③

FMA —

Q. Determine # distinct Elements in stream.
i/p stream ⇒ 1, 3, 2, 1, 2, 3, 4, 3, 1, 2, 3, 1.
hash fns. $h(x) = (6x+1) \bmod 5$

x	$h(x) = (6x+1) \bmod 5$	$(h(x))_2$	# Trailing 0's
1	$[6(1)+1] \bmod 5 = 7 \bmod 5 = 2$	010	1
3	4	100	2
2	3	011	0
1	2	010	1
2	3	011	0
3	4	100	2
4	0	000	0
3	4	100	2
1	2	010	1
2	3	011	0
3	4	100	2
1	2	010	1

∴ Max # Trailing 0's = 2 = r

∴ Distinct Value $R = 2^r = 2^2 = 4$
∴ There are 4 Distinct Elements.

0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7
2^2	2^1	2^0	

classmate

Date

Page

(4)

Bloom Filter – membership test using prob.
eg. checking availability of a user. 'it is taken'.
Search it from a list of Registered usernames.
FP.

Empty Bloom filter → | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
Empty Array of 0's of length 8.

Q. 'athrow' to be inserted
'catch' to be searched. window size = 10

0	0	0	0	0	0	0	0	0	0
0	1	2	3	4	5	6	7	8	9

→ a t h r o w
1 20 8 18 15 23
%10 %10 %10 %10 %10 %10
1 0 8 8 5 3

1	1	0	1	0	0	0	0	1	0
0	1	2	3	4	5	6	7	8	9

catch search:
c a t c h
3 1 20 3 8
%10 %10 %10 %10 %10

3 1 2 3 8
search for indices 3, 1, 2, 3, 8 if they're set to 1

they indeed are
∴ FP.

spell checks.

Q. Bloom filter.

m = 5

0	1	2	3	4
0	0	0	0	0

2 hash fns help avoid overlap ∴ fp ni hoga

↑ # hash

↓ # hash fns → $\bar{f}$

$h_1(x) = x \bmod 5$

$h_2(x) = (2x+3) \bmod 5$

1. Insert 9 2. Insert 11 3. check 15

		$h_1(x)$	$h_2(x)$
$x=9$ → $(9)_2$	0 | 1 | 0 | 0 | 1 (indices 0 1 2 3 4; ✓ at 1 and 4)	$9 \bmod 5 = 4$	$[2(9)+3] \bmod 5$ $21 \bmod 5 = 1$
$x=11$ → $(11)_2$	1 | 1 | 0 | 0 | 1 (indices 0 1 2 3 4)	$11 \bmod 5 = 1$	$[2(11)+3] \bmod 5$ $25 \bmod 5 = 0$.
15	1 | 1 | 0 | 0 | 1 (indices 0 1 2 3 4)	$15 \bmod 5 = 0$ set	$[2(15)+3] \bmod 5 = 3$ not set

Surely Not present.

(5)

DGIM Algo → estimate # 1's

Error < 50%

Q.

10101100010111011100101 10 .

10 1011 000 10 111 0 11 00 101 1 0

$2^2 = 4$ $2^2 = 4$ $2^1 = 2$ $2^1 = 2$ $2^0 = 1$ ← #1's in Buckets

Rightmost Side se Start

Rightmost bit of Bucket = 1

0's can be Bucketless

Right to left size of Bucket = $2^0, 2^0, 2^1, 2^1, \ldots$

1 0 1 0 11 0 0 0 1 0 11 1 0 1 1 0 0 1 0 1 1 0

2^2 2^1 2^1 2^0 2^0

u can repeat a Bucket size twice

i) New Bit '0' arrives (from Right to left)

→ No change. 101011 000 10111 0 11 00 101 1 0

ii) New Bit '1' arrives.

101011 000 10111 0 11 00 101 1 0 1 still ok.

2^2 2^2 2^1 2^1 2^0 2^0

20, 30 = 20 1st Window } u need whole window in mm

3

iii) One more 1 arrives.

101011 000 10111 0 11 0 0 101 1 00 1 1

4 4 2 2 1 1

101011 000 10111 0 1 00 1 0 1 1 00 1 1

1 1

4 4 2 2 2 1

101011 000 10111 0 11 0 0 101 1001 1

8 4

8 4 2 1

∴ 101011 0 00 10111 0 11 00 101 1001 1

1 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

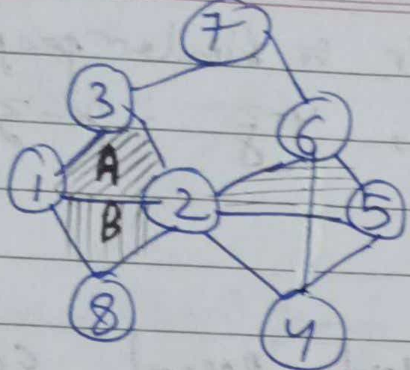
In last 20 bits, what is count of 1's?

