An Introduction to Network Analysis

A **network** is made up of a set of objects and their connections.

EXAMPLES OF NETWORKS

- Friend network

    Objects: friends
    Connections: friendships

- Twitter

    Objects: Twitter users
    Connections: who follows who

- International trade

    Objects: countries
    Connections: international exchanges of goods

- Citation network

    Objects: articles
    Connections: citations

- Infectious disease networks

    Objects: people
    Connections: infections

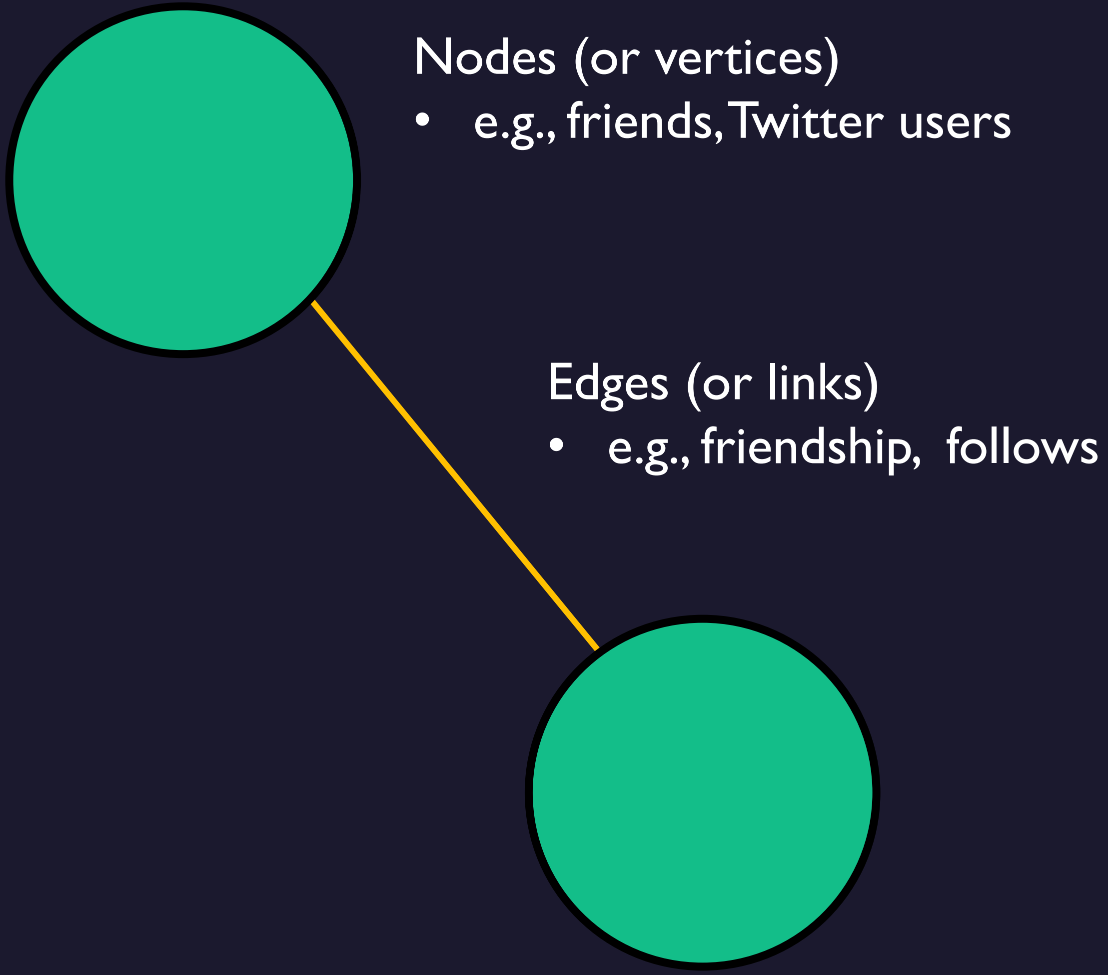
- Neural networks in the brain

    Objects: neurons
    Connections: synapses

Network Analysis

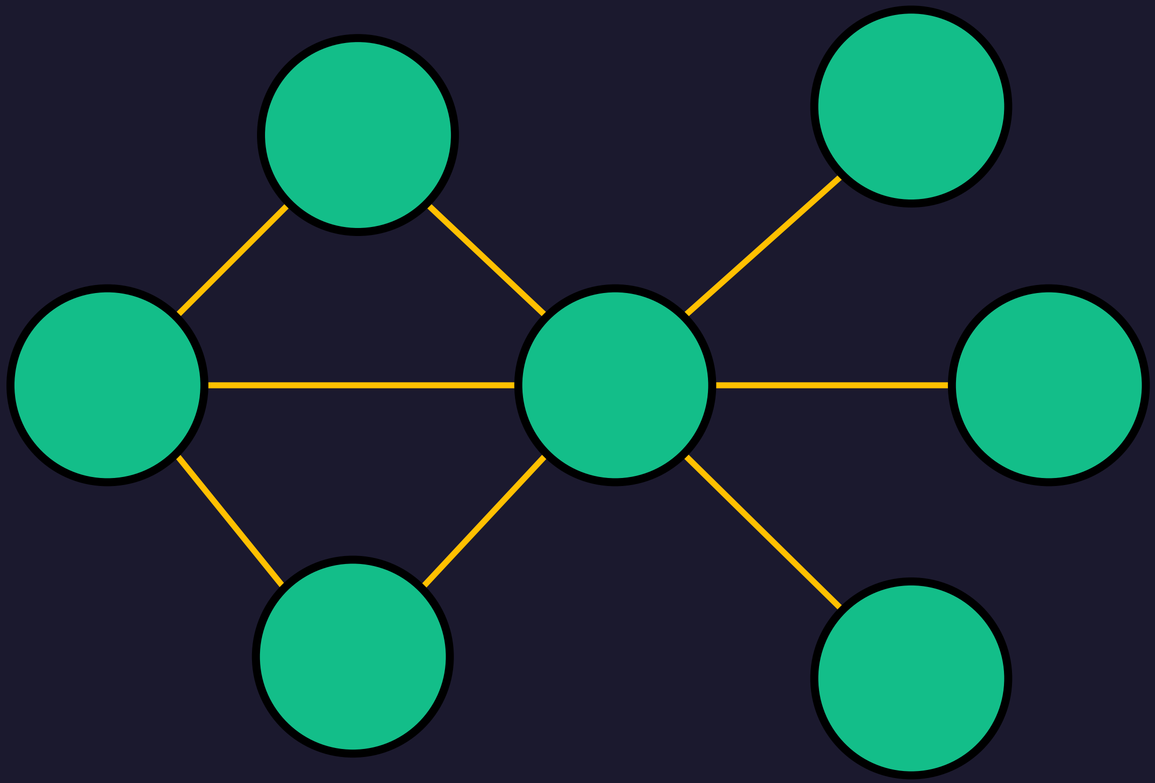
Network analysis is a tool for representing the relationships between objects in a network.

