20/06

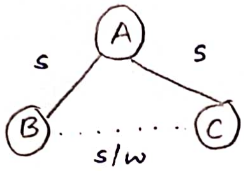
Behaviour and dynamics

- Level of structure who is linked to whom? [connectedness]
- Level of behaviour how one person's action affects others

→ To study the structure of the n/w, graph theory is used. Similarly, game theory is used to study the behaviour.

Strong and weak ties

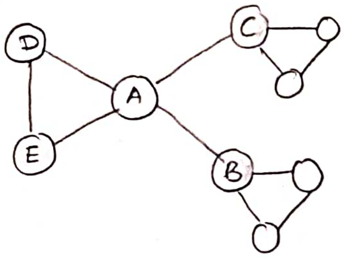
- Strong ties represent close and frequent social contacts whereas weak ties represent more casual and distinct social contains



Given that B-A and C-A are strong ties, BC can be a strong/weak tie.

- Triadic closure is used to recommend friends in social networks.

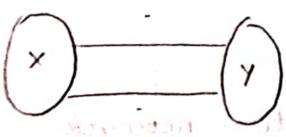
Structural hole



- Network in the form of graph. A is connected to all the members.
  A has the secret from B and C. Now, he has the authority to let D and E know about it or keep up the secret (disadvantage).

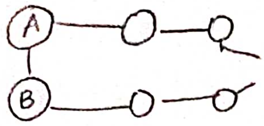
- 6 degrees of separation

Structural balance



Not all networks are balanced structurally.
X has group of united people who don't share their plans to Y

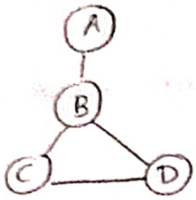
- Triadic closure, structural hole and structural balance come under graph theory which is used to study the structure and how it affects the network.
- Cascading effect (social contagion) spreads from one person to another in the style of a biological epidemic.



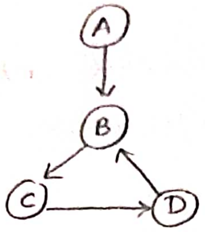
The price of a product can be determined using the cascading behaviour so that many people in the network buy.

