Social Network Analysis

Ego Network

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Photo credit: midjourney

Outline

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– Strong Tie and Weak Tie
– Quantify Ego-network Structure
– E-I Index for the Ego: Ego-level Homophily
– Brokerage
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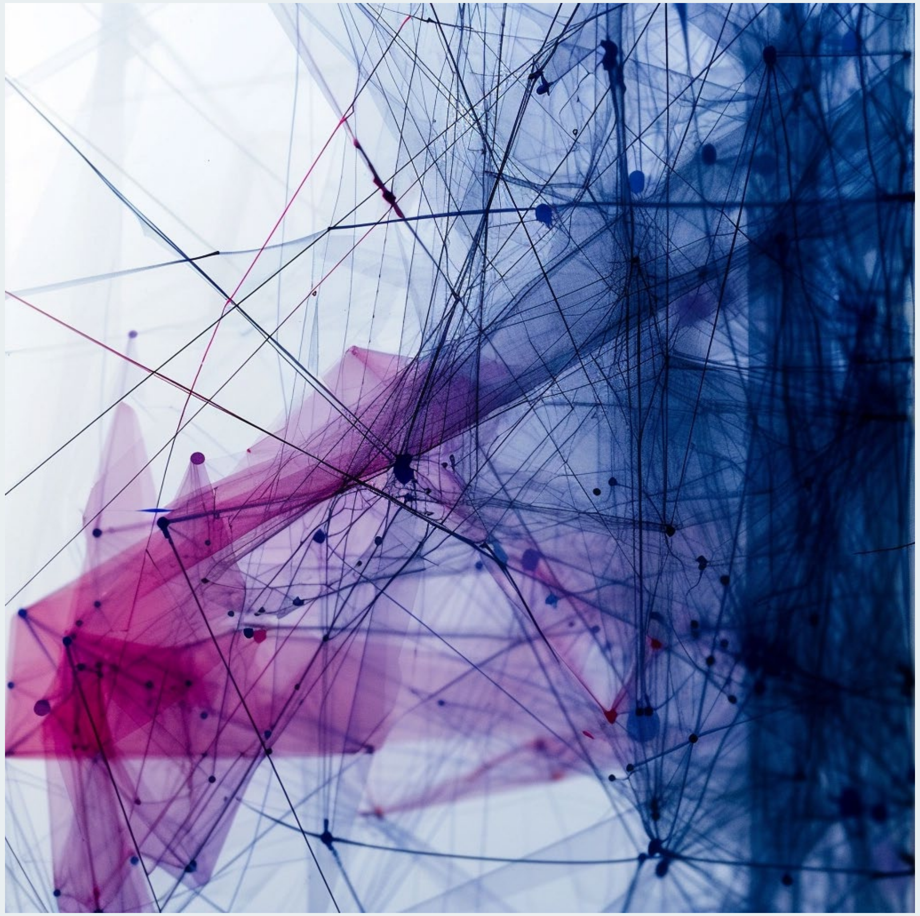

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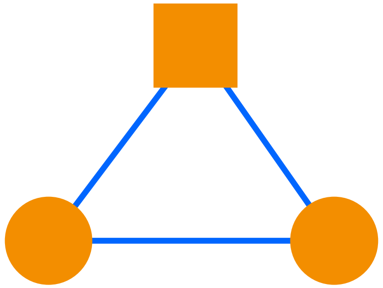
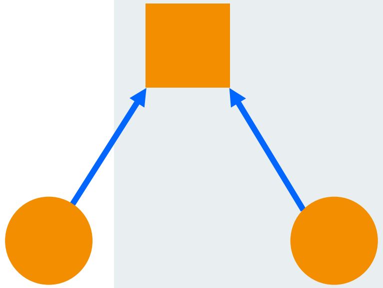
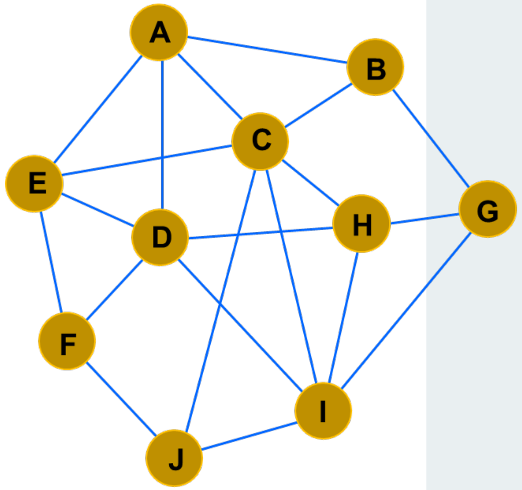
Network Category



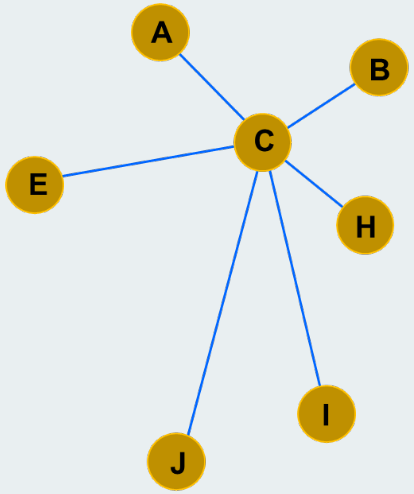
One-mode network



Two-mode network

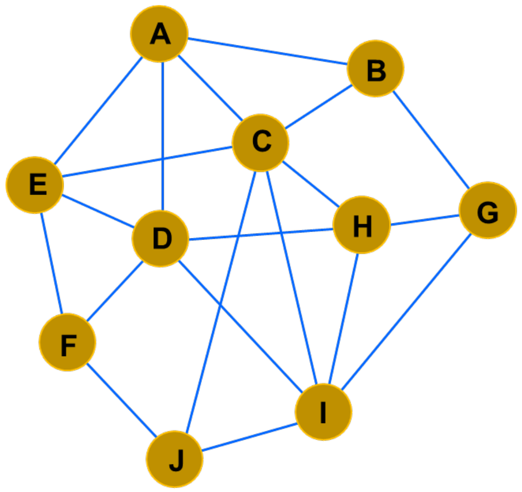


Whole network



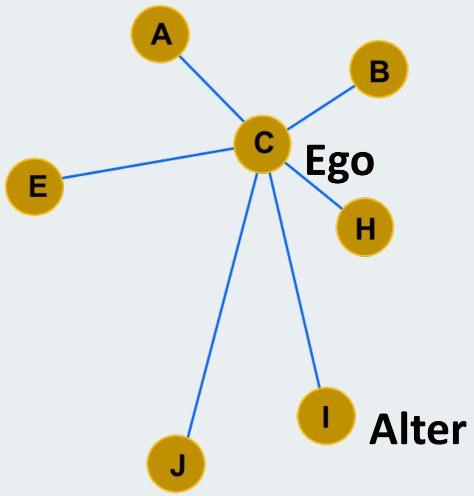
Ego network

Whole Network ←→ Ego Network



Whole network

- Global structure
- Concentration
- Flow of information



Ego network

- Structure
- Composition
- Shape

Ego Network

- The extent to which actors find themselves in social structures is characterized by ***dense***, ***reciprocal***, ***transitive***, and ***strong ties***.
- The central theme was to understand and index the extent and nature of the pattern of "**constraint**" on actors resulting from how they are connected to others.
- These approaches may tell us some interesting things about the entire population and its sub-populations, but they don't tell us very much about the opportunities and constraints facing individuals.

 Wasserman, S., & Faust, K. (1994). Social network analysis: Methods and applications.

