Algorithms and Data Structures for Data Science

Graph Implementations

CS 277

March 25, 2024

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Exam 2 Reflection

Average: 72%

The programming question was the most difficult

I also consider the programming question to be extremely fair

Consider going to office hours to go over exam

Learning Objectives

Practice implementing complex data structures (graphs)

Compare and contrast different implementations

Review Big O concepts in the context of graphs

Graph ADT

Constructor

Find: Need to be able to search for vertices, edges, and adjacency.

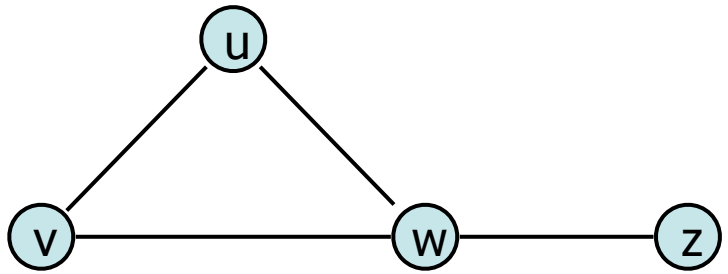
Insert: Need both a vertex and an edge insertion function

Remove: Need both a vertex and an edge removal function

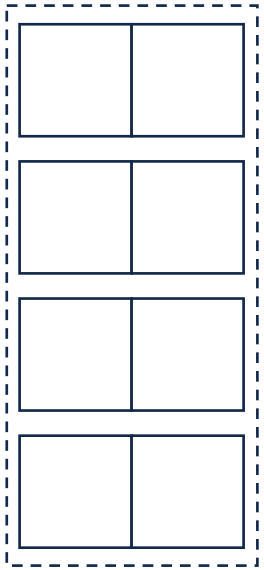
Traversal: Need to be able to traversal a graph efficiently

Graph Implementation: Edge List `|V|= n,|E|= m`

The equivalent of an 'unordered' data structure



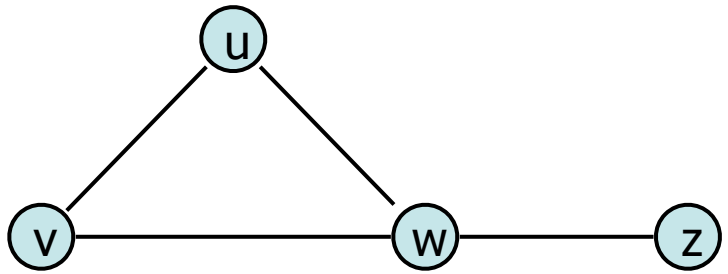
Vertex Storage:

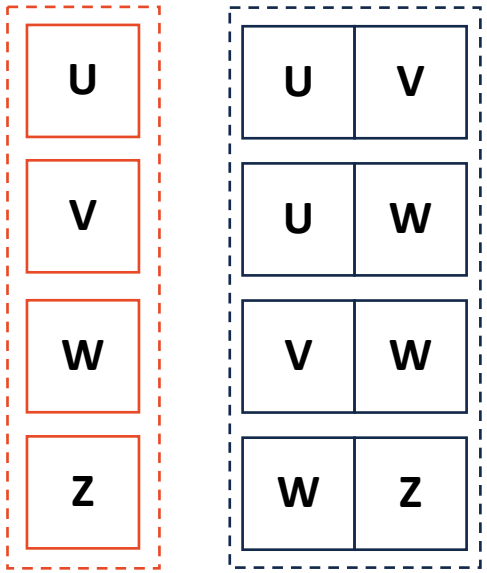


Edge Storage:

Graph Implementation: Edge List `|V|= n,|E|= m`

The equivalent of an 'unordered' data structure





Vertex Storage:

None

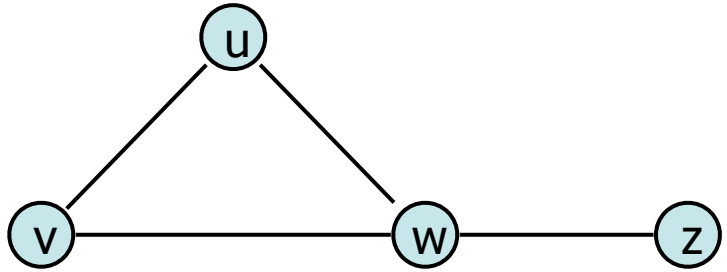
A list of vertex labels

Edge Storage:

A list of paired vertex labels

Graph Implementation: Edge List

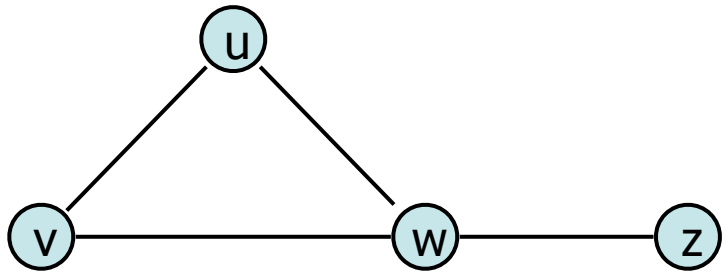
getVertices()

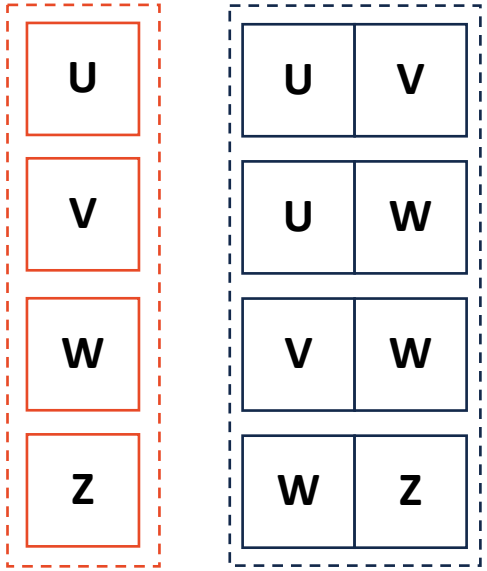


U
V
W
Z

U	V
U	W
V	W
W	Z

Graph Implementation: Edge List





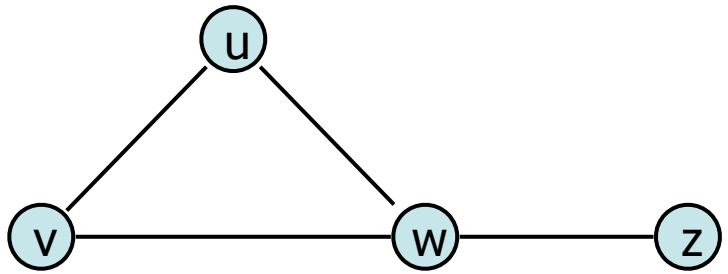
getVertices()

