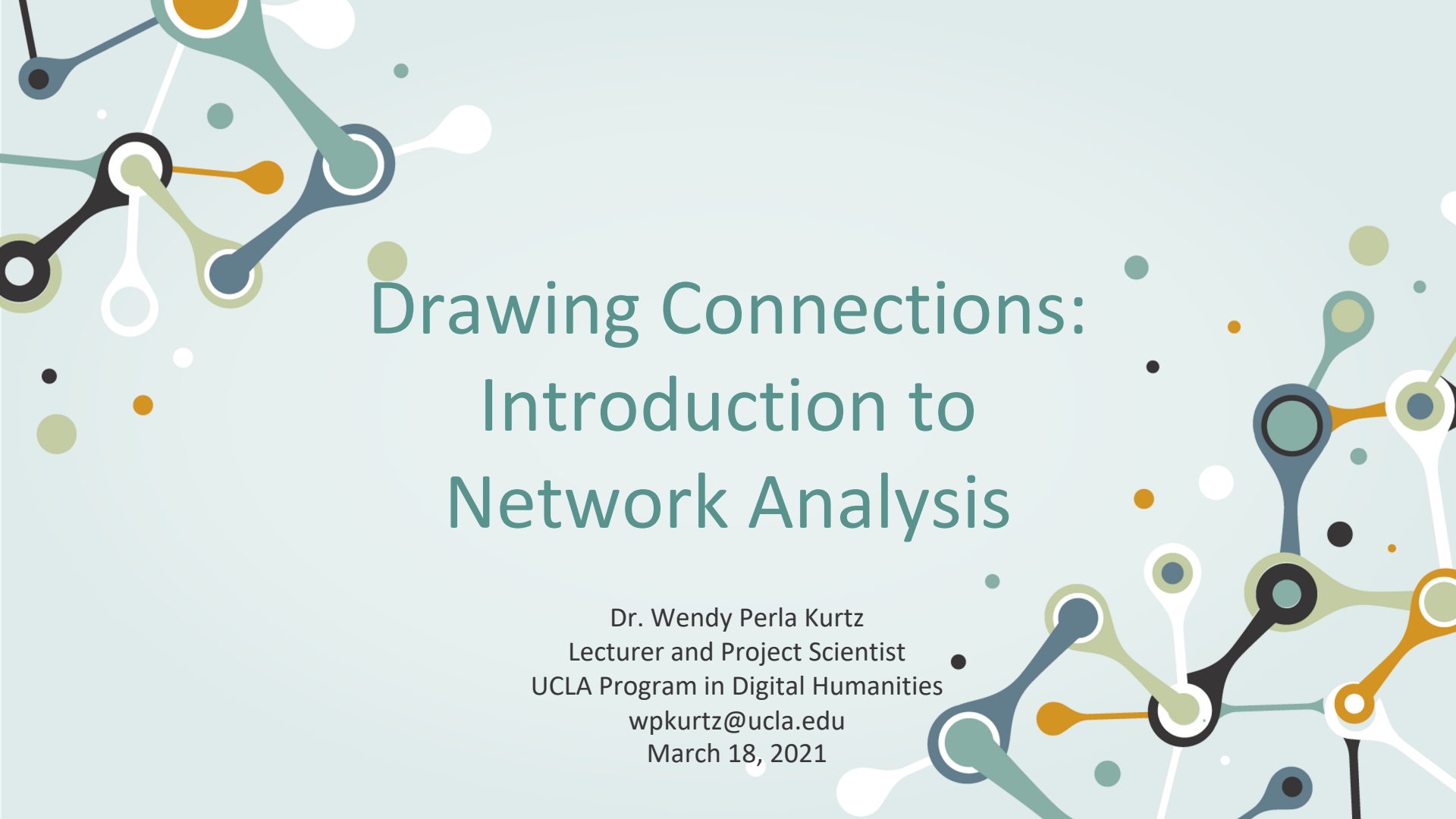




Drawing Connections: Introduction to Network Analysis

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Outline

- Review network analysis projects
- The basics of networks
- Measuring importance in networks (*centrality*)
- Description of the types of graphs:
 - Directed vs Undirected
 - Single-mode vs Multimode
 - Unweighted vs. weighted
- Tools to build networks
- Finding formatted datasets
- A look at structured data for networks
- Recommended readings