Ego Network

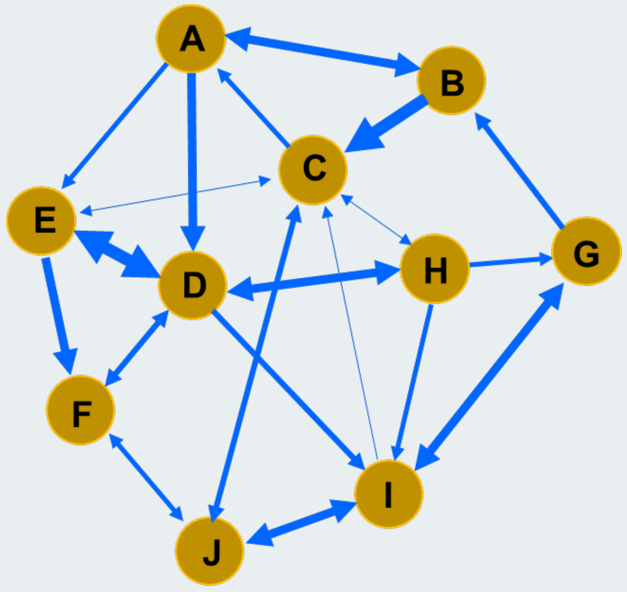

AB40 (0: 8287.0E-6)
A27 (1: 8187.0E-6)
AB26 (2: 5719.0E-6)
AB53 (3: 4377.0E-6)
B27 (4: 3738.0E-6)
AB46 (5: 3121.0E-6)
AB2 (6: 2940.0E-6)
B1 (7: 2731.0E-6)
AB9 (8: 2680.0E-6)
AB54 (9: 2539.0E-6)
B26 (10: 2529.0E-6)
B241 (11: 2513.0E-6)
AB29 (12: 2342.0E-6)
B533 (13: 2313.0E-6)
B199 (14: 2313.0E-6)
AB10 (15: 2246.0E-6)
AB49 (16: 2245.0E-6)
B447 (17: 2225.0E-6)
B76 (18: 2224.0E-6)
B558 (19: 2118.0E-6)
B66 (20: 2020.0E-6)
AB55 (21: 2017.0E-6)
B222 (22: 2015.0E-6)
B575 (23: 2011.0E-6)
B165 (24: 1999.0E-6)
B183 (25: 1989.0E-6)
B778 (26: 1972.0E-6)
B46 (27: 1970.0E-6)
AB44 (28: 1963.0E-6)
B292 (29: 1929.0E-6)
AB31 (30: 1897.0E-6)
B29 (31: 1892.0E-6)
B485 (32: 1862.0E-6)
B2 (33: 1854.0E-6)
AB36 (34: 1831.0E-6)
AB19 (35: 1801.0E-6)
B776 (36: 1782.0E-6)
B607 (37: 1756.0E-6)
B393 (38: 1724.0E-6)
B442 (39: 1708.0E-6)
B215 (40: 1706.0E-6)
B134 (41: 1692.0E-6)
B888 (42: 1682.0E-6)
B561 (43: 1682.0E-6)
B477 (44: 1669.0E-6)
AB35 (45: 1660.0E-6)
B208 (46: 1633.0E-6)
B339 (47: 1633.0E-6)
B196 (48: 1632.0E-6)
AB25 (49: 1630.0E-6)

Ego Network Characteristics

– "**Ego**" is an individual "**focal**" node. A network has as many egos as it has nodes. Egos can be persons, groups, organizations, or whole societies.

– "**Neighborhood**" is the collection of ego and all nodes to whom ego connects at some path length.

– In social/ complex network analysis, the "**neighborhood**" is almost always one step; that is, it includes only ego and directly adjacent actors.



Wasserman, S., & Faust, K. (1994). Social network analysis: Methods and applications.

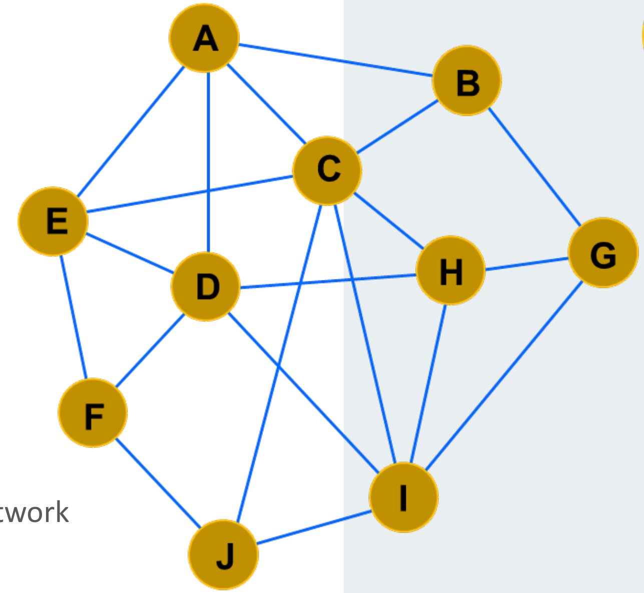
Ego Network Characteristics

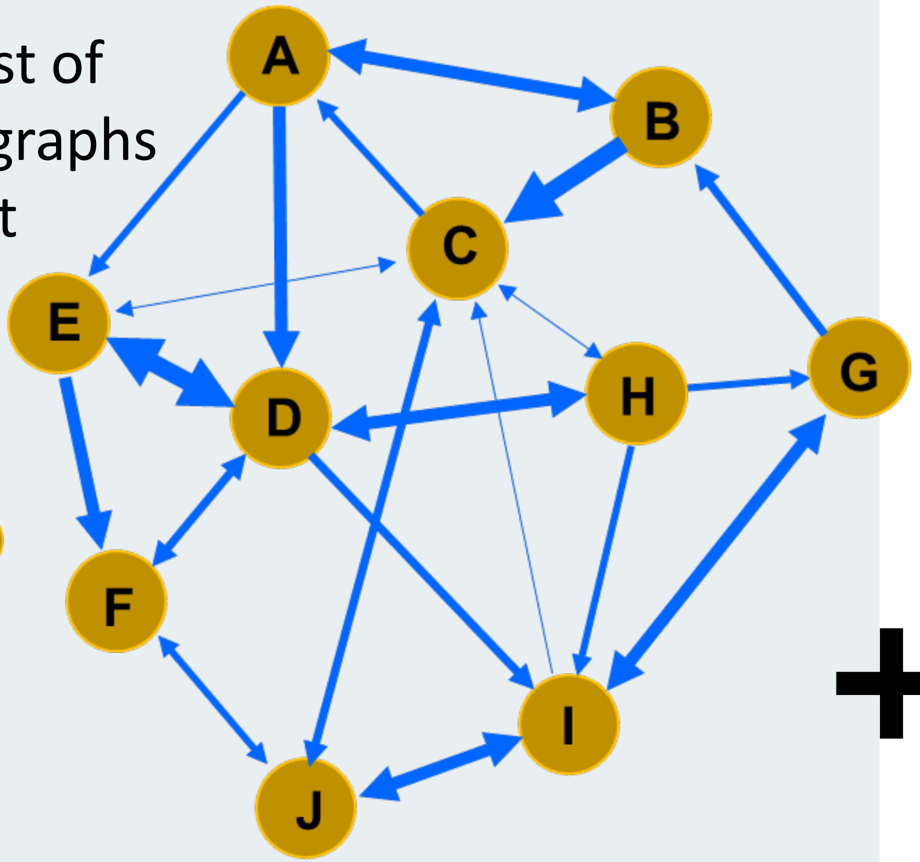
– “**N-step neighborhood**” expands the definition of the size of ego’s neighborhood by including all nodes to whom ego has a connection at a path length of N, and all the connections among all of these actors. Neighborhoods of greater path length than 1 (i.e., egos adjacent nodes) are rarely used in analysis.

