

**Oct. 19**

- 1. Administrative**
- 2. Some measures of centrality**
- 3. Complications: directed edges and weights**

## Lab 1 feedback sent

- ⋮ If you submitted (even late) but didn't get feedback, let me know!

## Précis due Thursday by 10pm

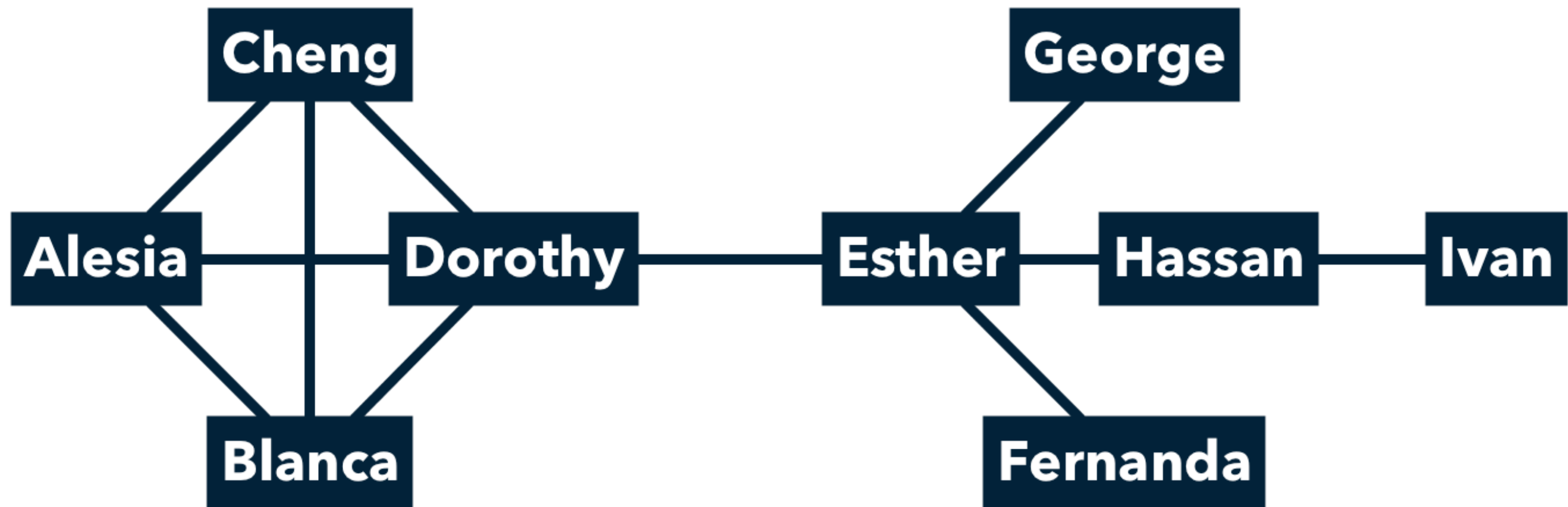
- ⋮ Make an appointment if you want to talk about your topic

## General logistical questions?

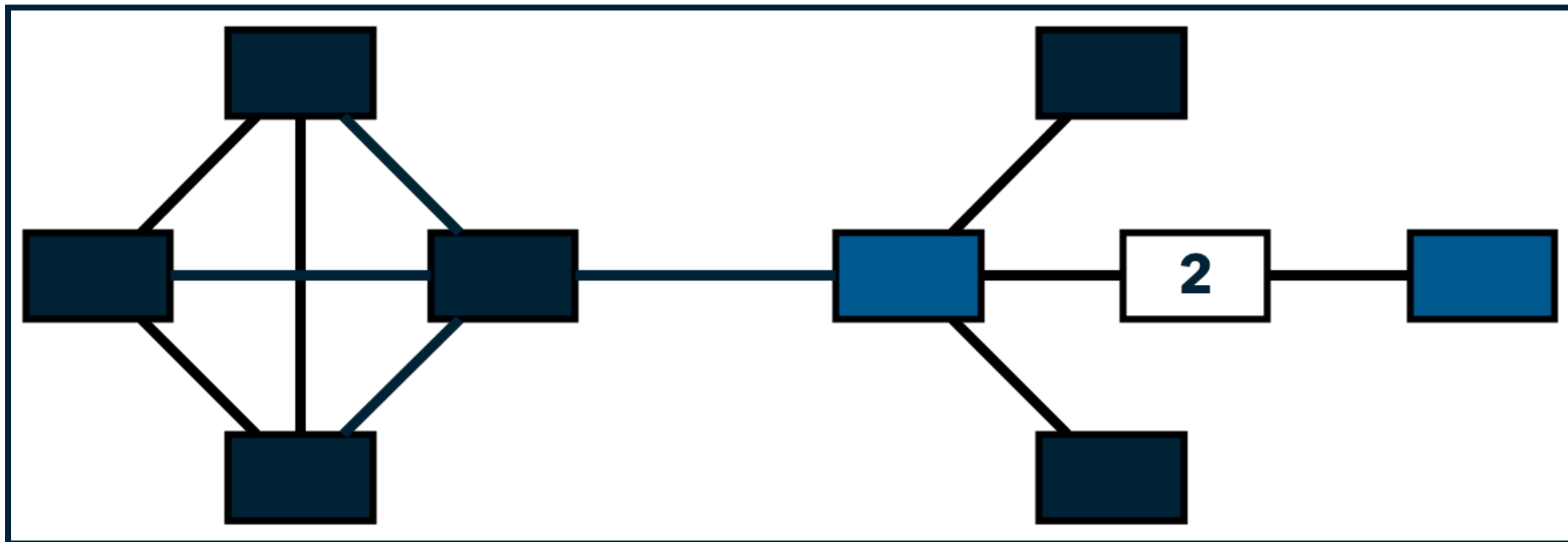
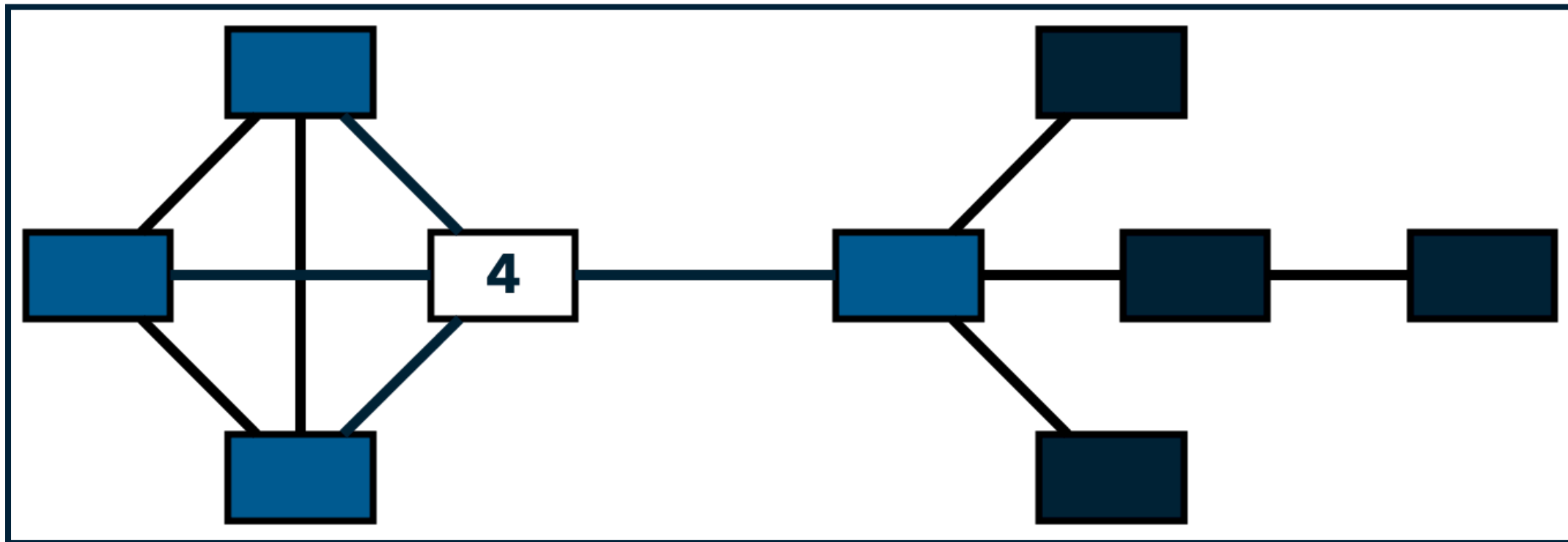
- ⋮ Project?
- ⋮ Class?
- ⋮ Readings?