When to Use Network Graphs

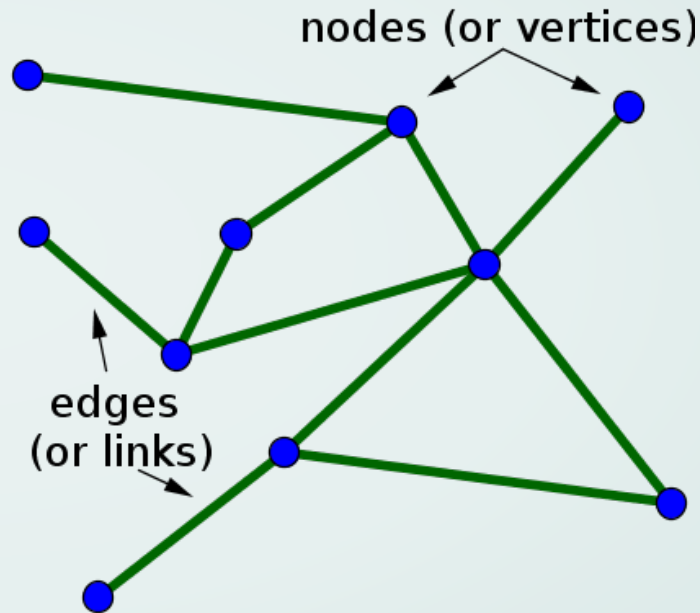


- Who knew whom?
- How might ideas (or formal motifs) have traveled?
- Have we overlooked important figures in communities of practice?
- Does a certain community have unusual or unexpected properties?
- ...

Network Graphs

Use networks to study entities (**nodes**) and their relationships (**edges**)

Nodes can have **attributes** that provides visual cues about that node.



A simple network representation from Nykamp DQ, "An introduction to networks." From Math Insight. http://mathinsight.org/network_introduction

Network Analysis Projects

- Star Wars Social Networks: The Force Awakens by Dr Evelina Gabašová
- Moviegalaxies by J. Kaminski, et al.
- Six Degrees of Francis Bacon by a team at Carnegie Mellon University
- Kindred Britain by Nicholas Jenkins, Elijah Meeks and Scott Murray (Stanford Center for Spatial and Textual Analysis)
- Grey's Anatomy Network of Sexual Relations by Gary Weissman, MD, MSHP



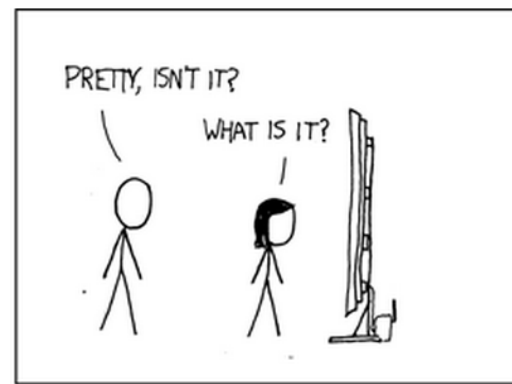
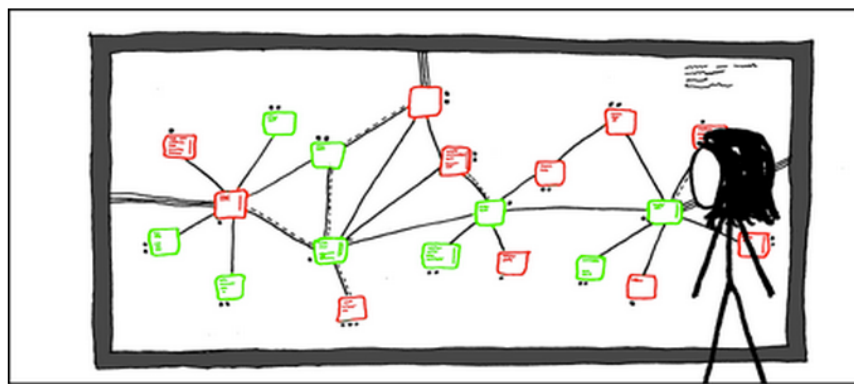