A Basic Network



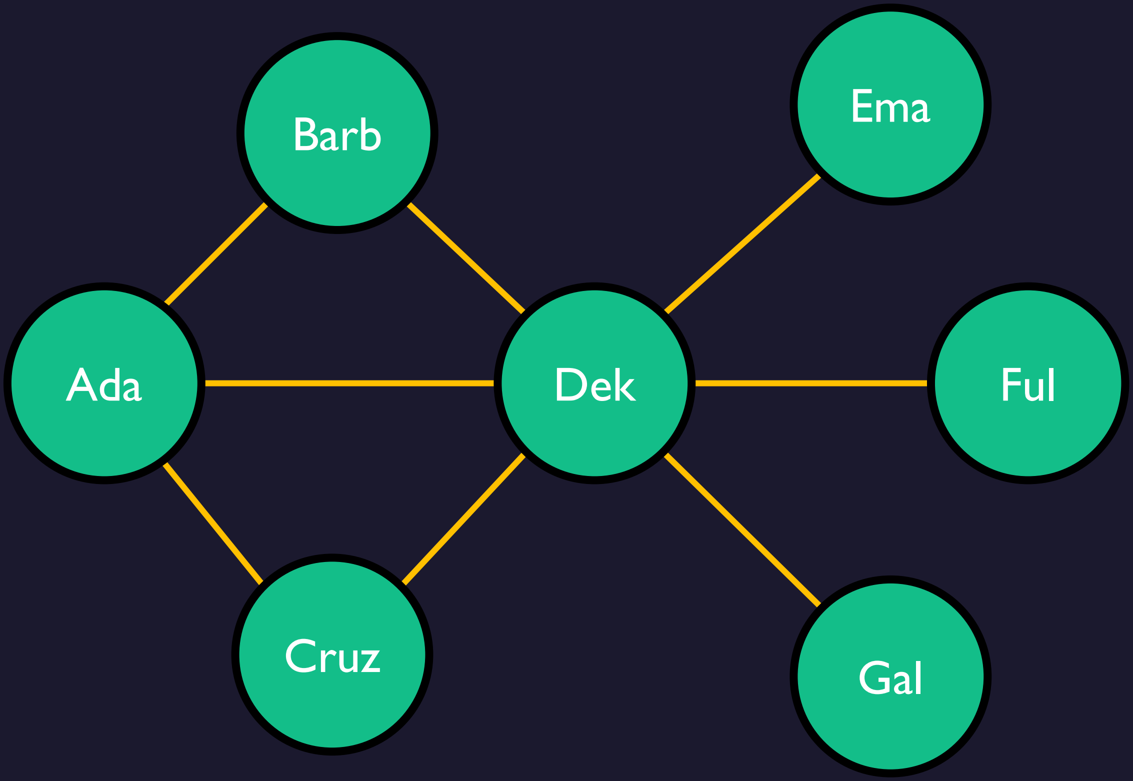
The researcher decides what **objects**, and what nature of **relationship** between objects, they want to represent in their network.

Networks can get much more complex



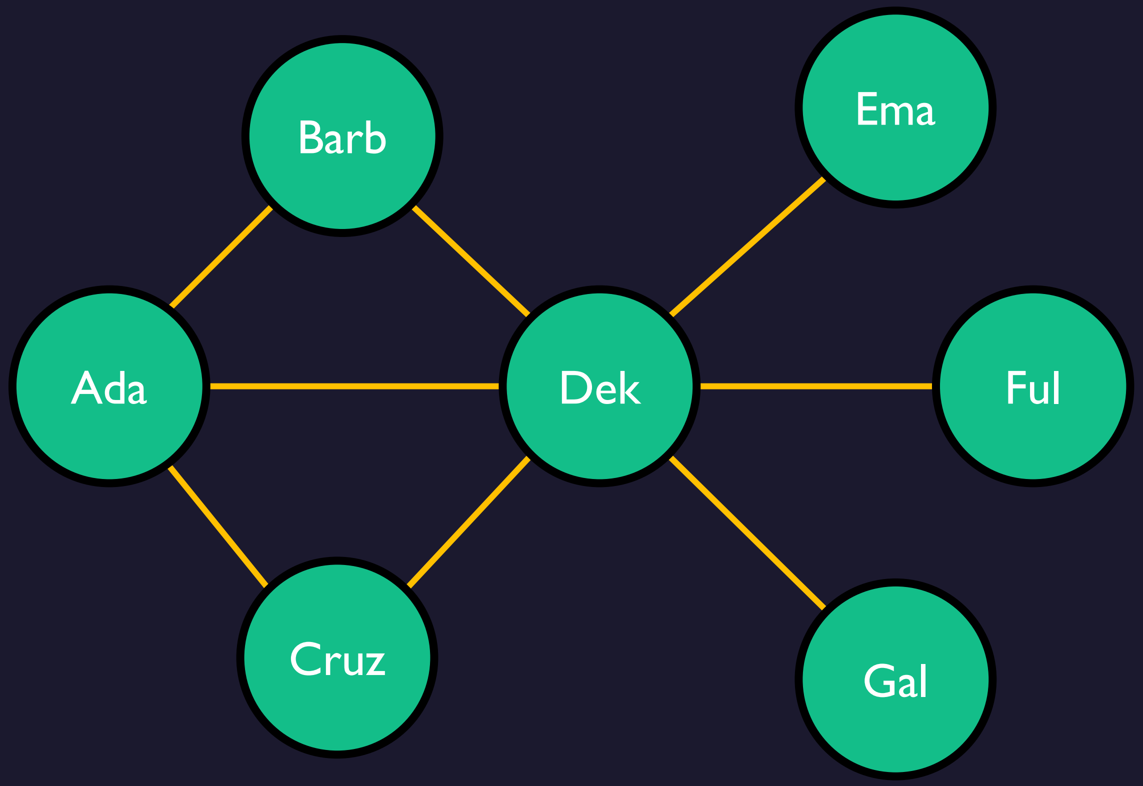
Network analysis provides a **simplification** of a complex, real-world phenomenon.