# Some measures of centrality

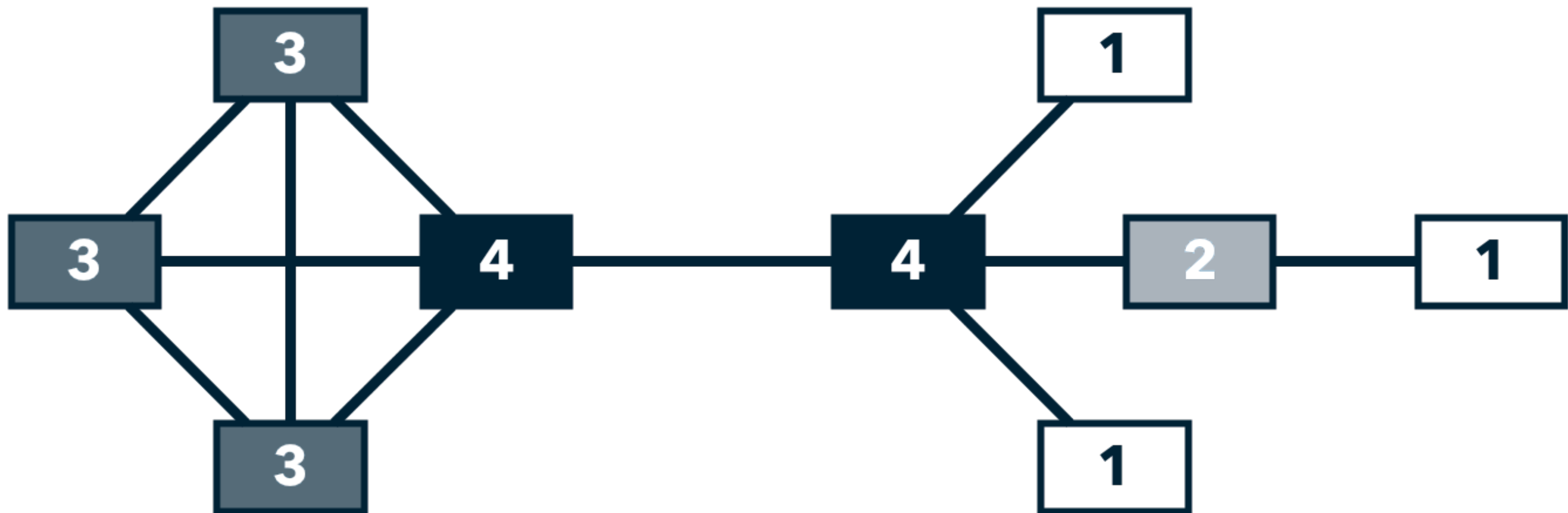
# An Artificial Example



# Degree Centrality

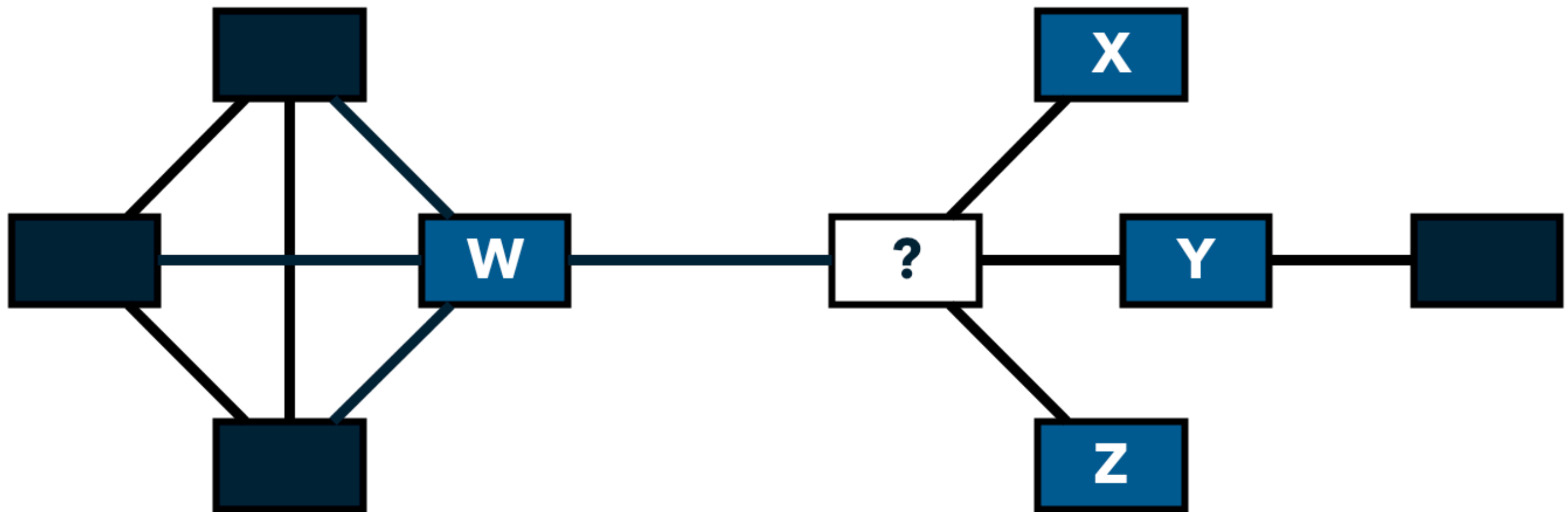


# Degree Centrality



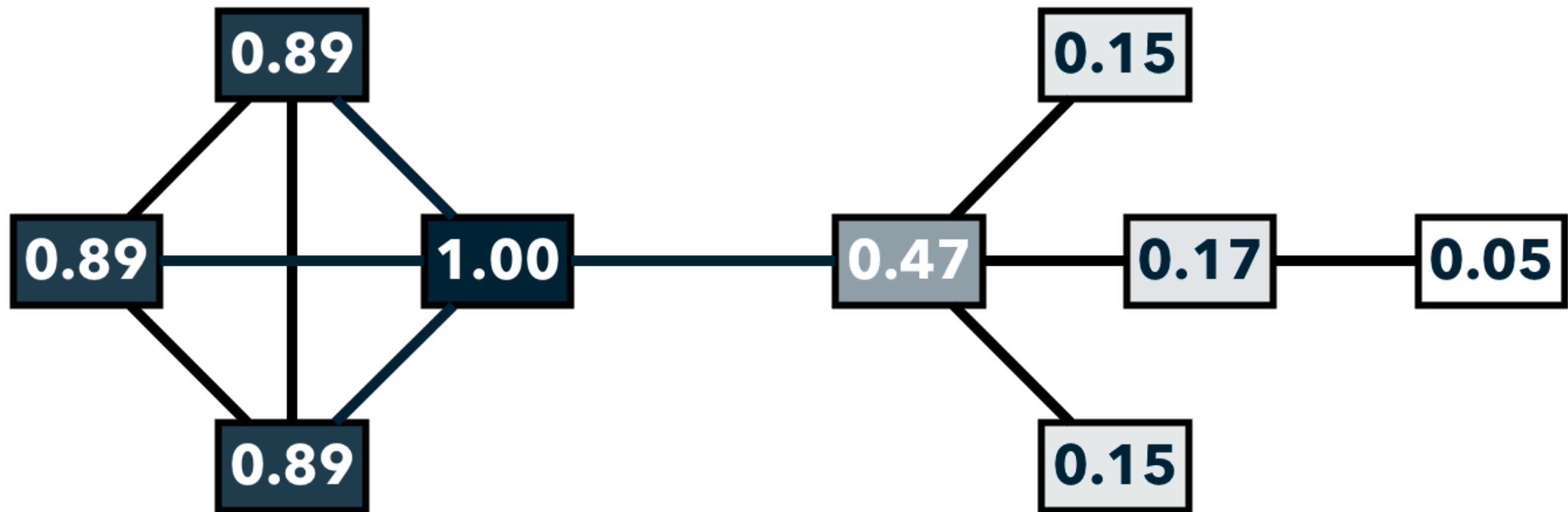
# Eigenvector Centrality

$$? = (W + X + Y + Z) / \lambda$$



$$C_E(i) = \frac{1}{\lambda} \sum_{j \in N(i)} C_E(j)$$

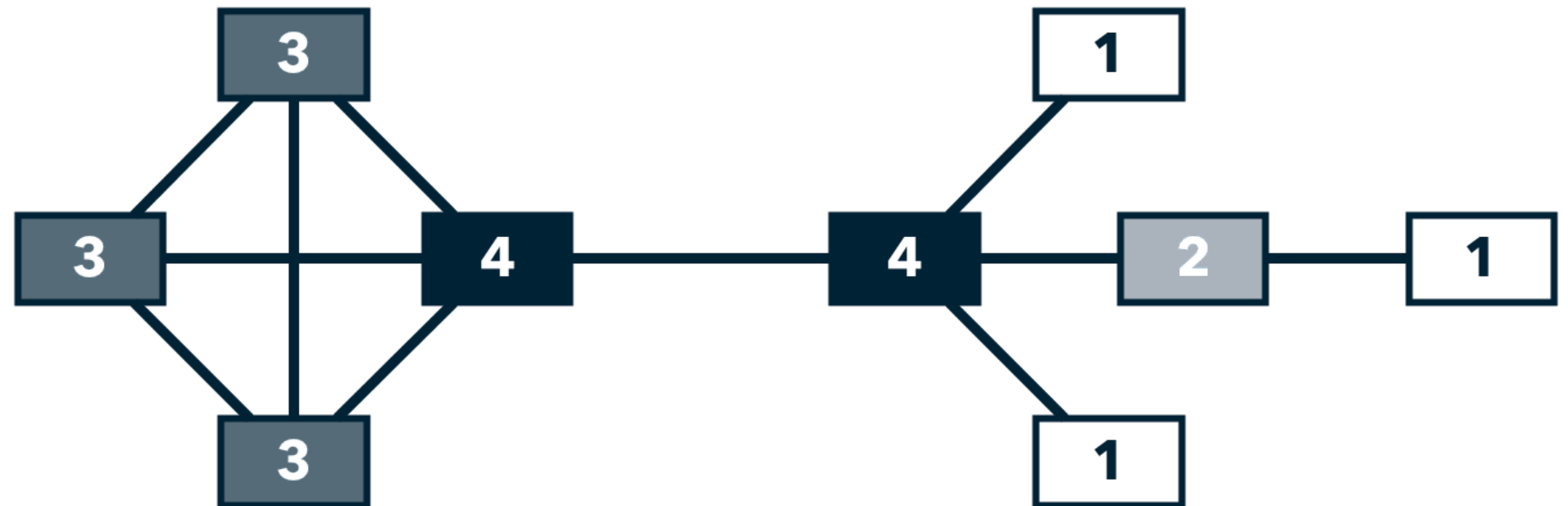