image excerpted from:
<http://xkcd.com/350/>

net•work

a group or system of interconnected people or things

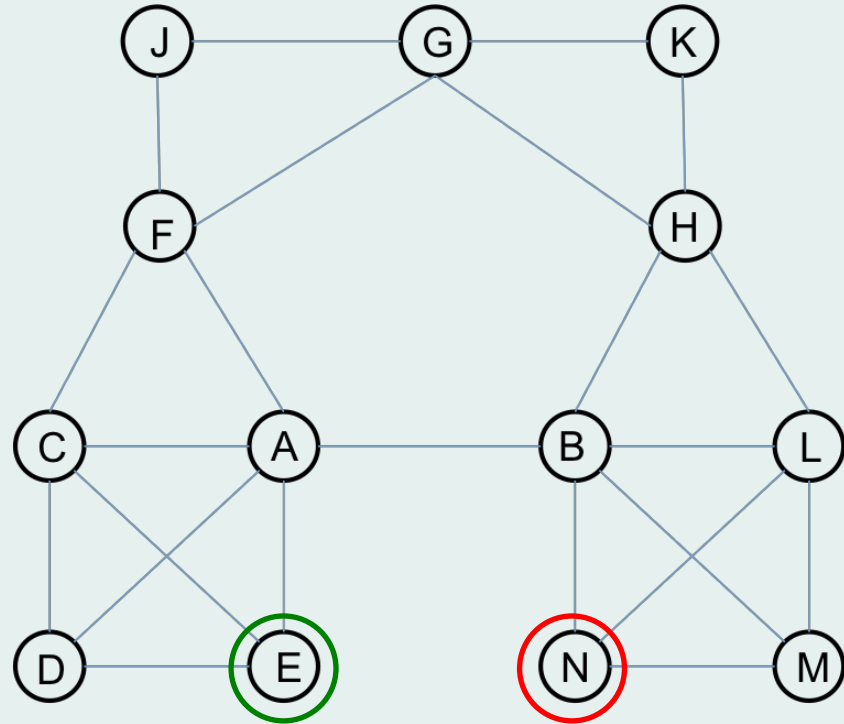
a•nal•y•sis

detailed examination of the elements or structure of something,
typically as a basis for discussion or interpretation

Reading a Network Graph

Path

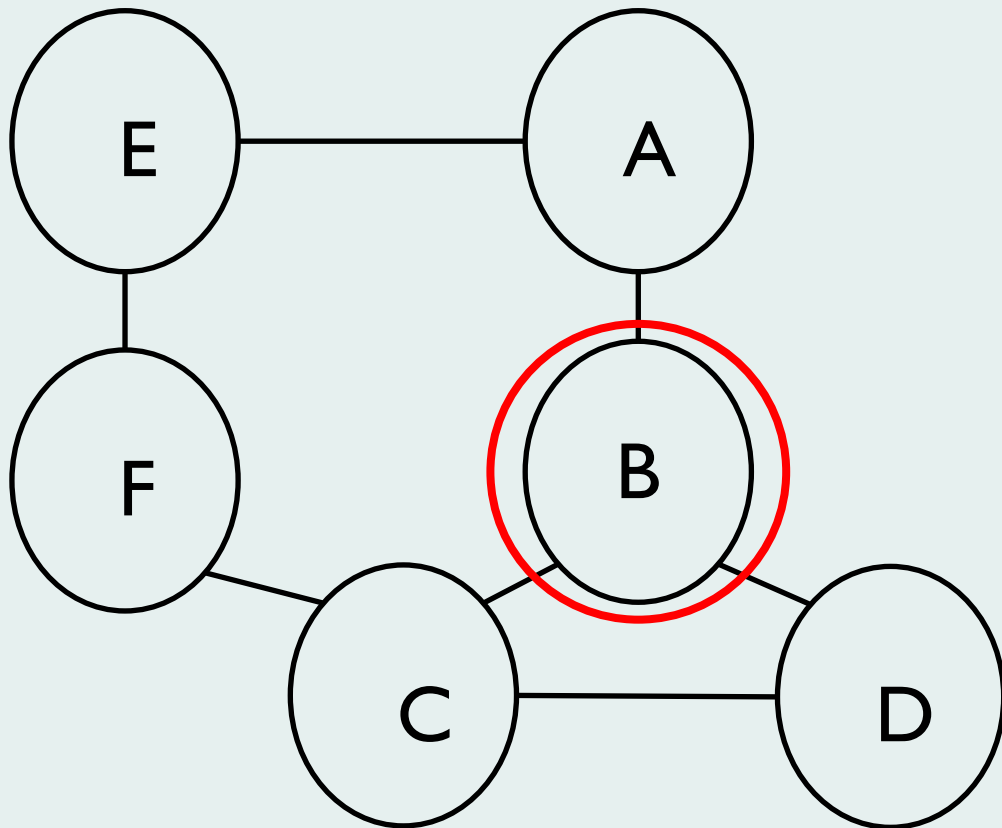
a sequence of nodes, where each node in the sequence is connected by an edge



Reading a Network Graph

Pivotal Node

node is pivotal if it lies on shortest path
between two pairs of nodes





Centrality: Measuring Importance in a Network

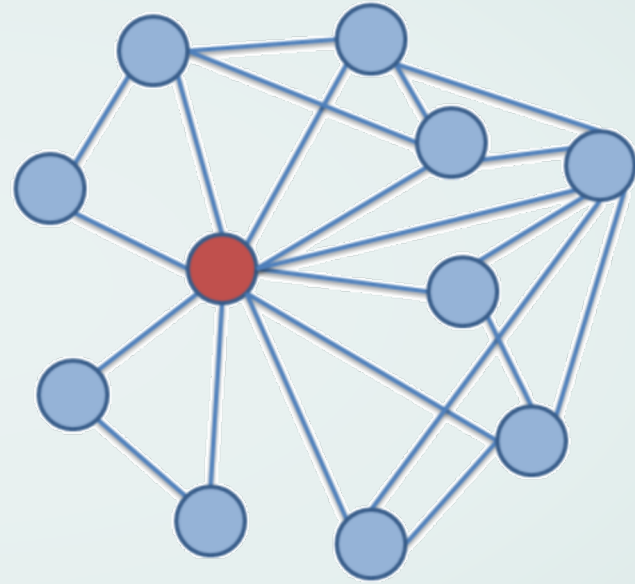
There are multiple ways to determine a node's importance, or centrality. The measure you use depends on how you define centrality.