Lists for describing networks



Node List	Edge List
Ada	(Ada, Barb)
Barb	(Ada, Cruz)
Cruz	(Ada, Dek)
Dek	(Barb, Dek)
Ema	(Cruz, Dek)
Ful	(Dek, Ema)
Gal	(Dek, Ful)
	(Dek, Gal)

Adjacency Matrix

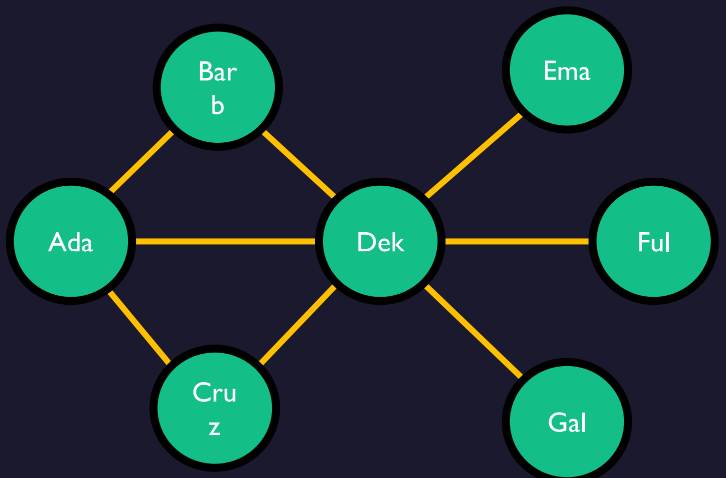


Adjacency Matrix

	Ada	Barb	Cruz	Dek	Ema	Ful	Gal
Ada	0	1	1	1	0	0	0
Barb	1	0	0	1	0	0	0
Cruz	1	0	0	1	0	0	0
Dek	1	1	1	0	1	1	1
Ema	0	0	0	1	0	0	0
Ful	0	0	0	1	0	0	0
Gal	0	0	0	1	0	0	0