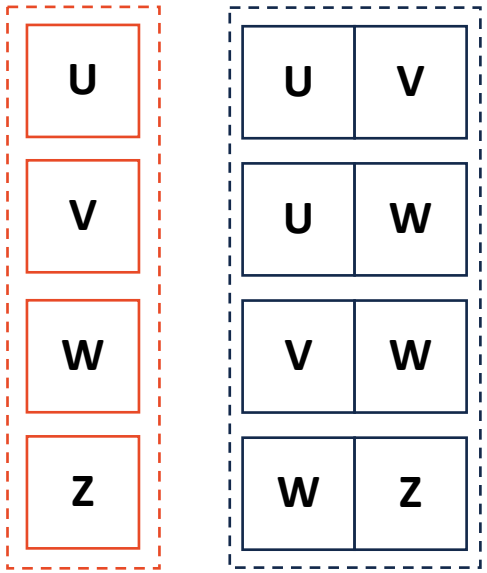
Return vertex list

Loop through edge list and build list of vertices

getEdges(v)

Graph Implementation: Edge List





getVertices()

Return vertex list

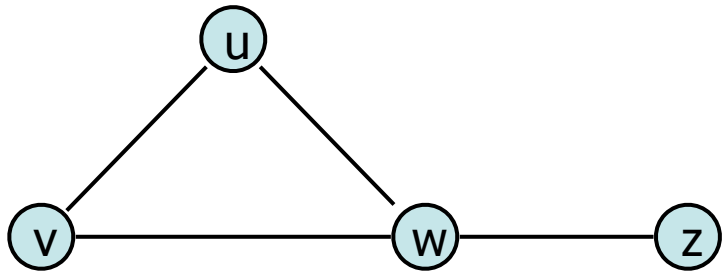
Loop through edge list and build list of vertices

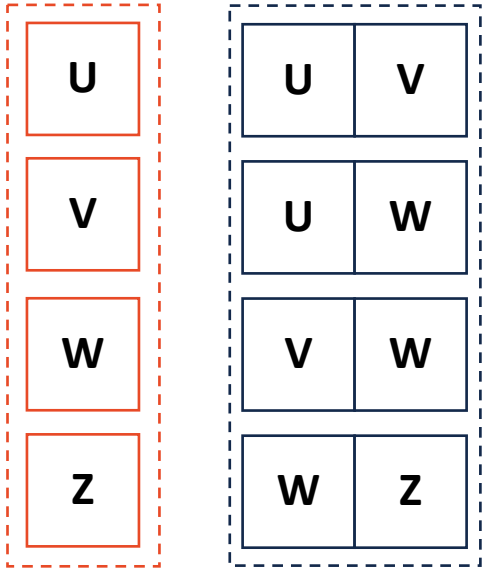
getEdges(v)

Loop through edge list and build list of edges

areAdjacent(u, v)

Graph Implementation: Edge List





getVertices()

Return vertex list

Loop through edge list and build list of vertices

getEdges(v)

Loop through edge list and build list of edges

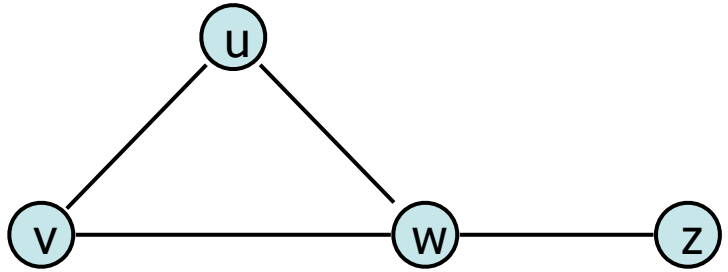
areAdjacent(u, v)

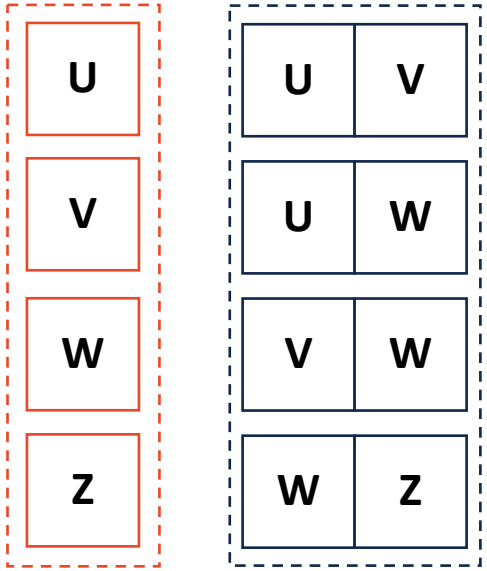
Loop through edge list and find (u, v) or (v, u)

Lets code this up!

Graph Implementation: Edge List

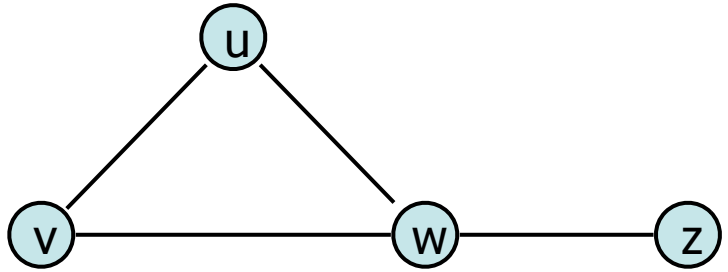
insertVertex(v)





insertEdge(u, v)

