Social Network

- A social network is social structure of people, related to each other through a common relation or interest.
- SNA is study of social networks to understand their structure & behaviour.

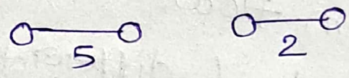
People - nodes
~~en~~ relations - edges

Social Network Analysis
→ Sociocentric (whole)
→ Egocentric

Types of social relations
→ friendship
→ a~~g~~cquaintance
→ kinship
→ advice
→ hindrance
→ sex.

Strength of Tie

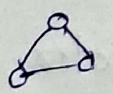

dichotomous


valued

class code :- $\boxed{\text{3c4fmde}}$

 actor

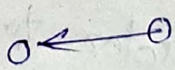
 dyad.

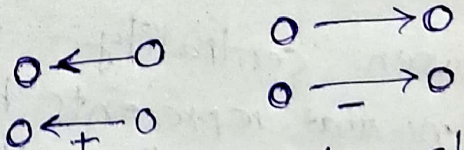
 triad.

friendship Relations.

kinship

 adjacent node to

 incident node to



3 isomorphism classes
~~conv~~
→ null dyad.
→ mutual dyad.
→ asymmetric.

converse of graph :-
Reverse direction of all arcs.

Density :- $\frac{\text{Number of ties that are present}}{\text{amount of ties that can be present}}$

out-degree :- sum of connections from an actor to others.

In-degree :- sum of connections to an actor.

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* Distance

- walk :- sequence of actors & relations that begins & ends with actors.

- Geodesic distance :- the shortest possible walk
  Number of relationship in from one actor to another.

- Maximum flow :-
  amount of different actors in neighbourhood of a source that lead to pathways to Target.

- Degree :- sum of connections from or to an actor.

- closeness centrality :-
  - Dist. of one actor to all others.

- Between centrality :-
  no. that represents how frequently an actor is between other actor's geodesic path.

centrality Measures :-

Who is the most prominent ?

Degree ← → Who knows the most actors?

* Who controls knowledge flow ? → Between.

* Who has shortest distance ?
  ↳ closeness

Who has more power?

What are LinkedIn connections?

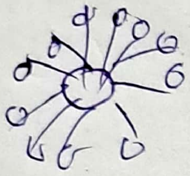
1st - directly connected

2nd - people connected to 1st degree

3rd - people connected to 2nd degree.

Why 6 degrees of separation? 6 degrees of ~~Freedom~~. separation

Each friend connected to 44 people



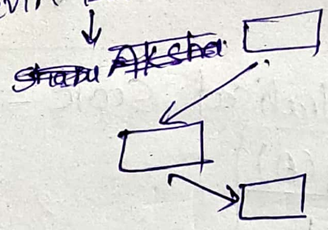
$(44)^6 \approx 7.26$ Billion people

small world theorem.

You can get job connections easily through Random acquaintances than through your close friends! - Veri~~s~~tasium.

strength of weak Tie.

The oral of Bacon! → Kevin Bacon



Bacon : 3.

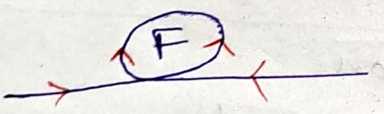
Erdős Number project.

• Adjacency Matrix └ one mode • Affiliation Matrix └ Two mode.	Adjacency matrix vs Attribute Matrix

order :- no. of nodes in graph.
cardinality :- no. of edges.
size :- max. no. of edges, ie $\frac{n(n-1)}{2}$ for undirected.
$n(n-1)$ for directed.

Degree centrality
↳ for directed node → in-degree, → out-degree.

Average degree ⇒ $\frac{Deg(A) + Deg(B) + \cdots Deg(N)}{n}$



• Loop
• $Deg(F) = 4$

?

Degree centralised score = $\frac{\cancel{Deg(A)}}{\cancel{max(\text{Deg of an any node})}}$

= $\boxed{\frac{Deg(A)}{n-1}}$

?

standardised score or normalised form.

---

closeness centrality :- ⇒ ~~avg (dist with all nodes)~~

⇒ inverse of sum of distance between a node & other nodes in a network.

closeness score ⇒ $\frac{1}{\text{total dist}}$

standardised score → $\frac{1}{\text{total dist}} \times (n-1)$

most closest node ⇒ ~~sta~~ highest standardised score

Betweenness centrality :-

$$g(v) = \sum_{s \neq v \neq t} \frac{\sigma_{st}(v)}{\sigma_{st}}$$

$$normal(g(v)) = \frac{g(v) - min(g)}{max(g) - min(g)}$$

which results in max normal ⇒ 1

σ_{st} is total no. of shortest path from $s \rightarrow t$.

$\sigma_{st}(v)$ is no. of paths passing through v. ('v' is not 's' or 't')

~~v is not~~

Q] For friendship network, which is most popular person?

ans:- degree centrality (but there is never fixed answer)

Q] Find section in an information flow network that can most efficiently ~~for info~~ flow info?

ans:- closeness centrality.

Q] Which section controls, information flow?

ans:- betweeness centrality

THANK YOU!

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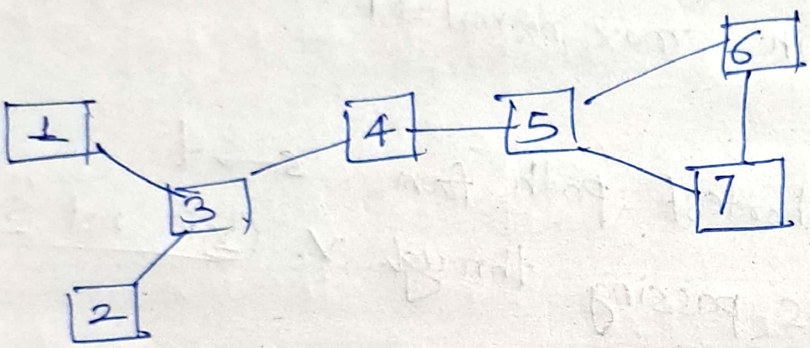
* do all maths yourself.
* GEPHI network Lab pratical.
* Install NetworkX.
* Next to Next class :- Quiz.

Data Management :-

- Adjacency Matrix.
  - Asymmetric binary
  - Asymmetric weighted.
- Affiliation Matrix.



consider only paths involving 4 in them.
As they will have contribution in Betweeness.

(1-3) ✗ (1-5) ✓

1-3-4-5

Node 3

1-2	1
1-4	1
1-5	1
1-6	1
1-7	1
2-4	1
2-5	1
2-6	1
2-7	1
	9

for directed divide by $(n-1)(n-2)$

for undirected divide by

$$\frac{(n-1)(n-2)}{2} = \frac{(7-1)(7-2)}{2} = 15$$

Hence:- $\frac{9}{15}$ (Here undirected).

Node 5

1 − 6	1
1 − 7	1
2 − 6	1
2 − 7	1
3 − 6	1
3 − 7	1
4 − 6	1
4 − 7	1
6 − 7	0 ⇒ not 5 in between

$\boxed{\frac{8}{15}}$

node	score
1	0
2	0
3	$\frac{9}{15}$
4	$\frac{9}{15}$
5	$\frac{8}{15}$
6	0
7	0

Another formula

$$\text{Between}(s,t) = \frac{\text{no. of paths}}{\text{no. of nodes}}$$

ex:- Between.