Start

Graphs, nodes and edges



Undirected graph



Directed graph

Three types of network

i) Communication n/w

Nodes - computer / device that relay msgs

Edges - direct links through which msgs can be transmitted

ii) social n/w

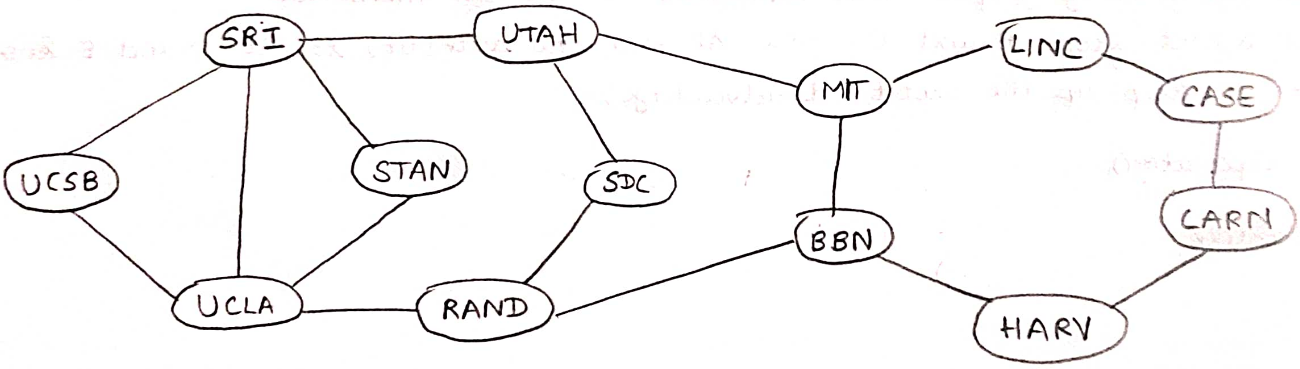
Nodes - people / groups of people

Edges - some kind of social interaction

iii) Information n/w

Nodes - Webpages

Edges - Links



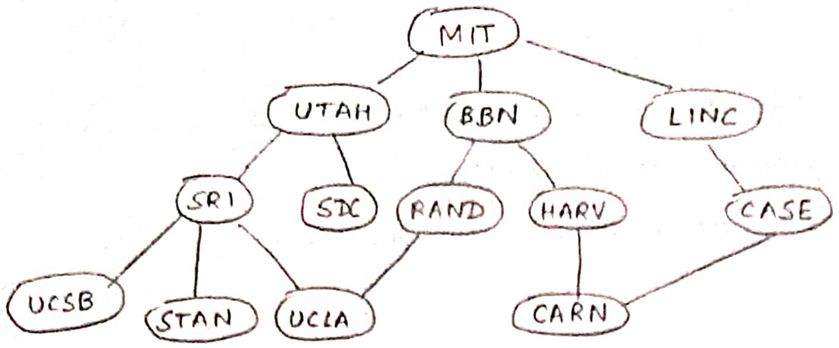
13 Node Internet graph which is a communication network.

Path : Set of nodes traversed from start to end node

Cycle : If beginning and end node is same

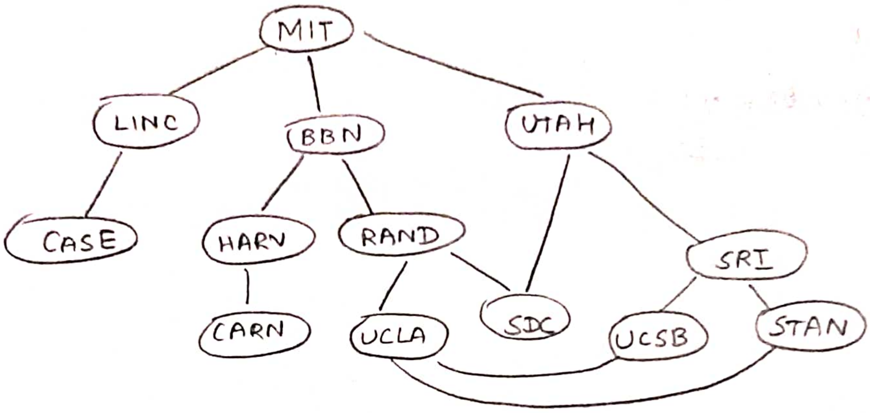
Redrawing the above graph for BFS

start node : MIT



21/06

Mam's version.



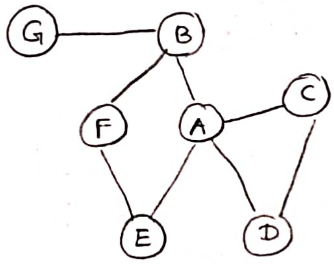
Easily find the neighbours and the distance between them by drawing BFS.

▲ Distance and Breadth First Search

Strong and weak ties

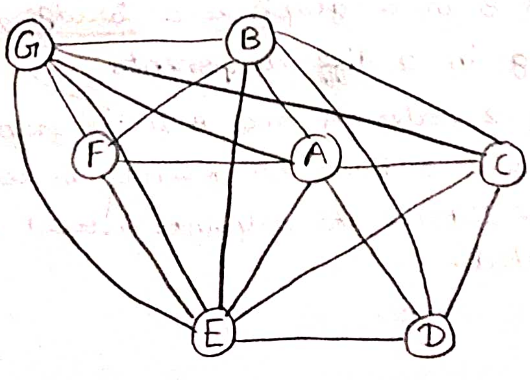
Triadic closure

If two people in a social network have a friend in common, then there is an increased likelihood that they become friends themselves at some point in the future.



← GRAPH 1

Applying triadic closure to the above graph, new edges are formed as below.



Clustering coefficient

Clustering coefficient of node A is defined as a probability that 2 randomly selected friends of A are friends with each other.

