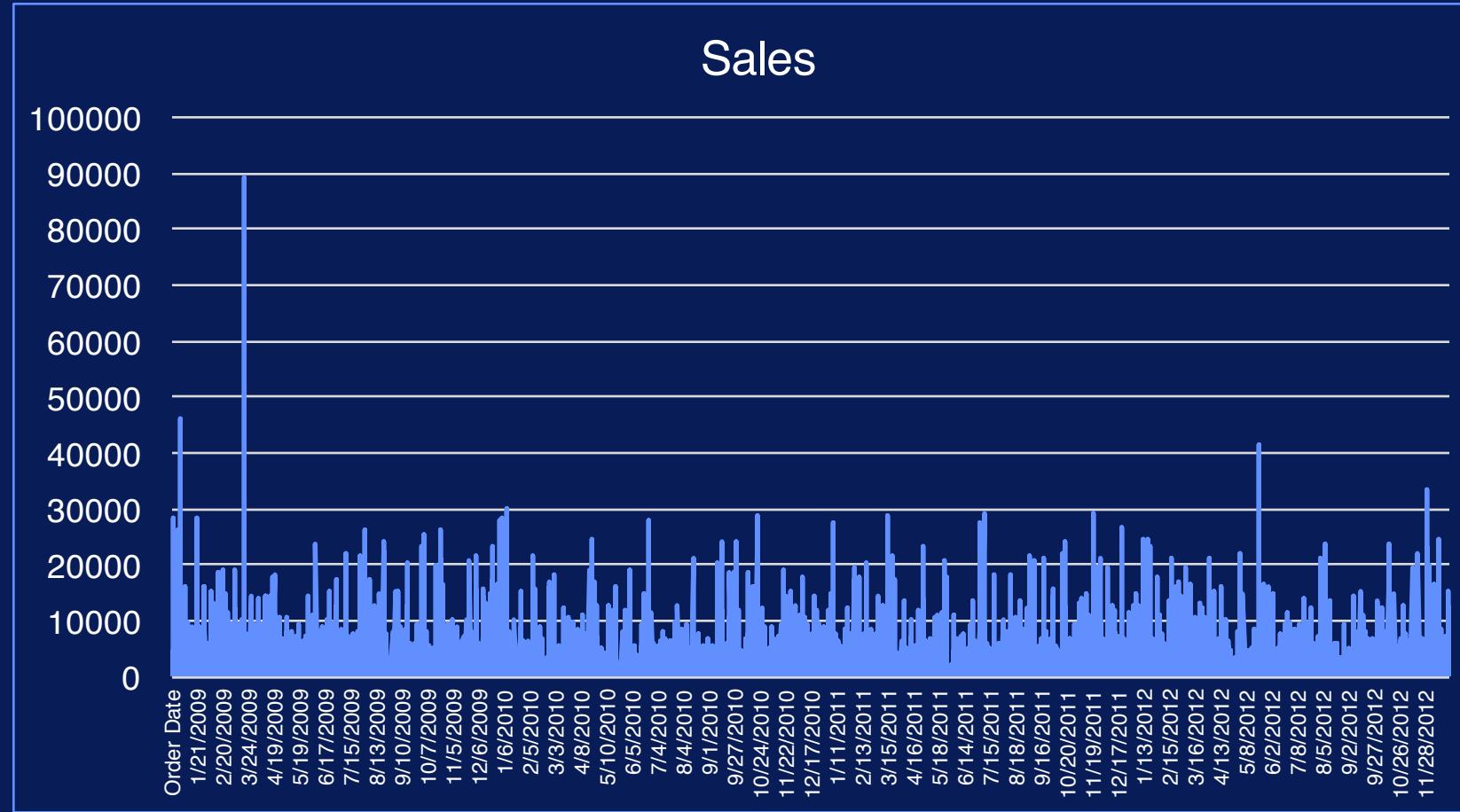


What is a Graph?

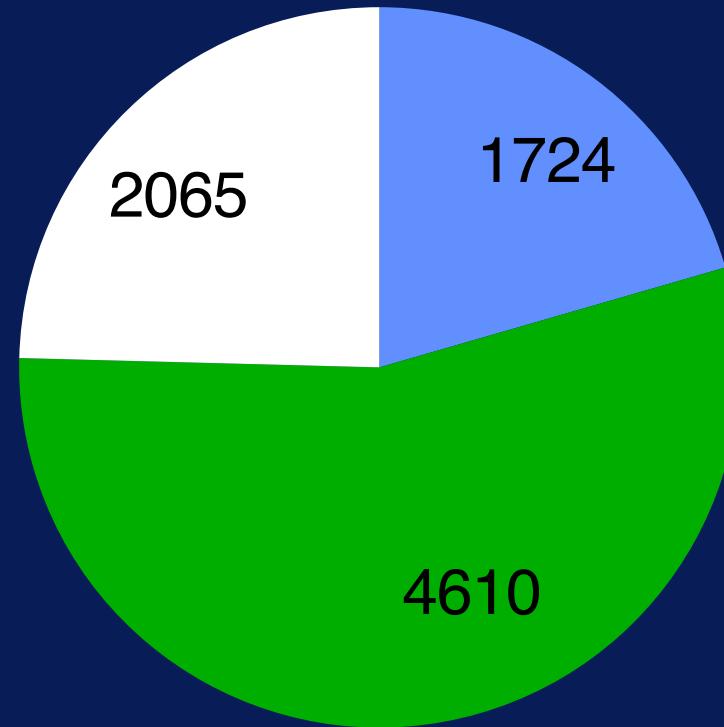


Is this a Graph?