$(1,5) \Rightarrow \frac{1}{2}$ 1 — $\boxed{3 — 4}$ — 5

$(3-5) \Rightarrow \frac{1}{1}$ 3 — 4 — 5.

$(2-5) \Rightarrow \frac{1}{2}$ 2 — $\boxed{3 — 4}$ — 5

$(2-7) \Rightarrow \frac{1}{3}$ 2 — $\boxed{3 — 4 — 5}$ — 7

Graph Measures :-

★ Eccentricity ($\varepsilon(v)$)

$\varepsilon(v)$ of vertex 'v' in connected graph G is max. graph distance between v and any other vertex u of G.

$$\varepsilon(v) = \max_{u \in V} d(u, v)$$

For disconnected point $\varepsilon(v) = \infty$.

- **Diameter** :- max eccentricity
- **Radius** :- min eccentricity
- **Central Point** :- $\varepsilon(v)$ = Radius

Eigenvector centrality (You are powerful if friends are powerful)

Influence of node in network:-

Importance of node depends on importance of its neighbours in recursive manner.

$$Av = \lambda v$$

select an eigen vector associated with largest eigen value

Eigen Vector $\boxed{A - \lambda|I| = 0}$

- A is some matrix.
- size of matrix, tells no. of Eigen values

ex:- 3x3, then 3 eigen values

Greatest Eigen value is EigenVector Centrality

~~Compute~~ A is adjacency matrix Here.

Katz centrality

- almost same as Eigen vector centrality.
- quality (who) and quantity (how many) matters
- Also considers Attenuation in influence.

Bonacich centrality

Two parametric centrality measure $c(\alpha, \beta)$.

α is normalisation factor

β can be +ve or -ve.

+ve → connected to powerful

-ve → connected to weak node.

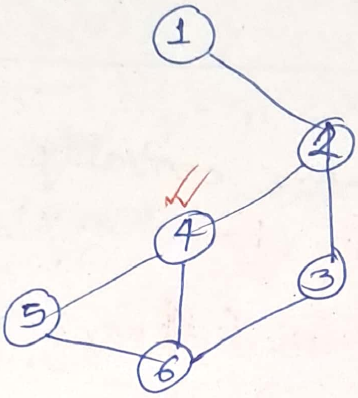
Eigen vector centrality works well for strongly connected network. but not for weakly connected network.

Eigenvector Centrality Example :- exam question

Solve $A - \lambda I$.

$\lambda = 2, 1, \underline{2.54}, 1.5$
max.

$$v = \begin{array}{c} \begin{bmatrix} 0.31 \\ 0.79 \\ 0.69 \\ \boxed{1.00} \\ 0.78 \\ 0.97 \end{bmatrix} \end{array} \begin{array}{c} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{array}$$

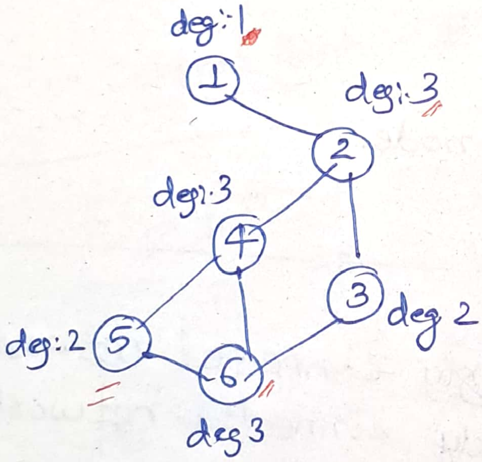


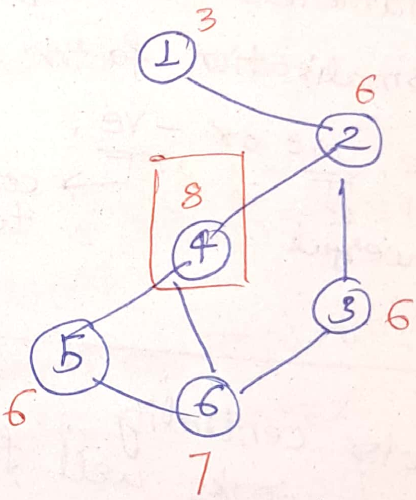
$Av = 2.54\,v$

choose eigen vector v, with highest eigen value.

(use. Matrixcalc.org
Matrix calculator)

Trick : add degree of your friends.





new power = sum of power of neighbours

Intuitive Approach (Power iteration method)

net power ← sum of power of neighbours

normalise (divide by max, Here 52

	0	1	2	3	4	
1	1	1	3	6	17	0.32
2	1	3	6	17	38	0.73
3	1	2	6	13	37	0.71
4	1	3	8	19	52	1.00
5	1	2	6	15	39	0.75
6	1	3	7	20	47	0.90

similar as → eigen vector

$$v = \begin{bmatrix} 0.31 \\ 0.79 \\ 0.69 \\ 1.00 \\ 0.78 \\ 0.97 \end{bmatrix}$$

why stop at round 4? (~~no answer~~ search at Home).

because at round 5, maybe instead of node 4, node 6 wins

	5
1	38
2	106
3	85
4	124
5	99
6	128

Stop?

$$x_t = A^T x_{t-1}$$

Stop when new−old < threshold.

or do this until highest eigen value.

Why iterations?

because wrt time, friends and connections will change

Lets check

	0	1	2	3	4
1	1	0.33	0.375	0.3	0.28
2	1	1	0.75	0.85	0.73
3	1	0.66	0.75	0.65	0.71
4	1	1	1	0.95	1
5	1	0.66	0.75	0.25	0.75
6	1	1.	0.875	1	0.90
	$\sqrt{6}$	6	2.51	2.524	

reaching eigen value.

Stopping criteria

1) L_2 norm $\sqrt{\Sigma x^2}$

$(t_t - t_{t-1}) \leq \delta$

2) Fluctuation/oscillation.

3) $|x_t - x_{t-1}| < \delta$

4) Rayleigh Quotient

H.W

Read Tutorial on PCA by L i smith.

$cov(x,x) = var(x)$.

$cov(x,y) = cov(y,x)$

In links

For → directed: ~~$A^T X_t$~~ $\boxed{AX_t = X_{t+1}}$

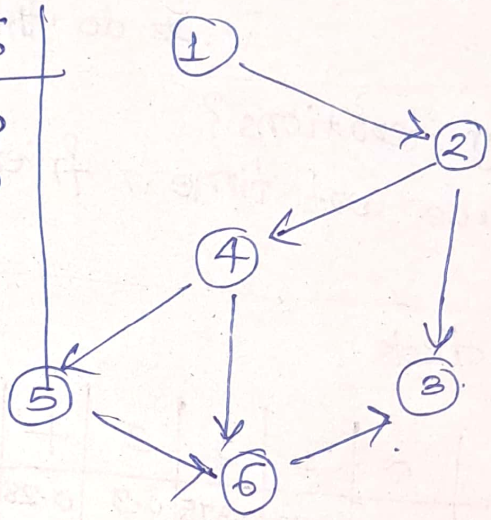
For → indirected: $\boxed{A^T X_t = X_{t+1}}$

---

calculate Eigen vector centrality for directed graph:-

in-degree

t	0	1	2	3	4	5	6
1	1	0	0	0	0	0	0
2	1	1	0	0	0	0	0
3	1	2	3	2	2	1	0
4	1	1	1	0	0	0	0
5	1	1	1	1	0	0	0
6	1	2	2	2	1	0	0



* acyclic diagraph.