 Wasserman, S., & Faust, K. (1994). Social network analysis: Methods and applications.

Ego Network Characteristics

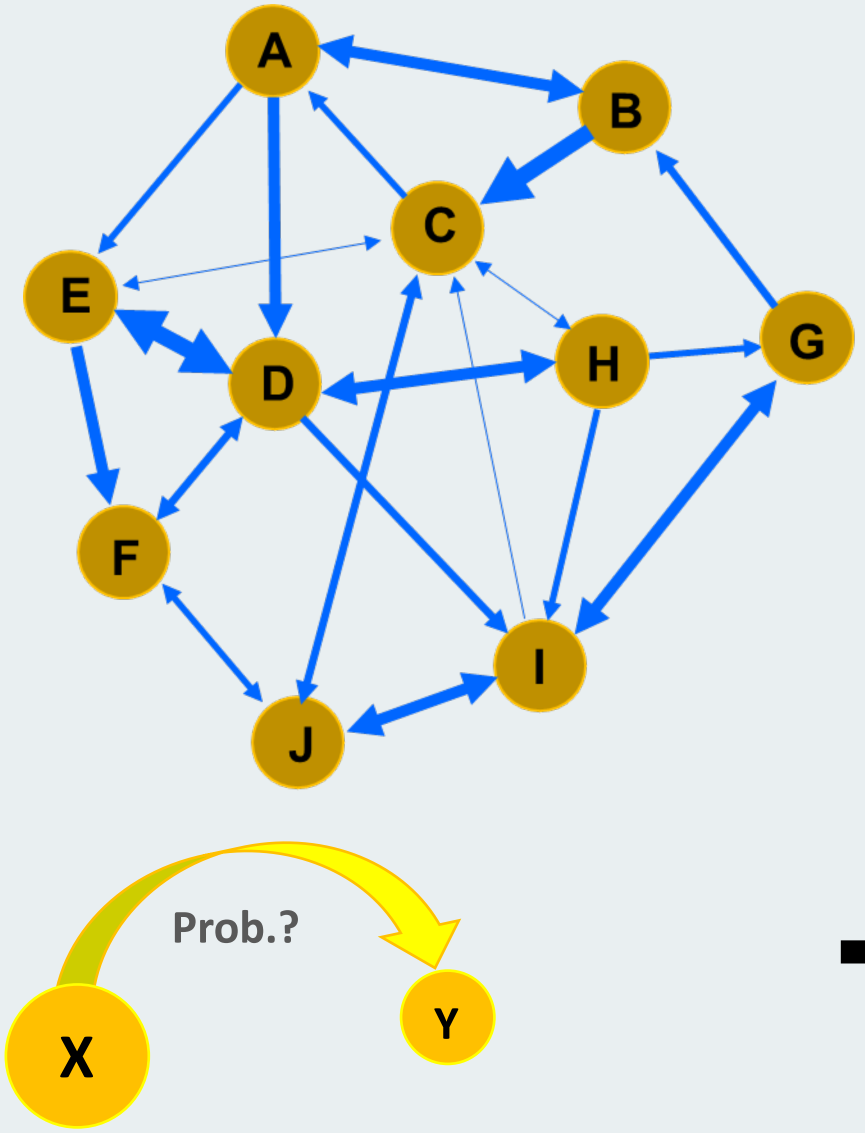
– "**In**" and "**out**" and other kinds of neighborhoods. Most of the analysis of ego networks uses simple graphs (i.e., graphs that are symmetric and show only connection/not, not direction).





Wasserman, S., & Faust, K. (1994). Social network analysis: Methods and applications.

Strong Tie and Weak Tie



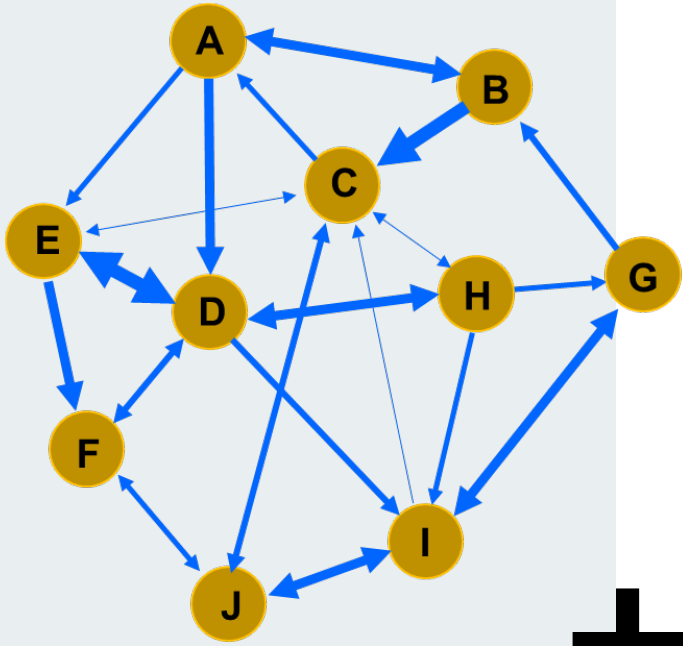
– With ties that are **measured as strengths or probabilities**, a reasonable approach is to define a cut-off (or, better, explore several reasonable alternatives).

– Where the information about ties includes information about positive/negative, the most common approach is to analyze the positive tie neighborhood and the negative tie neighborhood separately.

Wasserman, S., & Faust, K. (1994). Social network analysis: Methods and applications.

Strong Tie and Weak Tie

- “**Strong and weak tie neighborhood.**”
- Most analysis of ego networks uses binary data – two actors are connected or they aren't, and this defines the ego neighborhood.
- But if we have measured the strength of the relation between two actors, and even it’s valence (positive or negative), we need to make choices about when we are going to decide that another actor is ego’s neighbor.