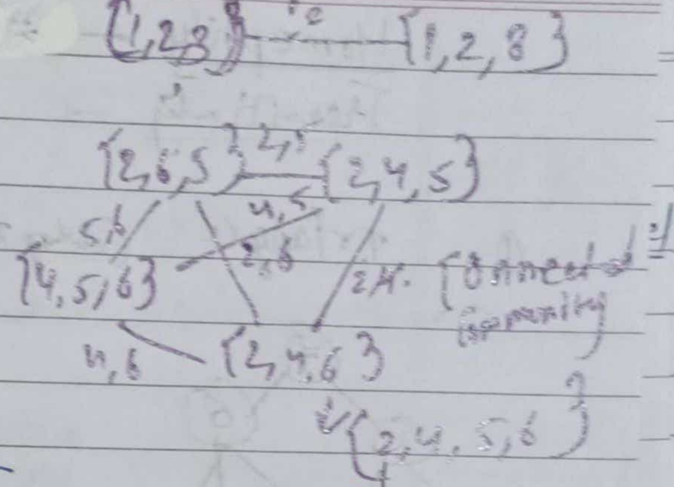
$\therefore 1+2+4+4 = \underline{11}$.

⑤

no common nodes ↓ no community

Q.





cliques

draw 'em

1,2,3	K=3	A, B	(A,B) 1,2.	1,2,3,8
1,2,8				
2,6,5		C, D	2,5 (C,D)	2,6,5,4
2,4,5				
4,5,6		E, F	4,6 (E,F)	4,5,6,2
2,4,6		G		
~~2~~,4,5,6	K=4			

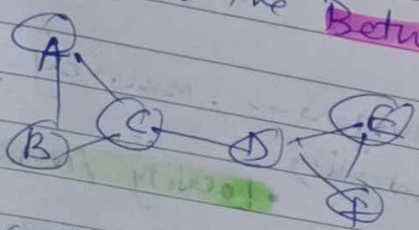
Q.

	are there ≠ 2 adj nodes ↓	Communities.
1,2,3	(1,3)	1,2,3,4
1,3,4		
4,5,6	5,6	4,5,6,7,8.
5,6,7		
5,6,8		
5,7,8	7,8	
6,7,8		

WSN Measure of Similarity / Dissimilarity

$d(x,y) = \infty$ .. No Edge
or $= 1$ — No Edge : not connected
$= 0$ ... Edge present : connected

Q. Calculate the Betweenness Centrality for node C.



∴ A, B, C, D, E, F. (z = C)

Sol^n^ :

	(x,y)	$\sigma(x,y)$	is it via C? $\sigma(x,y)(z)$ or via z	$\sigma(x,y)$ via z / $\sigma(x,y)$
1	(A,B)	1	0 no	0/1 = 0
	(A,C)	1	1 yes	
	(C,D)	1	1	
2	(D,E)	1	0	
3	(D,F)	1	0	0/1 = 0
4	(E,F)	1	0	0/1 = 0
	(B,C)	1		0/1 = 0
5	(A,D)	1	1	1/1 = 1
6	(A,E)	1	1	1/1 = 1
7	(A,F)	1	1	1/1 = 1
8	(B,D)	1	1	1/1 = 1
9	(B,E)	1	1	1/1 = 1
10	(B,F)	1	1	1/1 = 1

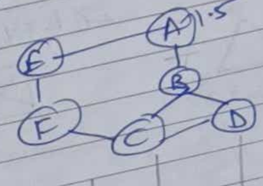
write all edges down except their start & end in C,
are they connected? Endir. or directly
are they connected via C?
yes / Total

∴ Between Centrality for C = 6

∴ level of C = level of D
∴ Centrality of D also = 6.