# Eigenvector Centrality



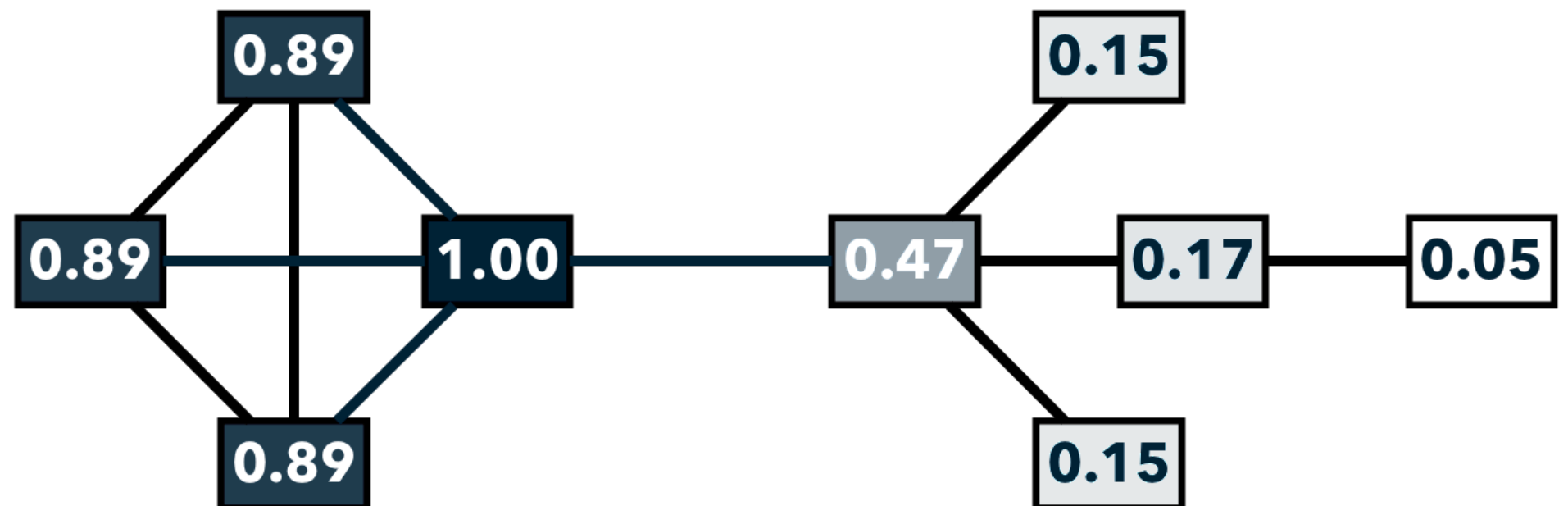


# Degree vs eigenvector

Degree



Eigenvector



# Dolphins



**Lusseau, David, Karsten Schneider, Oliver J. Boisseau, Patti Haase, Elisabeth Slooten, and Steve M. Dawson. 2003. "The Bottlenose Dolphin Community of Doubtful Sound Features a Large Proportion of Long-Lasting Associations." *Behavioral Ecology and Sociobiology* 54 (4) (September 1): 396–405.**