Below are several of these measures:

- Degree centrality
- Betweenness centrality
- Closeness centrality
- Eigenvector centrality

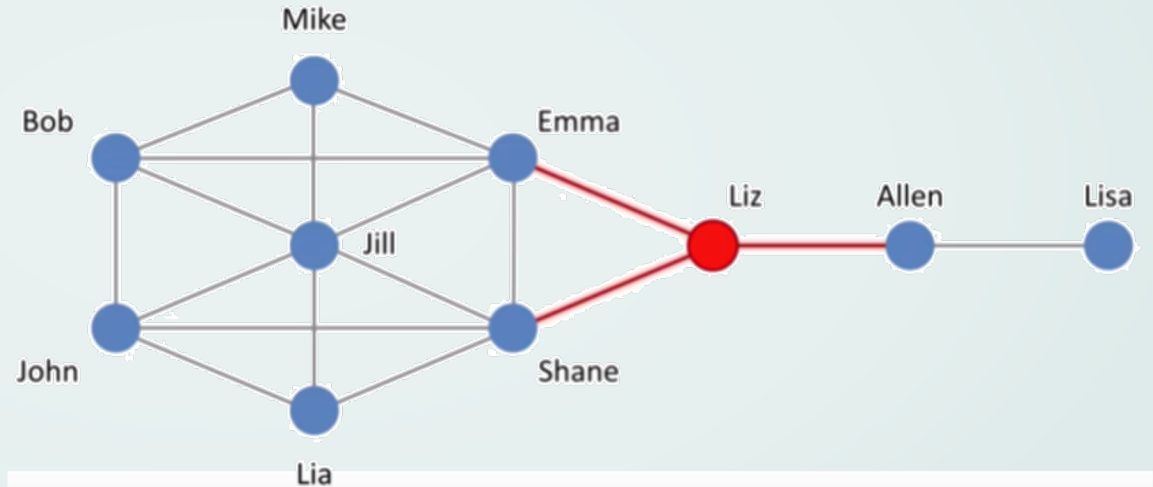
Degree Centrality

Who's connected to the most people?



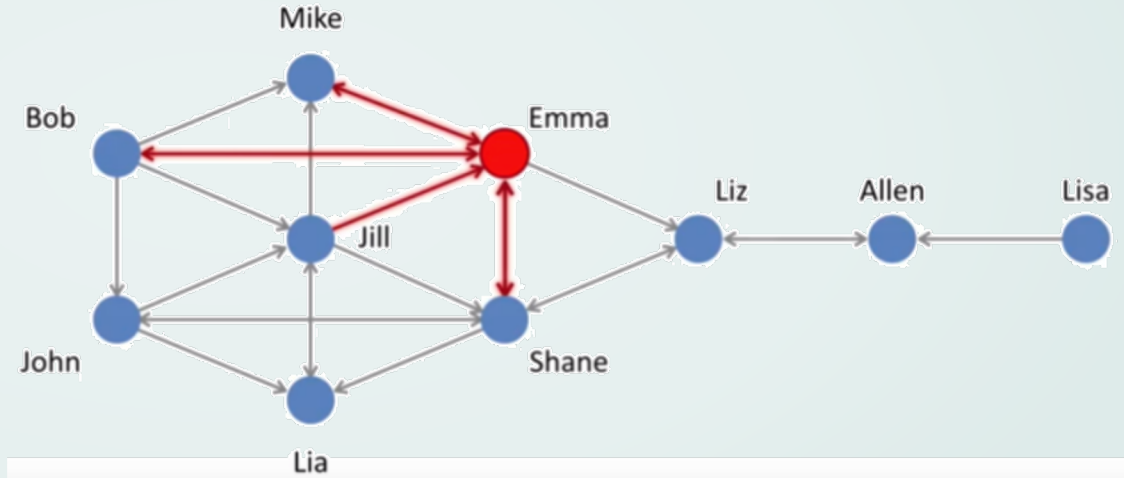
Betweenness Centrality

Who do you have to go through in order to reach everyone in the network?