B.C. for A = 0 (Kisike path ke beech nai h)
— " — B = 0
— " — E = 0
— " — F = 0

Q. B.C. for All nodes. ABCDEF



for A —

AB	1		
AC	1		
AD	1		
AE	1		
AF	1		
BC	1	0	0/1
BD	1	0	0/1
BE	1	1	1/1
BF	1	0	0/1
CD	1	0	0/1
CE	1	0	0/1
CF	1	2	1/2
DE	1	0	0/1
DF	1	0	0/1
EF	1	0	0/1

D [B→A→F / C→F→E
Both shortest ∴ 2 paths ∴ 1/2

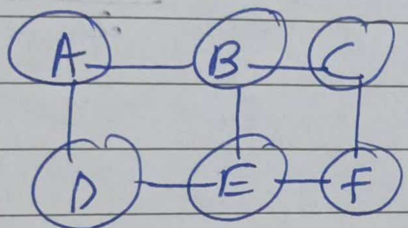
1.5

Shortest path dekh lega
through A?
ni, w/o A hai

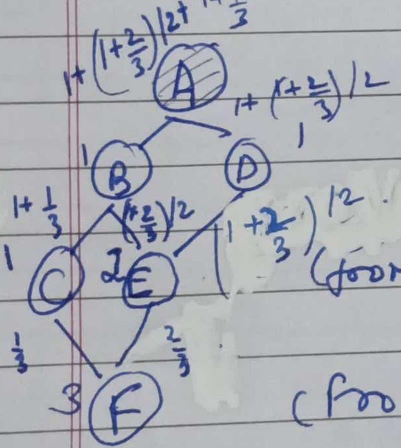
Sol: Teleportation / Taxation
link spam ; Topic Sensitive PR

Girvan Newman Algo — BFS, Divisive hierarchial clustering Edge Betweeness

Q. Calculate the Betweeness centrality for edges, Solve using GNA.

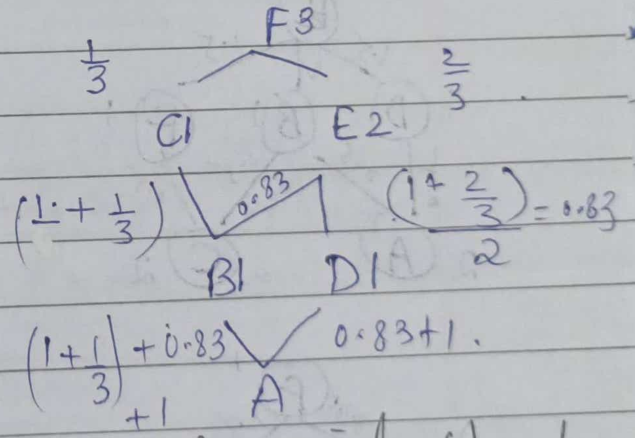
→ 

A B, D
B C, E
D E
E F



(from B=1, D=1)

(from C=1, E=2).



Algo is for Detection & Analysis of Community Structure

— depends on iterative Eliminate of edges w highest values.

Recommendations = Search query movies

System — Content Based (CB) personal pref. — Collab. (CF) like minded people

— movies
— lectures
— webs

Offline [work / school]

Social n/ws

person1
person1
person1

$\left(\frac{1}{3}+1\right)+1+\left(\frac{2}{3}+1\right)$

$\left(\frac{2}{3}+1\right)+1$

$D=1,\ A=1,\ E=1,\ B=2,\ F=1,\ C=3$

$BC = \frac{B}{C} = \frac{2}{3}$

$FC = \frac{F}{C} = \frac{1}{3}$

$AB = \frac{\left(\frac{BC}{2}\right) + A}{} = \frac{\left(\frac{2}{3}\right)+1}{2} = 0.83$

$EF = 0.33 + E = 1.33$

$DA = 0.833 + D = 1.833$

$DE = D + 1.33 + 0.833 = 3.163$

$DA = \frac{1}{2}$

$ED = 1+0.5 = 1.5$

$EB = 1+0.5+0.5 = 2$

$EF = 1+0.5 = 1.5$

$DA = \frac{1}{3} = 0.33$

$ED = 1+0.33 = 1.33$

$CB = \left(\frac{1+0.67}{2}\right) = 0.835$

$FE = 1+1.33+0.835 = 3.165$

$FC = 1+0.835 = 1.835$

Add All A→B, A→C … Everything

AB: $3.165+1.5+1.33+0.835+0.5+0.667 = 8$

AD: $1.835+0.5+0.33+1.835+0.5+0.33 = 5.33$

BC: $3.165+1.5+1.3+0.835+0.5+0.667 = 8$

BE: $0.835+2+0.835+0.835+2+0.835 = 7.34$

CF: $1.835+0.5+0.33+1.835+0.5+0.33 = 5.33$

DE: $3.165+1.5+1.33+0.835+0.5+0.667 = 8$

EF: $3.165+1.5+1.33+0.835+0.5+0.667 = 8$

Directionless
Bidirect.
∴ ÷2

Remove edges w highest value

∴ 3 Communities formed.

Stop here ∵ further : will lead to 1 Node Communities

o/p stream.