Directed vs Undirected Networks

Undirected Network



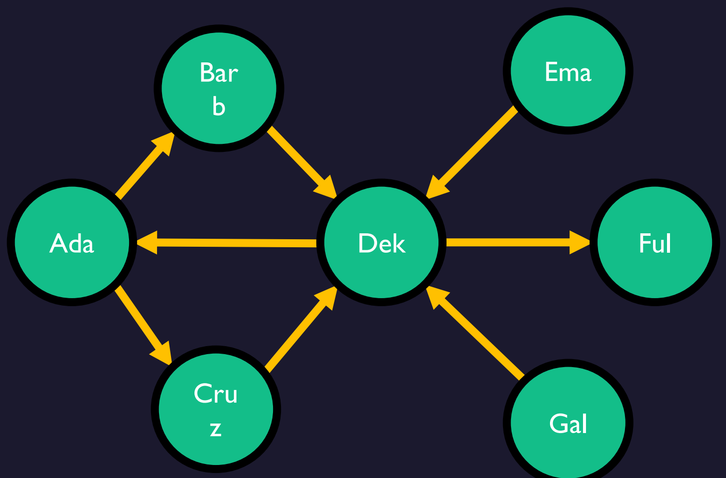
Edge List

(Ada, Barb)
(Ada, Cruz)
(Ada, Dek)
(Barb, Dek)
(Cruz, Dek)
(Dek, Ema)
(Dek, Ful)
(Dek, Gal)

Adjacency Matrix

	Ada	Barb	Cruz	Dek	Ema	Ful	Gal
Ada	0	1	1	1	0	0	0
Barb	1	0	0	1	0	0	0
Cruz	1	0	0	1	0	0	0
Dek	1	1	1	0	1	1	1
Ema	0	0	0	1	0	0	0
Ful	0	0	0	1	0	0	0
Gal	0	0	0	1	0	0	0

Directed Network



(Ada, Barb)
(Ada, Cruz)
(Barb, Dek)
(Cruz, Dek)
(Dek, Ada)
(Dek, Ful)
(Ema, Dek)
(Gal, Dek)

	Ada	Barb	Cruz	Dek	Ema	Ful	Gal
Ada	0	1	1	0	0	0	0
Barb	0	0	0	1	0	0	0
Cruz	0	0	0	1	0	0	0
Dek	1	0	0	0	0	1	0
Ema	0	0	0	1	0	0	0
Ful	0	0	0	0	0	0	0
Gal	0	0	0	1	0	0	0

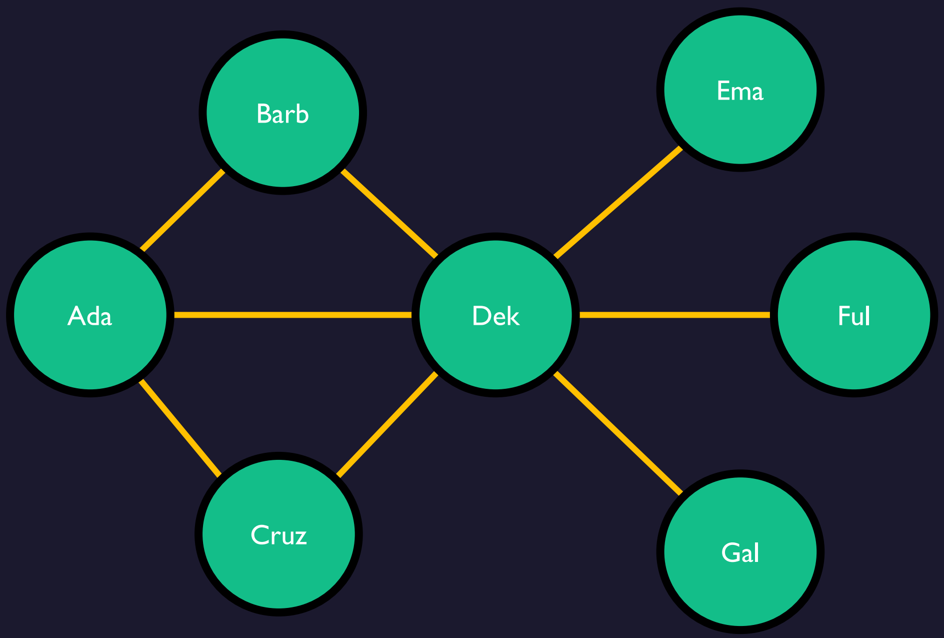
Assessing Centrality

One aspect of networks that researchers may be interested in is which actors are most *central* to the network.