• all power leaks out.

citation networks are acyelic, so eigen vector centrality is useless.

Adaptation for directed networks:-

$$\boxed{X = \underbrace{\alpha A X}_{\text{power from neighbours}} + \underbrace{\beta 1}_{\text{intrisic power}}}$$

when this converges, we get:-

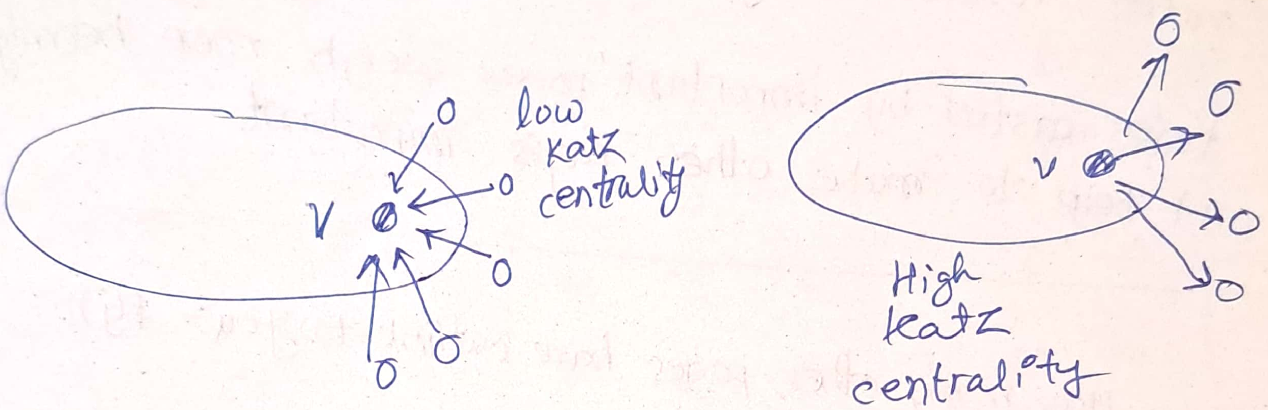
$$X = \beta (1 - \alpha A^T)^{-1} 1$$

$$\boxed{X = (1 - \alpha A^T)^{-1} 1}$$

Katz centrality
$\beta = 1$

- If $\alpha = 0$, $X = I$, centralities $= 1$
- As $\alpha \uparrow\uparrow$, centralities increase
- At $\frac{1}{\lambda_1}$, (λ_1 is largest eigen value) things diverge

Hence $\boxed{0 \leq \alpha \leq \frac{1}{\lambda_1}}$



*PageRank is most powerful measure.

Next class:- 1, 2, 3 chapter.
Eigen, Katz, bonachich.
Hard copy Quiz.

Note:- We stop when Eigen vector values converge.

PAGE RANK ~~anal~~

For web link analysis models.

PageRank interprets a hyperlink from page x to page y as a vote, by page x, for page y.

However, Page Rank looks at more than sheer number of votes; it also analyses the page that casts the vote.

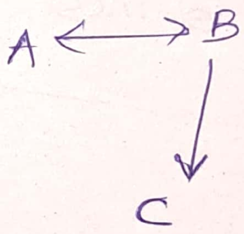
Votes casted by "important" pages weigh more heavily and help to make other pages important.

How many other pages have outlink to you :- $P(j)$

How many votes they give :- O_j

B. votes = 2

$$P(A) = \frac{P(B)}{2} = 1.5.$$



A. votes = 1

$$P(B) = \frac{P(A)}{1} = 1.5$$

Lets assume $P(B) = 3$.
Then calculate $P(A)$ & $P(C)$.

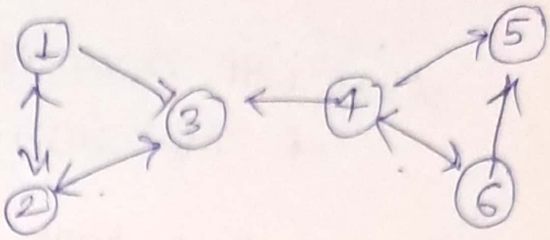
"If your network has low Rank pages,
Your page Rank will also decrease"

Solving Page Rank

$$\boxed{P_{i+1} = A^T P_i}$$

stopping criteria $\Rightarrow$ $P_{i+1} - P_i < 0.1$.

$$\bar{A} = \begin{bmatrix} 0 & 1/2 & 1/2 & 0 & 0 & 0 \\ 1/2 & 0 & 1/2 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1/3 & 0 & 1/3 & 1/3 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1/2 & 1/2 & 0 \end{bmatrix}$$



Let

$$P_0 = \begin{pmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{pmatrix}$$

$$A^T = \begin{bmatrix} 0 & 1/2 & 0 & 0 & 0 & 0 \\ 1/2 & 0 & 1 & 0 & 0 & 0 \\ 1/2 & 1/2 & 0 & 1/3 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1/2 \\ 0 & 0 & 0 & 1/3 & 0 & 1/2 \\ 0 & 0 & 0 & 1/3 & 0 & 0 \end{bmatrix}$$

$P_1 = A^T P_0$

$P_2 = A^T P_1$

$\vdots$

$P_9 = A^T P_8$

$$P_8 = \begin{bmatrix} 4.518 \\ 8.898 \\ 6.784 \\ 0.210 \\ 0.315 \\ 0.182 \end{bmatrix} \quad P_9 = \begin{bmatrix} 4.501 \\ 9.096 \\ 6.830 \\ 0.143 \\ 0.213 \\ 0.122 \end{bmatrix}$$

$P_9 - P_8 < 0.1$, so stop.

$\therefore$ Rank :- 2, 3, 1, 5, 4, 6

Irrespective of P_0, same Rank will be achieved.

How compare importance of pages?.

start with normalisation
& Total sum = 1

∵ 6 pages, Each Rank is 1/6.
Total sum = 1.

∴ Updated page Rank :-

$$P(i) = (1-d) + d \sum_{(j,i \in E)} \frac{P(j)}{O_j}$$

Also $d = 0.8$ is recommended.

$$= (1-d) + d(A^T P)$$

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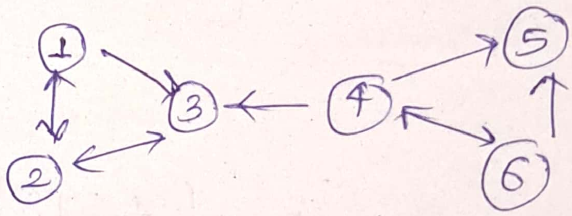
ex:- let $P_0 = \begin{bmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{bmatrix}$

$d = 0.8$



~~P(1) = (1-0.8)~~

$P(1) = (1-0.8) + 0.8\,(2/2) = 1$

$P(3) = (1-0.8) + 0.8\,(1/2 + 3/2 + 4/3) = 2.86.$

.... Likewise

Ranking :- $[5, 2, 3, 4, 1, 6]$
Iteration 1)

Iteration 2) :- $[2, 3, 1, 5, 4, 6]$.
which is answer.