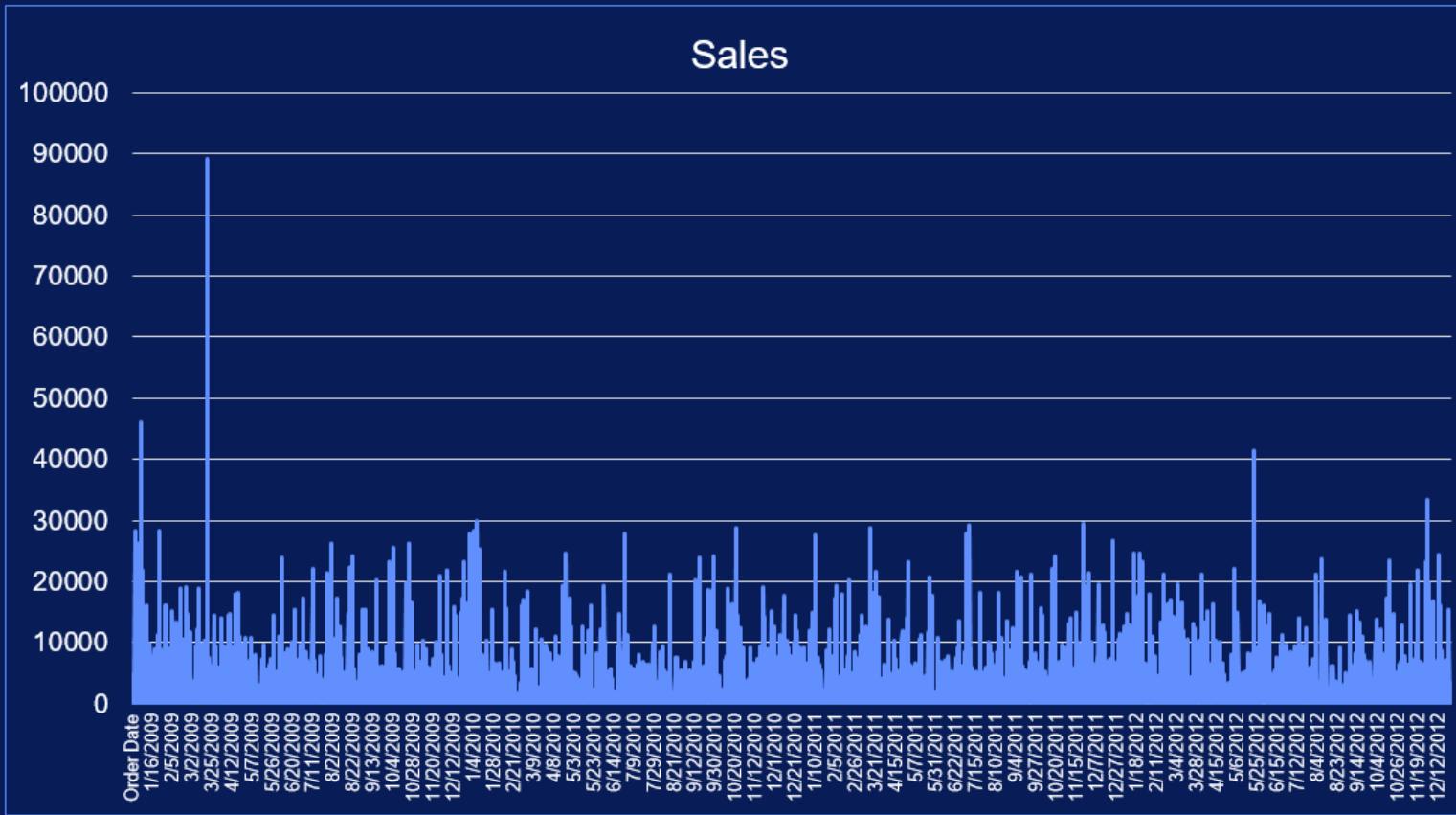
Is this a Graph?

Count of Product Category



What is NOT a Graph?

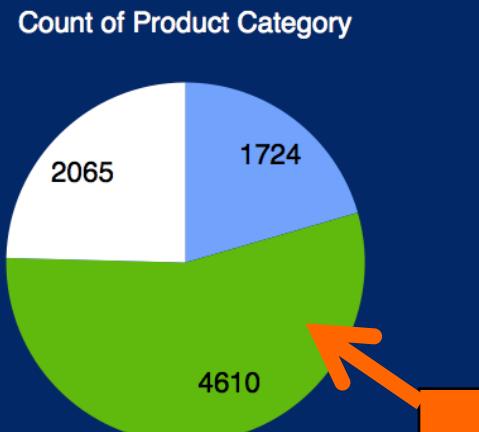
- This is a chart!