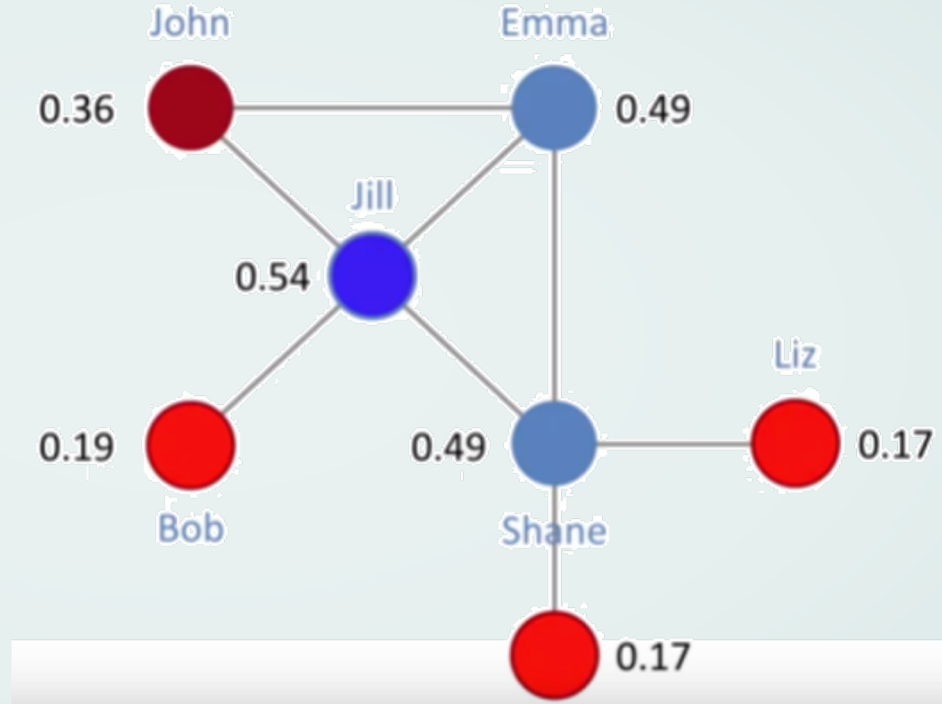
Closeness Centrality

Who will reach everyone in the network with the smallest number of “hops”?



Eigenvector Centrality

Who is the “person behind the curtain”?

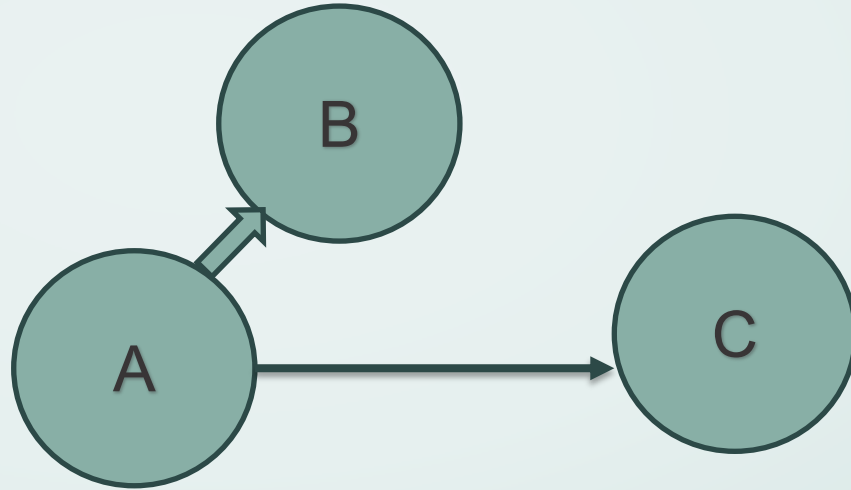


Network Analysis: Distance Matters

Person A ---> Person B = 3

Person A ---> Person C = 1

A is closer to B



Types of Graphs

Undirected vs. Directed

- Undirected graph (fig 1): When the relationship is always valid in both directions, then it is called undirected graph.

- *If Dave is friends with Raj on Facebook, then Raj is also friends with Dave.*

- Directed graph (fig 2): When the relationship may not be valid in both directions (connecting nodes), then it is called a directed graph.