Next improvement (improved normalisation)

$$P = (1-d)\frac{1}{n} + d\left(\frac{PR(i)}{O(i)} + \frac{PR(j)}{O(j)} + \cdots \frac{PR(n)}{O(n)}\right)$$

cutpoint - delete node to increase components.

bridge - delete edge, to increase components

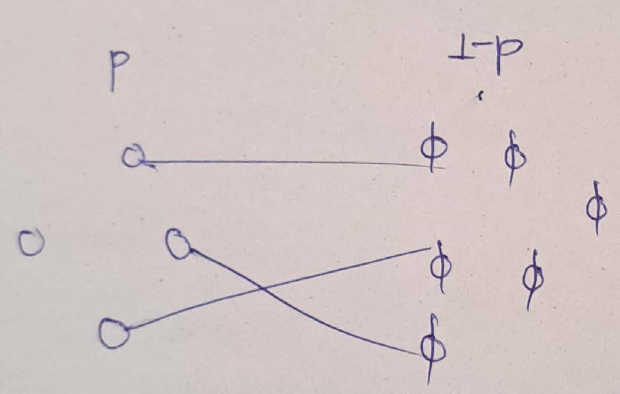
Homophily :- Birds of feather flock together.

Netlogo Web → Social science → segmentation

Consider random network $G(V, E^r)$
where each node is assigned ~~must~~ male :- p
female :- 1-p.

Let $G = (V, E)$ be random sample of R with p fraction of male and 1-p fraction of female.

- consider any edge $(i, j) \in E^r$ of random network R.

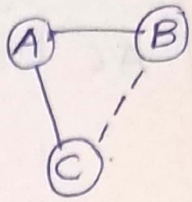


$$E(x^2) - (E(x))^2 = p(1-p) + (1-p)p = 2p(1-p)$$

Computer networks :- Hoax calls, mails (phishing links)

uptill Homophily mid-sem

Social vs selection Influence



* Triadic Closure.
* Focal closure
* membership closure

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* Community Homophily :-

Asian origin vertices:- 5, 7, 8, 10, 11, 12.

Caucasian origin vertices :- 1, 2, 3, 4, 6, 13, 14.

Hispanic origin vertices:- 9, 15, 16, 17, 18, 19, 20.

$\#\text{Links} = \frac{\text{sum of degrees}}{2} = 47$

A : $\frac{6}{20} = 0.3$

C : $\frac{7}{20} = 0.35$

H : $\frac{7}{20} = 0.35.$

A & C	H
p	(1-p)
$\frac{13}{20}$	$\frac{7}{20}$

$2p(1-p) = 2 \times \frac{13}{20} \times \frac{7}{20} = \frac{182}{400}$

A & H	C
$\frac{13}{20}$	$\frac{7}{20}$

$2p(1-p) = \frac{182}{400}$

C & H	A
$\frac{14}{20}$	$\frac{6}{20}$

$2p(1-p) = 2 \times \frac{14}{20} \times \frac{6}{20} = \frac{168}{400}.$

consider any 2 groups.

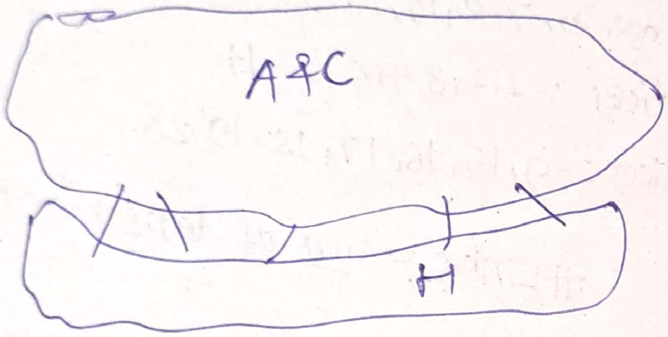
Fraction of A-C Links $= \frac{12}{47} = 0.26$

$> 2*A*C = 2*0.3*0.5 = \boxed{0.21}$

~~Fraction~~ Final community detected

2 communities

→ $\boxed{A\&C}$ $\boxed{H}$



Mid-sem exam syllabus over

~~Not taken~~ Homophily.

Assignments :- 35 marks

Evaluating modularity

A_{ij} → adjacency matrix

d_i, d_j – degree of i, j

m – edges.

overall & individual higher modularity → Better partition.

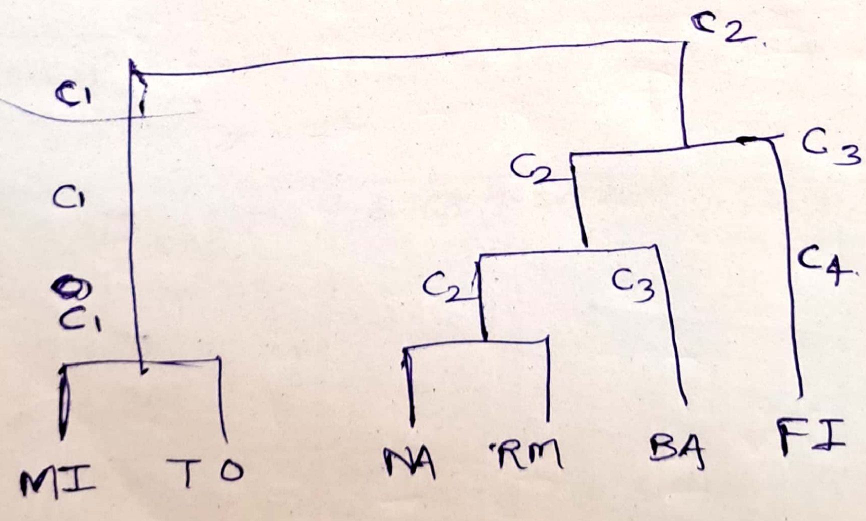
single linkage – minimal

complete linkage – maximal.