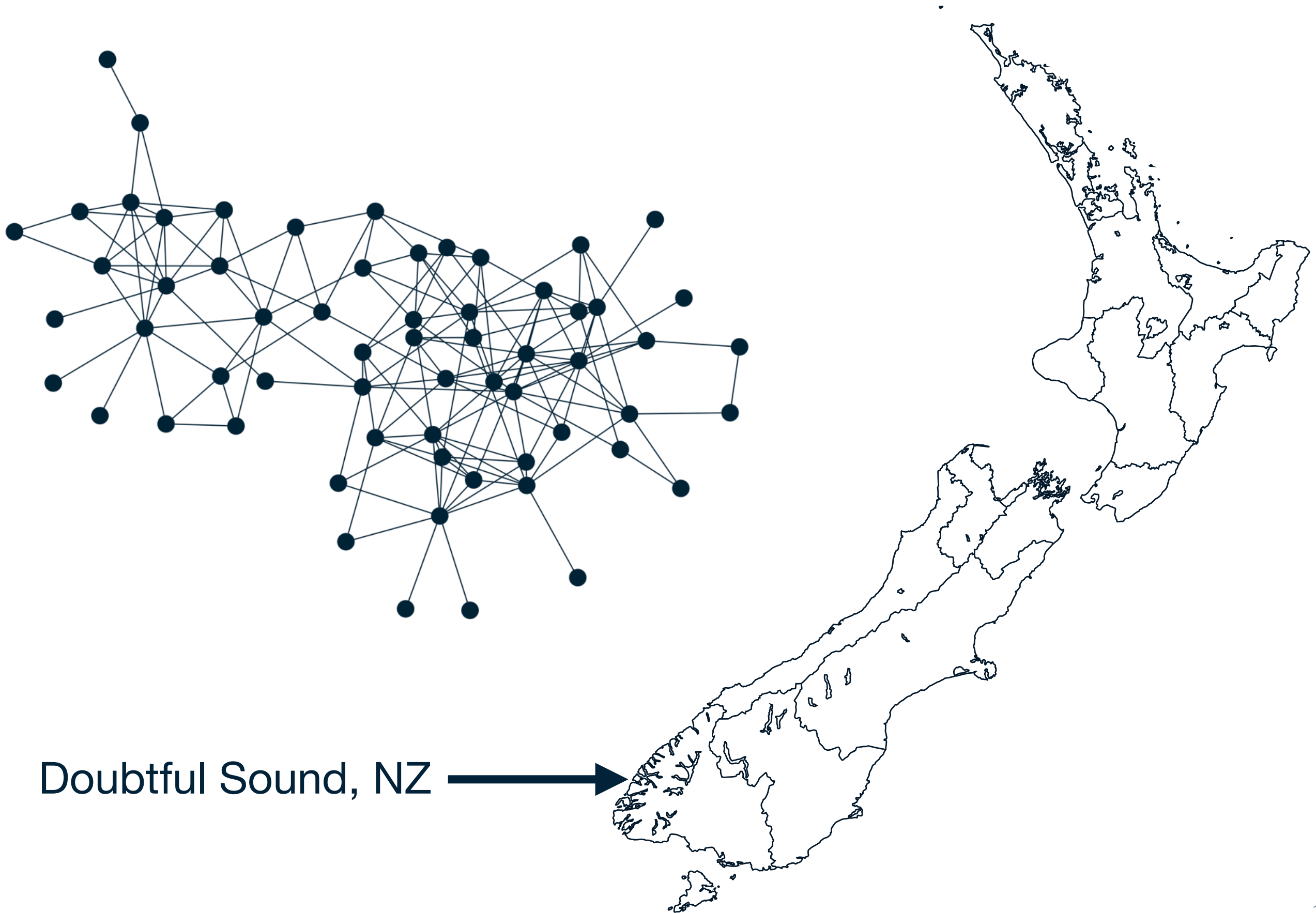
# Dolphins



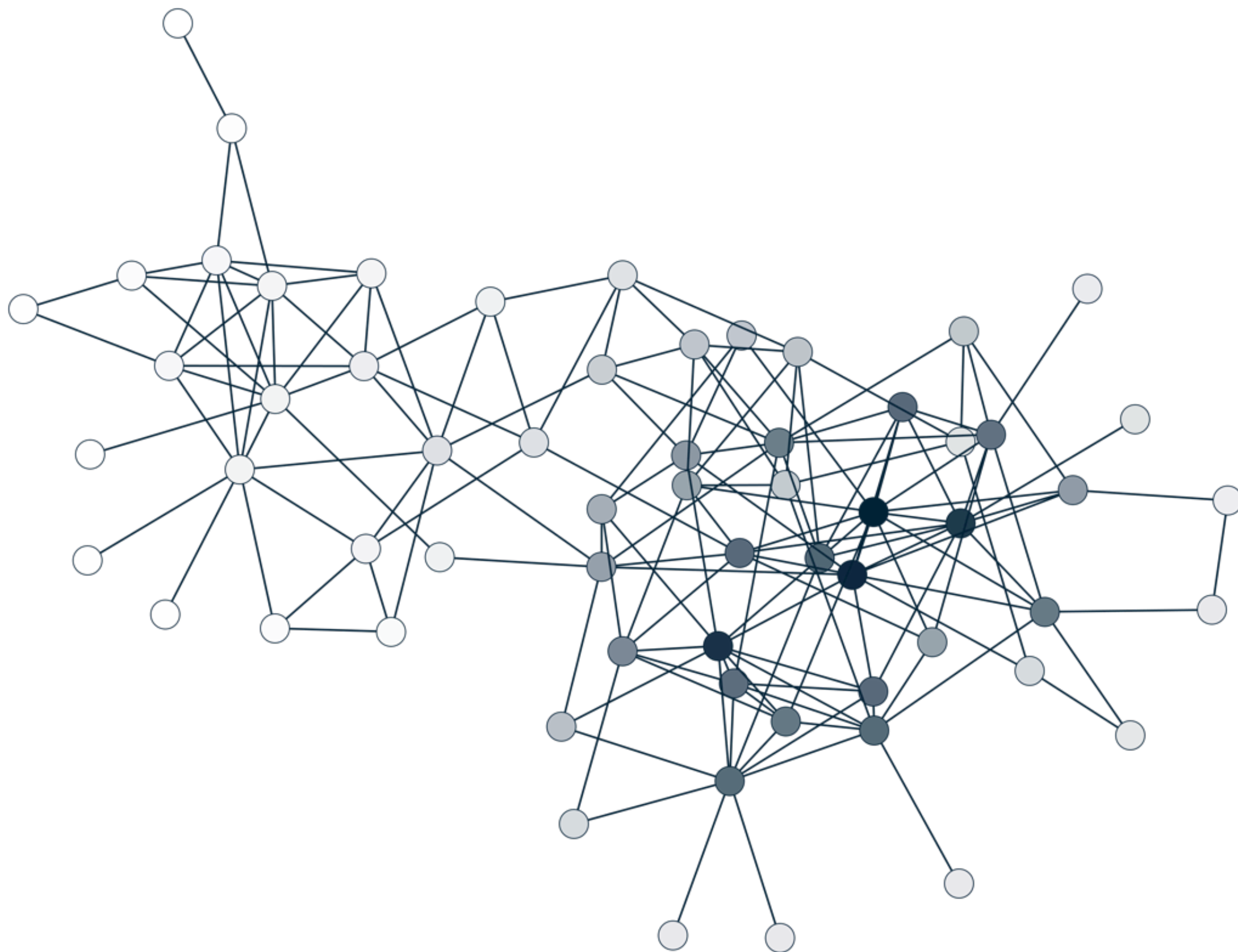
Doubtful Sound, NZ



# Dolphins

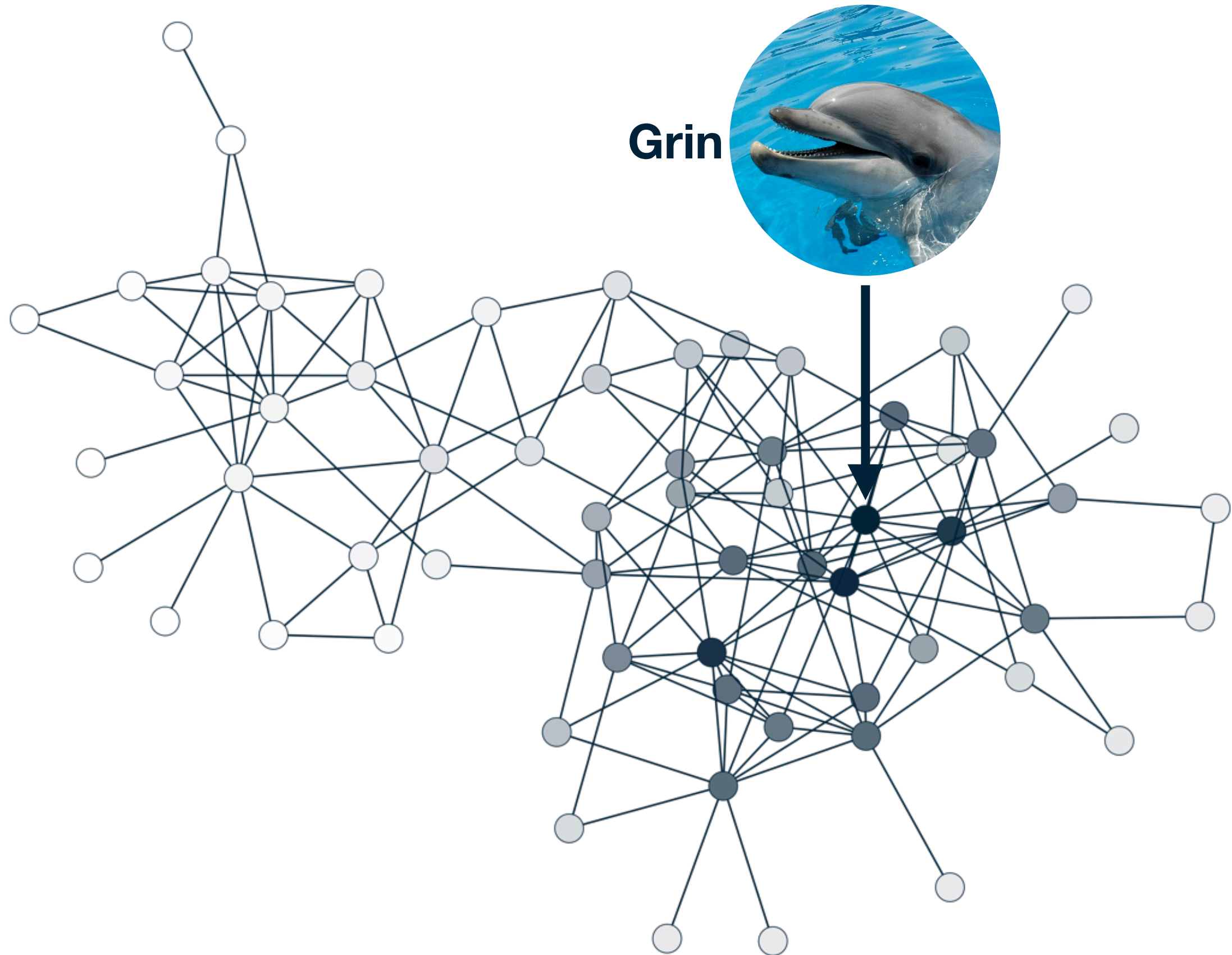


# Eigenvector Centrality

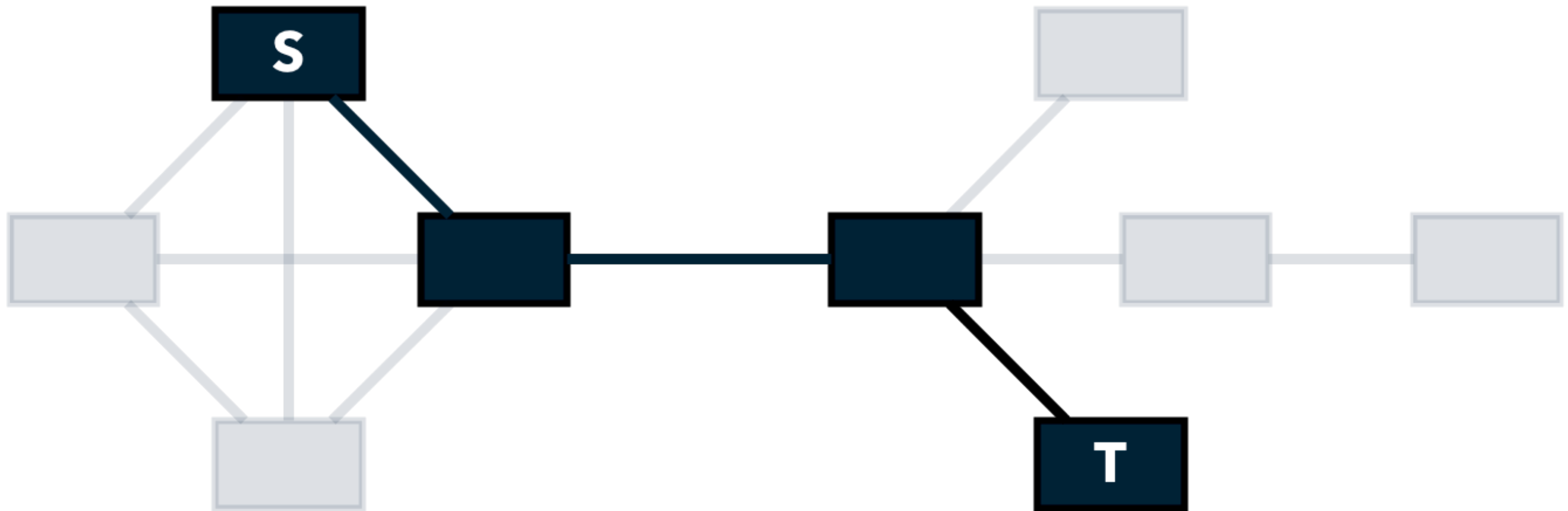