In other words, it is the fraction of pairs of A as friends that are connected to each other.

Consider node A of graph 1

BE, BC, BD, ED, CE, CD

Only CD is connected

So, clustering coefficient $= \frac{2}{4}$ — No. of friends connected / No. of total friends

// Consider node A only!

Reasons for triadic closure

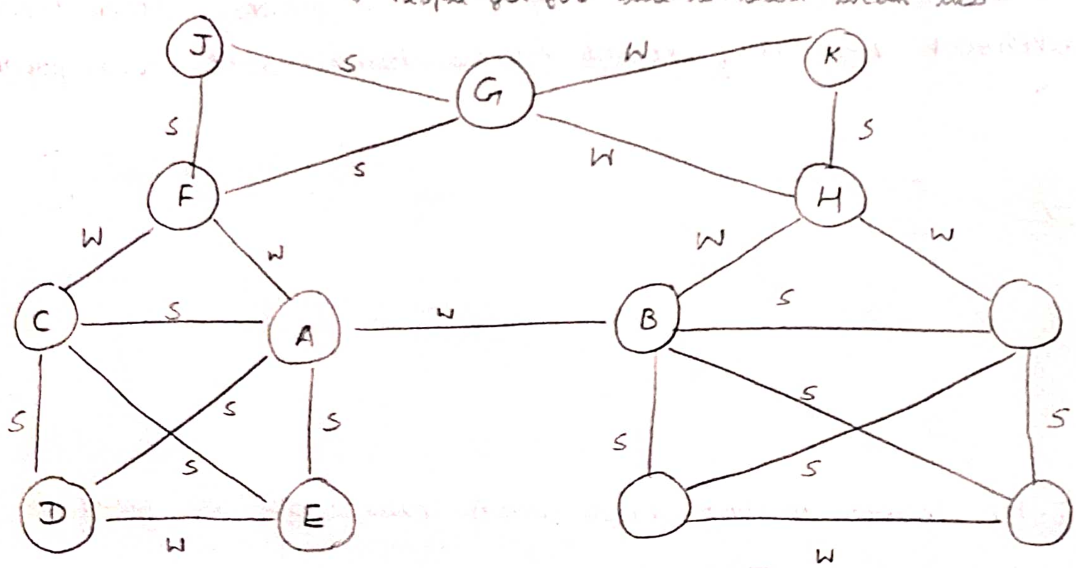
" Link prediction"

1) Opportunity
2) Trusting
3) Incentive

<u>25/06</u>

Strengths of weak ties

// People get job due to their weak ties



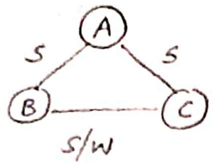
Graph 'A'

- The edge joining 2 nodes A and B in a graph is a bridge, if deleting the edge causes A and B lying in 2 diff components.
- Local bridge → an edge joining 2 nodes A and B in a graph is a local bridge if its endpoints A and B have no friends in common.
  The span of a local bridge is the distance its endpoints would be from each other if the edge is deleted.

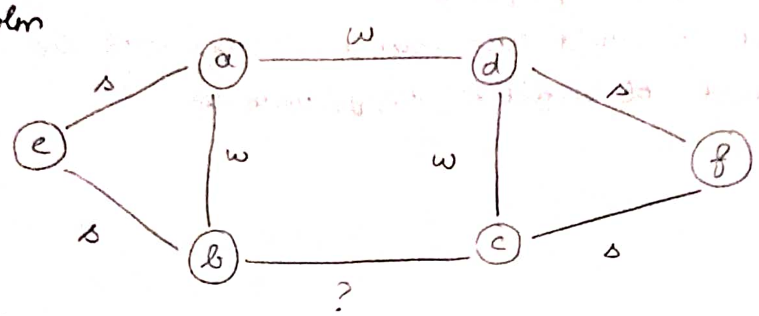
A to B via F - span 4

Strong triadic closure property

If a node A has an edge to nodes B and C, then BC edge is especially likely to form if A's edges to B and C are both strong ties.