MI/TO → other

distance calculation ⇒ max [MI → other, TO → other]

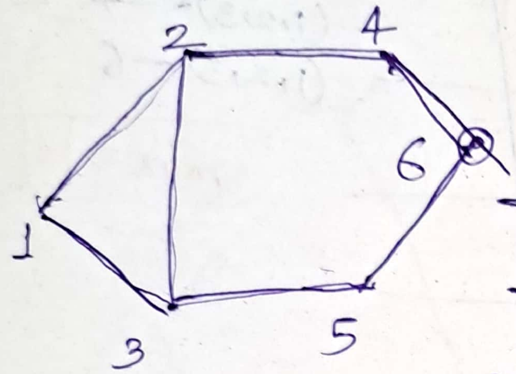
https://matteucci.faculty.polimi.it/clustering/tutorial_html/hierarchial.html



~~2 communities~~

Hiearchial Linkage

based on min.dist



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

	1,2	3	4	5	6
1,2	0	1	2	2	3
3		0	2	1	2
4			0	2	1
5				0	1
6					0

(1,2) — 3 $\boxed{\frac{2}{3}}$

3 − 5 $\frac{1}{2}$

4 − 6 $\frac{1}{2}$

5 − 6 $\frac{1}{2}$

$\frac{5}{3} = 1.6$

1 − 5
2 − 5
3 − 4

$\frac{3}{2} = 1.5$

	1,2,3	4	5	6
1,2,3	0	2	2	3
4		0	2	1
5			0	1
6				0

	1,2,3	4,6	5
1,2,3	0	3	2 (5)
4,6		0	2 (3)
5			0 (0)

For distance
(1,2,3) — (4,6)
(1,2,3) — 4 2
(1,2,3) — 6 3

max ⇒ $\boxed{3}$

Tie, here :- choosing pair with minimum total distance ÷ pair size

ex :- 1,2,3 — 5

1 − 5 : 2
2 − 5 : 2
3 − 5 : 1

5 ÷ (3) $\boxed{\cancel{5/4}}$ $\frac{5}{3}$ ✓ $\boxed{1.66}$

pairsize ⇒ 3

4,6 — 5

4 − 5 2
6 − 5 1

3 $\cancel{\div 2}$ ⇒ $\boxed{\cancel{1}}$ $\frac{3}{2}$ ✓ $\boxed{1.5}$

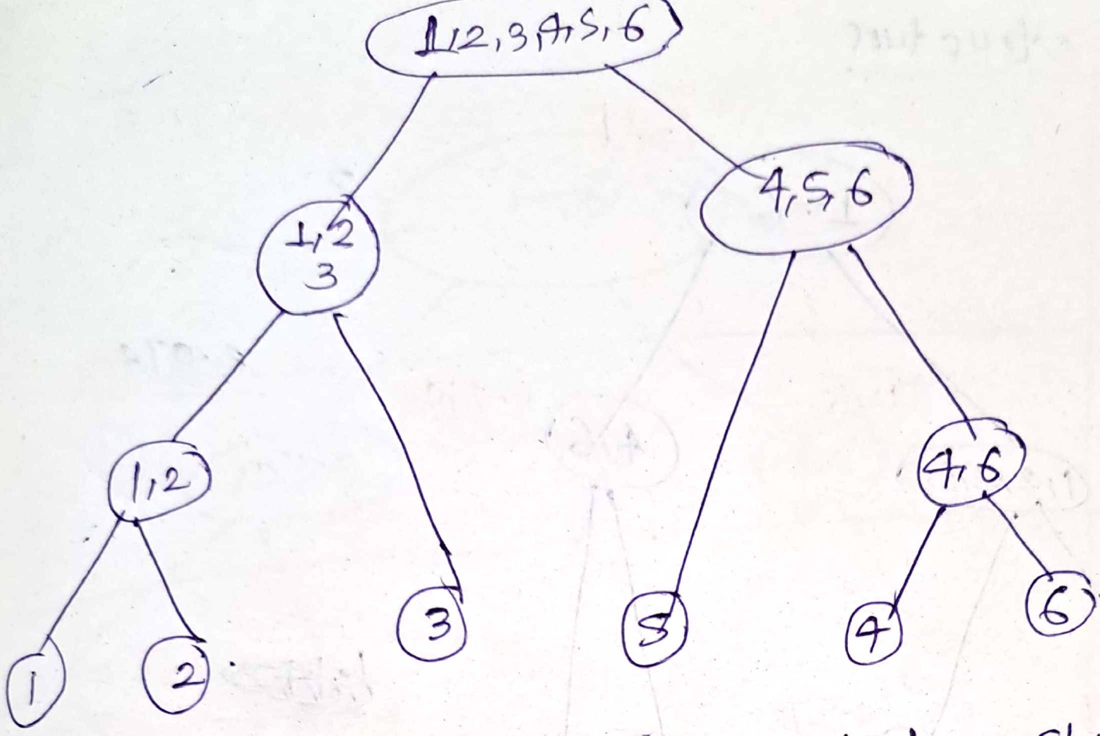
pairsize = 2

~~For just dista (1,2,3) − (3,5)~~

Final

	1,2,3	4,6,5
1,2,3	0	3
4,6,5		0

1,2,3 — 4,6 : 3
1,2,3 — 5 : 2



complete Linkage clustering.

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modularity values

ex:- (1,2,3) ⟶ 1.49

How?