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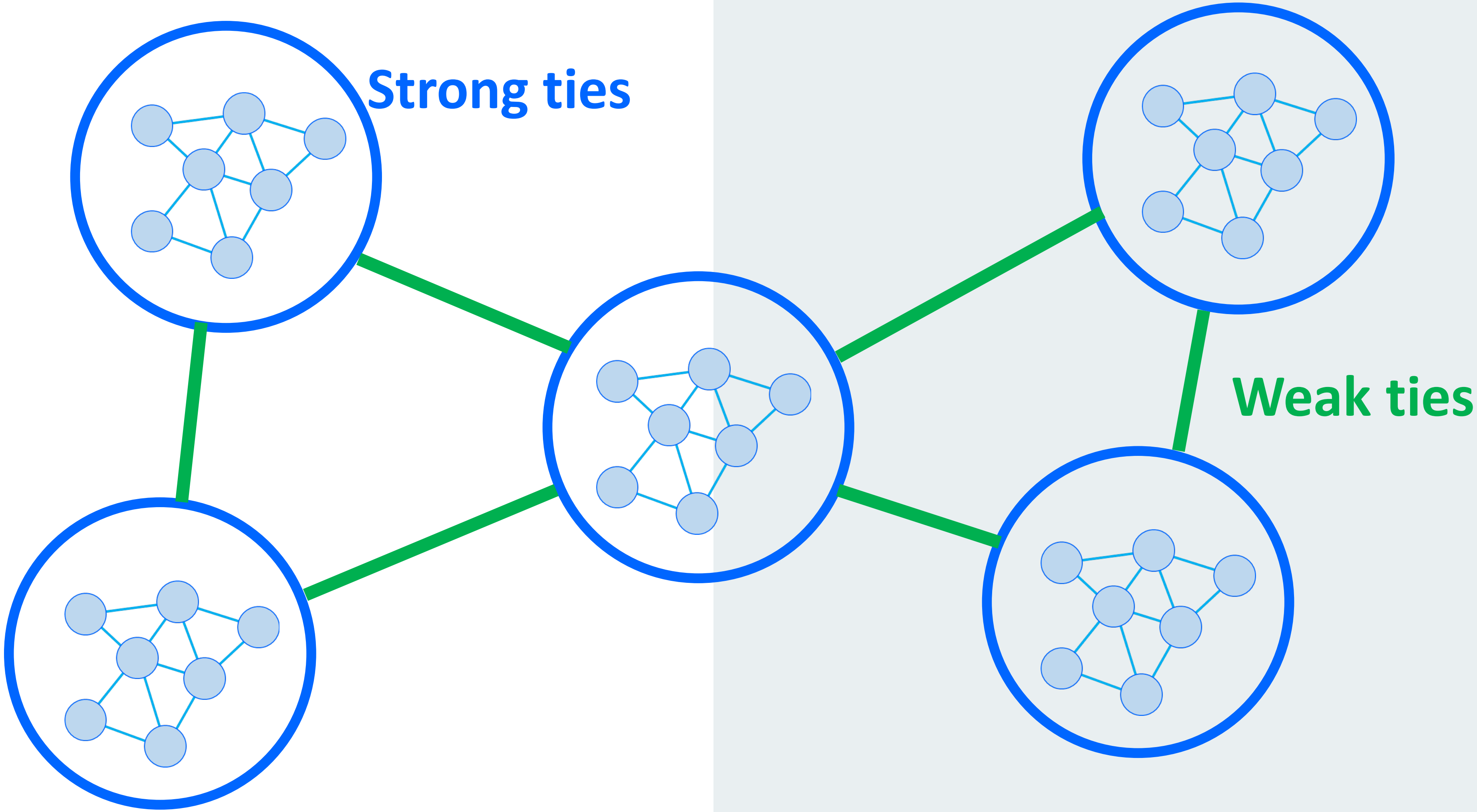
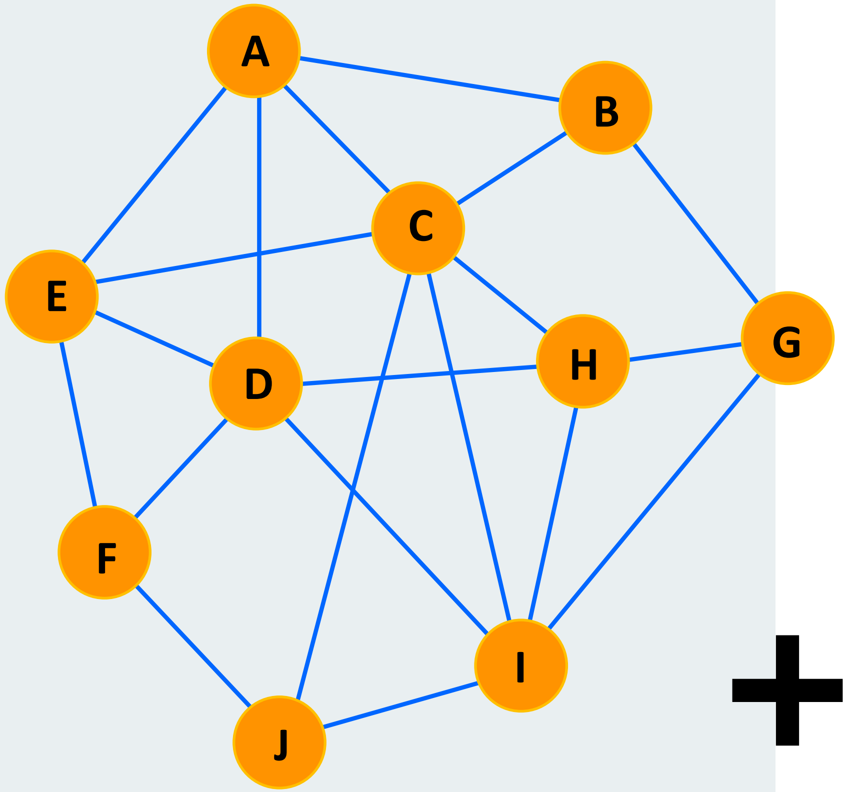
Strong Tie and Weak Tie



Quantify Ego-network Structure

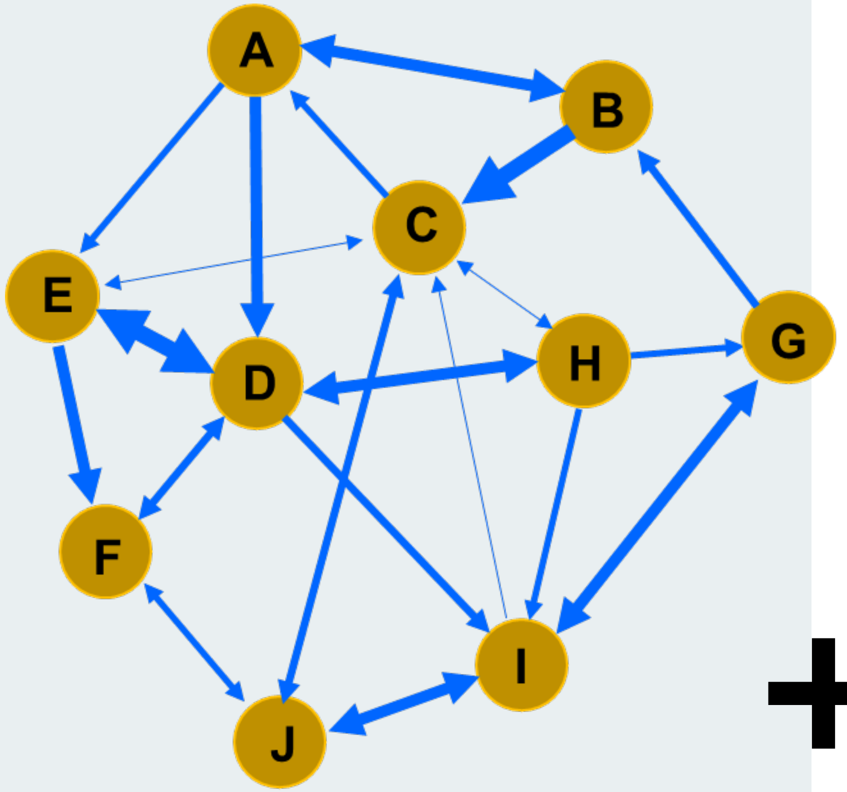
- **Number of weak components:** A weak component is the largest of actors who are connected, disregarding the direction of the ties (a strong component pays attention to the direction of the ties for directed data).
- **Number of weak components divided by size.** The likelihood that there would be more than one weak component in the ego's neighborhood would be a function of neighborhood size if connections were random.



Wasserman, S., & Faust, K. (1994). Social network analysis: Methods and applications.

Quantify Ego-network Structure

- **Size of ego networks:** is the number of nodes that are one step out of the neighbors of ego, plus ego itself.
- **Number of directed ties:** is the number of connections among all the nodes in the ego network.
- **Number of ordered pairs:** is the number of possible directed ties in each ego network.



Wasserman, S., & Faust, K. (1994). Social network analysis: Methods and applications.