Query Rep for stored proc.

and constantly, it's lost

Predefined Adhoc — Summ./Sketch of data/ synopses

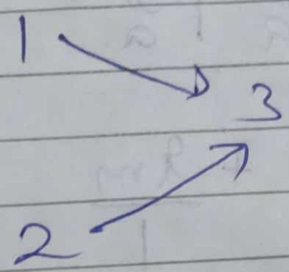
∴ Caring for fast stream/daily low

.ze query stream stored in su…

∴ ipl is more

5.7254

Q. Hits. Calculate Hubs & Auth. score.



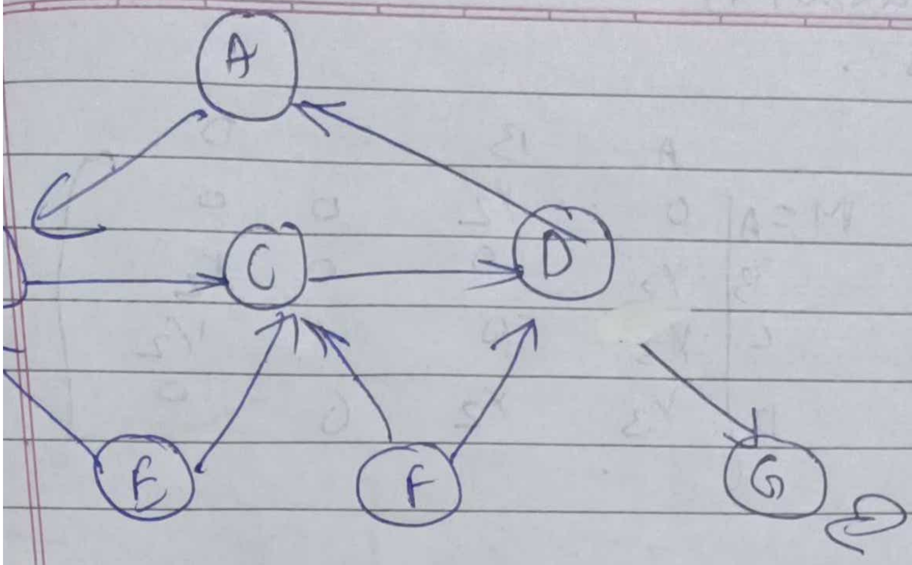
$$\begin{array}{c|ccc} & 1 & 2 & 3 \\ \hline 1 & 0 & 0 & 1 \\ 2 & 0 & 0 & 1 \\ 3 & 0 & 0 & 0 \end{array}$$

initial Hub weight vector $= \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} = u$

Auth. score $= v = A^t . u$

$$= \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 1 & 1 & 0 \end{bmatrix} \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} = \begin{pmatrix} 0 \\ 0 \\ 2 \end{pmatrix}$$

Hub score updated $= u = A \cdot v = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{bmatrix} \begin{pmatrix} 0 \\ 0 \\ 2 \end{pmatrix} = \begin{pmatrix} 2 \\ 2 \\ 0 \end{pmatrix}$



Identify Spider traps & dead Ends

	A	B	C	D	E	F	G
A	0	1	0	0	0	0	0
B	0	0	1	0	0	0	0
C	0	0	0	1	0	0	0
D	1	0	0	0	0	0	1
E	0	1	1	0	0	0	0
F	0	0	1	1	0	0	0
G	0	0	0	0	0	0	1

No dead Ends ∵ no full row = 0 (no node with # outlinks = 0).

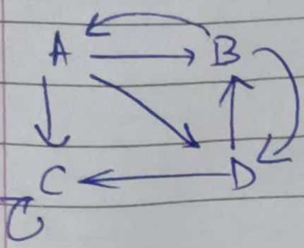
G is a Spider trap
∵ G is a Dead End except It has a Selfloop
u can't come back from G.
∴ it ends up getting all the PR
(a Honeypot : where on search, u end up that page itself)
Sol^n : Teleportation / Taxation
Sol^n to link spam :) Topic Sensitive PR

$V_{i+1} = M \cdot V_i$

PAGE:
DATE: / /

Q. Teleport-? / Taxation

assume $\beta = 0.8$.



$$M = \begin{array}{c|cccc} & A & B & C & D \\ \hline A & 0 & 1/2 & 0 & 0 \\ B & 1/3 & 0 & 0 & 1/2 \\ C & 1/3 & 0 & 1 & 1/2 \\ D & 1/3 & 1/2 & 0 & 0 \end{array}$$