Pblm



? is strong / weak tie

Ans 1 : e-a-b forms a component and d-f-c also forms a component according to strong triadic closure property.

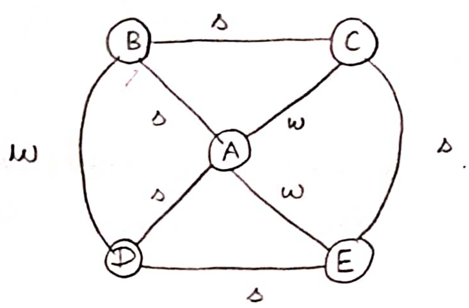
Ans 2 : If b-c is strong there should be a s/w tie between e and c.

Chap 3 pblms ?

HW

Exercises 3.7

3)

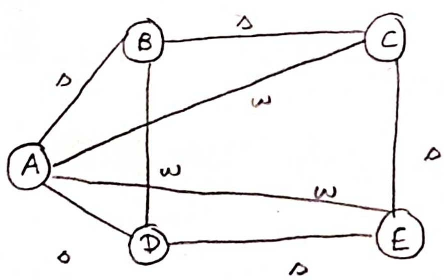


ABC → A and C is connected to B using a strong tie, AC bond is weak.

BAD → B and D is connected to A using strong tie, BD is weak tie

ADE → D is common friend, AE is weak tie

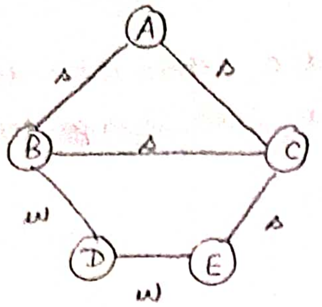
4)



BCE : C is a common friend connected to B and E using strong tie. BE should have been a strong / weak tie.

DEC : E is a common friend connected to D and C using strong ties. DC should be a strong / weak tie.

5)



- ABC satisfy the strong triadic closure property.
- ACE → C is a common friend, AE should have been a strong / weak tie.
- BCE → C is a common friend, BE should be strong / weak tie

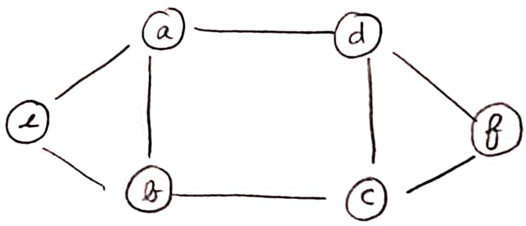
27/06

Neighbourhood overlap

Neighbourhood overlap of an edge connecting A and B is the ratio.

$$\frac{\text{No. of nodes who are neighbours of both A and B}}{\text{No. of nodes who are neighbours of atleast one of A or B}}$$

