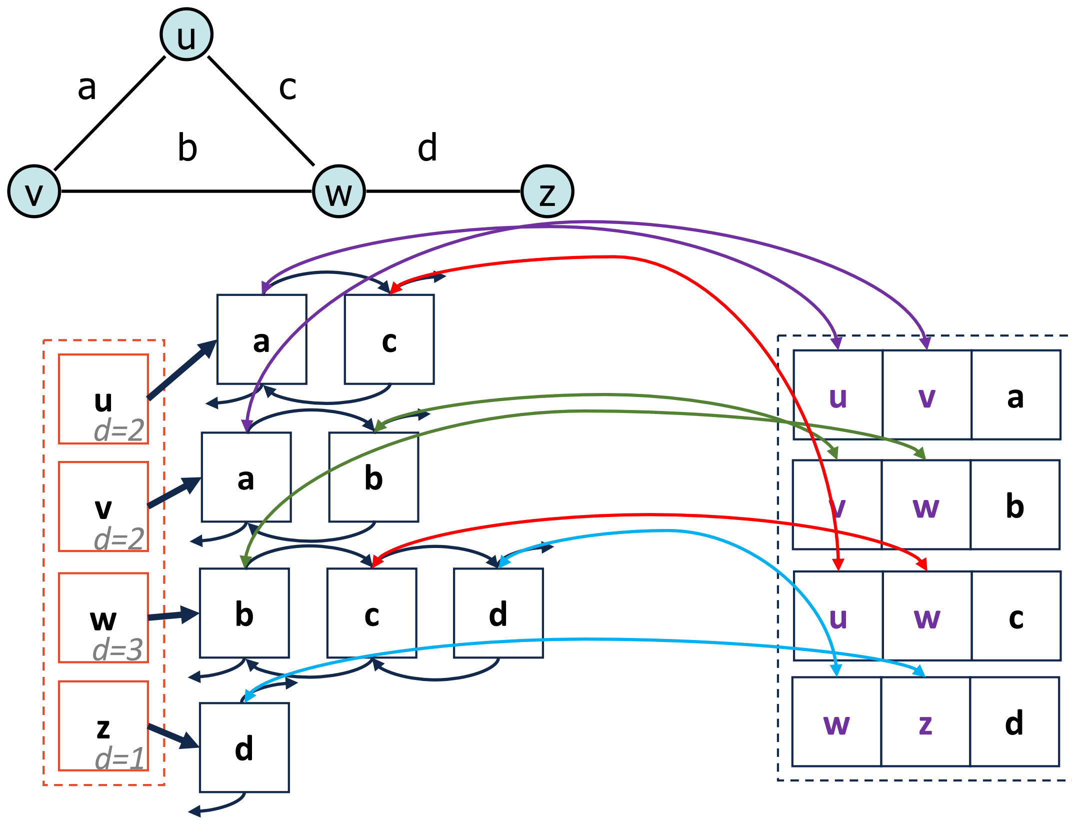
Adjacency List

areAdjacent(Vertex v1, Vertex v2):



Adjacency List

insertEdge(Vertex v1, Vertex v2, K key):



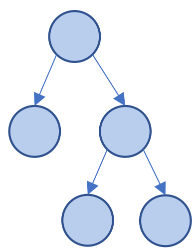
Expressed as O(f)	Edge List	Adjacency Matrix	Adjacency List
Space	n+m	n^2	n+m
insertVertex(v)	1	n	1
removeVertex(v)	m	n	deg(v)
insertEdge(v, w, k)	1	1	1
removeEdge(v, w)	1	1	1
incidentEdges(v)	m	n	deg(v)
areAdjacent(v, w)	m	1	min(deg(v), deg(w))

Traversal:

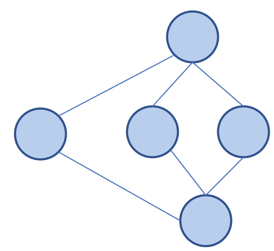
Objective: Visit every vertex and every edge in the graph.

Purpose: Search for interesting sub-structures in the graph.

We've seen traversal before ….but it's different:



- Ordered
- Obvious Start
-



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Traversal: BFS