C, A Spider Trap

$$[\beta M]v + (1-\beta)\frac{e}{n}$$

$$= \begin{bmatrix} 0 & 2/5 & 0 & 0 \\ 4/15 & 0 & 0 & 2/5 \\ 4/15 & 0 & 4/5 & 2/5 \\ 4/15 & 2/5 & 0 & 0 \end{bmatrix} \begin{bmatrix} 1/4 \\ 1/4 \\ 1/4 \\ 1/4 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} \times \frac{0.2}{4}$$

V is initial PR; e is all 1's matrix

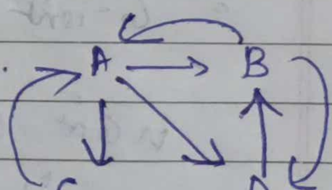
$$v' = \begin{bmatrix} 9/60 \\ 13/60 \\ 25/60 \\ 13/60 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}$$ if normal PR method followed

↓

so on for many iteration

Q. Topic Specific PR →

Eg.



$$V = \begin{array}{c} A \\ B \\ C \\ D \end{array} \begin{bmatrix} 0 \\ 1/2 \\ 0 \\ 1/2 \end{bmatrix}$$

Given: Teleport set = {B, D}

$\beta = 0.8$

∴ A & C ke liye V initial 0

$$(1-\beta)\frac{e}{n} = \frac{0.2}{2}\begin{bmatrix} 0 \\ 1 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ 1/10 \\ 0 \\ 1/10 \end{bmatrix}$$

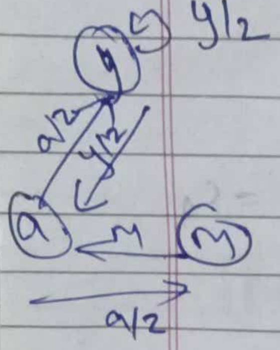
(n=2 only B & D)

rest same

Simple PR

- Links = votes.
- Recursive formulation
- flow model:

nodes	in	out
y	y a	a, y
a	y, m	y, m
m	a	a



PR of a $\Rightarrow \frac{r_y}{2} + \frac{r_m}{1}$ $\frac{\text{(incom)}}{\text{(outg)}}$

PR of y $\Rightarrow \frac{r_y}{2} + \frac{r_a}{2}$

PR of m $\Rightarrow \frac{a}{2}$.

$$\begin{array}{c|ccc} & y & a & M \\ \hline y & 1/2 & 1/2 & 0 \\ a & 1/2 & 0 & 1 \\ M & 0 & 1/2 & 0 \end{array} = M$$

power iteration 1.

$\therefore V_1 = \underset{3\times3}{M} \cdot \underset{3\times1}{V}$, $V = \begin{bmatrix} 1/3 \\ 1/3 \\ 1/3 \end{bmatrix}$

$= \begin{bmatrix} 1/3 \\ 3/6 \\ 1/6 \end{bmatrix}$.

(2nd iter.) $V_2 = \begin{bmatrix} 5/12 \\ 1/3 \\ 3/12 \end{bmatrix}$ . . .

9/24

11/24

1/6.

$V_2 = M \cdot V_1$

$V_3 = M \cdot V_2$

$= M \cdot (M \cdot V_1) = M^2 \cdot V_1$

now check for highest Again.

	old A^{in}	old H^{out}	New A	New H
N1	1/9	3/9	3/9	$\frac{8}{9}$
N2	2/9	3/9	6/9	7/9
N3	4/9	2/9	$\frac{3}{9}+\frac{3}{9}+\frac{2}{9}+\frac{1}{9}=1$	6/9
N4	2/9	1/9	$\frac{3}{9}+\frac{2}{9}=\frac{5}{9}$	4/9

9   ΣA ΣH

outdegr(N1) = N2, N3, N4 $\bar{c}$ Auth.

$= \frac{2}{9}+\frac{4}{9}+\frac{2}{9}=\frac{8}{9}$

Indegree(N1) = only N2 $\Rightarrow$ outdegree(N2) = old H of N_2

Indegree(N2) = N1 & N2 = Σoutd. N1 & N2 = $\frac{3}{9}+\frac{3}{9}=\frac{6}{9}$

So on.

as K↑, H & A values do converge

Calculate in & outdegrees

↓

Normalize 'em

New A for node N_1

= [Indeg. of N1]'s outdegree.

... (adj column

New H for node N_1

= [outdeg of N1]'s indegree

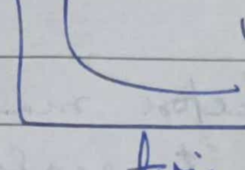
= 1st col.

OAin OHout

Exponentially Decaying windows.