Find out the neighbourhood overlap of AF

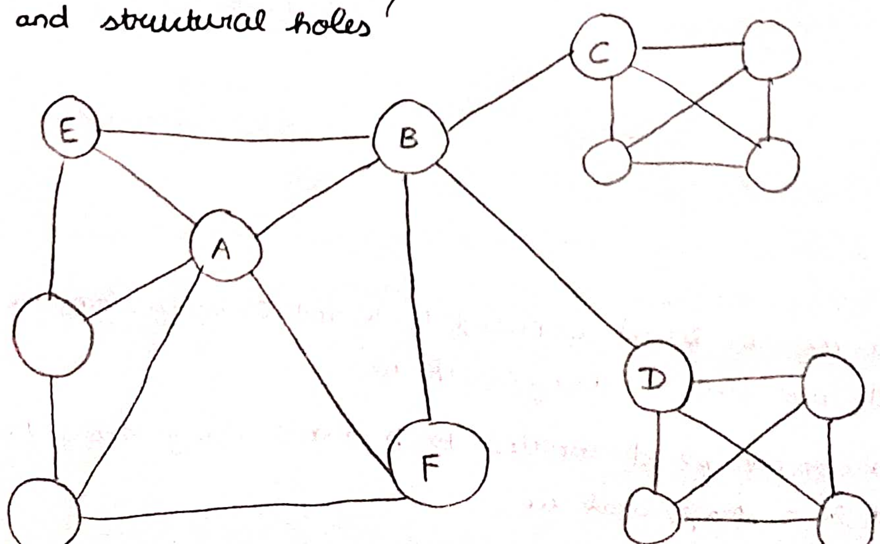


Neighbours of 'a' : e, b, d
Neighbours of 'f' : d, c
Neighbourhood overlap = $\frac{1}{4}$

For the 'Graph A' in previous page : $\frac{1}{6}$

Pg 66 & 67

Closure and structural holes



Adv: Say B has connections to other organisations through C and D. B can take the organisational ideas and implement it in their own org.

Disadv: If B gets access to info and keeps it confidentially, the information is not passed when needed.

Embeddedness

Embeddedness of an edge in a network is the no. of common neighbours the two endpoints have.

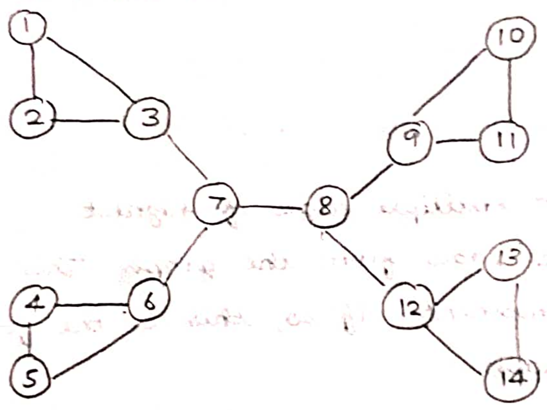
Find embeddedness of edge A-B in above graph

E and F are common neighbours of A and B. So, embeddedness = 2

Methods for graph partitioning

1) Agglomerative

2) Divisive



Betweenness of an edge is defined to be the total amount of flow it carries, counting flow between all pairs of nodes using this edge.

Betweenness of 7-8 edge

From node 1 to {8, 9, 10, 11, 12, 13, 14} = 7 nodes

From node 2 to {8, 9, 10, 11, 12, 13, 14} = 7 nodes

⋮

From node 7 to {8, 9, 10, 11, 12, 13, 14} = 7 nodes

So, betweenness is 7 X 7 = 49

Betweenness of 3-7 edge

3 X 11 = 33

Betweenness of 1-3 edge

1 X 12 = 12 // Node 2 is not considered, you can directly reach

28/6

Mam's explanation:

- 1 unit flow flows from node 1 to nodes 8, 9, 10, 11, 12, 13, 14. Full unit of flow passing from 7-8 edge is $7 \times 7 = 49$
∴, the betweenness of 7-8 edge is 49.

- 3-7 edge carries the full unit of flow from each node among 1, 2 and 3 to each node among 4-14. ∴, the betweenness of this edge is $3 \times 11 = 33$
Same goes for edges 6-7, 8-9 and 8-12.

- 1-2 edge only carries flow between its endpoints. So its betweenness is 1
Edges 4-5, 10-11 and 13-14 also hold this. (from book!)

swap

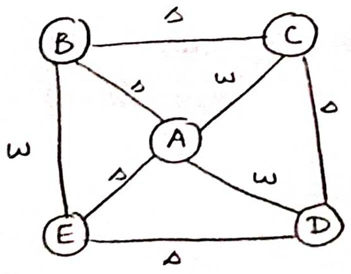
- The 1-3 edge carries all the flow from 1 to every other node except 2. As a result its betweenness is 12. By strictly symmetric reasoning, the other edges linked from 3, 6, 9 and 12 into their respective Δles have betweenness 12 as well.

Girvan-Newman method's algorithm: // Successively deleting edges of high b/w ...