take pairs modularity

1,2 → 0.57

1,3 ⟶ 0.57

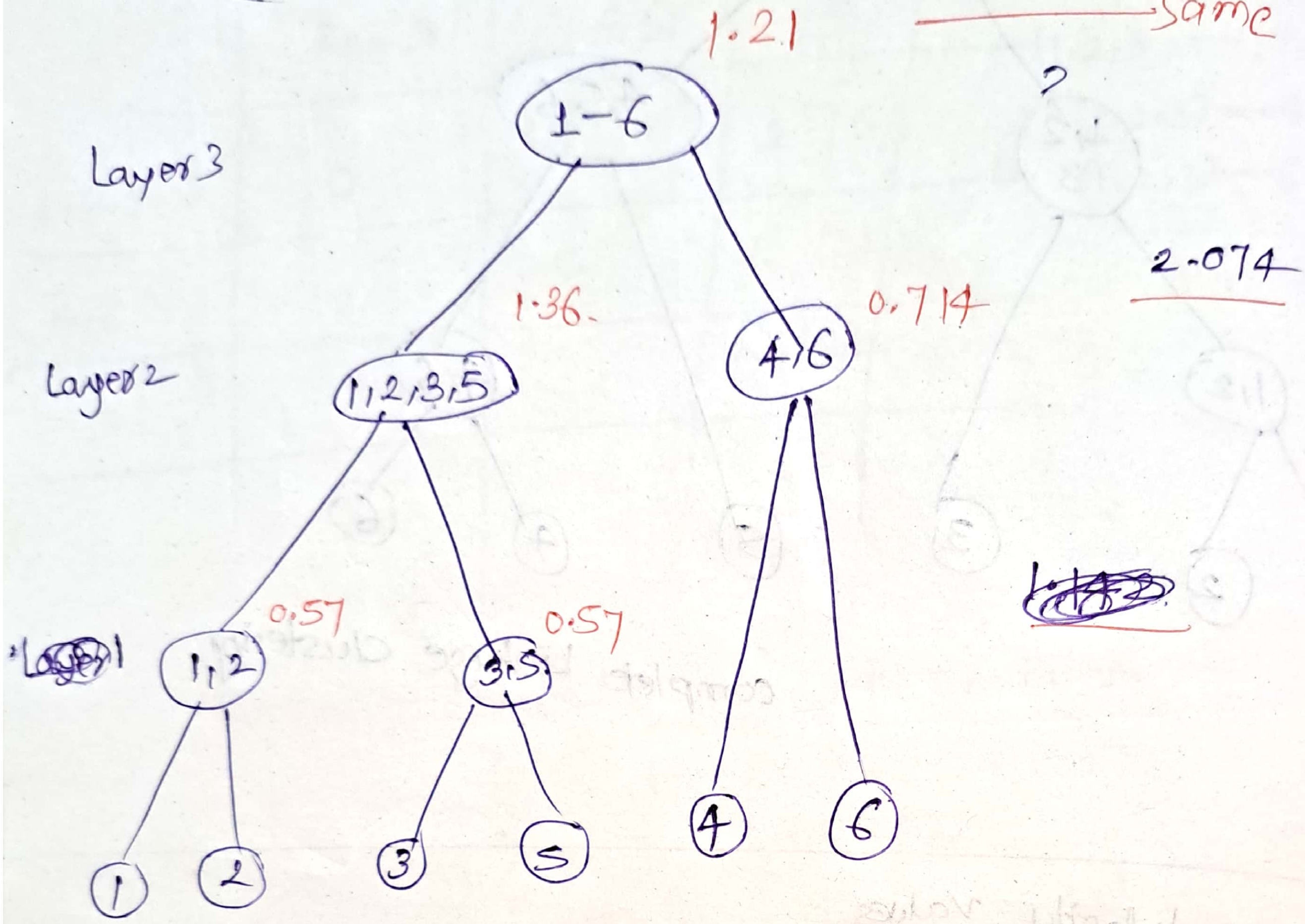
2,3 ⟶ 0.35

1.49

Note:- Hierachial diagram can be different, but if done correctly, modularity scores overall will be same.

Layerwise overall modularity must be more.

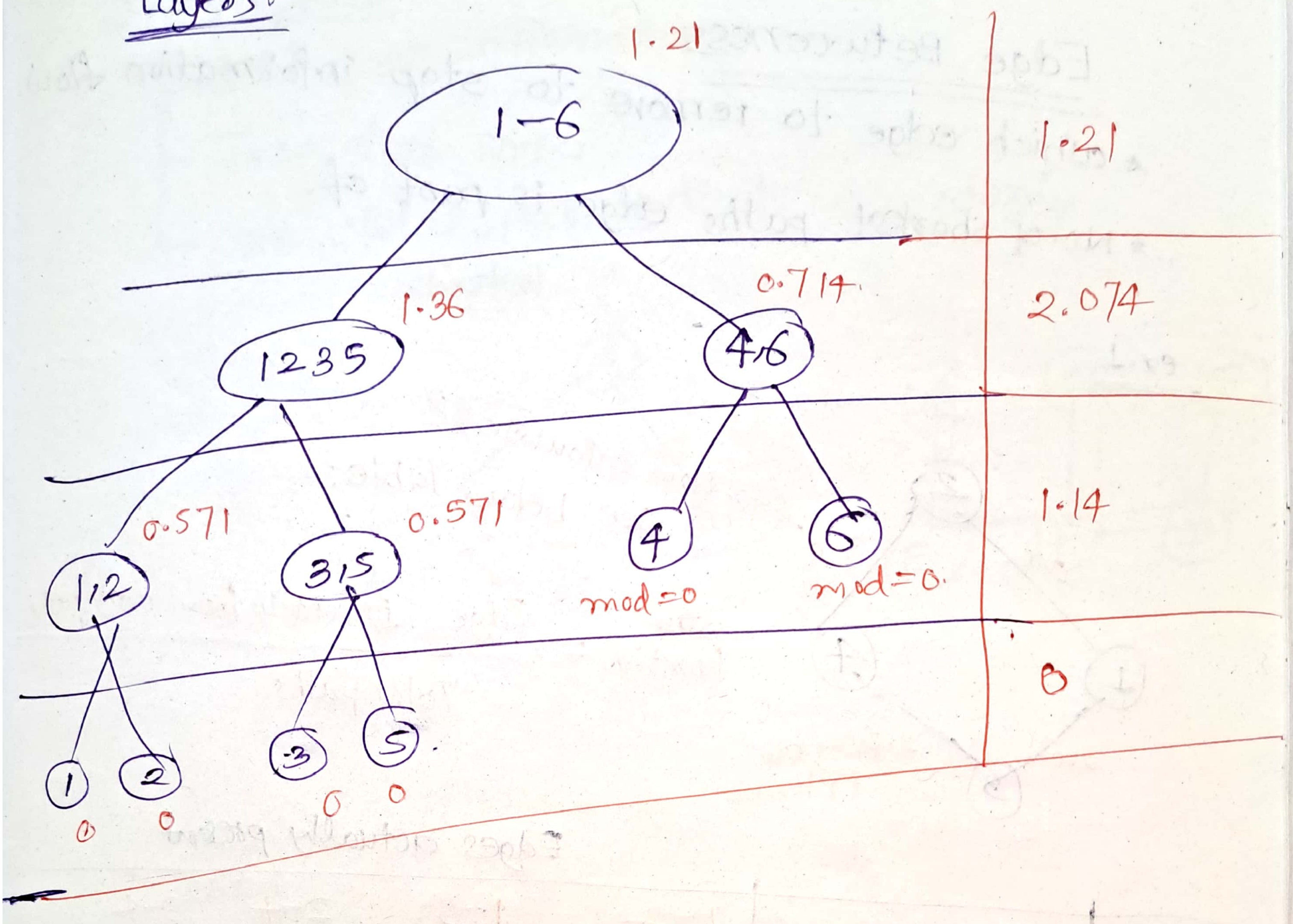
another structure



This has less Layerwise modularity, so this is wrong Hierarchial structure

complet Linkage clustering need not always give optimum solution.

Layers:-

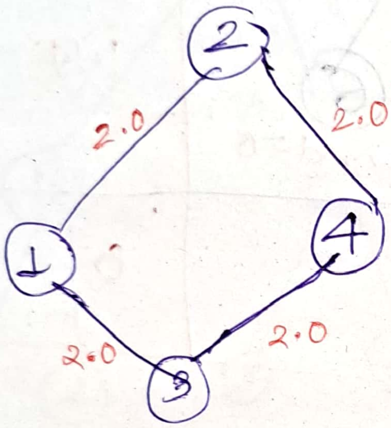


1.21
1–6
1.21
1.36
0.714
2.074
1235
4,6
0.571
0.571
1.14
1,2
3,5
4
6
mod=0
mod=0
0
1
2
3
5
0
0
0
0

Edge Betweeness

* which edge to remove to stop information flow.
* No. of shortest paths edge is part of.