Sliding window $\left[\begin{array}{l}\text{timebased} \\ \text{size based}\end{array}\right\}$ Recent / After a time.

but to avoid making this distinct", & j assign weights
↑ weight to new.

weight  weight Decays over time Exponentially

time

Q. fifa, ipl, fifa, ipl, ipl, ipl, fifa — Exponential Decaying windows Numerical

if u see, # fifa = 3
ipl = 4

Sol^n — Current word = Fifa. (Add 0 if word = ipl
1 fifa)

fifa = $1 * (1-0.1) = 0.9$
ipl = $0.9 * (1-0.1) + 0 = 0.81$
fifa = $0.81(1-0.1) + 1 = 1.729$
ipl = $1.729 * (1-0.1) + 0 = 1.5561$
ipl = $1.5561(1-0.1) + 0 = 1.4005$
ipl = $1.4005(1-0.1) + 0 = 1.2605$
Fifa = $1.2605(1-0.1) + 1 = \boxed{2.135}$

now Current word = ipl (Add 1 if word = ipl
0 Fifa)

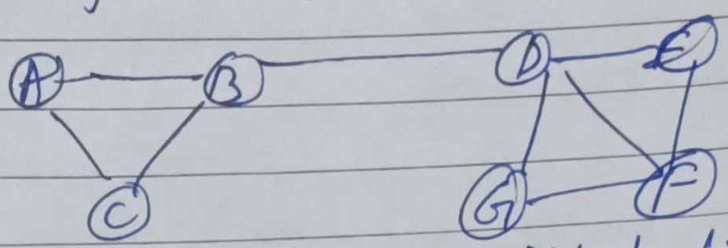
fifa = $0 * (1-0.1) + 0 = 0$
ipl = $0 * (1-0.1) + 1 = 1$
fifa = $1 * (1-0.1) + 0 = 0.9$
ipl = $0.9 * (1-0.1) + 1 = 1.81$
ipl = $1.81 * (1-0.1) + 1 = 2.7919$
ipl = $2.7919 * (1-0.1) + 1 = 3.764$
fifa = $3.764 * (1-0.1) + 0 = \boxed{3.7264}$

score of fifa < score of ipl ∴ ipl is more TRENDING than fifa
3.7264

XY, YZ : XZ
triadic closure
or
friendship paradox

Locality property

Q.



tick over edges that do exist fr.

does this graph exhibit locality property

→

∀ Vertices ↓	neighbours / Adj vertices	Combinations	#✓ / Total combos
A	B, C	BC	1/1 = 1
B	A, C, D	AC, AD, CD	1/3 = 0.33
C	A, B	AB	1/1 = 1
D	B, E, G, F	BE, BG, BF, EG, EF, GF	2/6 = 0.167
E	D, F,	DF	1/1 = 1
F	G, D, E	GD, DE, GE	2/3 = 0.667
G	D, F	DF	1/1 = 1

$\frac{9}{16} = 0.563$

nodes = 7   A B C D E F G

Edges = 9

possible Edges = $\frac{\#n(n-1)}{2} = \frac{7\times 6}{2} = 21$

$\frac{\text{actual \# Edges}}{\text{total possible \# edges}} = \frac{9}{21} = 0.429.$

∴ Conclude locality prop does Exist here

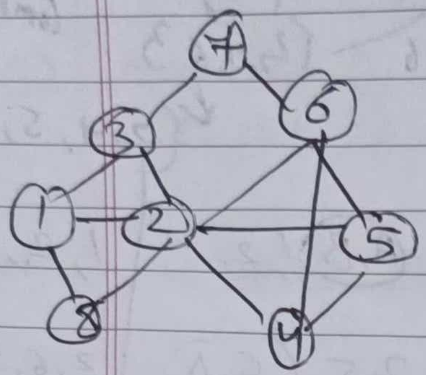
For 2 Edges, $\frac{9-2}{21-2} = 0.368$ prob.

$\therefore \boxed{0.563 > 0.368}$

Sol: Teleportation / Taxation

Soln to link spam : Topic Sensitive PR

Q. Triangle Count:



Vertex	Degree	Edge
1	3	(1,2) (1,3) (1,8)
2	6	(2,6) (2,5) (2,4) (2,3) ~~(2,1)~~ (2,8)
3	3	~~(3,1)~~ ~~(3,2)~~ (3,7)
4	3	~~(4,2)~~ (4,5) (4,6)
5	3	~~(5,2)~~ (5,6) ~~(5,4)~~
6	4	~~(6,2)~~ ~~(6,5)~~ ~~(6,4)~~ ~~(6,7)~~
7	2	~~(7,3)~~ ~~(7,6)~~
8	2	~~(8,1)~~ ~~(8,2)~~

Key → count: 2 if No dir.