(1) Find the edge of highest betweenness - or multiple edges of highest betweenness, if there is a tie - and remove edges from the graph. This may cause the graph to separate into multiple components. If so, this is the first level of regions in the partitioning of the graph.

(2) Now recalculate all betweenness, and again remove the edge or edges of highest betweenness. This may break some of the existing components into smaller components. If so, these are the regions nested within larger regions

(...) Proceed in this way as long as edges remain in graph, in each step recalculating all betweenness and removing the edge or edges of highest betweenness.



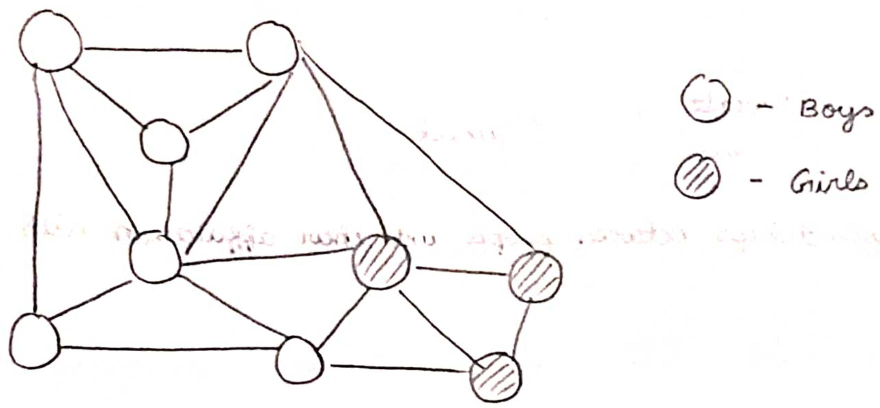
Strong triadic closure?

(Doubt) ABC, AED and BAE satisfy strong triadic closure property.
BCD, BED, ECD, ACD, BEC → don't satisfy

Homophily (Networks in their surrounding contexts)

One of the basic notions governing the structure of social networks is homophily - the principle that we tend to be similar to our friends.

Homophily test : If the fraction of cross - gender edges is significantly less than $2pq$, then there is evidence for homophily.



- We have a n/w in which 'p' fraction of all individuals are male and 'q' fraction of all individuals are female.
- If we independently assign each node the gender male with prob. p and gender female with prob. q, then both ends of edge will be male with prob. p^2 and both ends will be female with prob. q^2.
- On the other hand, if the first end of the edge is male and second is female or vice versa, then we have a cross gender edge with prob. $2pq$.

Total no. of edges = 18

No. of cross gender edges = 5

So, $\frac{5}{18}$

Total no. of nodes = 9

$p = \frac{6}{9} = \frac{2}{3}$ and $q = \frac{3}{9} = \frac{1}{3}$

$2pq = 2 \times \frac{2}{3} \times \frac{1}{3} = \frac{4}{9}$

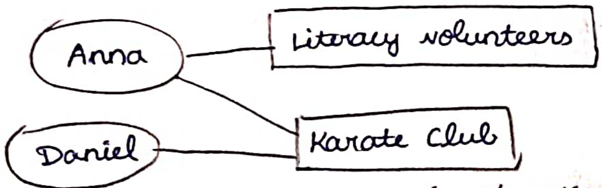
$\frac{5}{18} < \frac{4}{9}$, so homophily exists.

02/07

Mechanisms underlying homophily

- Selection and social influence (Pg 91)