Graph vs. Graph of a Function

- Charts represent the *graph of a function*

Function – Mapping from
Category to **Total**



Chart

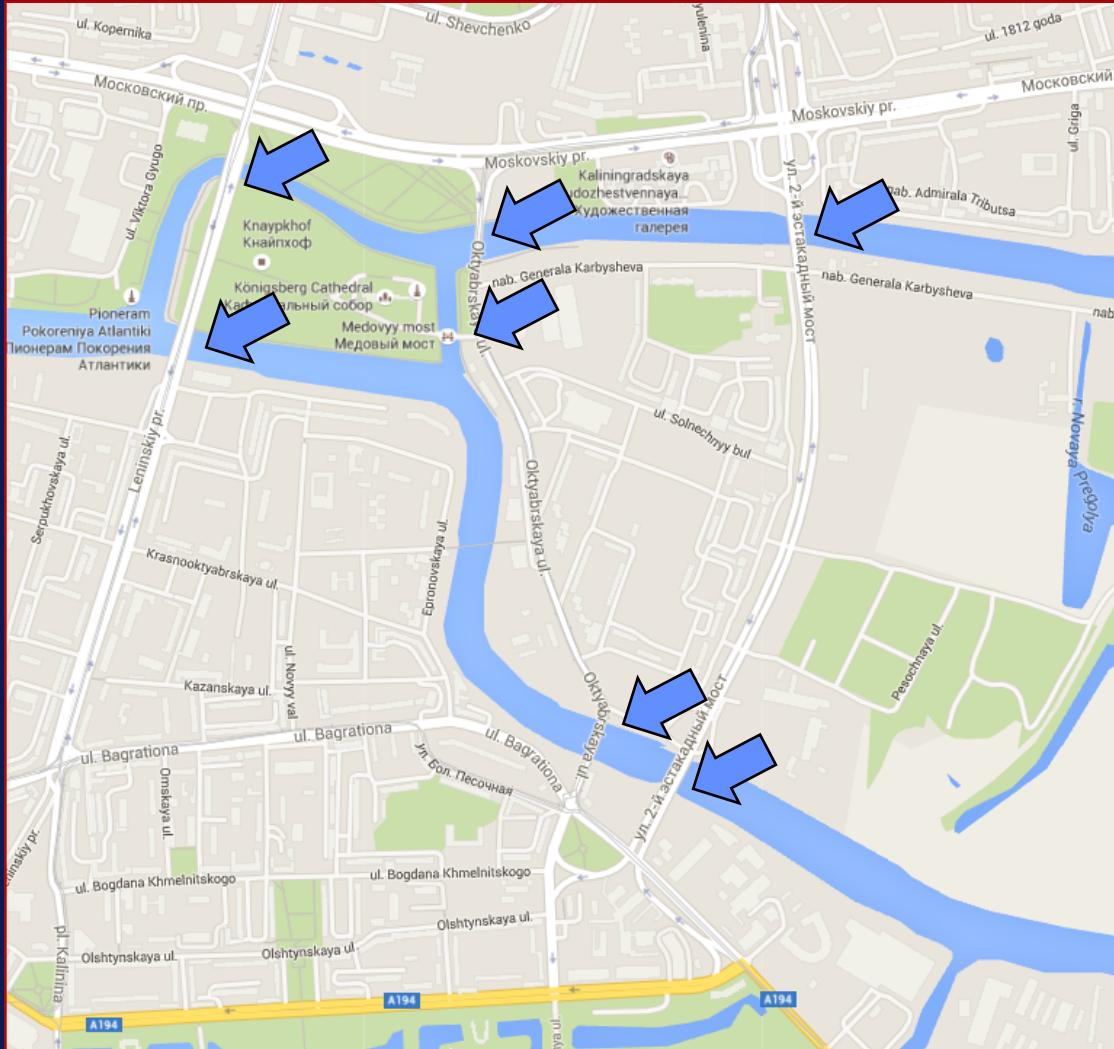
<u>Product Category</u>	<u>→</u>	<u>Total</u>
Furniture		1724
Office Supplies		4610
Technology		2065

Graph Analytics is based on Graph Theory



The city of Königsberg in Prussia (now Kaliningrad, Russia)

Graph Theory Came From An Urban Planning Problem!!