- *If Bill is following Steve on Twitter and Steve is not following Bill, the relationship is directed.*

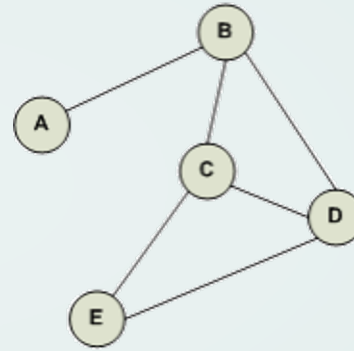


Fig 1. Undirected Graph

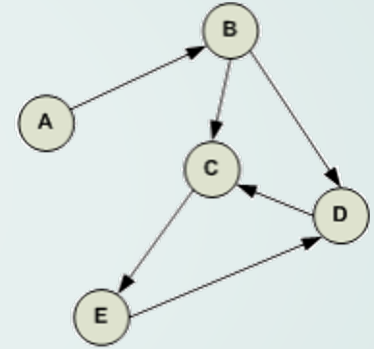
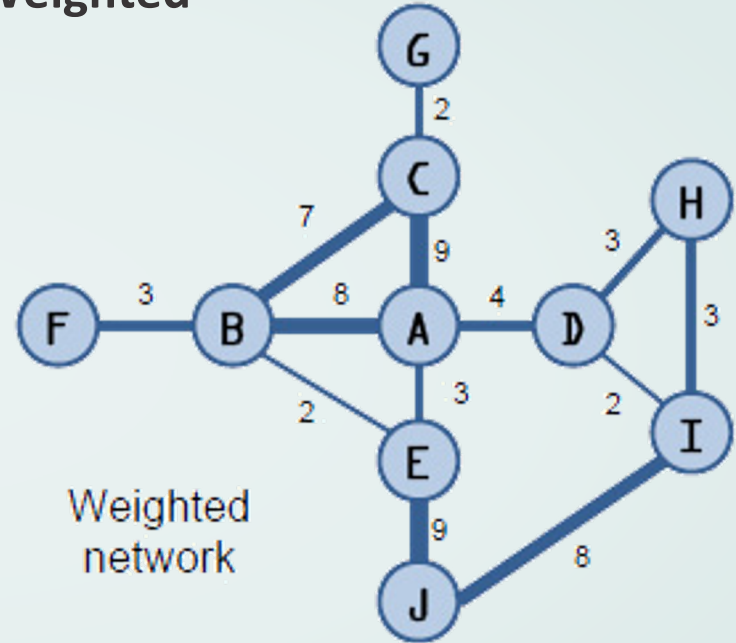


Fig 2. Directed Graph

Types of Graphs: Unweighted vs. Weighted

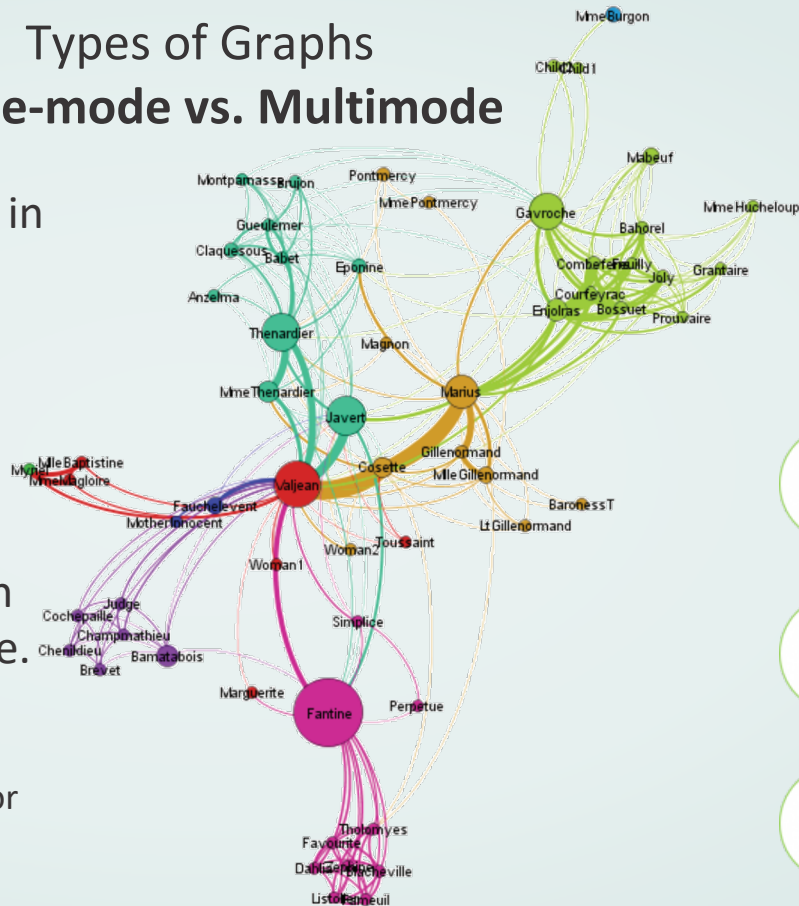
- Weighted network: A network in which the edges between nodes have weights (corresponding to, e.g., the strength of a relationship) assigned to them.
- Unweighted network: A network in which the edges between nodes do not have weights assigned to them.