# Eigenvector Centrality

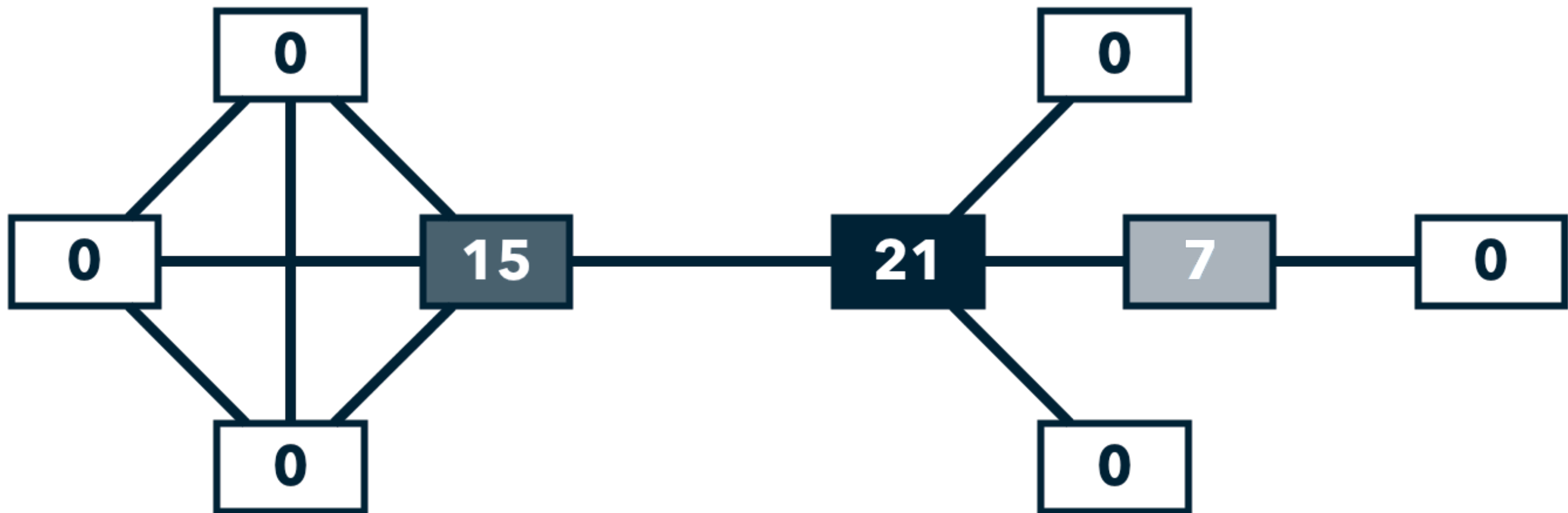


# Betweenness Centrality



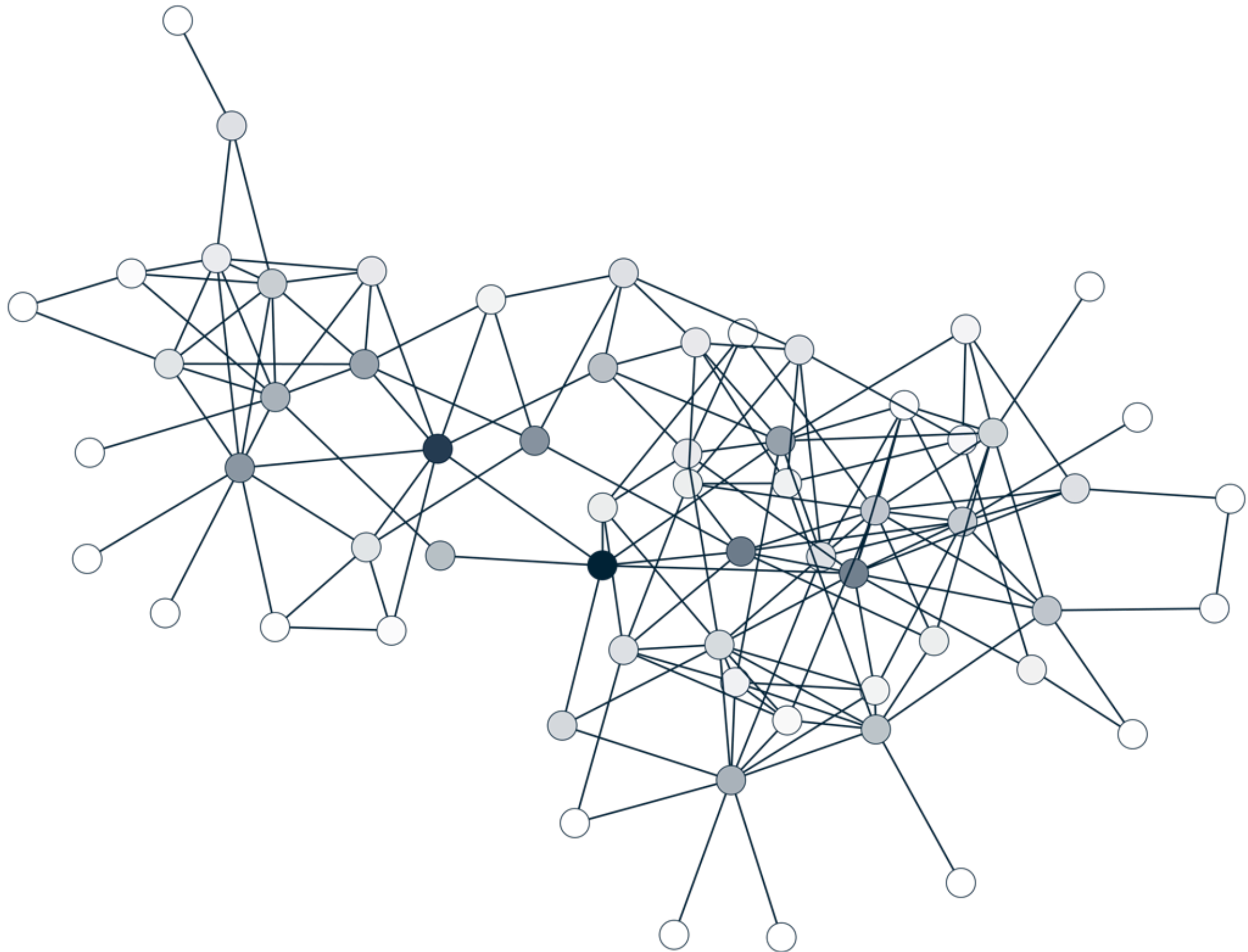
*Shortest path  
(geodesic) from  
S to T*