Graph Implementation: Edge List



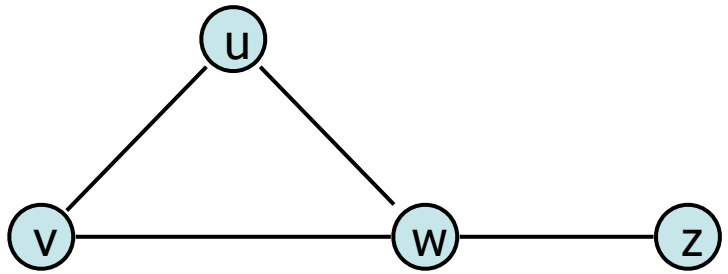
removeVertex(v)

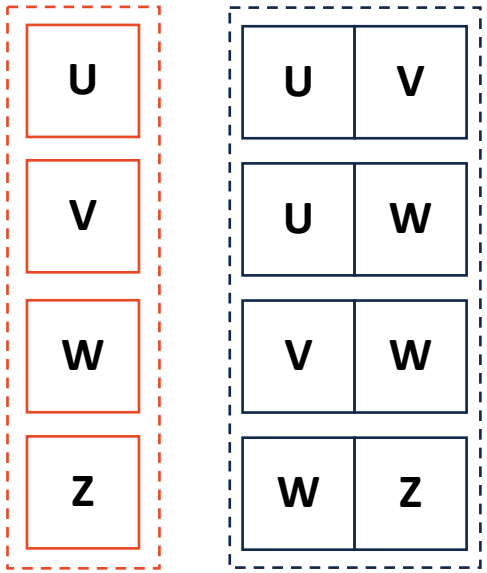
U
V
W
Z

U	V
U	W
V	W
W	Z

removeEdge(u, v)

Graph Implementation: Edge List

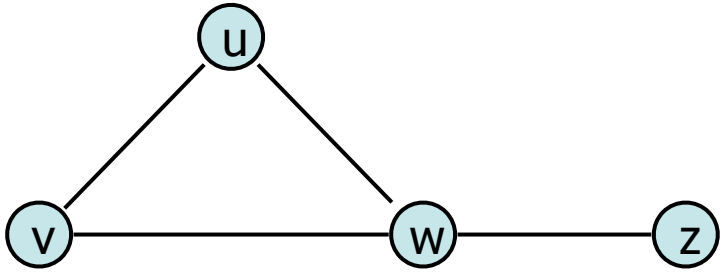




Pros:

Cons:

Graph Implementation: Adjacency Matrix



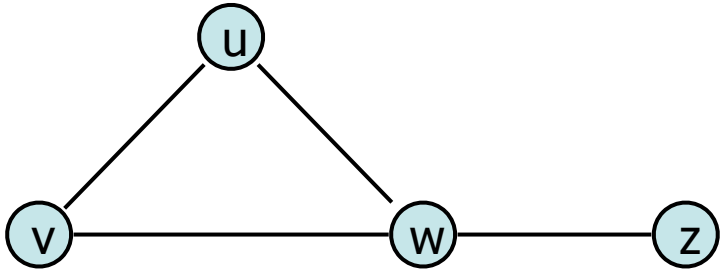
Vertex Storage:

u	
v	
w	
z	

Edge Storage:

	u	v	w	z
u				
v				
w				
z				

Graph Implementation: Adjacency Matrix



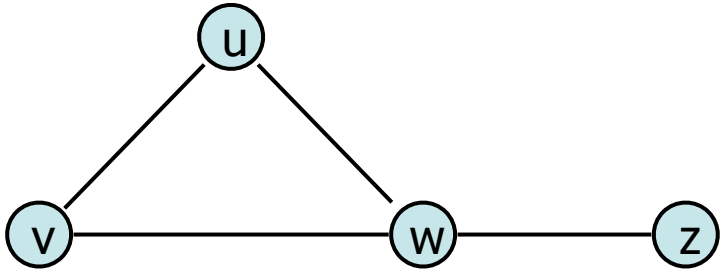
Vertex Storage:

U	0
V	1
W	2
Z	3

Edge Storage:

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

Graph Implementation: Adjacency Matrix

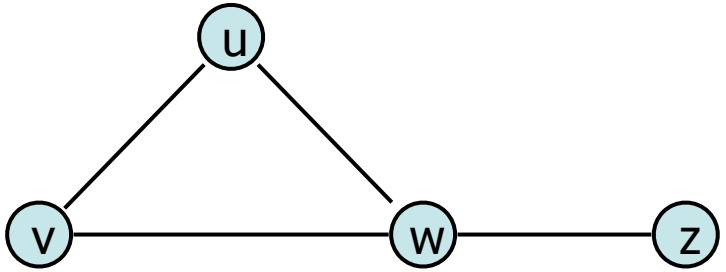


getVertices():

U	0
V	1
W	2
Z	3

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

Graph Implementation: Adjacency Matrix

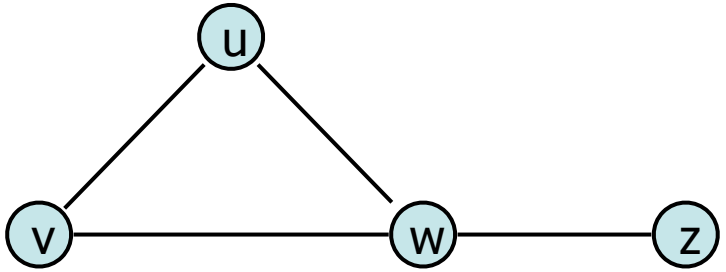


getEdges(v):

U	0
V	1
W	2
Z	3

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

Graph Implementation: Adjacency Matrix

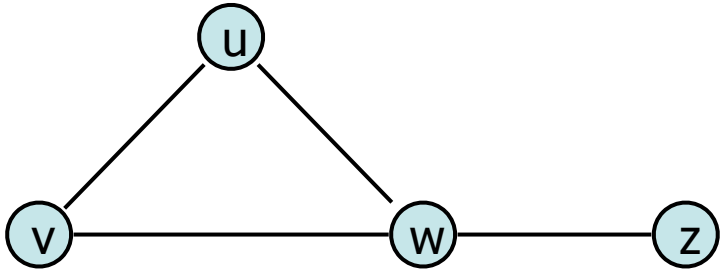


areAdjacent(u, v):