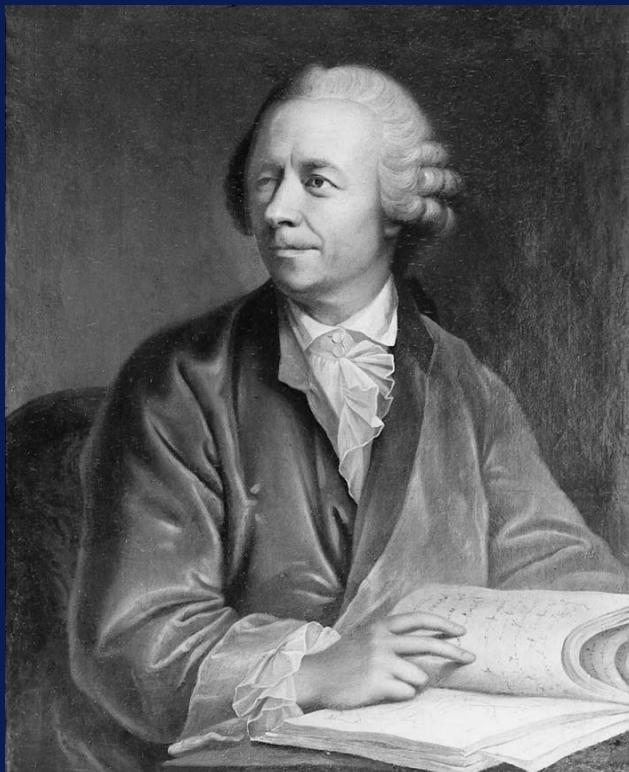
7 Crossing Points
on the Pregel
River

***Devise a walk
through the city*** that
would cross each
bridge once and only
once

***Mathematician Euler
solved the problem
in 1736***

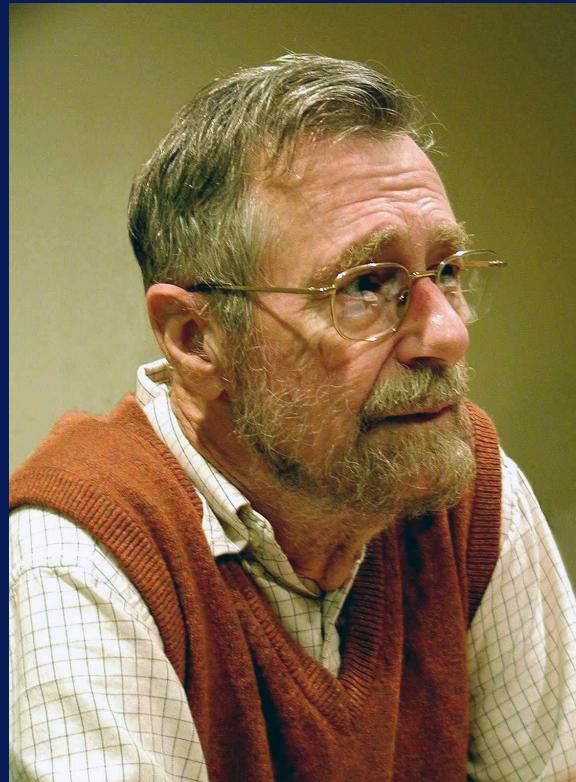
Graphs: Defined Differently by Different People

Mathematicians



Leonhard Euler

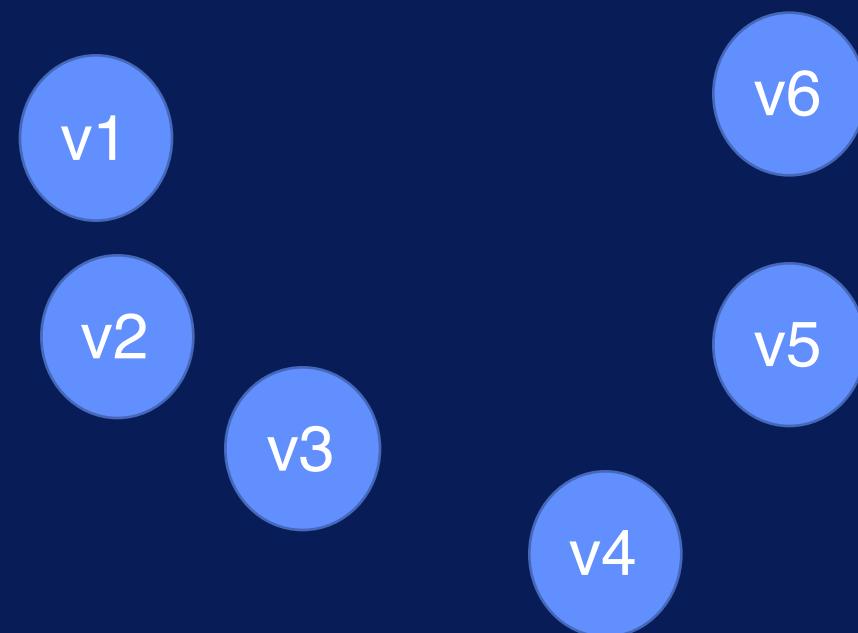
Computer Scientists



Edsger W. Dijkstra

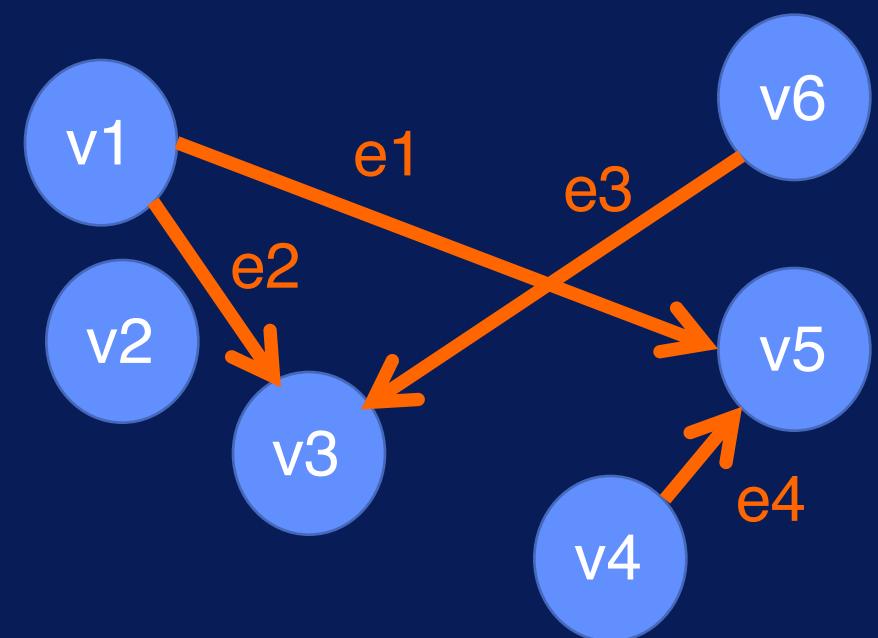
Mathematical Definition:

- V : a set of vertices



Mathematical Definition:

- V : a set of vertices
- E : a set of edges
 - $E = \{e_1, e_2, e_3, e_4\}$

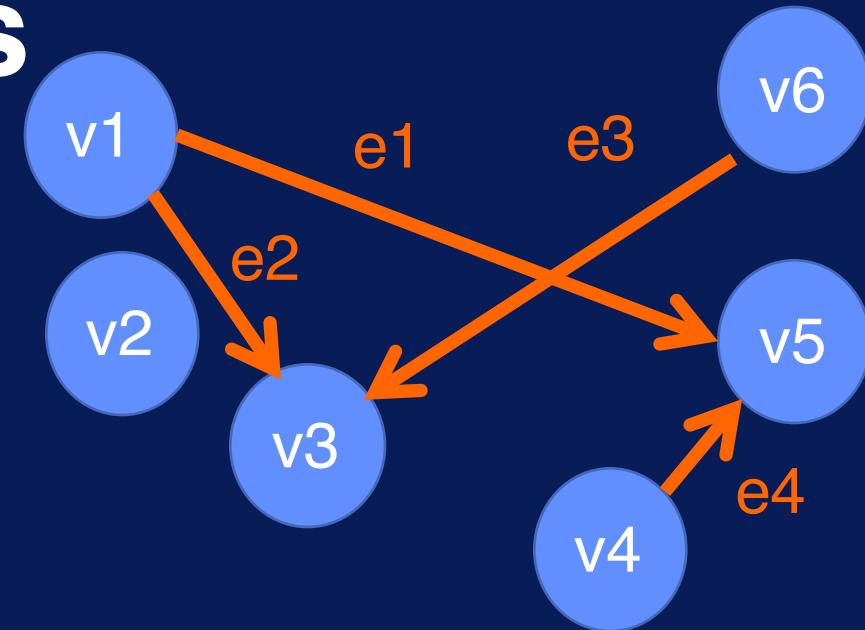
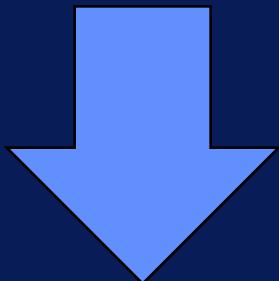


Mathematical Definition:

- V : a set of vertices
- E : a set of edges

$$E = \{e_1, e_2, e_3, e_4\}$$

e: an edge
designates a
pair of vertices



$$E = \{(v_1, v_5), (v_1, v_3), (v_6, v_3), (v_4, v_5)\}$$

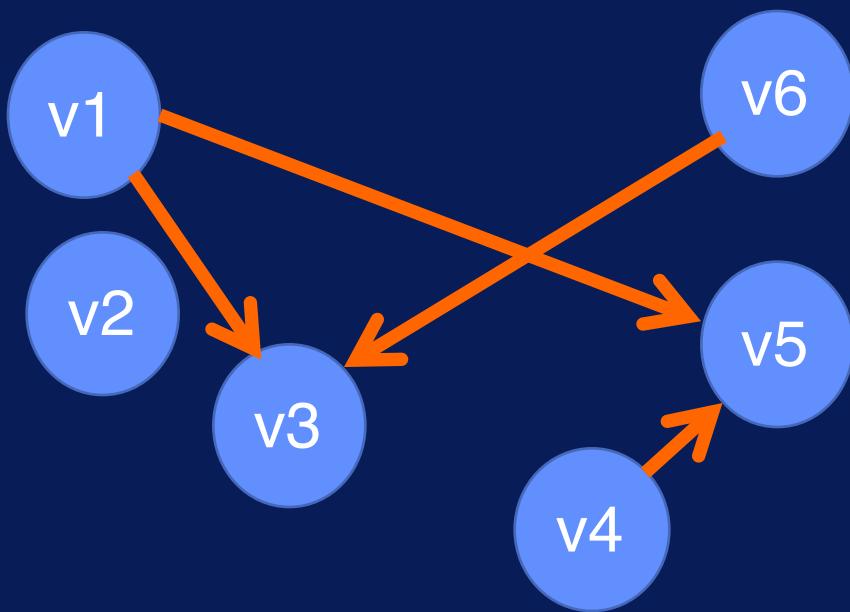
What about the Computer Science definition?