Degree Centrality

Determining centrality based on how many connections a node has to other nodes

+ A node's 'degree' is the number of edges connected to it

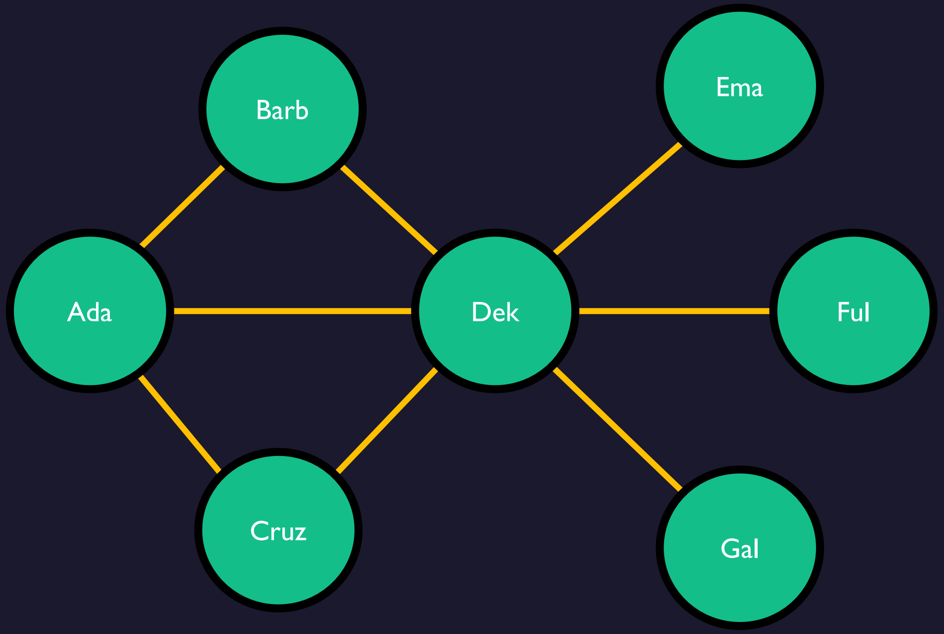


Node List	Degree
Ada	3
Barb	2
Cruz	2
Dek	6
Ema	1
Ful	1
Gal	1

Eigenvector Centrality

Determining centrality based on how many connections a node's neighbor has

+ Requires some complex matrix calculations
+ Higher values indicate greater centrality

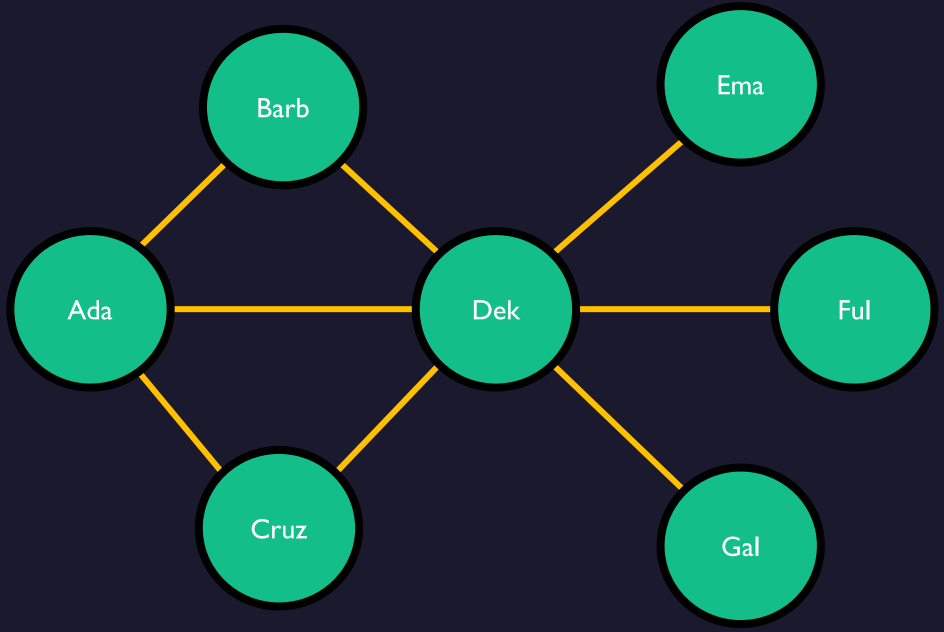


Node List	Eigenvector Centrality
Ada	0.46
Barb	0.37
Cruz	0.37
Dek	0.62
Ema	0.21
Ful	0.21
Gal	0.21