Key	values
(1,2) (2,1) (1,3) (3,1) (1,8) (8,1)	w
(2,6) (6,2) (2,5) (5,2) (2,4) (4,2) (2,3) (3,2) (3,7) (7,3)	x
(4,5) (5,4) (4,6) (6,4)	y
(5,6) (6,5)	z
(6,7) (7,6)	

hash table

we can identify if (1,2) exists or no either bidir or uni

arrange the table in ascend order of degrees.

10.2.1 Parameters Used in Graph (Social Network)

> **Q.** Explain the graph parameters listed below :
> (i) Degree (ii) Geodesic distance (iii) Density.
>
> **Q.** How degree, closeness, between's centrality is measured?

Every node is distinct in a network and it is part of graph by set of links. Some general parameter consider for any social network as graph are :

(a) **Degree** : Number of adjacent nodes (considering both out degree and in-degree). Degree of node n_i denoted by $d(n_i)$.

(b) **Geodesic Distance** : Actual distance between two node n_i and n_j, expressed by d (i, j).

(c) **Density** : It gives correctness of a graph, it is useful to count closeness of network.

(d) **Centrality** : It tells about degree centrality i.e. nodes appearance in the centre of network centrality has types.

Example :

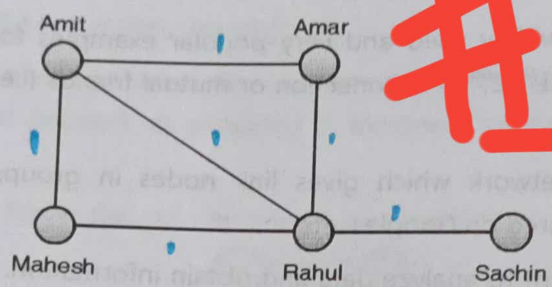


Fig. 10.2.1

#Edges / 2*#node = 6 / 2×5

Degree of each nodes are as follows :

Nodes	Degree
Amit	3
Amar	2
Mahesh	2
Rahul	4
Sachin	1

Density of undirected graph is 0.6.

Geodesic Distances between two nodes is as follows :

	Amit	Amar	Mahesh	Rahul	Sachin
Amit	–	1	1	1	2
Amar	1	–	2	1	2
Mahesh	1	2	–	1	2
Rahul	1	1	1	–	1
Sachin	2	2	2	1	–

ead ends

rsity Question

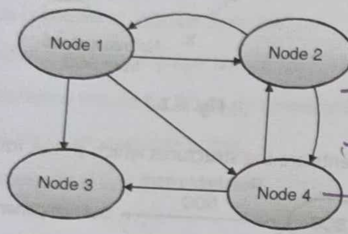
xplain how dead ends are handled in Page Rank. **MU : Dec. 16, 5 Marks**

In a given part of web, if we encountered with a page which doesn't have links which are going out from that page or component.

This will affect the transition matrix directly as, the column containing entry for dead end page will lead to sum = 0 instead of 1.

The property of having sum = 1 for most of the columns in a given transition matrix is known as '**Stochasticity**' and if there are dead ends then some of the columns have '0' entries.

Consider the Fig. 8.1.10.



	N1	N2	N3	N4
N1	0	1/3	1/3	1/3
N2	1/2	0	0	1/2
N3	0	0	0	0
N4	0	1/2	1/2	0

Fig. 8.1.10 : Node 3 is dead end

referring Fig. 8.1.10 we came to know that, Mode 3 is dead end and while searching if we countered on the Node 3. i.e. at dead end then web surfing will struck at that page or node as there ot a single out link from Node 3. Hence, transition matrix for Fig. 8.1.10 is,

$$\begin{array}{cc} & \begin{array}{cccc} 1 & 2 & 3 & 4 \end{array} \\ M = \begin{array}{c} 1 \\ 2 \\ 3 \\ 4 \end{array} & \begin{bmatrix} 0 & 1/2 & \boxed{0} & 0 \\ 1/3 & 0 & 0 & 1/2 \\ 1/3 & 0 & 0 & 1/2 \\ 1/2 & 1/2 & 0 & 0 \end{bmatrix} \end{array}$$

All zereos

are the ways to deal with dead ends :

ach to deal with dead ends we can delete that node by removing their incoming links.

antage of this approach is it will introduce more dead ends which has to be solved with the same ch in recursive manner.