Affiliation network

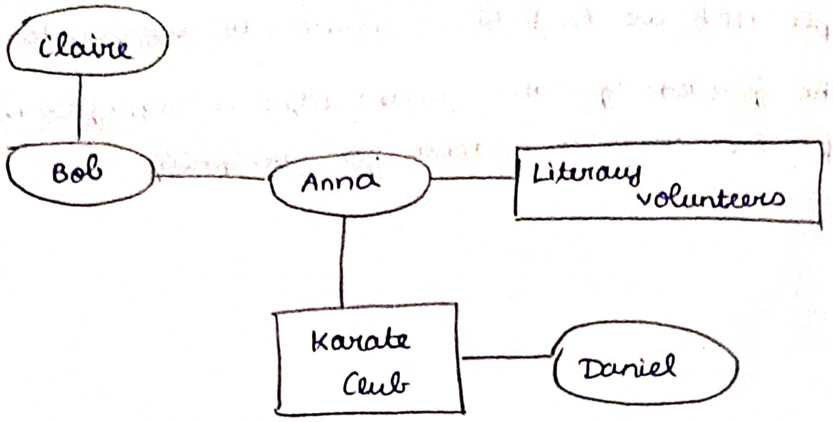


Nodes on each side are not connected.

It is a bipartite graph that shows which individuals are affiliated with which groups / activities.

People are ~~not~~ connected to ppl and activities not connected to activities

Coevolution of social and affiliation networks

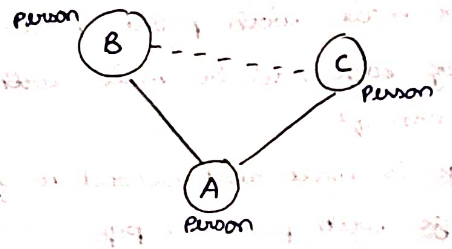


Shows both the friendships between people and their affiliation with different social foci.
Group/ activity

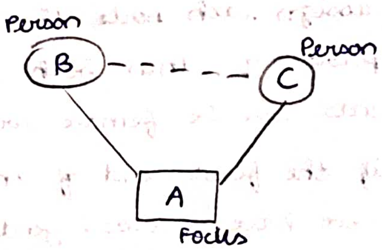
// Both Anna and Daniel go to Karate club and there is a possibility that they become friends.

// Anna can tell Bob about Literary volunteers and Bob may join.

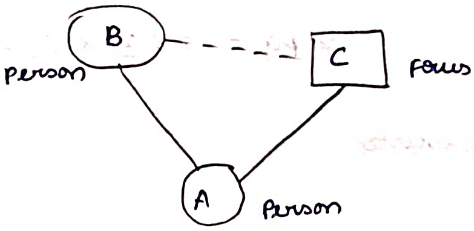
Different closures



(Triadic closure)

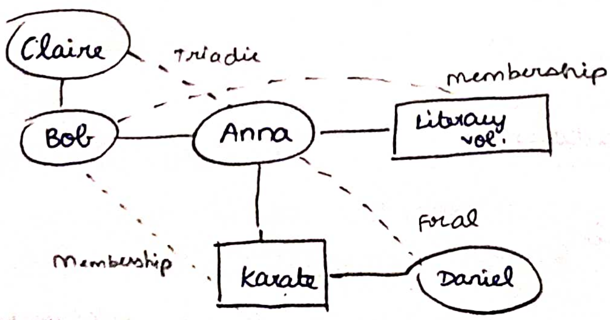


(Focal closure)



(Membership closure)

Applying all the closures to the above graph:



A spatial model of Segregation

Schelling model

04/07

Agents of diff. kind occupy a space that is split into grids

Higher threshold → when the space is very large

Suppose, threshold value is 3 and neighbours of same type < 3, the agent has to move!

X_1'	X_2'				
X_3	O_1'		O_2		
X_4	X_5	O_3	O_4	O_5'	
X_6'	O_6			X_7	X_8
	O_7	O_8	X_9'	X_{10}	X_{11}
		O_9	O_{10}	O_{11}'	

← Initial configuration

i) Start with X_1. Move it to a place that is empty and where X_1 will have similar neighbours greater than or equal to threshold. (See diagonal also!)

ii) Next is X_2 and subsequently others

X_3	X_6	O_1	O_2		
X_4	X_5	O_3	O_4		
	O_6	X_2	X_1	X_7	X_8
O_5	O_7	O_8	X_9	X_{10}	X_{11}
O_{10}	O_{11}	O_9	O_{10}		

For every move check every node's threshold!

Every agent is accumulated in specified places (group of same agents are formed).