- **An abstract data type**
 - 1) Has a data structure to represent the mathematical graph
 - 2) Supports a number of operations (on that graph)

What about the Computer Science definition?

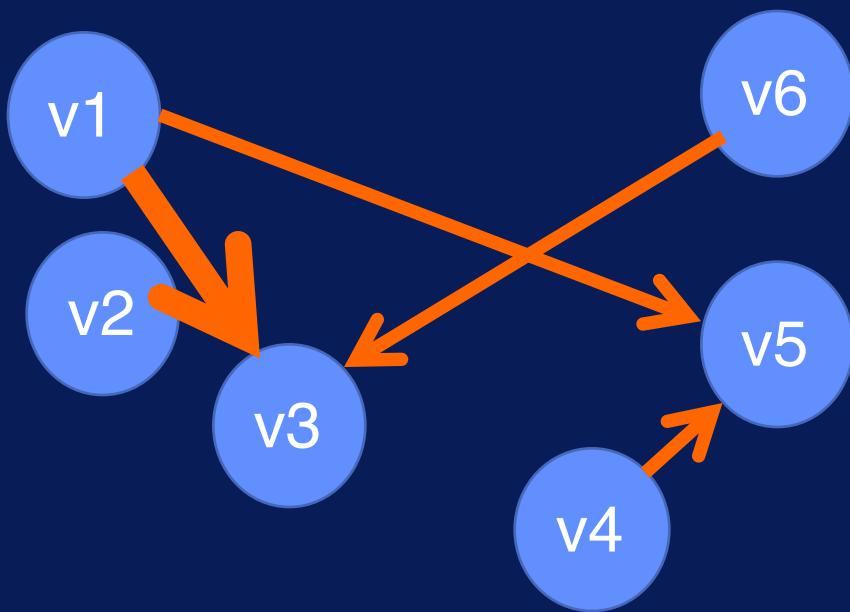
- **An abstract data type**
 - 1) Has a data structure to represent the mathematical graph
 - 2) Supports a number of operations (on that graph)
 - Add_edge
 - Add_vertex
 - Get_neighbor (and others)

One Computer Science Representation: Matrix



	To					
From	v1	v2	v3	v4	v5	v6
v1			1		1	
v2						
v3						
v4					1	
v5						
v6			1			

One Computer Science Representation: Matrix



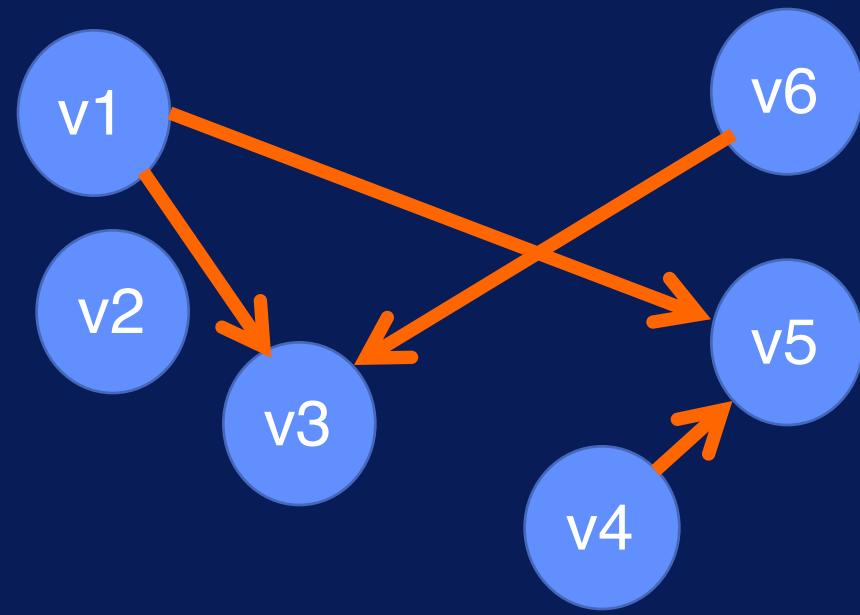
	To					
From	v1	v2	v3	v4	v5	v6
v1			1		1	
v2						
v3						
v4					1	
v5						
v6			1			

What about the Computer Science definition?

- An abstract data type
 - 1) Has a data structure ...
and
 - 2) Supports a number of operations (on that graph)
 - Add_edge
 - Add_vertex
 - Get_neighbor (and others)
- Let's look at operations**