Quantify Ego-network Structure

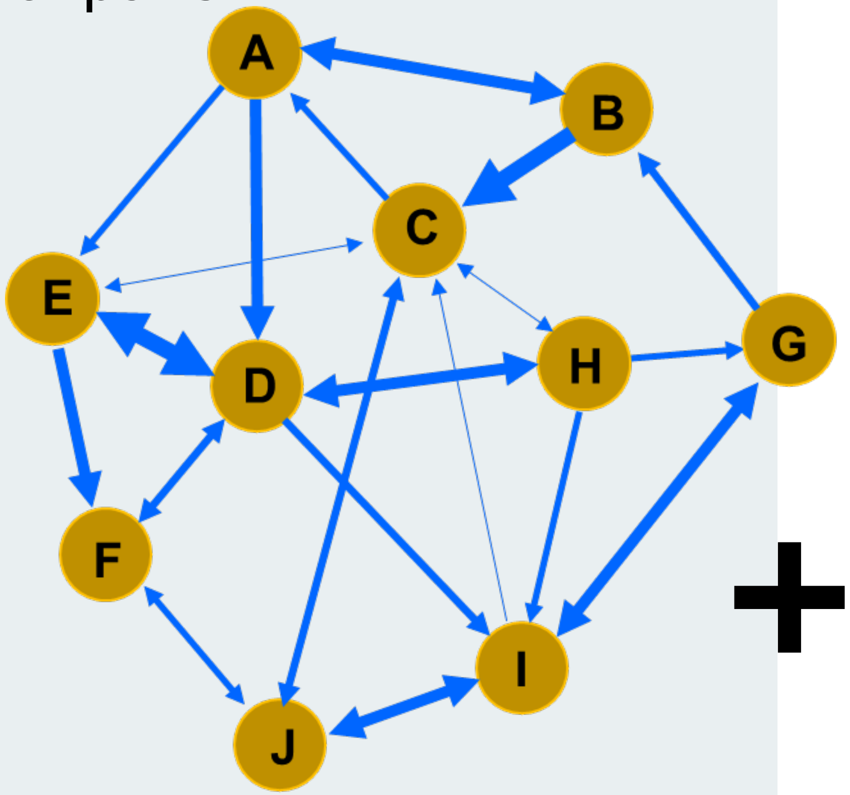
– **Density:** is the number of ties divided by the number of pairs. The density for undirected graphs is

$$d = \frac{2m}{n(n-1)}$$

and for directed graphs is

$$d = \frac{m}{n(n-1)}$$

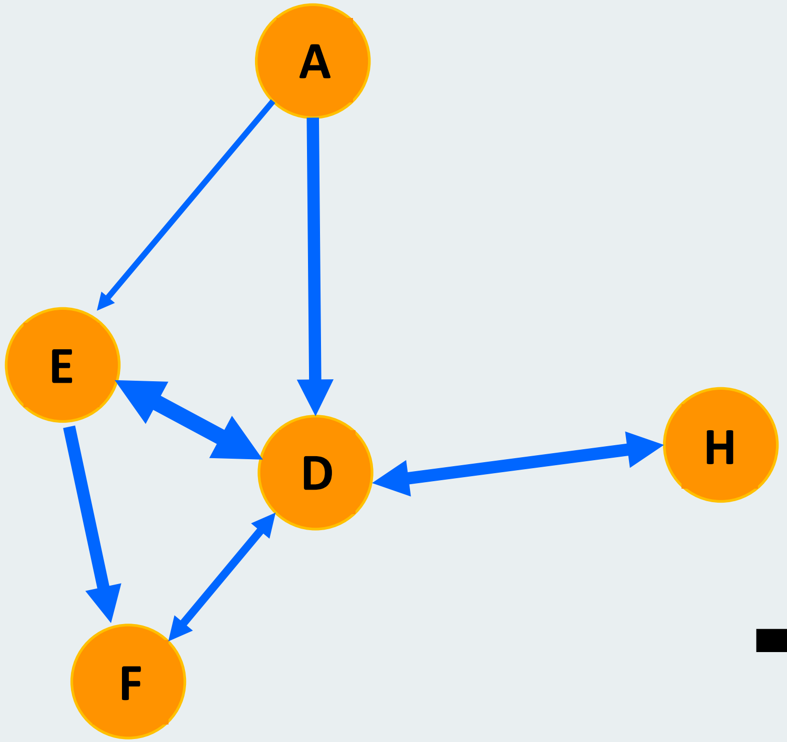
where n is the number of nodes and m is the number of edges in graph.



Wasserman, S., & Faust, K. (1994). Social network analysis: Methods and applications.

Quantify Ego-network Structure

- **Average geodesic distance:** is the mean of the shortest path lengths among all connected pairs in the ego network.
- **Diameter of an ego network:** is the length of the longest path between connected actors (just as it is for any network). The idea of a network diameter is to index the span or extensiveness of the network.



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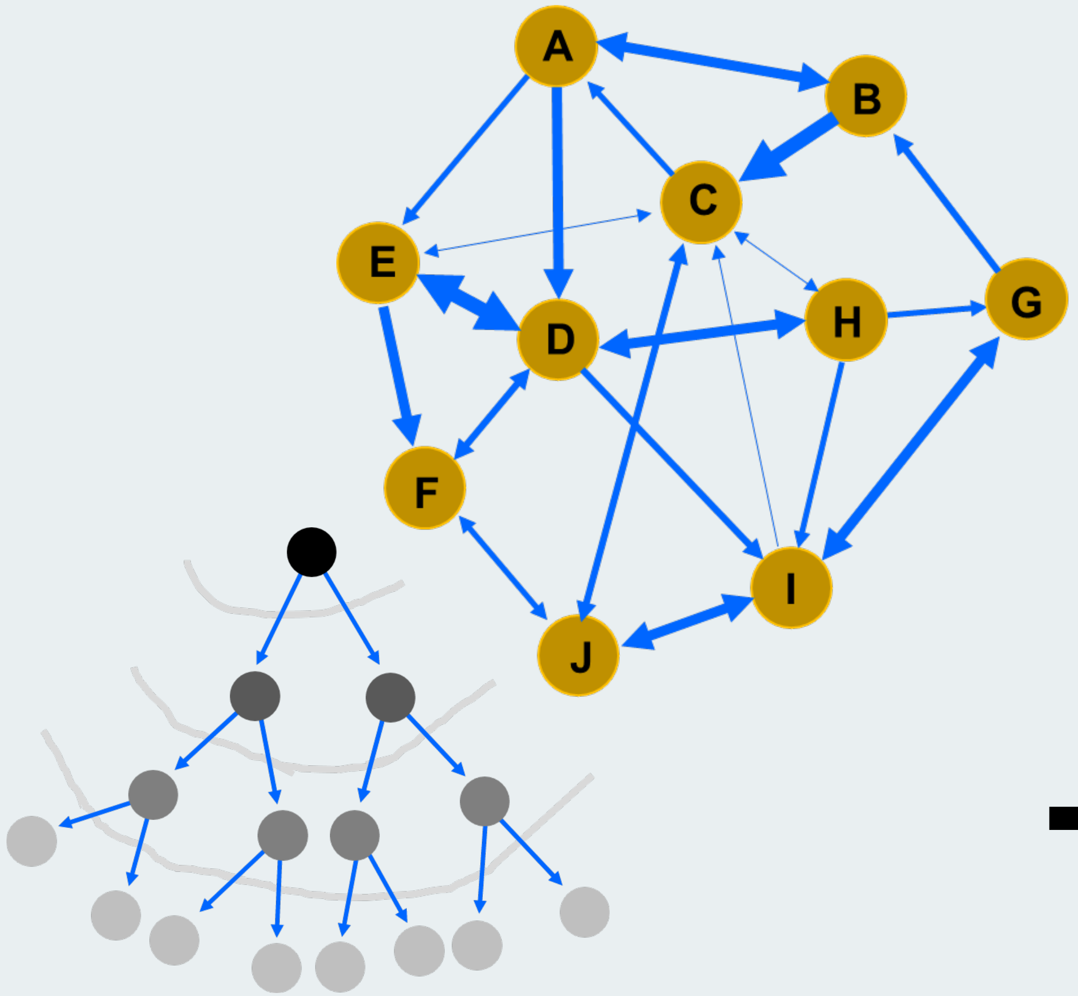
Quantify Ego-network Structure

- **Two-step reach**: goes beyond ego's one-step neighborhood to report the percentage of all actors in the whole network that are within two directed steps of ego.
- "**Reach efficiency**" (two-step reach divided by size) norms the two-step reach by dividing it by size.