ex.1



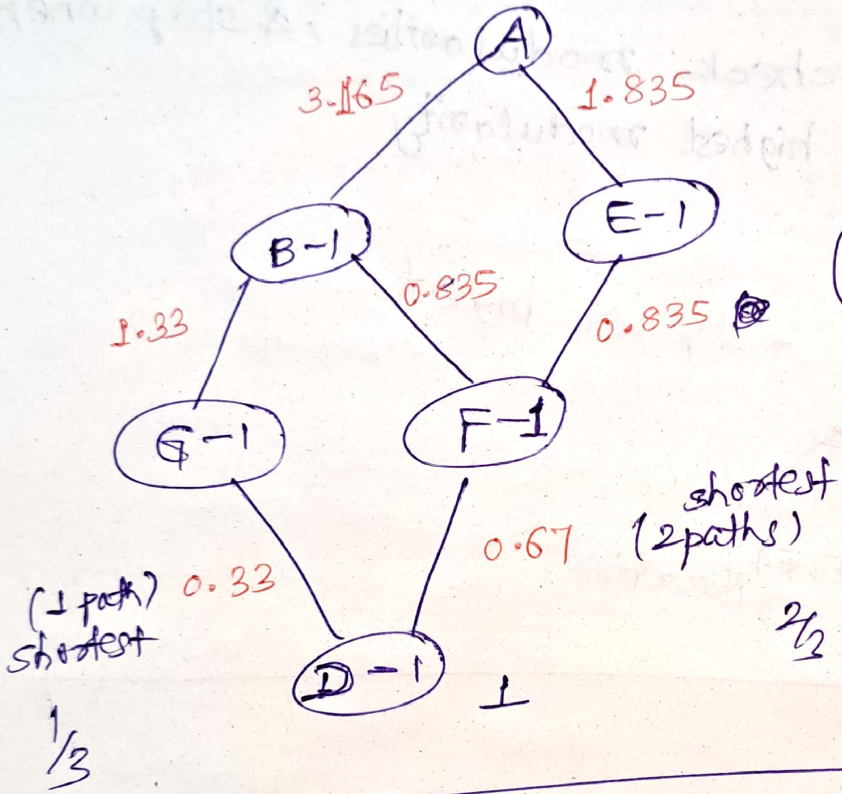
How calculated? see below Table:-

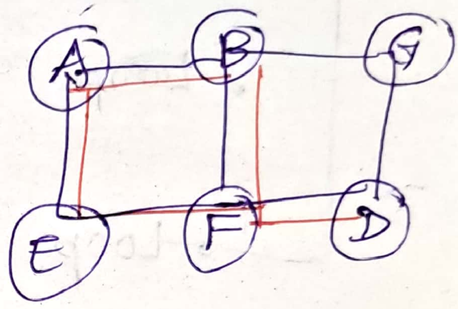
$$\text{Fraction} = \frac{\text{Edge Present in how many paths}}{\text{Total paths.}}$$

Pairs	Paths	1-2	1-3	2-4	3-4
		Edges actually present			
(1,2)	1-2	1/1			
(1,3)	1-3		1/1		
(1,4)	1-2-4, 1-3-4	1/2	1/2	1/2	1/2
(2,3)	2-1-3, 2-4-3	1/2	1/2	1/2	1/2
(2,4)	2-4			1/1	
(3,4)	3-4				1/1
EdgeBW		2	2	2	2

Info spread

- Add your information
- Take other info
- see total, shortest paths & divide accordingly.





Node betweeness

$$\text{NodeBWC}(i) = \frac{\left\{ \sum_{(i,j)\in E} \text{EdgeBWC}(i,j) \right\} - \{C_i - 1\}}{2}$$

C_i :- total nodes

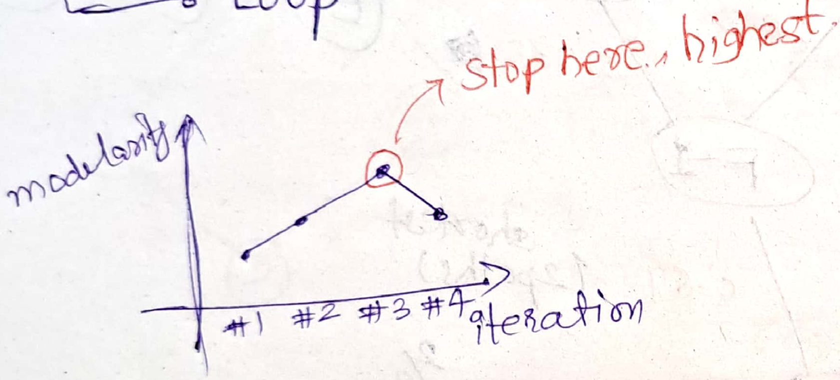
e

How compare node BWC using Edge Betweeness and our old formula.

GN algorithm (Girvann Newman)

Find Edge betweeness

- highest value edge break karo.
- compute modularity, Take sum.
- ~~Loop~~ check modularities, & stop when highest modularity
- Loop



Nover score :-

Find neighbours of A & B, excluding A & B.

$$\boxed{\text{Nover score} = \frac{\text{Intersection}}{\text{Union}}}$$

Nover-based GN algorithm :-

- Break edges with least NOVER scores.

Weak Ties / Strong Ties

* one step algorithm
* optimum threshold finding matters.

Strong Triadic Property :- (helps set NOVER score)

If A connected strongly to B & C.

Then B & C must atleast be weakly connected.

$$\text{Extent of Homophily} = 1 - \frac{\text{observed}}{\text{expected}}.$$

~~Link Prediction~~/
Information Diffusion and Cascades.

★ Triadic closure will be useful.

Link prediction :- Given a network, predict which edges will be formed in future.

Basic measures :- no. of common neighbours
Jaccard coeff
Resource Allocation Index
Adamic-Adar Index.
preferential Attachment score.

Measures requiring community :-
- Sundar-rajan . Hoffman Croft score

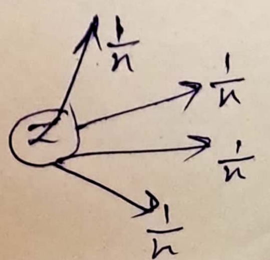
→ The ones with most common neighbours will connect first
i.e (A, C, 2) will connect first.
- Then others value will be updated
- Then again connect most common neighbour pair.
- Loop

$$\text{Jacc-coff} = \frac{\#\text{common neighbours}}{\#\text{Total neighbours}}.$$

Resource Allocation.

$$\text{res\_alloc}(X, Y) = \sum_{u \in \text{common neighbour}} \frac{1}{N(u)}$$

$X \xrightarrow{1} Z$ If z has neighbours.



Adamic Adar Index (Exam)*

- similar to res-alloc, but log

$$\text{adamic-adar}(X,Y) = \sum_{u \in common} \frac{1}{\log(N(u))}$$

(Exam*)

Pref Attachment:- $|N(X) * N(Y)|$

$\text{pref}(A,C) = 3 * 3 = 9.$

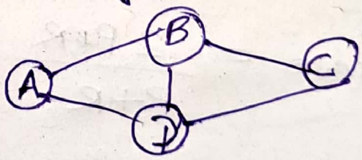
product of node's degree

community structure

No. of common neighbours with bonus for neighbours in same community.

$$|N(X) \cap N(Y)| + \sum_{u \in N(X)\cap N(Y)} f(u)$$

$$f(u) = \begin{cases} 1, & \text{same community} \\ 0, & \text{different community.} \end{cases}$$



ex:- $(A,C) \to 4$

$(E,I) \to 2$

$(A,G) \to 1.$

$(A-C) \Rightarrow B + D + 1 + 1$

$\Rightarrow 1+1+1+1$

$\boxed{(A-c) \Rightarrow \boxed{4}}$

7. Community Resource Allocation

ra-soundarrajan-hopcroft $(X,Y) = \sum_{u \in common} \frac{f(u)}{N(u)}$.