U	0
V	1
W	2
Z	3

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

Graph Implementation: Adjacency Matrix

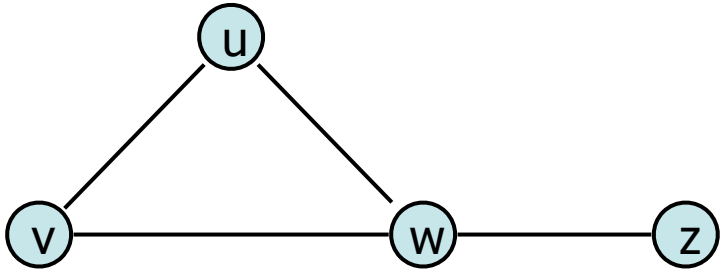


insertVertex(v):

U	0
V	1
W	2
Z	3

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

Graph Implementation: Adjacency Matrix

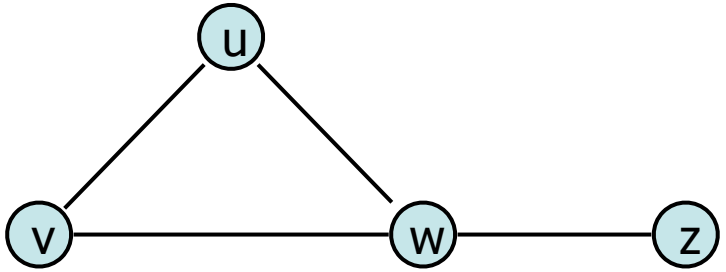


insertEdge(u, v):

U	0
V	1
W	2
Z	3

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

Graph Implementation: Adjacency Matrix



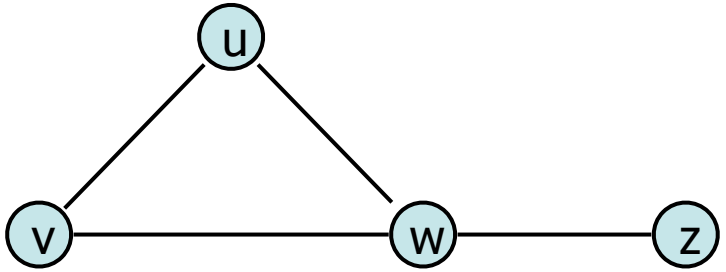
U	0
V	1
W	2
Z	3

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

removeVertex(v):

removeEdge(u, v):

Graph Implementation: Adjacency Matrix



U	0
V	1
W	2
Z	3

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

Pros:

Cons:

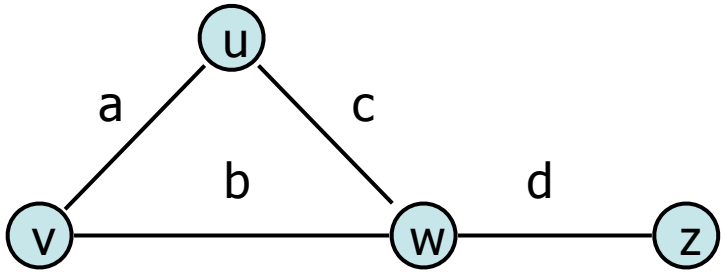
Graph Implementations

We want something…

Faster than an edge list

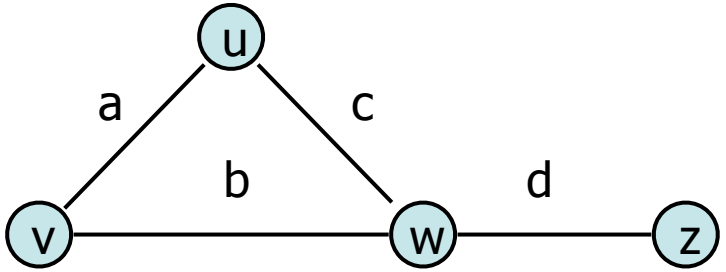
Less space than an adjacency matrix

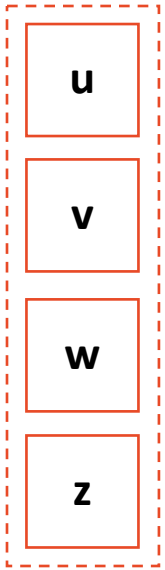
Particularly good at finding adjacent elements

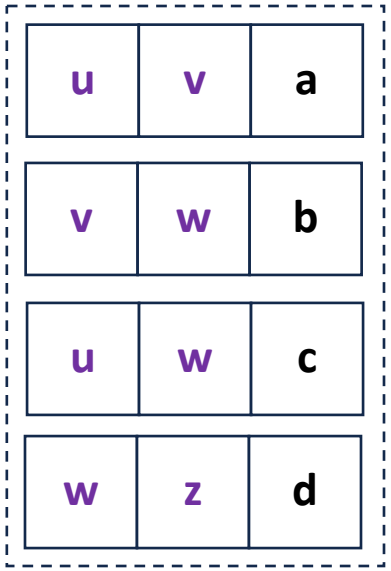


Graph Implementation: Edge List + ?