Wasserman, S., & Faust, K. (1994). Social network analysis: Methods and applications.

E-I Index for the Ego

Ego-level Homophily

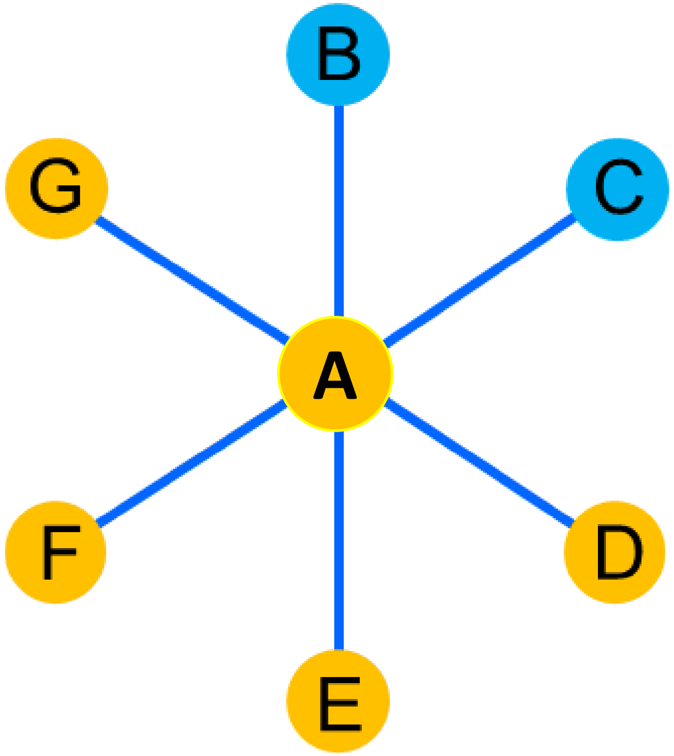
– The EI homophily index is a measure of *in- and out-group preference.* One simply subtracts the number of out-group ties from the number of in-group ties, divided by the total number of ties.

$$EI = \frac{External - Internal}{External + Internal}$$

– Thus, an EI score of -1 means complete homophily- the individual only has relationships with actors of the same “type” as they themselves are. An EI score of 1 means complete heterophily- all the alters are of a different “type” than they themselves are. Finally, an EI score of 0 means that an equal number of alters are of both the same “type” as the ego, and different types.

E-I Index for the Ego

Ego-level Homophily



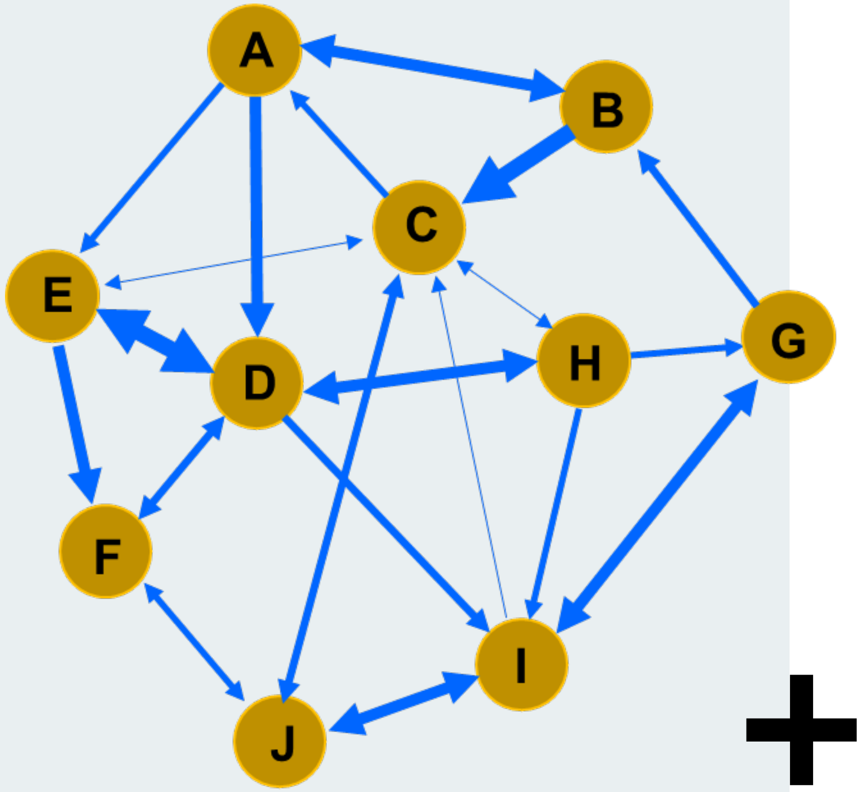
A is the Ego

$$EI = \frac{External - Internal}{External + Internal} = \frac{2-4}{2+4} = \frac{-2}{6}$$

$$= -0.3333$$

Brokerage

– **Brokerage** (number of pairs not directly connected). The idea of brokerage is that ego is the "**go-between**" for pairs of other actors. In an ego network, the ego is connected to every other actor. If these others are not connected directly to one another, the ego may be a "broker" that falls on the paths between the others.



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Structure Hole

- **Structural holes** are a concept from social network research, originally developed by Ronald Stuart Burt. The study of structural holes spans the fields of sociology, economics, and computer science. Burt introduced this concept in an attempt to explain the origin of differences in social capital.
- Burt's theory suggests that individuals hold certain positional advantages/disadvantages from how they are embedded in neighborhoods or other social structures. A structural hole is understood as a gap between two individuals with complementary information sources.

https://en.wikipedia.org/wiki/Structural_holes
Wasserman, S., & Faust, K. (1994). Social network analysis: Methods and applications.