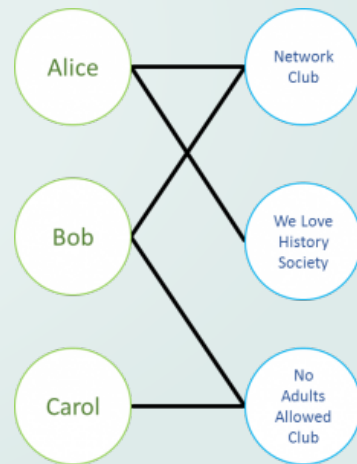
Types of Graphs

Single-mode vs. Multimode

- Single-mode graph: A type of graph in which all nodes belong to the same category.
 - For example, in a graph of Facebook friends, each node is a person.
- Multimode graph: A type of graph in which all nodes are not of same type.
 - For example, a graph that includes both “buyers” and “sellers” is a multimode (or two-mode, or bimodal) graph.



Coappearance weighted network of characters in the novel “Les Misérables” from Victor Hugo (Gephi sample)



Making Network Graphs

Network Graphs

Web-based Network Viz

- [Palladio](#)
- [Flourish](#)
- [Graph Commons](#)
- [Onodo](#)



Stanford | HUMANITIES + DESIGN

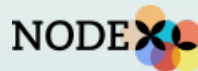
Graph Commons **Flourish**



Network Analysis

Locally installed software

- [Gephi](#)
- [Cytoscape](#)
- [NodeXL](#)



Confident Coder

Scripting packages/libraries

- [Igraph](#) (R package)
- [D3.js](#) (JavaScript library)





Finding Data

- [Stanford Large Network Dataset Collection](#)
- [UC Irvine Network Data Repository](#)
- [Gephi Datasets](#)
- Harvard Dataverse

Structuring Data

Anatomy of a Node List & Edge List

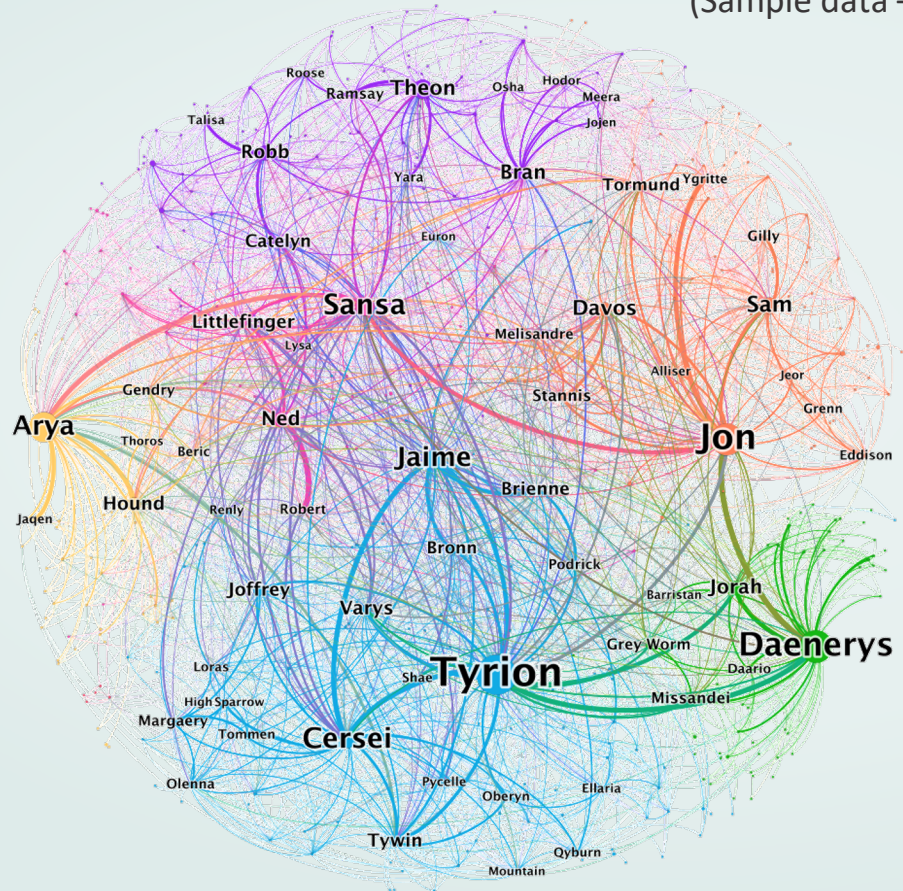
(Sample data – Game of Thrones)