# Betweenness Centrality

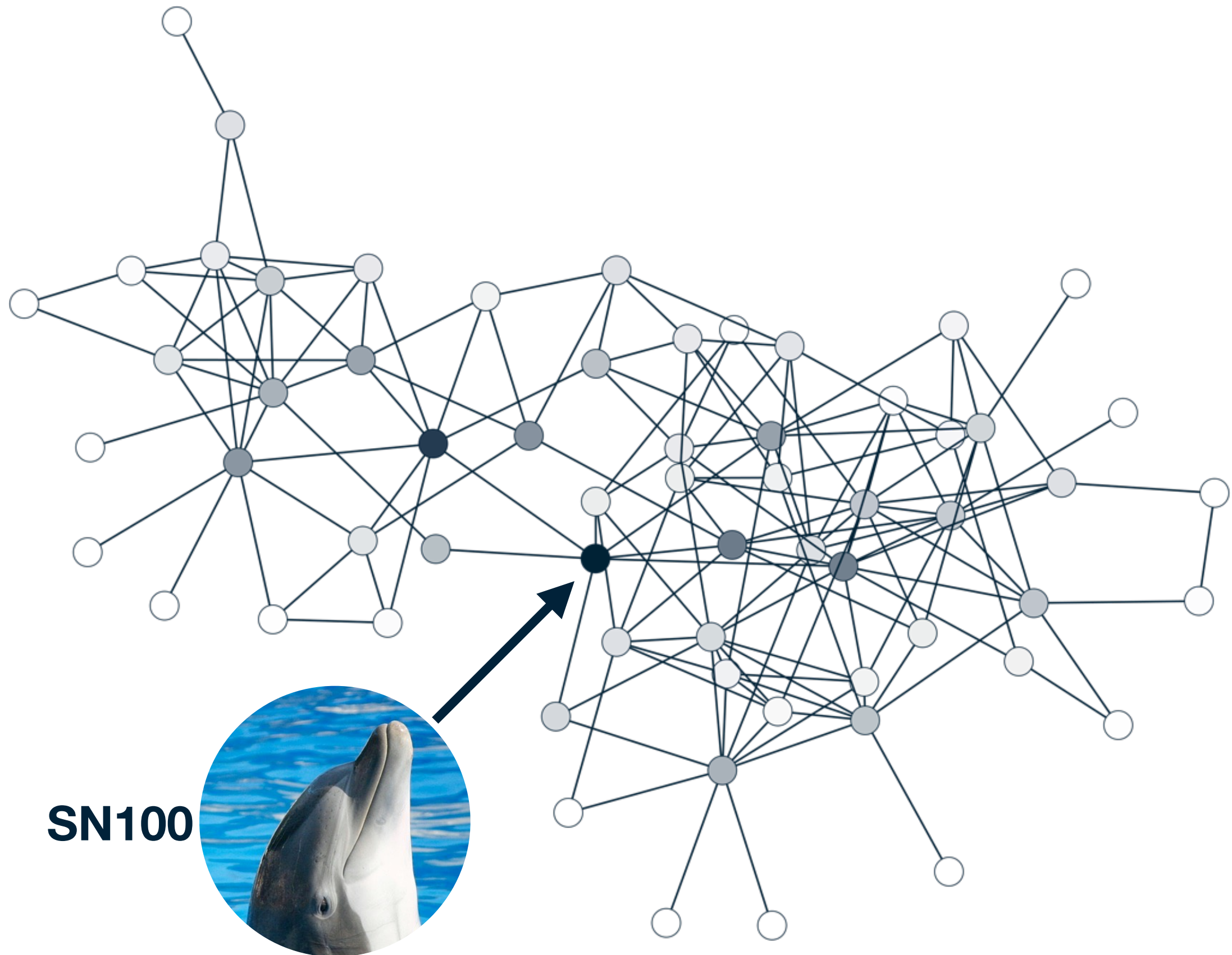




# Betweenness Centrality

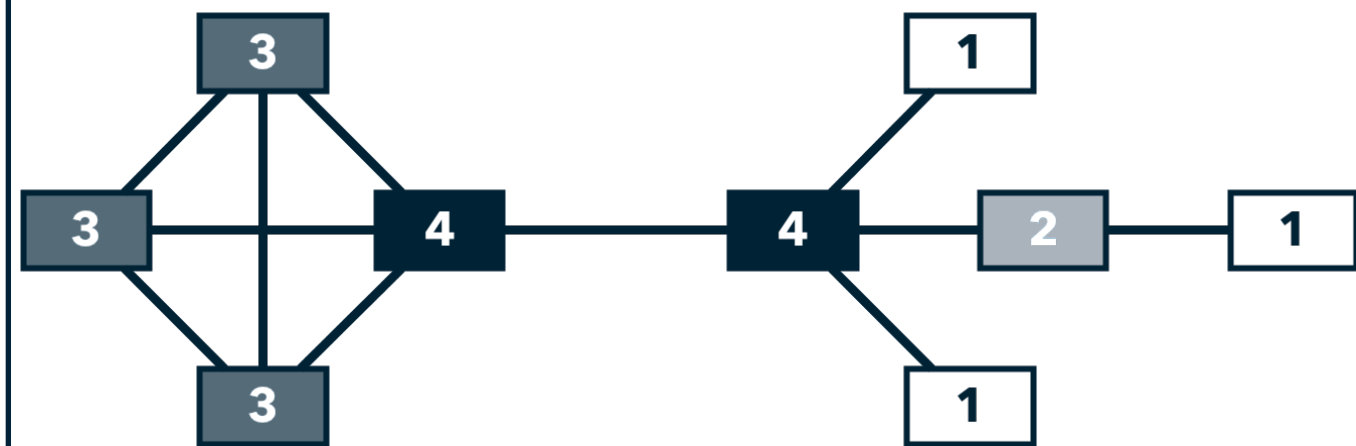


# Betweenness Centrality



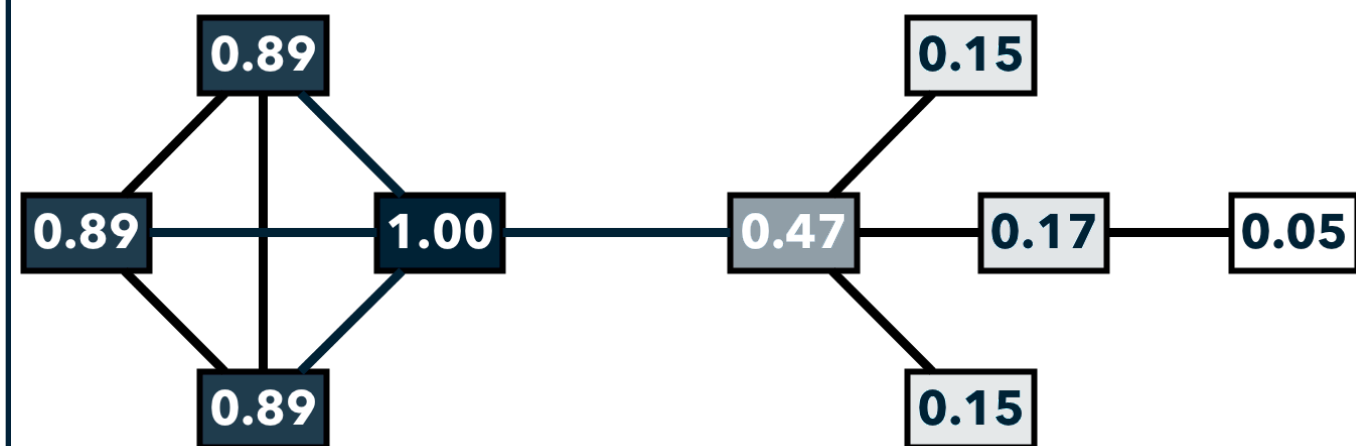
# Comparison

## Degree



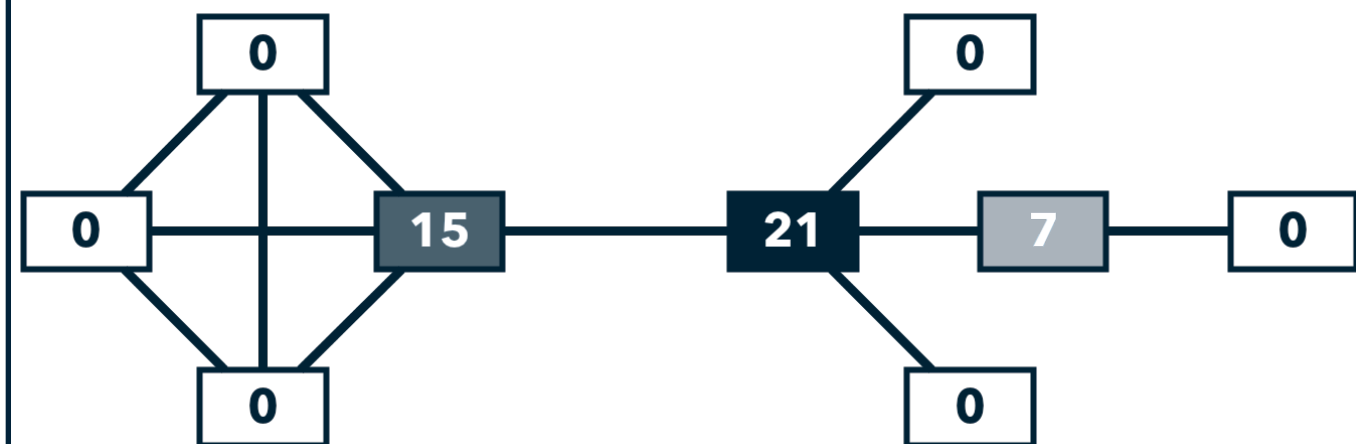
connected to many other vertices

## Eigenvector



connected to many other *well connected* vertices

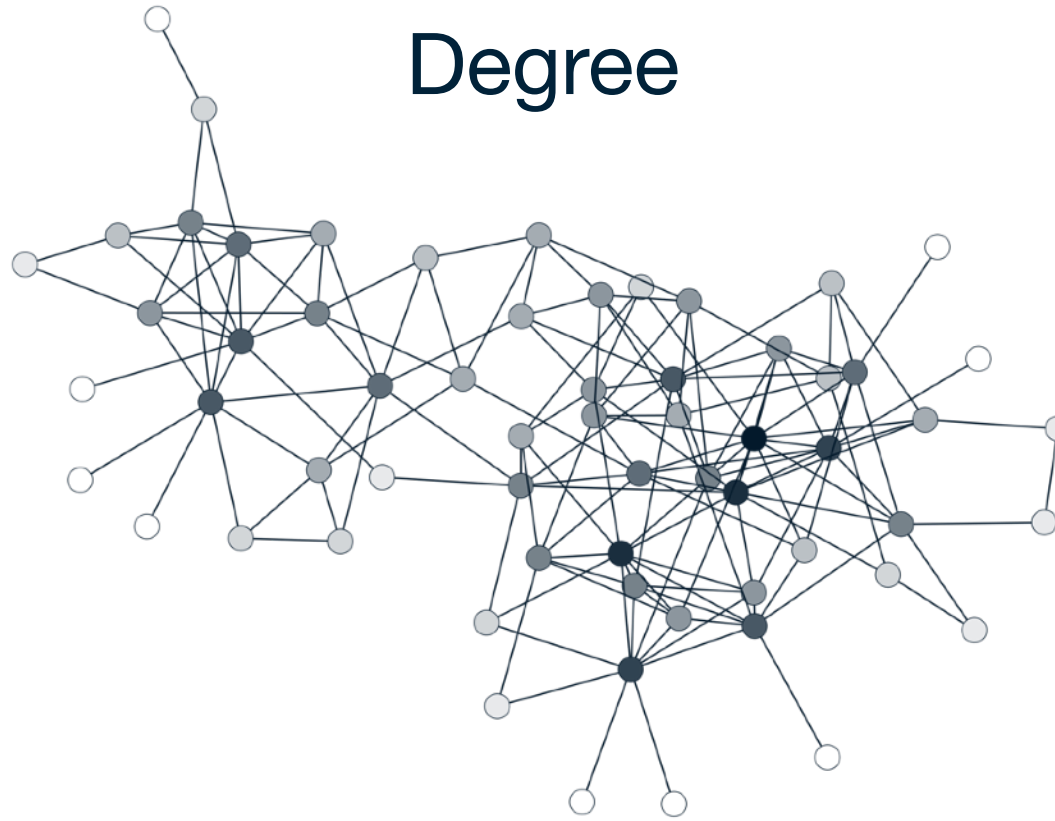