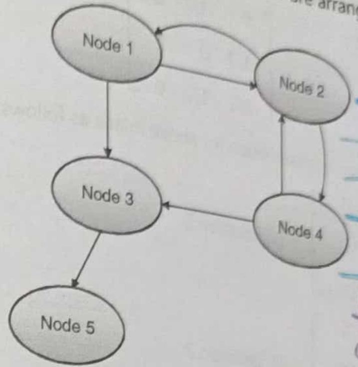
we delete the node but total page rank for a given graph to or web will be kept as it is the which are not available in graph G, but we can consider the set of other nodes which acts as ssors for the calculation of page rank.

ally we can consider the successor nodes and have a division operation.

procedure, some nodes might be there which are not available in graph G but they are done predecessors calculations.

e iterations all nodes has their page rank the order in which page ranks are calculated is posite to node deletion order.

- Suppose we have graph containing nodes and these nodes are arranged in following manner as shown in Fig. 8.1.11.

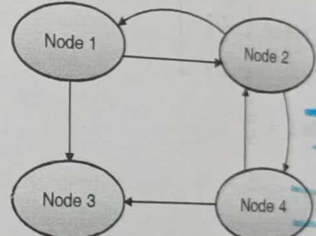


	1	2	3	4	5
1	0	1	1	0	0
2	1	0	0	1	0
3	0	0	0	0	1
4	0	1	1	0	0
5	0	0	0	0	0

whole row = 0.
∴ Node 5 = Deadend

Fig. 8.1.11

- If we observe the Fig. 8.1.11 to calculate the page rank. We find that, Node 5 is the dead end as it doesn't have any forward links i.e. the links going out from Node 5.
- So hence, to avoid the dead ends, delete the Node 5 and its corresponding are coming from Node 3. So now the graph G becomes.



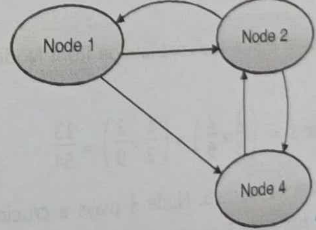
just discard it

	1	2	3	4
1	0	1	1	0
2	1	0	0	1
3	0	0	0	0
4	0	1	1	0

Fig. 8.1.12 : Graph a after deletion of node 5

- By observe the Fig. 8.1.12 we came to know that now 'node 3' is '**dead end**'.
- Now as we are avoiding the dead ends. Hence delete 'Node 3' and it is respective in coming edges. Now, Graph G becomes,

removing 5 node 3 a deadend.
∴ Remove 3 also.



	1	2	4
1	0	1/2	1/2
2	1/2	0	1/2
4	0	1/1	0

Fig. 8.1.13 : After deletion of node 3

- Now every node : Node 1, Node 2, and Node 3 has edges coming out i.e. forward links. Hence, is no dead end in graph 'G'.

- The transition matrix for above graph will be,

$$M = \begin{bmatrix} 0 & 1/2 & 0 \\ 1/2 & 0 & 1 \\ 1/2 & 1/2 & 0 \end{bmatrix}$$

We can have component vector representation for above matrix as follows :

$$\begin{bmatrix} 1/3 \\ 1/3 \\ 1/3 \end{bmatrix} \text{ – (1) Iteration 1}$$

$$\begin{bmatrix} 1/6 \\ 3/6 \\ 2/6 \end{bmatrix} \text{ – (2) Iteration 2}$$

$$\begin{bmatrix} 3/12 \\ 5/12 \\ 4/12 \end{bmatrix} \text{ – (3) Iteration 3}$$

Final value for component vector will be, $\begin{bmatrix} 2/9 \\ 4/9 \\ 3/9 \end{bmatrix}$

Page rank for node 1 $= \frac{2}{9}$

Page rank for node 2 $= \frac{4}{9}$

Page rank for node 4 $= \frac{3}{9}$

P.R. for node 3 = ?

" 5 = ?

- We have to calculate the page rank for Node 3 and Node 5 with the exact opposite order of node deletion. Here Node 1, Node 2, Node 4 are in the role of predecessors.
- Number of successor to Node 1 = 3, Hence, the contribution from Node 1 for calculating the page rank of Node 3 is 1/3
- For Node 5 it has 2 successors. Hence the contribution from Node 5 for calculating the page rank of node 3 is 1/2.

$$\text{Page rank of Node 3} = \left(\frac{1}{3}\times\frac{2}{9}\right) + \left(\frac{1}{2}\times\frac{3}{9}\right) = \frac{13}{54}$$

- For calculating the page rank of Node 5, Node 3 plays a crucial role. As Node 3 has, number of successors = 1 and node 1 has node 3 as its predecessor. Hence, we can conclude that Node 5 was page rank same as that of Node 3.
- As the aggregate of their page rank is greater than 1, so it doesn't indicate the distribution for a given user who is surfing through that web page. Still it highlights the importance of web page relatively.