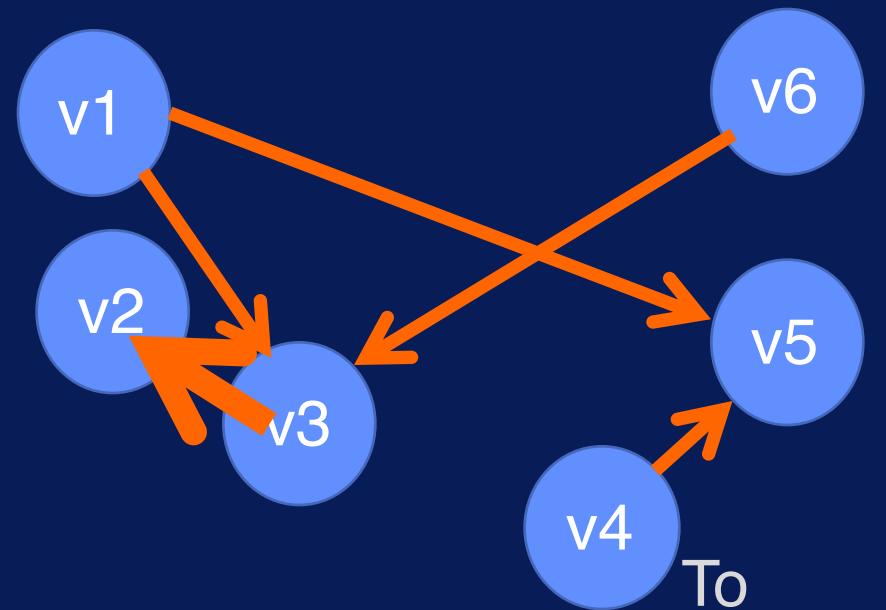
A Basic Operation: Add_edge

	To					
	v1	v2	v3	v4	v5	v6
v1			1		1	
v2						
v3						
v4					1	
v5						
v6			1			



Add_edge (v3,v2)

A Basic Operation: Add_edge



From

	To					
	v1	v2	v3	v4	v5	v6
v1			1		1	
v2						
v3						
v4					1	
v5						
v6			1			

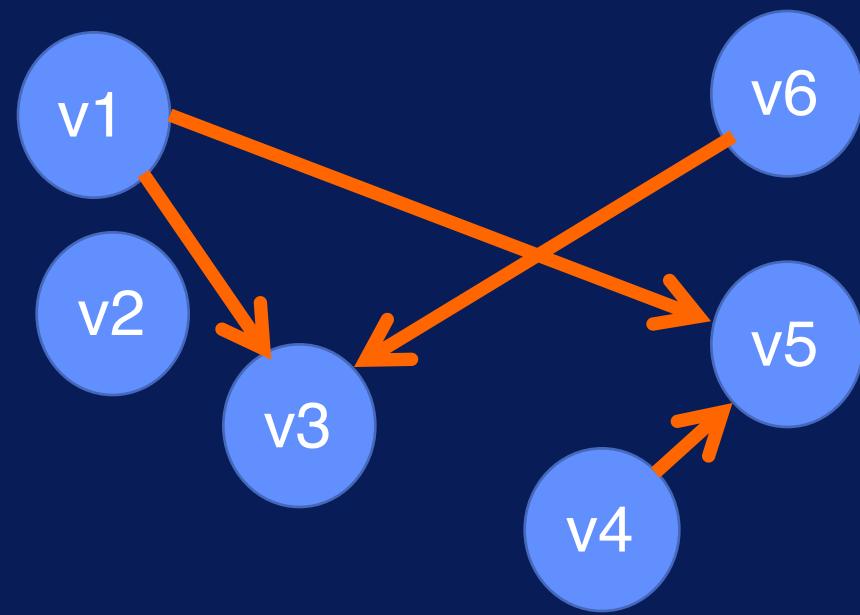
Add_edge (v3,v2)

From

	To					
	v1	v2	v3	v4	v5	v6
v1			1		1	
v2						
v3			1			
v4						1
v5						
v6					1	

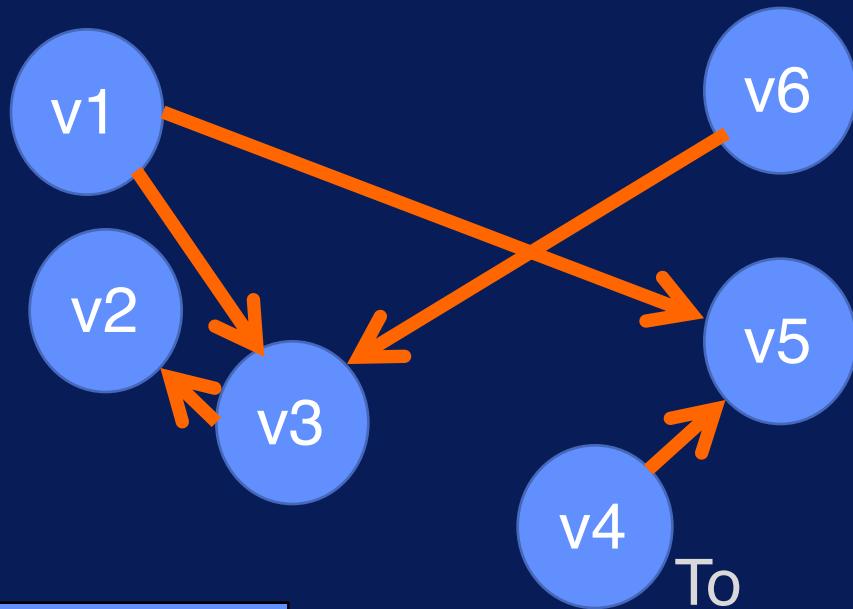
Another Operation: Get_neighbor

	v1	v2	v3	v4	v5	v6
v1			1		1	
v2						
v3		1				
v4					1	
v5						
v6			1			



Get_neighbor(v3)