## Betweenness



on the shortest path connecting many pairs of vertices

# Comparison

Degree



Eigenvector

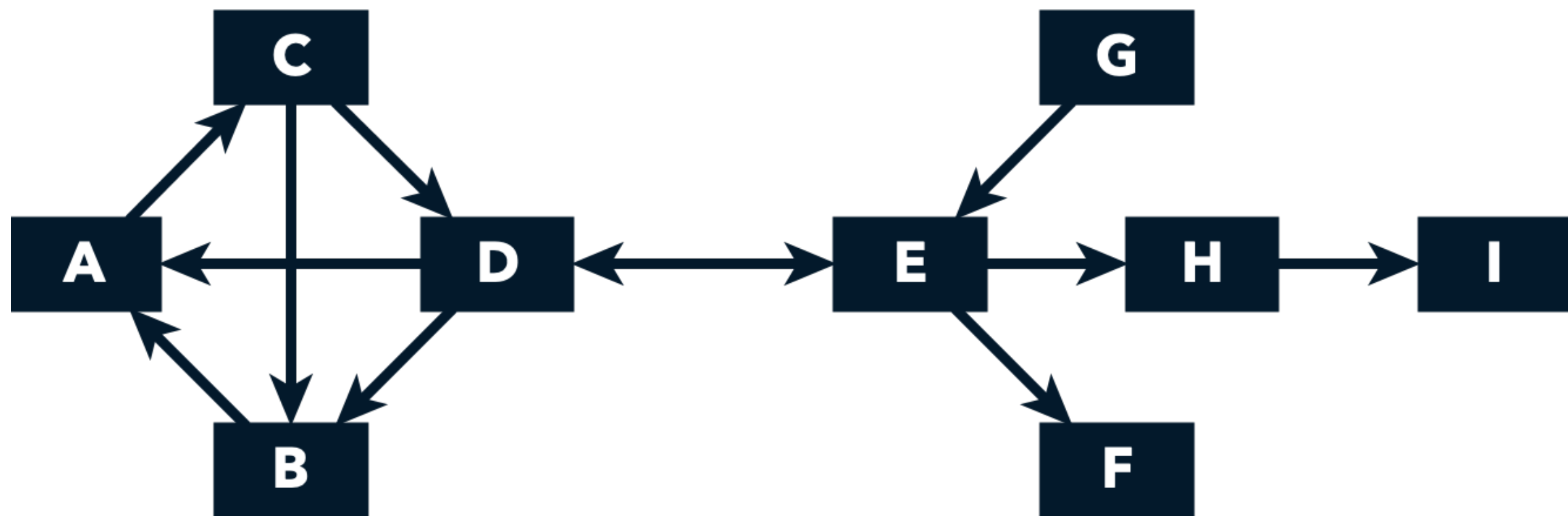


Betweenness



# Complications: directed edges and weights

# Directed edges



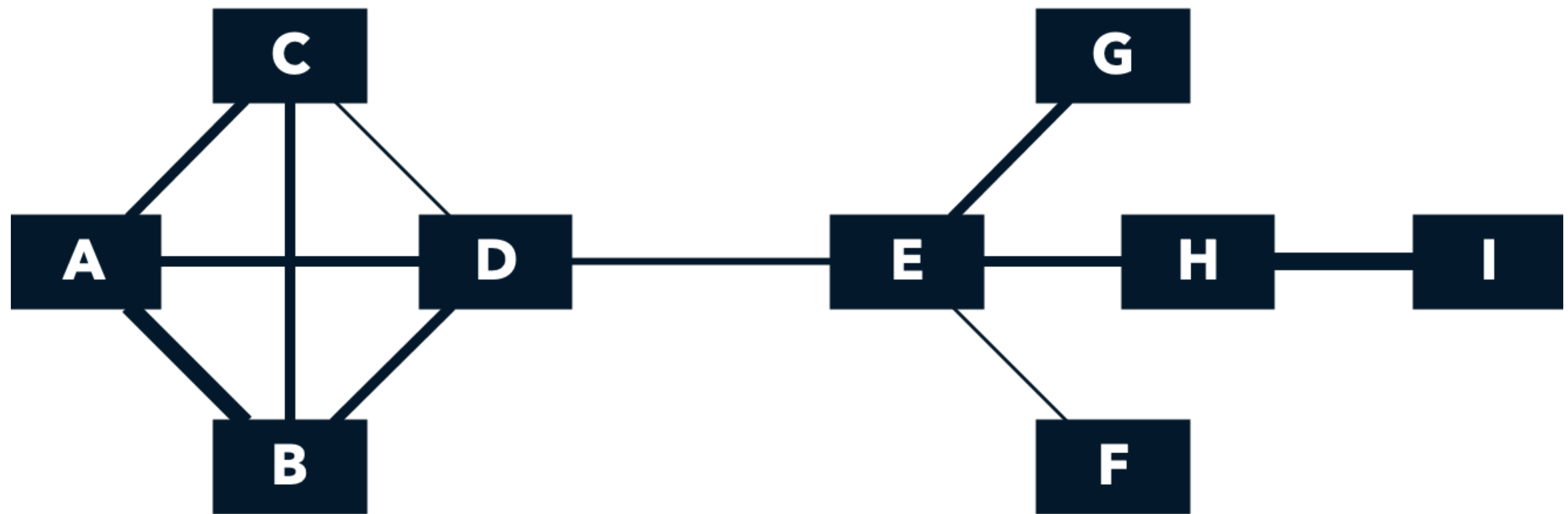
## Directed edges affect *degree*

- ∴ *In-degree*: number of edges coming into a node
- ∴ *Out-degree*: number of edges coming out of a node