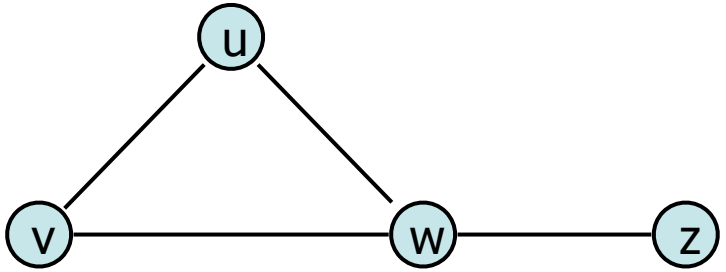
|V|= n,|E|= m



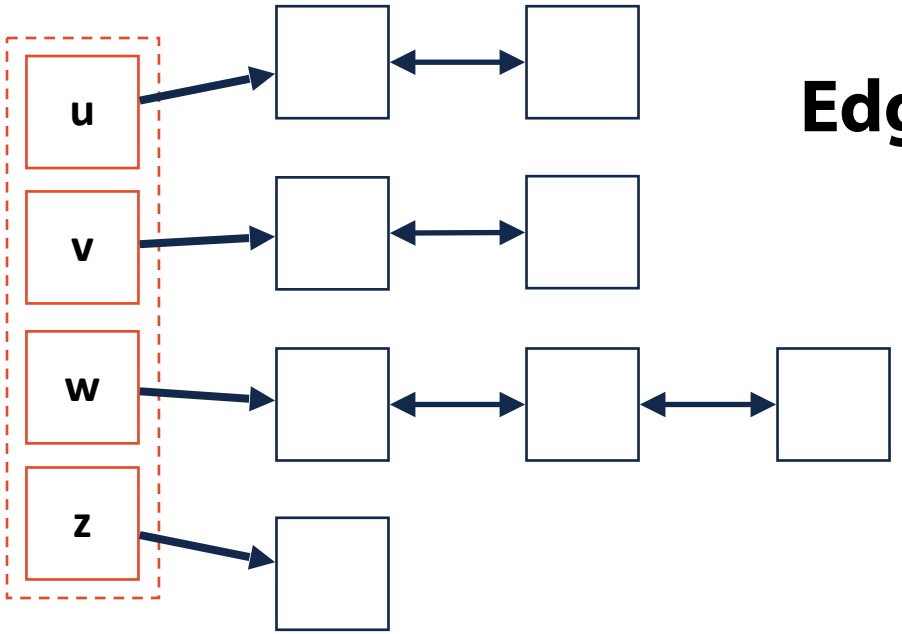




Adjacency List

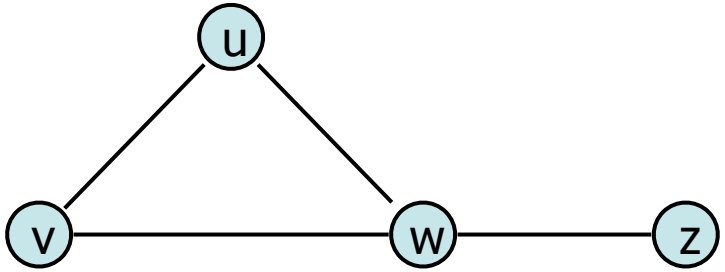


Vertex Storage:

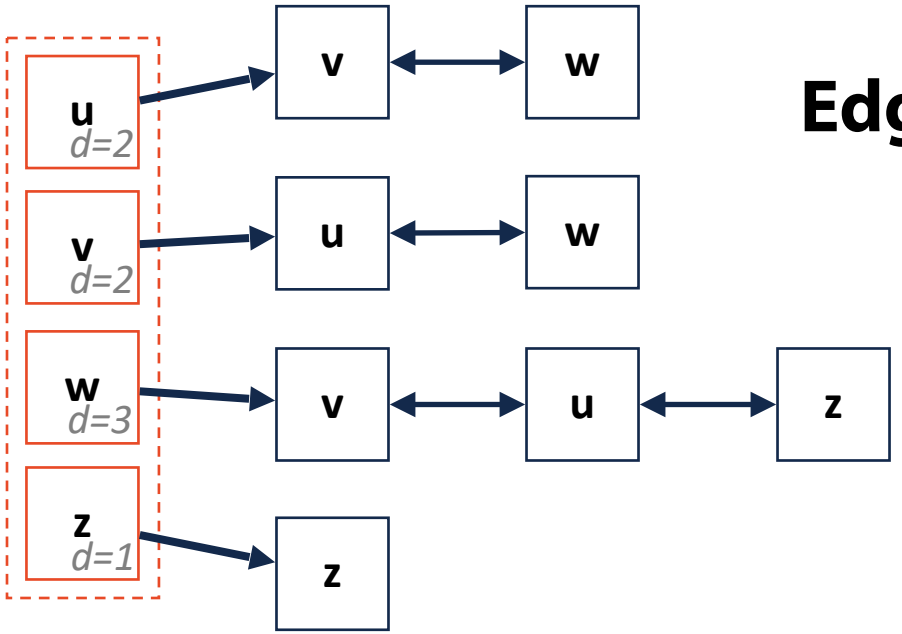


Edge Storage:

Adjacency List

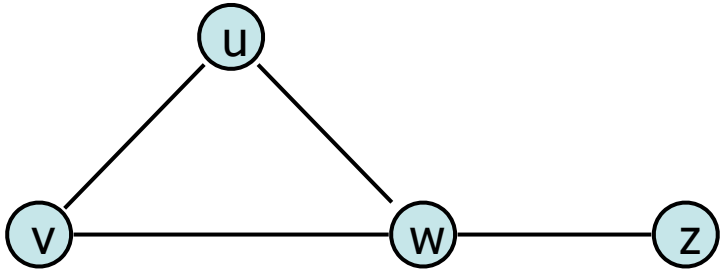


Vertex Storage:

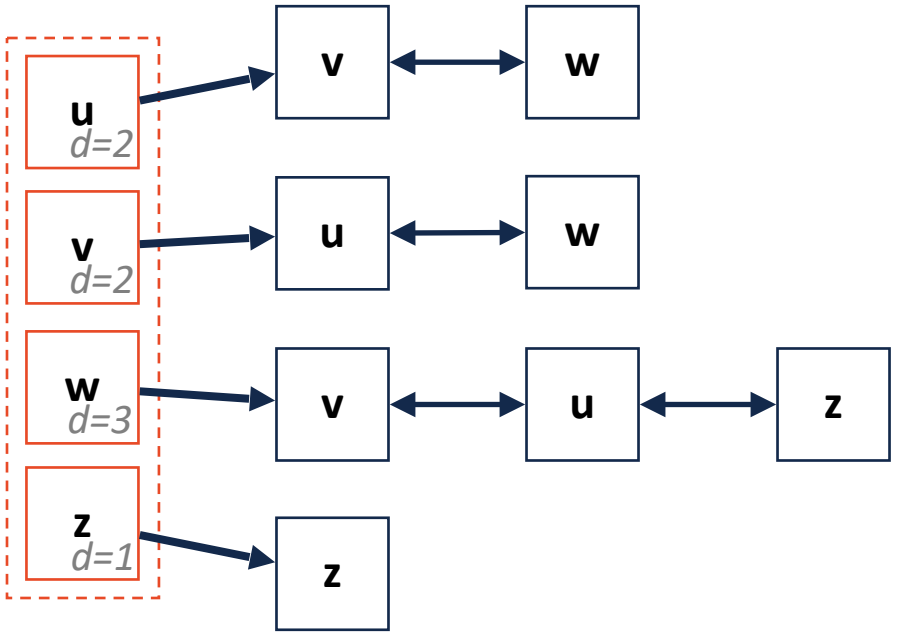


Edge Storage:

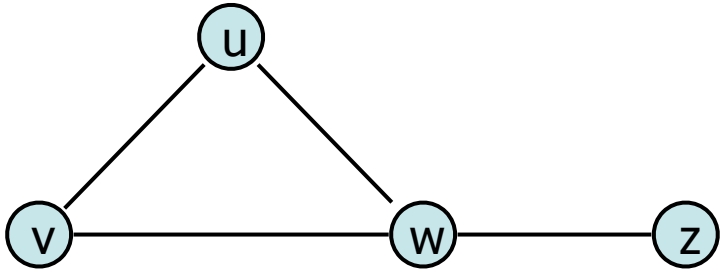
Adjacency List



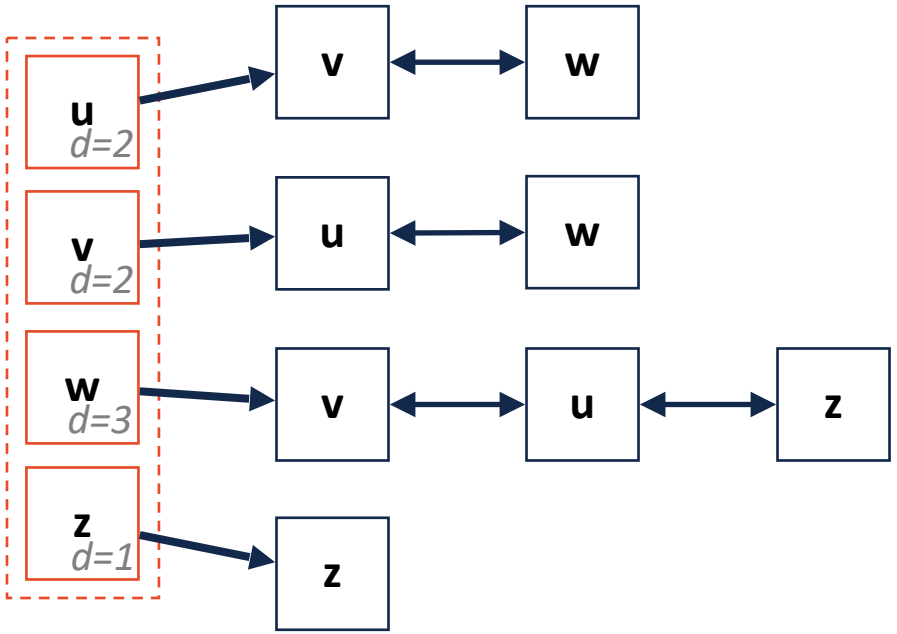
getVertices():



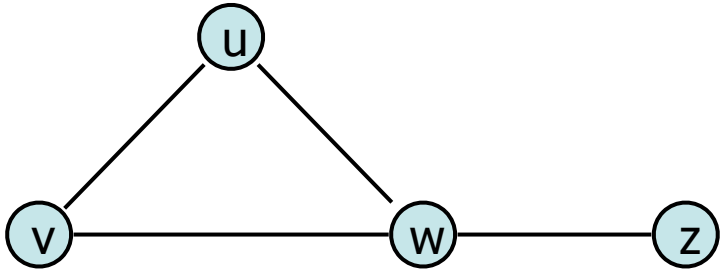
Adjacency List



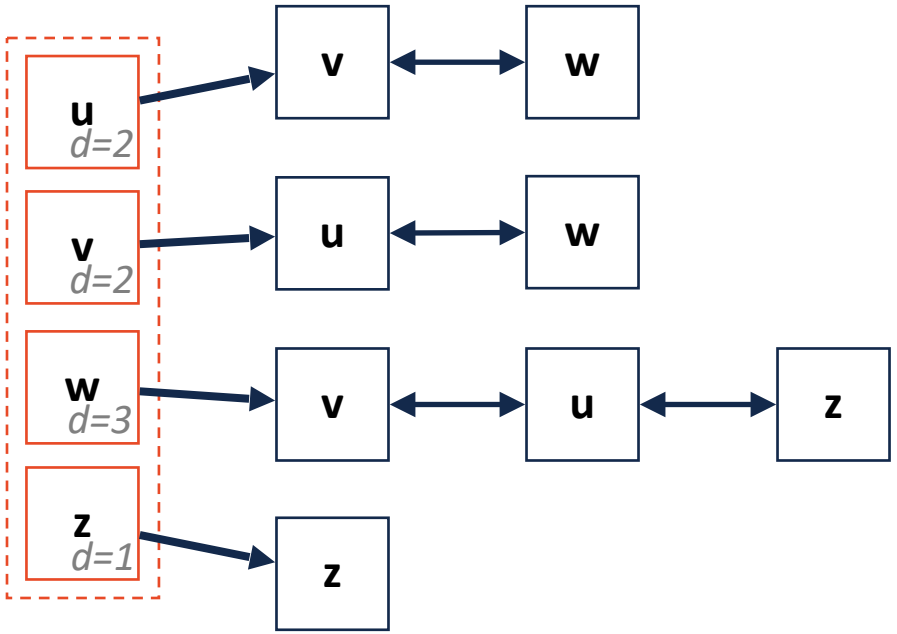
getEdges(v):



Adjacency List



areAdjacent(u, v):