Node List		Edge List							Type		id	weight
Id	Label	Source		Target		Type	id	weight				
Addam-Marbrand	Addam Marbrand	Addam-Marbrand		Brynden-Tully		Undirected		0			3	
Aegon-Frey-(son-of-Stevron)	Aegon Frey (son of Stevron)	Addam-Marbrand		Cersei-Lannister		Undirected		1			3	
Aegon-I-Targaryen	Aegon I Targaryen	Addam-Marbrand		Cyrice-Borbarthor		Undirected		2			3	
Aegon-Targaryen-(son-of-Rhaegar)	Aegon Targaryen (son of Rhaegar)		A		B	C	D	E	Undirected		3	14
Aegon-V-Targaryen	Aegon V Targaryen	1	Source	Target		Type	id	weight	Undirected		4	3
Aemon-Targaryen-(Dragonknight)	Aemon Targaryen (Dragonknight)	758	Bronn	Vardis-Egen		Undirected	756	11	Undirected		5	3
Aemon-Targaryen-(Maester-Aemon)	Aemon Targaryen (Maester-Aemon)	759	Bronn	Varys		Undirected	757	12	Undirected		6	3
Aenys-Frey	Aenys Frey	760	Bronn	Willis-Wode		Undirected	758	5	Undirected		7	4
Aeron-Greyjoy	Aeron Greyjoy	761	Brus-Buckler	Malegorn		Undirected	759	6	Undirected		8	3
Aerys-I-Targaryen	Aerys I Targaryen	762	Brus-Buckler	Narbert-Grandison		Undirected	760	4	Undirected		9	7
Aerys-II-Targaryen	Aerys II Targaryen	763	Brus-Buckler	Selyse-Florent		Undirected	761	5	Undirected		10	6
Aggar	Aggar	764	Bryce-Caron	Cortnay-Penrose		Undirected	762	3	Undirected		11	4
Aggo	Aggo	765	Bryce-Caron	Eldon-Estermont		Undirected	763	3	Undirected		12	4
Alayaya	Alayaya	766	Bryce-Caron	Guyard-Morrigen		Undirected	764	5	Undirected		13	5
Albett	Albett	767	Bryce-Caron	Renly-Baratheon		Undirected	765	7	Undirected		14	3
Alebelly	Alebelly	768	Bryce-Caron	Stannis-Baratheon		Undirected	766	3	Undirected		15	6
Alerie-Hightower	Alerie Hightower	769	Brynden-Rivers	Meera-Reed		Undirected	767	3	Undirected		16	13
Alester-Florent	Alester Florent	770	Brynden-Tully	Catelyn-Stark		Undirected	768	29	Undirected		17	4
Alla-Tyrell	Alla Tyrell	771	Brynden-Tully	Daven-Lannister		Undirected	769	3	Undirected		18	4
Allar-Deem	Allar Deem	772	Brynden-Tully	Edmure-Tully		Undirected	770	24	Undirected		19	3
Allard-Seaworth	Allard Seaworth	773	Brynden-Tully	Edwyn-Frey		Undirected	771	3	Undirected		20	4
Alleras	Alleras	774	Brynden-Tully	Emmon-Frey		Undirected	772	7	Undirected		21	4
Alliser-Thorne	Alliser Thorne	775	Brynden-Tully	Hostr-Tully		Undirected	773	5	Undirected		22	3
Alyn	Alyn	776	Brynden-Tully	Jaime-Lannister		Undirected	774	29	Undirected		23	3
Alys-Arryn	Alys Arryn	777	Brynden-Tully	Lyle-Crakehall		Undirected	775	4	Undirected		24	3
Alys-Karstark	Alys Karstark	778	Brynden-Tully	Lysa-Arryn		Undirected	776	10	Undirected		25	11
Alysane-Mormont	Alysane Mormont	779	Brynden-Tully	Nestor-Royce		Undirected	777	3	Undirected		26	7
Amabel	Amabel	780	Brynden-Tully	Rickard-Karstark		Undirected	778	4	Undirected		27	3
		781	Brynden-Tully	Robb-Stark		Undirected	779	27	Undirected			
		782	Brynden-Tully	Ryman-Frey		Undirected	780	3	Undirected			
		783	Brynden-Tully	Theon-Greyjoy		Undirected	781	6	Undirected			
		784	Brynden-Tully	Tyrian-Lannister		Undirected	782	4	Undirected			
		785	Brynden-Tully	Tywin-Lannister		Undirected	783	10	Undirected			
		786	Brynden-Tully	Walder-Frey		Undirected	784	7	Undirected			
		787	Bump	Varamyr		Undirected	785	5	Undirected			

Structuring Data

Anatomy of a Node List & Edge List

(Sample data – Game of Thrones)





Recommended Bibliography

- “Demystifying Networks, Parts I & 2” by Scott Weingart
- “Network Analysis, Plot Theory” by Franco Moretti
- Networks: An Introduction by Mark Newman
- Networks, Crowds, and Markets by David Easley and Jon Kleinberg
- “If Everything is a Network, Nothing is a Network” by Mushon Zer-Aviv
- “Are Some Things Unrepresentable?” Alexander Galloway’s