## Directed edges affect *paths*

- ∴ Paths follow edge directions
- ∴ Path from B to E is longer than the path from E to B

# Edge weights



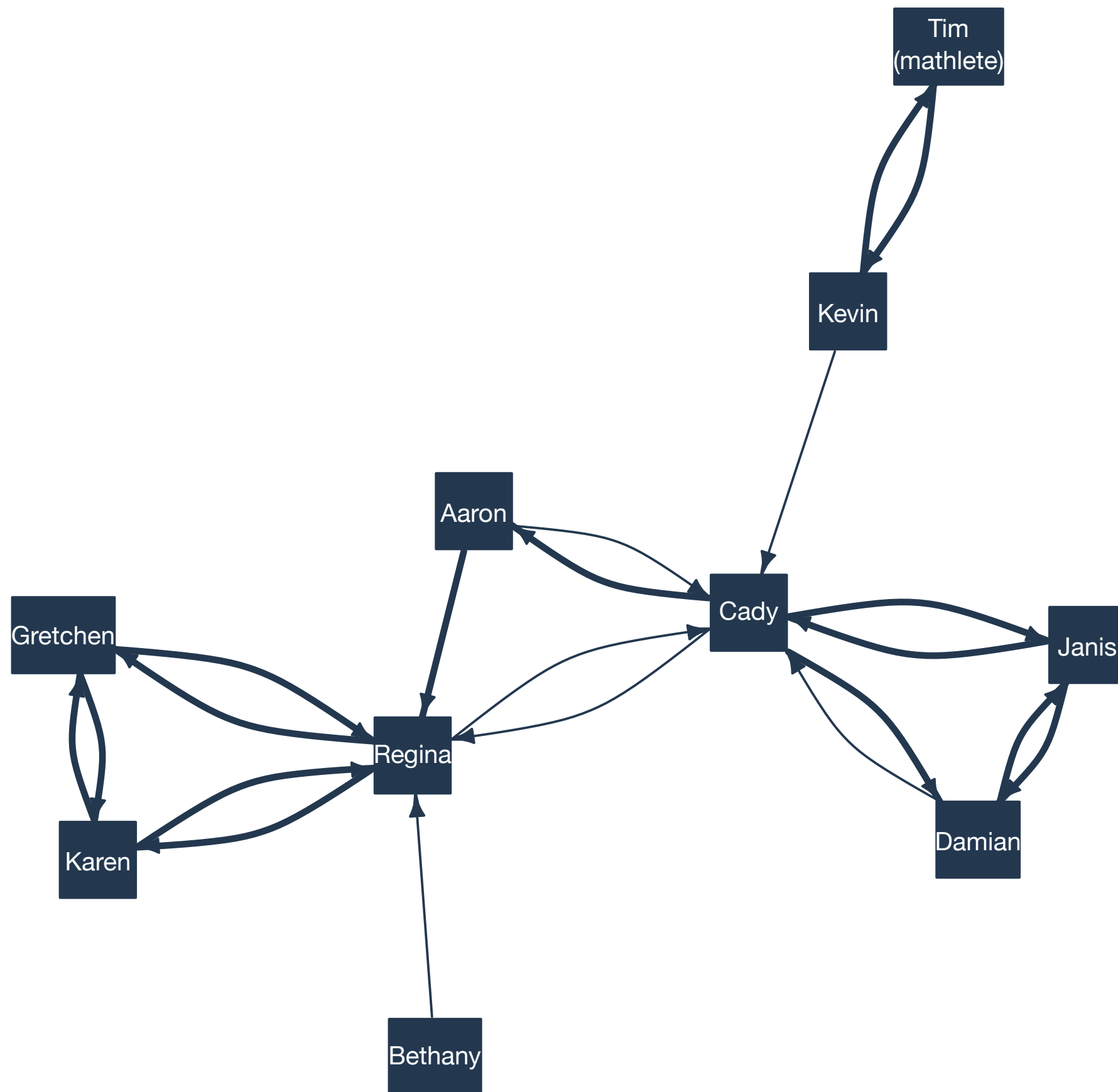
## Edge weights affect *degree*

- ∴ Often want stronger edges contribute more to degree
- ∴ Node with a few strong relations can have the same “degree” as a node with many weak relations

## Edge weights affect *paths*

- ∴ Often want stronger relations to be indicate “closer” nodes
- ∴ Large weights  $\Rightarrow$  short paths

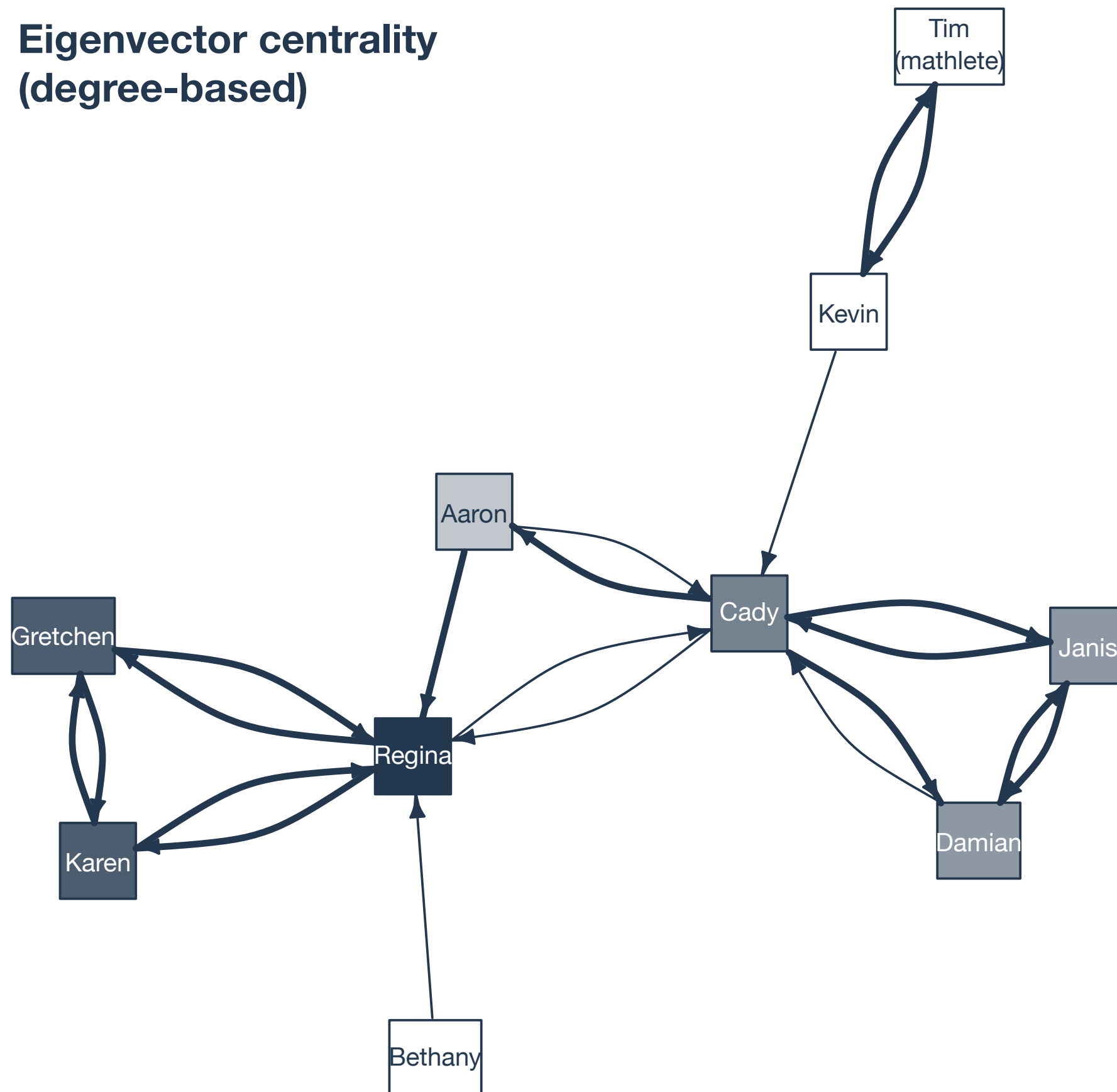
# Example





# Example

**Eigenvector centrality  
(degree-based)**



# Example

**Betweenness centrality  
(path-based)**