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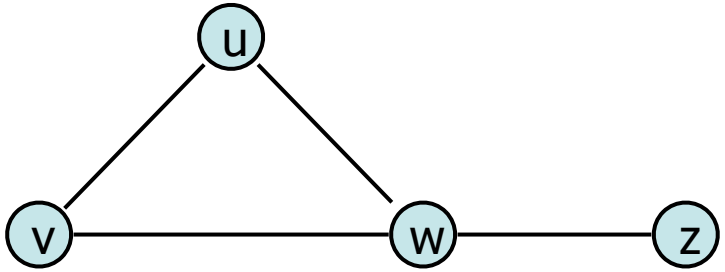
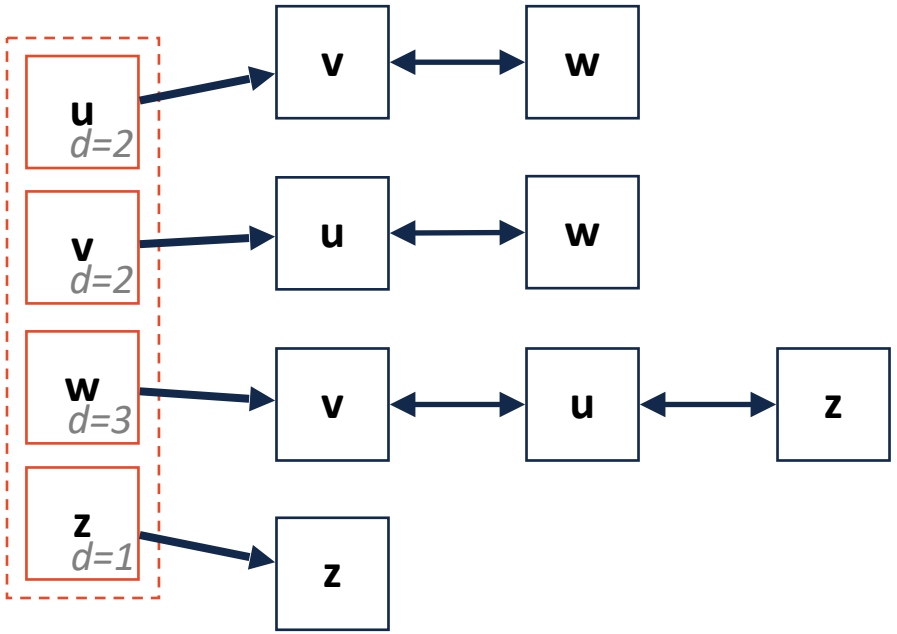
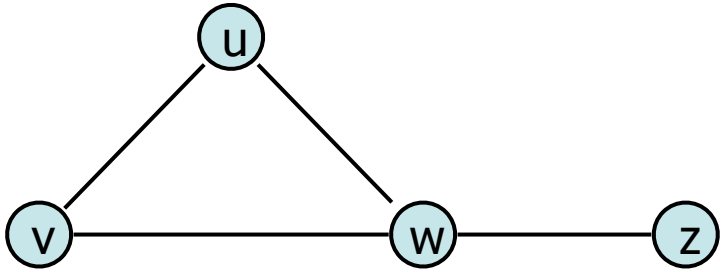


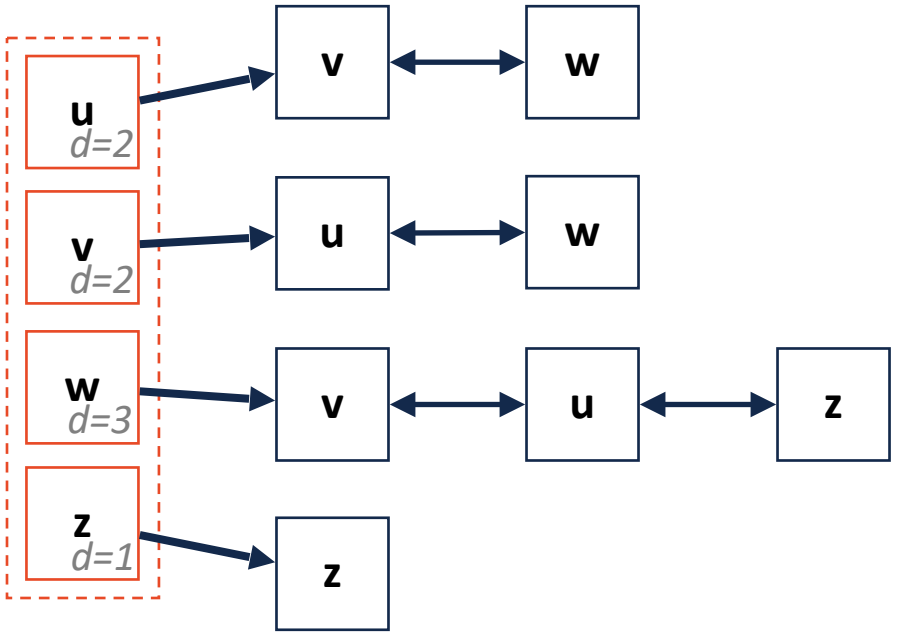
insertVertex(v):



Adjacency List



removeVertex(v):



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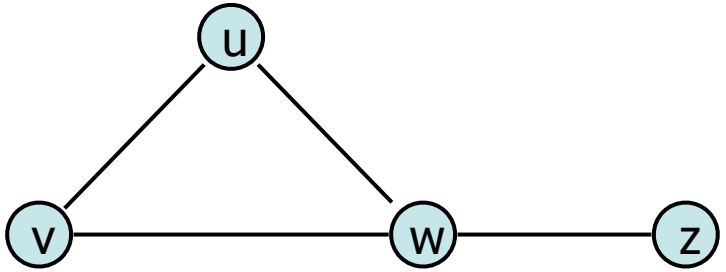
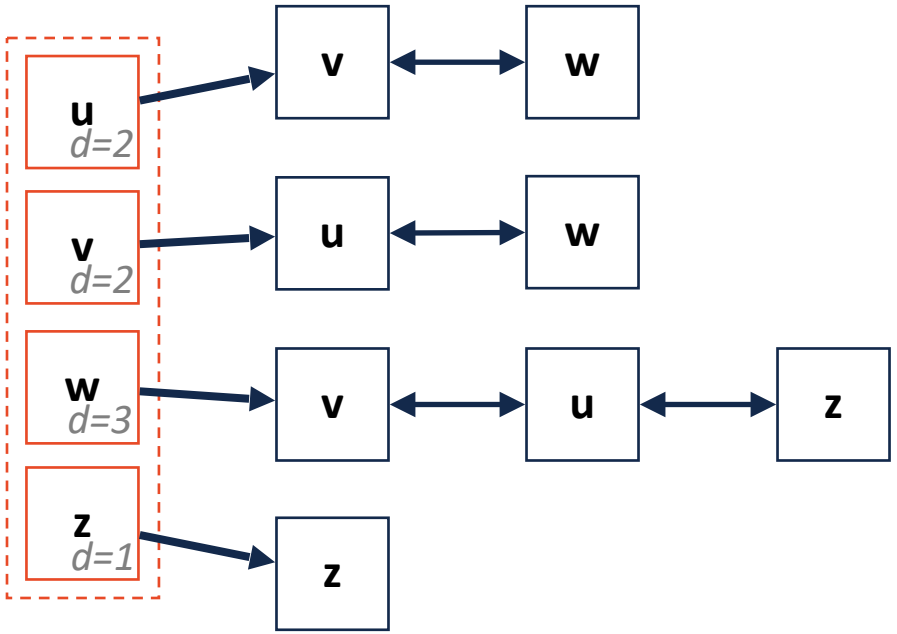


insertEdge(u, v):