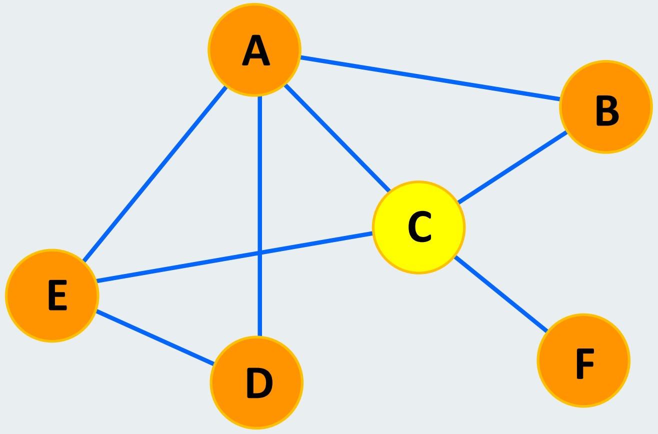
Structure Hole – Redundancy

– **Redundancy**

$$redundancy_{ij} = p_{iq}m_{jq}$$

where p_{iq} is proportion of i's energy invested in relationship with q, and m_{jp} is calculated as j's interaction with q divided by j's strongest relationship with anyone.

$$alter\ A = \frac{1}{4} \times 2$$



For Ego(**C**) | A | B | D | E | F |

Redundancy 2/4 1/4 2/4 1/4 0/4 = 0.3

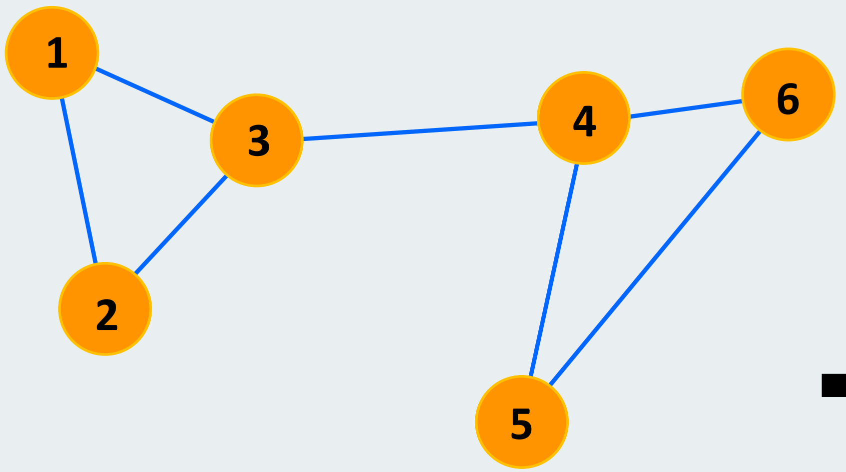
Effective Size (C) = # of alters – Sum(redundancy of C's alters) = 4 – 1.5 = 2.5

Structure Hole – Effective Size

– The **effective size** of the network is the number of alters that the ego has minus the average number of ties that each alter has to other alters.

$$effective\ size = size - redundancy$$

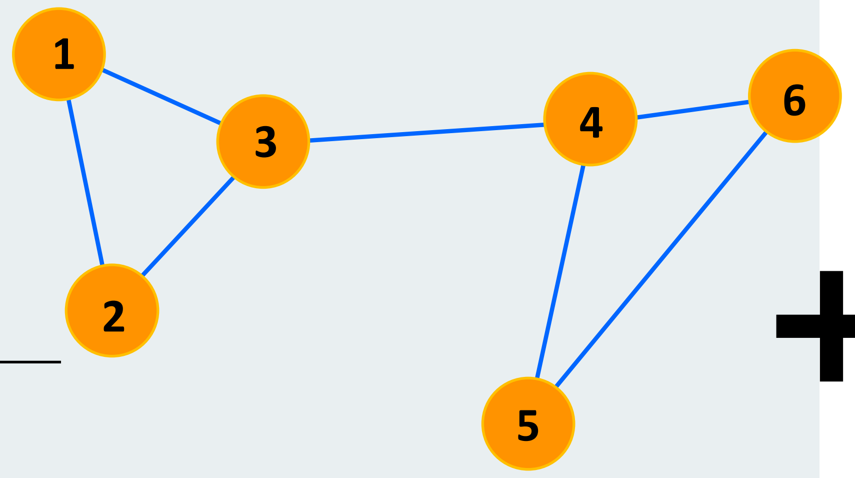
Node	Size	Redundancy	Effective Size	Efficiency
1	2	1	1	0.5
2	2	1	1	0.5
3	3	0.667	2.333	0.778
4	3	0.667	2.333	0.778
5	2	1	1	1
6	2	1	1	1



Structure Hole – Efficiency

– **Efficiency** norms the effective size of ego's network by its actual size.

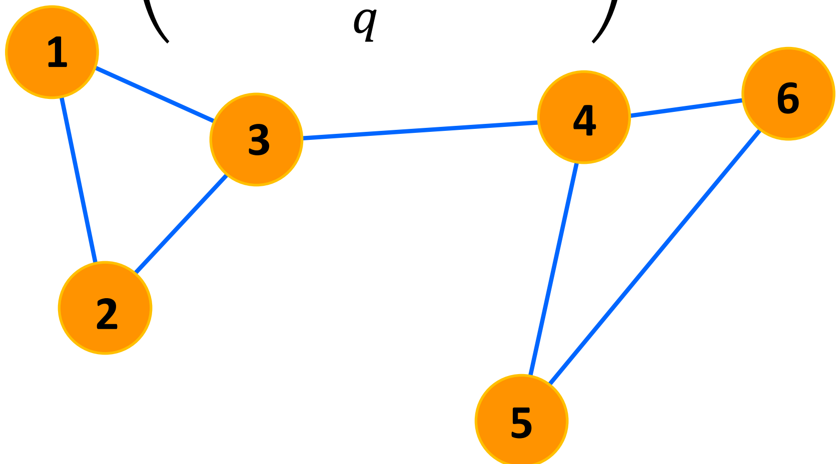
Node	Size	Redundancy	Effective Size	Efficiency
1	2	1	1	0.5
2	2	1	1	0.5
3	3	0.667	2.333	0.778
4	3	0.667	2.333	0.778
5	2	1	1	1
6	2	1	1	1



Structure Hole – Constraints

- **Constraints** is a summary measure that taps the extent to which ego's connections are to others who are connected to one another.

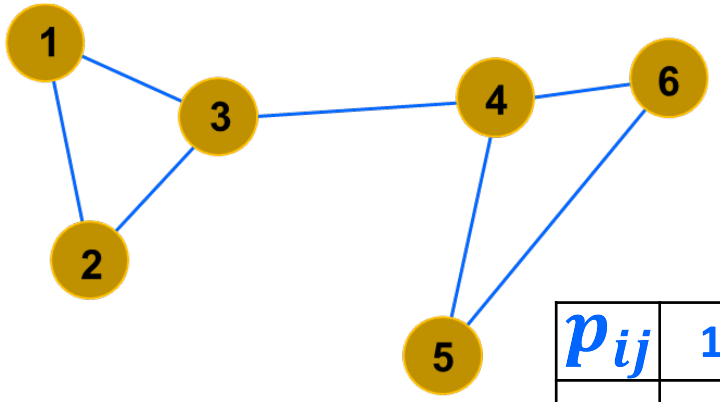
$$c_{ij} = \left(p_{ij} + \sum_{q} p_{iq} p_{qj}\right)^2, i \neq q \neq j$$



p_{ij}	1	2	3	4	5	6
1	0	0.5	0.5	0	0	0
2	0.5	0	0.5	0	0	0
3	0.3	0.3	0	0.3	0	0
4	0	0	0.3	0	0.3	0.3
5	0	0	0	0.5	0	0.5
6	0	0	0	0.5	0.5	0

A	1	2	3	4	5	6
1	0	1	1	0	0	0
2	1	0	1	0	0	0
3	1	1	0	1	0	0
4	0	0	1	0	1	1
5	0	0	0	1	0	1
6	0	0	0	1	1	0

Structure Hole – Constraints



$$c_{ij} = \left(p_{ij} + \sum_{q} p_{iq}p_{qj}\right)^2, i \neq q \neq j$$

p_{ij}	1	2	3	4	5	6
1	0	0.5	0.5	0	0	0
2	0.5	0	0.5	0	0	0
3	0.3	0.3	0	0.3	0	0
4	0	0	0.3	0	0.3	0.3
5	0	0	0	0.5	0	0.5
6	0	0	0	0.5	0.5	0

p^2	1	2	3	4	5	6
1	0	0.167	0.250	0.167	0	0
2	0.167	0	0.250	0.167	0	0
3	0.167	0.167	0	0	0.111	0.111
4	0.111	0.111	0	0	0.167	0.167
5	0	0	0.167	0.250	0	0.167
6	0	0	0.167	0.250	0.167	0