Another Operation: Get_neighbor



From

	To					
	v1	v2	v3	v4	v5	v6
v1			1		1	
v2						
v3	1					
v4				1		
v5						
v6		1				

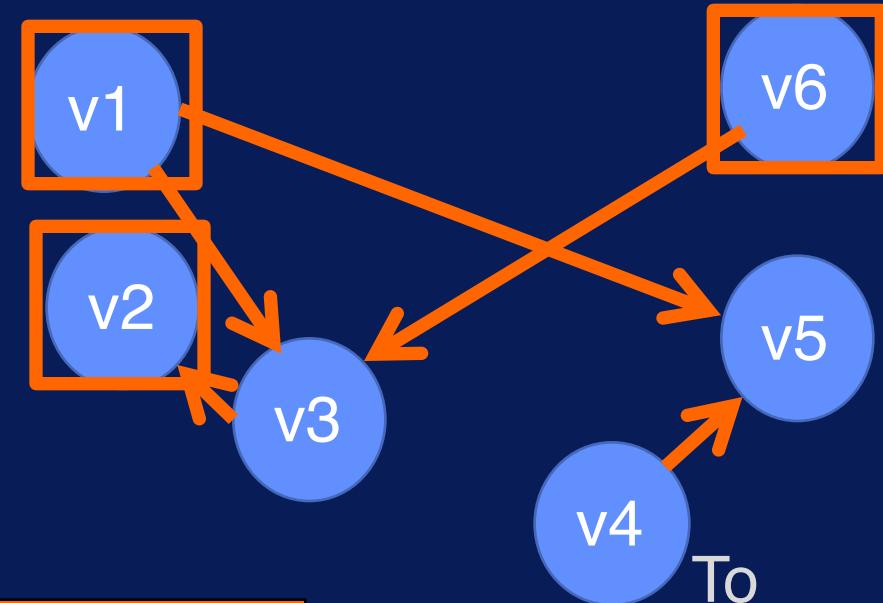
Search both row and column

Get_neighbor(v3)

From

	v1	v2	v3	v4	v5	v6
v1			1		1	
v2						
v3	1					
v4						1
v5						
v6		1				

Another Operation: Get_neighbor



From To

	v1	v2	v3	v4	v5	v6
v1			1		1	
v2						
v3		1				
v4					1	
v5						
v6			1			

Any entries are neighbors

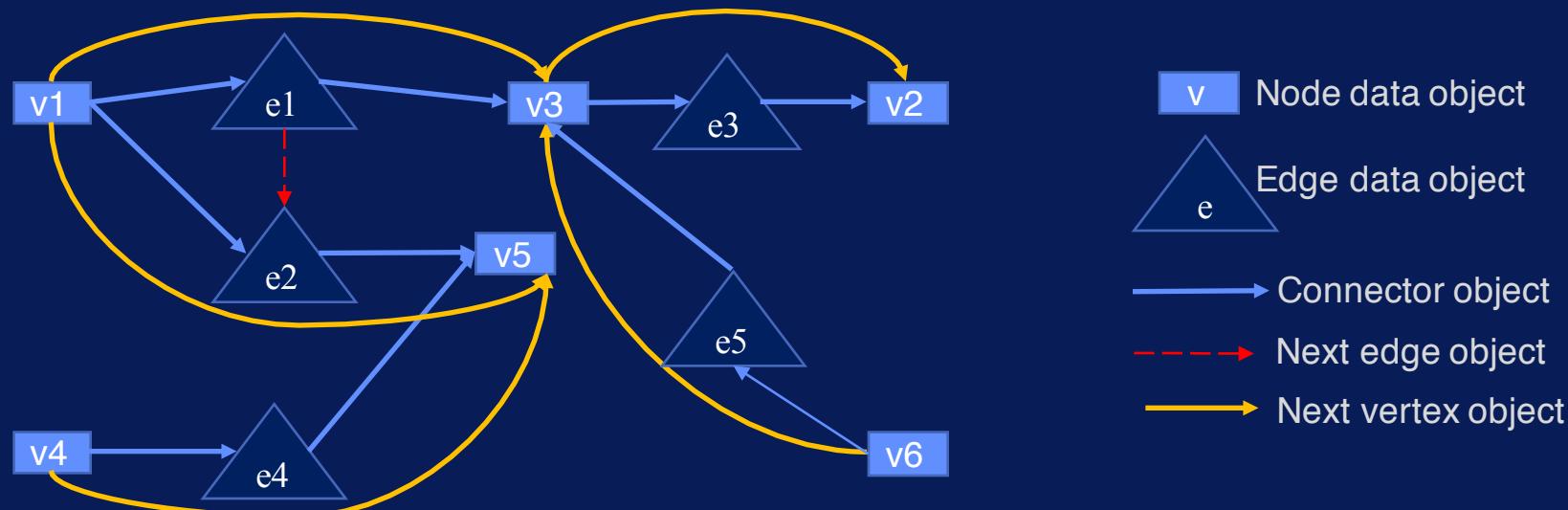
Get_neighbor(v3)

From

To

	v1	v2	v3	v4	v5	v6
v1			1		1	
v2						
v3			1			
v4						1
v5						
v6						1

A Different Representation (just FYI – there are others)



Used internally by some Graph Database Systems

Next: Why we
need graphs