Betweenness Centrality

Determining centrality based on how many direct connections between other nodes a node is involved in

+ To calculate, look at each pair of nodes and calculate the number of times another node can interrupt the path between them



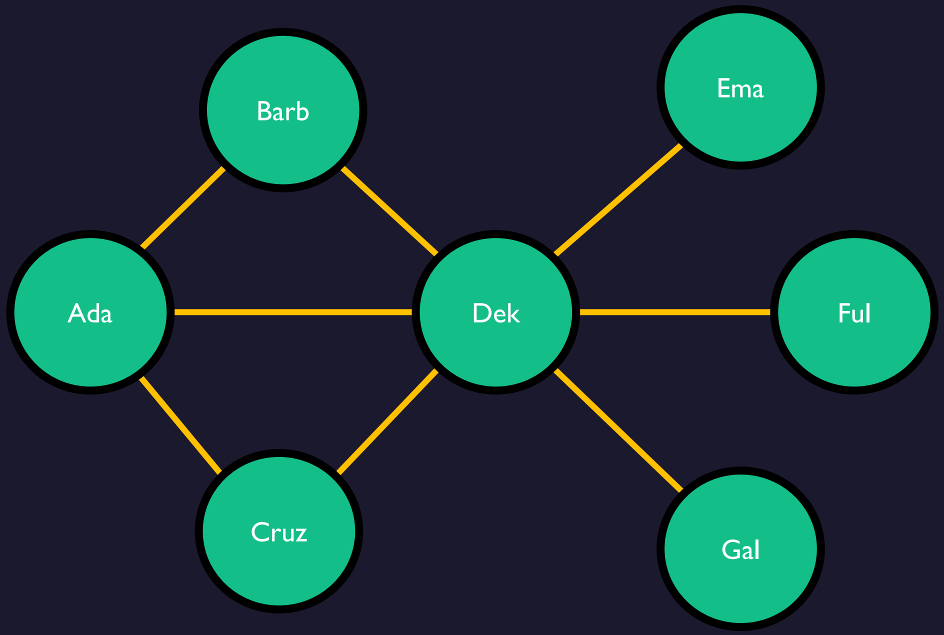
Node List	Betweenness Centrality
Ada	2
Barb	0
Cruz	0
Dek	18
Ema	0
Ful	0
Gal	0

*Note: The calculation in R is slightly more complicated and provided in the .rmd file.

Closeness Centrality

Determining centrality based on the average distance between a node and all other nodes

+ Calculate by taking the average of the shortest path length from a particular node to every other node, and then take the inverse



Node List	Closeness Centrality
Ada	1 / (1+1+1+2+2+2)/6 = .67
Barb	1 / (1+2+1+2+2+2)/6 = .6
Cruz	1 / (1+2+1+2+2+2)/6 = .6
Dek	1 / (1+1+1+1+1+1)/6 = 1
Ema	1 / (2+2+2+1+2+2)/6 = .55
Ful	1 / (2+2+2+1+2+2)/6 = .55
Gal	1 / (2+2+2+1+2+2)/6 = .55

*Note: In R, these closeness values are multiplied by 1/(*n*-1) to standardize the maximum possible value.

Describing Communities

Network Density: a measure of how "dense" the network is, calculated by dividing the number of edges in the network by the total number of possible edges

Clustering: a measure of which nodes tend to cluster together, calculated using different algorithms (e.g., Louvain)

Transitivity: also called the "clustering coefficient"; a measure of the probability that each node in a network will be connected to adjacent nodes