Structure Hole – Constraints

$$c_{ij} = \left(p_{ij} + \sum_{q} p_{iq}p_{qj}\right)^2, i \neq q \neq j$$

$p+p^2$	1	2	3	4	5	6
1	0	0.667	0.750	0.167	0	0
2	0.667	0	0.750	0.167	0	0
3	0.500	0.500	0	0.333	0.111	0.111
4	0.111	0.111	0.333	0	0.500	0.500
5	0	0	0.167	0.750	0	0.667
6	0	0	0.167	0.750	0.667	0

$(p+p^2)^2$	1	2	3	4	5	6
1	0	0.444	0.563	0.028	0	0
2	0.444	0	0.563	0.028	0	0
3	0.250	0.250	0	0.111	0.012	0
4	0.012	0.012	0.111	0	0.250	0.2500
5	0	0	0.028	0.563	0	0.5625
6	0	0	0.028	0.563	0.444	0

Structure Hole – Constraints

$$c_{ij} = \left(p_{ij} + \sum_{q} p_{iq} p_{qj}\right)^{2}, i \neq q \neq j$$

$(p + p^2)^2$	1	2	3	4	5	6
1	0	0.444	0.563	0.028	0	0
2	0.444	0	0.563	0.028	0	0.444
3	0.250	0.250	0	0.111	0.012	0.250
4	0.012	0.012	0.111	0	0.250	0.012
5	0	0	0.028	0.563	0	0
6	0	0	0.028	0.563	0.444	0

Row Sum →

	constraint
1	1.006944
2	1.006944
3	0.611111
4	0.611111
5	1.006944
6	1.006944

Paper Reading

The American Review of Public Administration
41(2) 205–223

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http://arp.sagepub.com
SAGE

Exploring the Role of Social Networks in Affective Organizational Commitment: Network Centrality, Strength of Ties, and Structural Holes

Jooho Lee[1] and Soonhee Kim[2]

Abstract

Although studies in public management have identified personal attributes, job characteristics, and organizational rewards as key factors that influence affective organizational commitment, limited attention has been paid to the influence of social networks on affective commitment. Given that organizational attitudes and behaviors are often socially constructed, this article argues that employees' affective commitment is influenced by their social networks in an organization. What are the social network configurations that lead to affective organizational commitment? This study attempts to answer this question by focusing on nonlinear relationships between several network dimensions (i.e., network centrality, tie strength, and structural holes) and affective commitment. These relationships are empirically tested by using both social network data and employee survey data collected from two local governments in South Korea. Results of the study show that employees' network centrality has an *inverted* U-shaped relationship with affective commitment and structural holes have a U-shaped association with affective commitment, controlling for certain organizational rewards and individual attributes. However, the relationship between a tie strength and affective commitment is not statistically significant. The practical and theoretical implications of the study findings are discussed.

Lee, J., & Kim, S. (2011). Exploring the role of social networks in affective organizational commitment: Network centrality, strength of ties, and structural holes. The American Review of Public Administration, 41(2), 205-223.

Questions:

1. What is the objective of this paper?
2. What are the nodes (actors) and edges (ties) of transportation network in this paper?
3. What are the findings of this study?
4. If you want to achieve the same objective, how do you formulate the network?

References

- Wasserman, S., & Faust, K. (1994). Social network analysis: Methods and applications.
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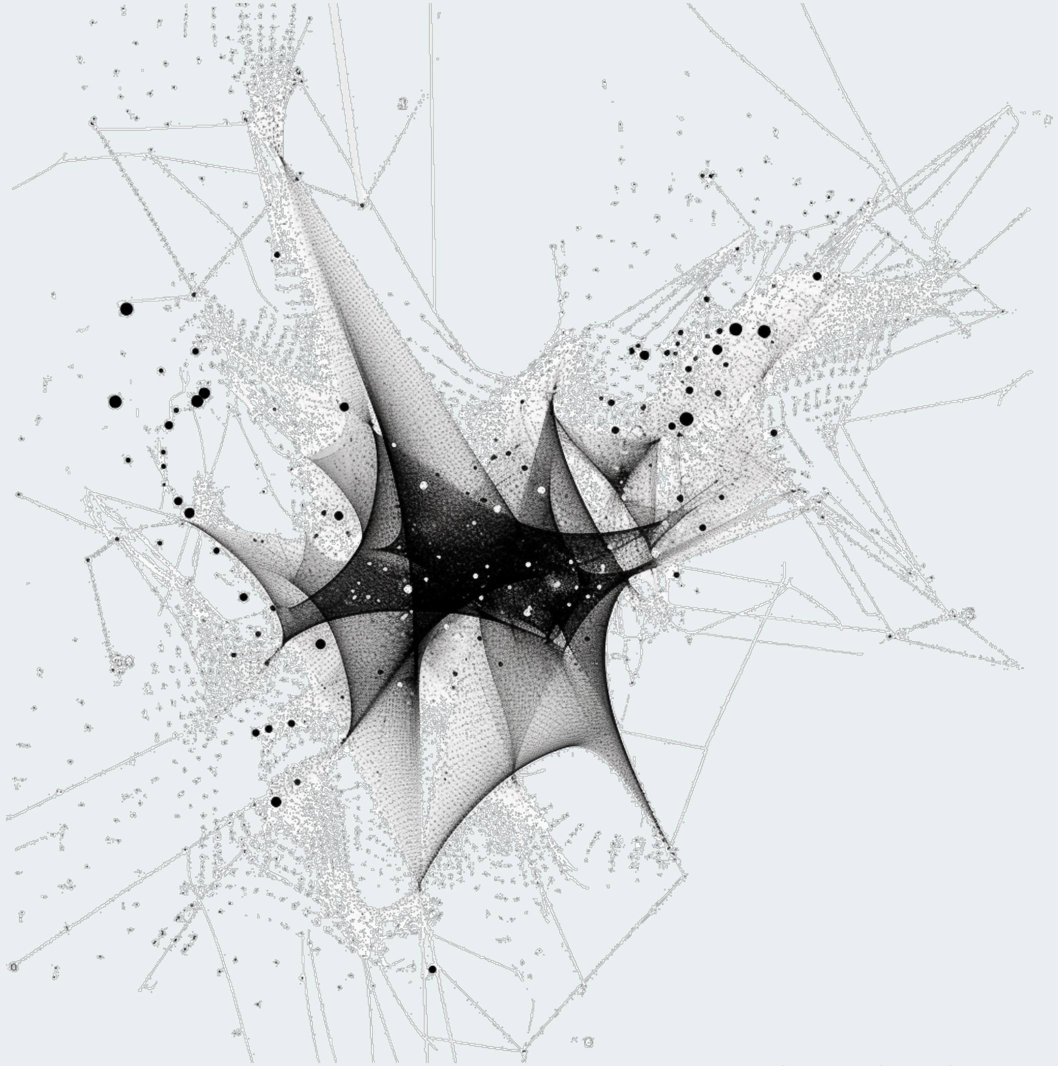

Photo credit: midjourney

The End

Thank you for your attention!

Email: chchan@ntnu.edu.tw
Website: toodou.github.io

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