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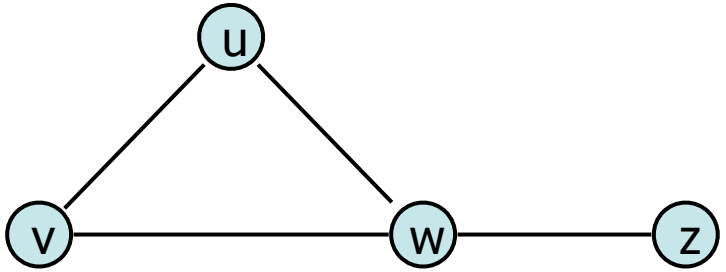
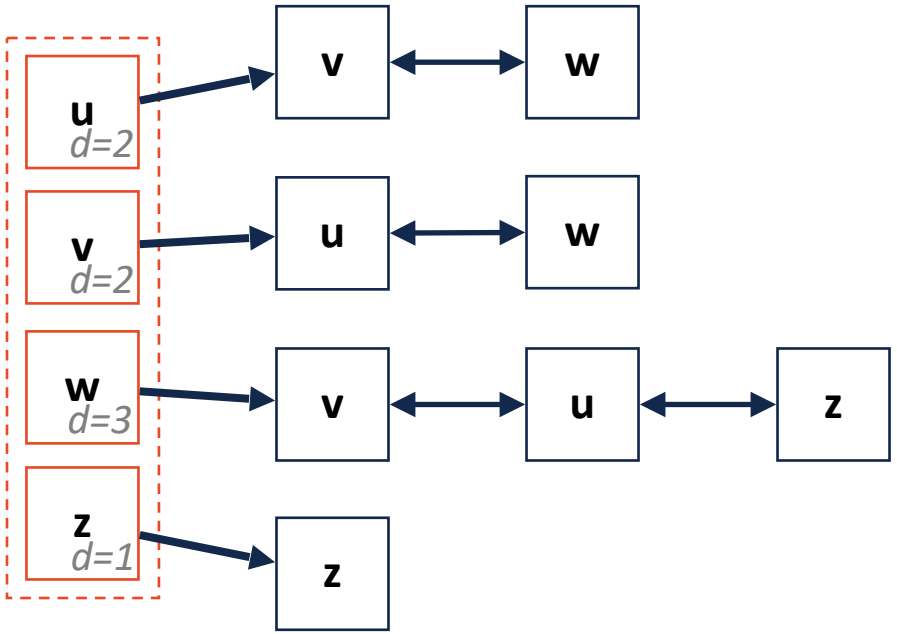
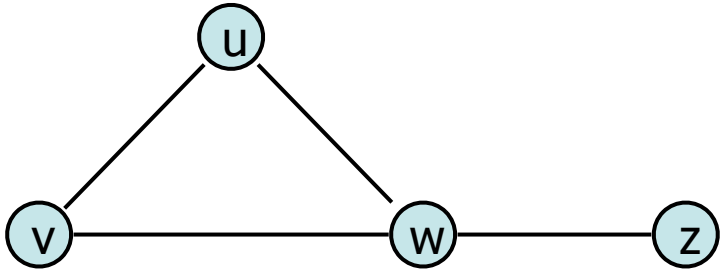
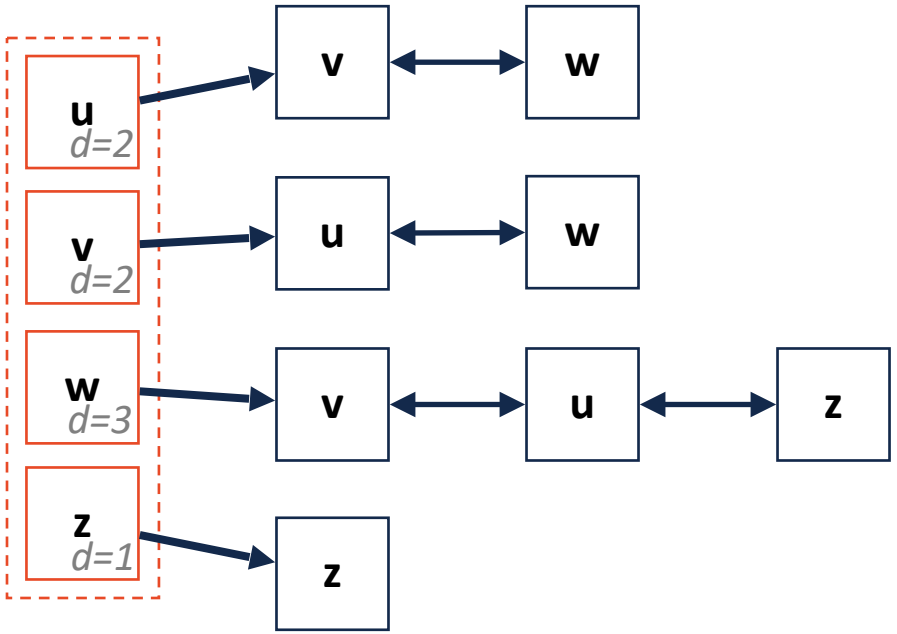


removeEdge(u, v):



Adjacency List





Pros:

Cons:

$|V| = n, |E| = m$

Expressed as O(f)	Edge List	Adjacency Matrix	Adjacency List
Space			
insertVertex(v)			
removeVertex(v)			
insertEdge(u, v)			
removeEdge(u, v)			
getEdges(v)			
areAdjacent(u, v)			