$(A,C) = \frac{1}{3} + \frac{1}{3} = \boxed{\frac{2}{3}}$

$(A,G) = \frac{0}{3} = \boxed{0}$

---

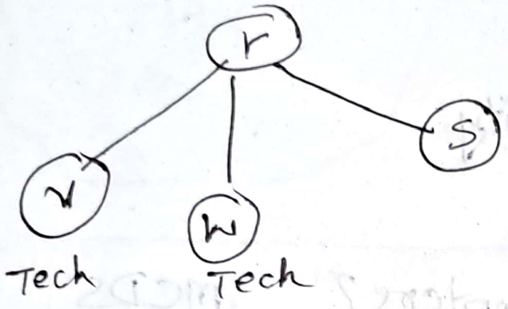
critical success Index $= \frac{TP}{TP + FP + FN}$.

Precision $= \frac{TP}{TP + FP}$

Recall $= \frac{TP}{TP + FN}$

F1 score $= \frac{2 P * R}{P + R}$.

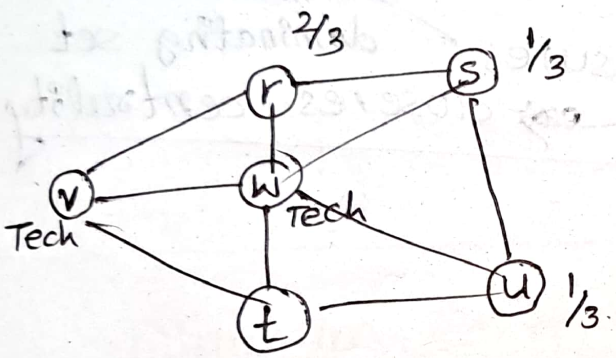
Lec 10 :- Information Cascade and Cascading Capacity of a Network :-



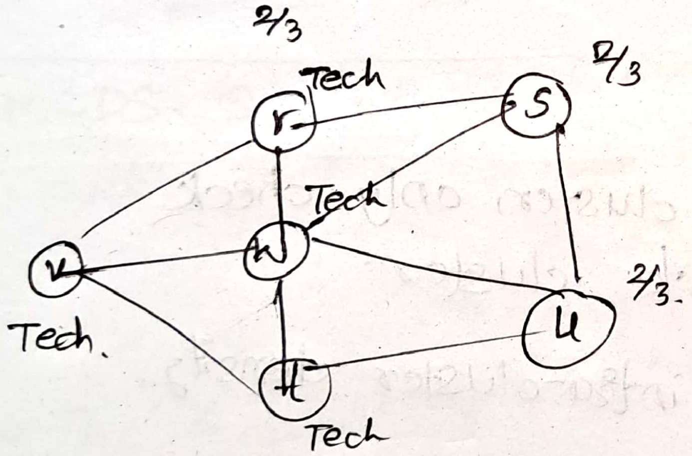
r has 3 neighbours

2 adopted technology.

∴ $\boxed{\frac{2}{3}}$ is ~~adopti~~ cascading capacity of r.



Here, q is threshold for evaluate information passing

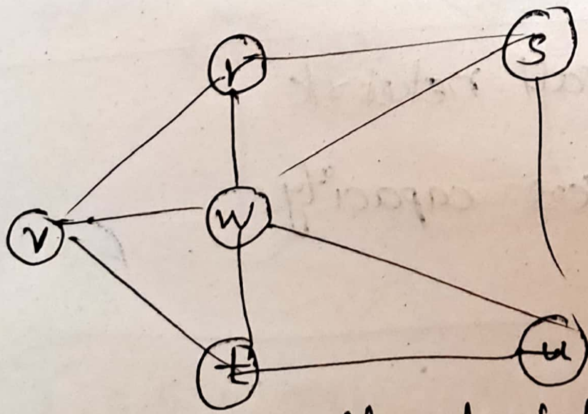


> Cascading capacity is max q (threshold) after which full network cannot adopt technology.

Instead of $q = 0.5$.

if $q \leq 2/3$ (max).

$q > 2/3$:- all cannot adopt tech.



all adopted Technology

Q] What proposition of neighbours should adopt a decision before a node starts adopting it?

ans:- 'q' proportion/ fraction

q is cascading capacity.

? Choice of Initial adopters? MCDS

> minimum connecting dominating set.

ans:- use centrality measures. ex closeness centrality.

---

* Intra-cluster density.
* Density of cluster

//

~~Intra~~ c

For penetrability of cluster, only check bridge nodes to cluster

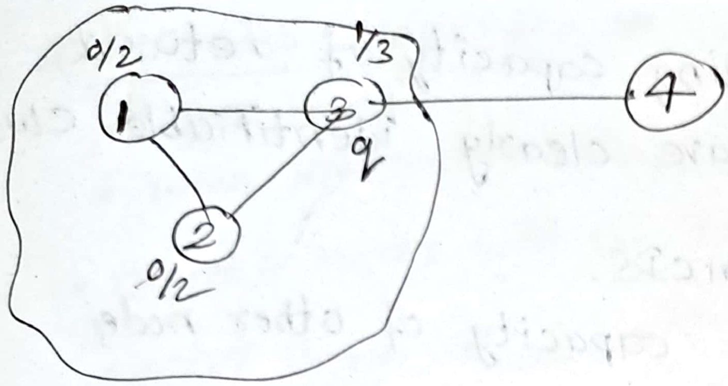
∴ Take min. intra-cluster density

~~then~~ q

---

cascading cap. of overall network

= min. of its clusters capacity.



$1-q$ is less than cluster density then cluster cannot be penetrated.

i.e. $q \leq 1 - \text{cluster density}$.

Minimum Connected Dominating Set

MCDS is min. set of nodes,

such that → node in MCDS

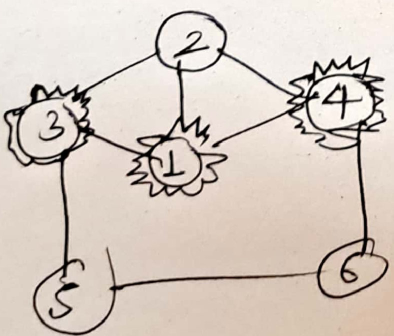
→ or neighbour of MCDS.

→ must be connected nodes.

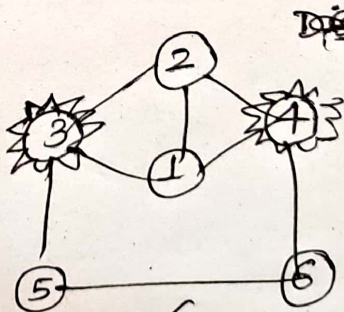
★ This is NP-complete problem.

~~Disconnected~~

ex:-



✓



X

The MCDS must be connected set

ex:-

$\left.\begin{array}{l}1,3,5\\1,3,4\\1,4,6\\2,3,4\end{array}\right\}$ min.

How to find cascading capacity of network that does not have clearly identifiable clusters?

- After coloring MCDS.
- Find cascading capacity of other nodes
- min capacity of them is cascading capacity

Advantage of MCDS:-

others will be coloured in 1 tick.

Disadvantage

If we taken less than MCDS set, we need more iterations to color whole network.

★ d-MCDS Heuristic ★

- degree based.
- when information adopted, set degree = 0
- degree = nodes with no information.
- color again, those with max.degree
  - stop when all get information.

Then find cascading capacity, min. is answer

Almost syllabus Over.