

Centrality

- Degree

– how well connected; direct influence

- Closeness

– how far from all others

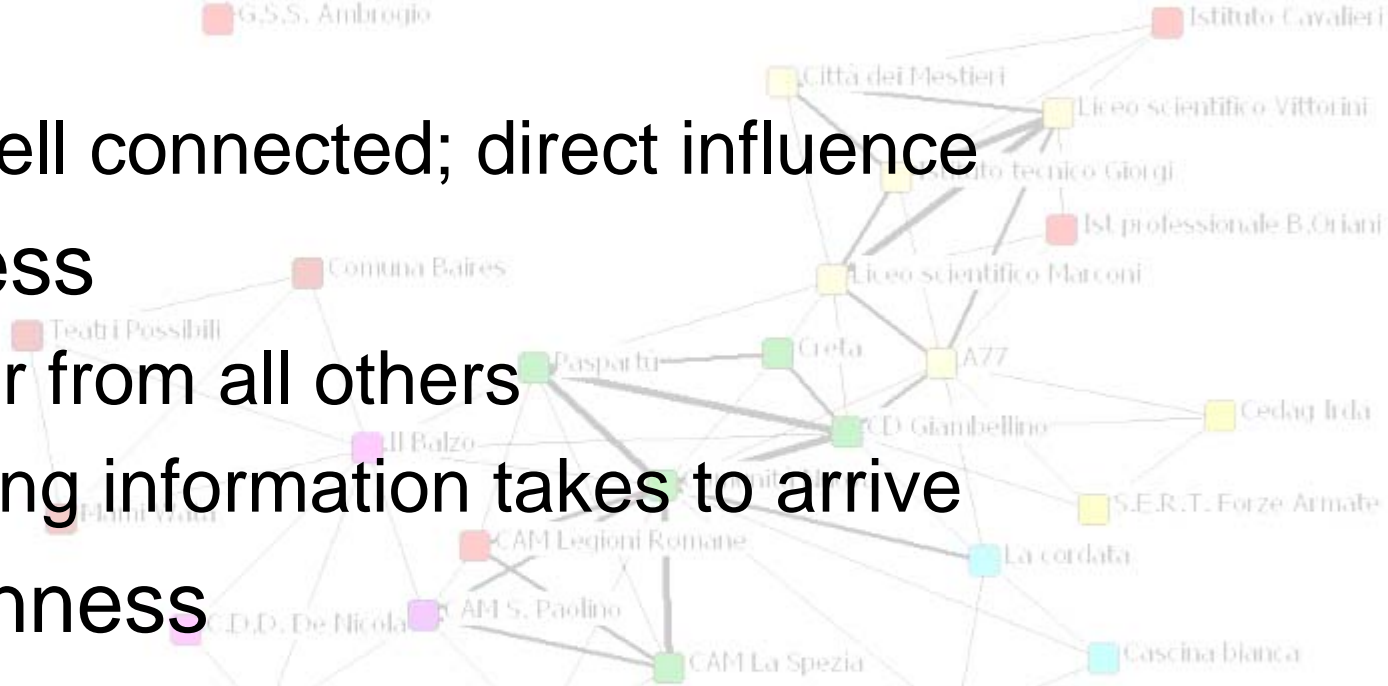
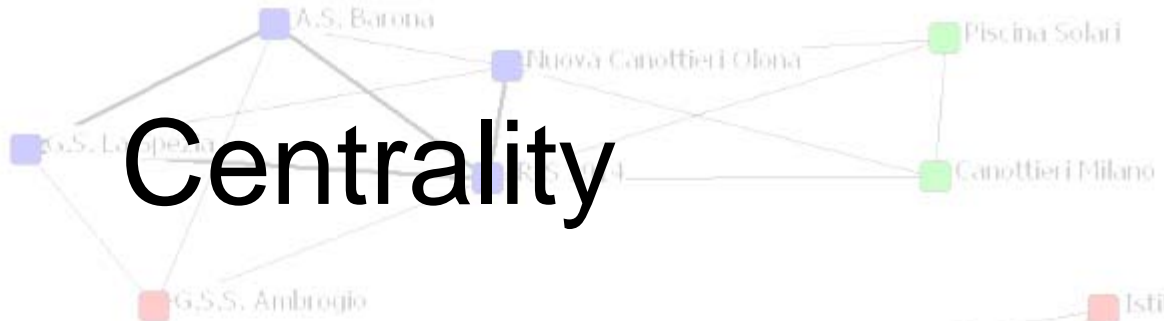
– how long information takes to arrive

- Betweenness

– brokerage, gatekeeping, control of info

- Eigenvector (popularity)

– being connected to the well connected

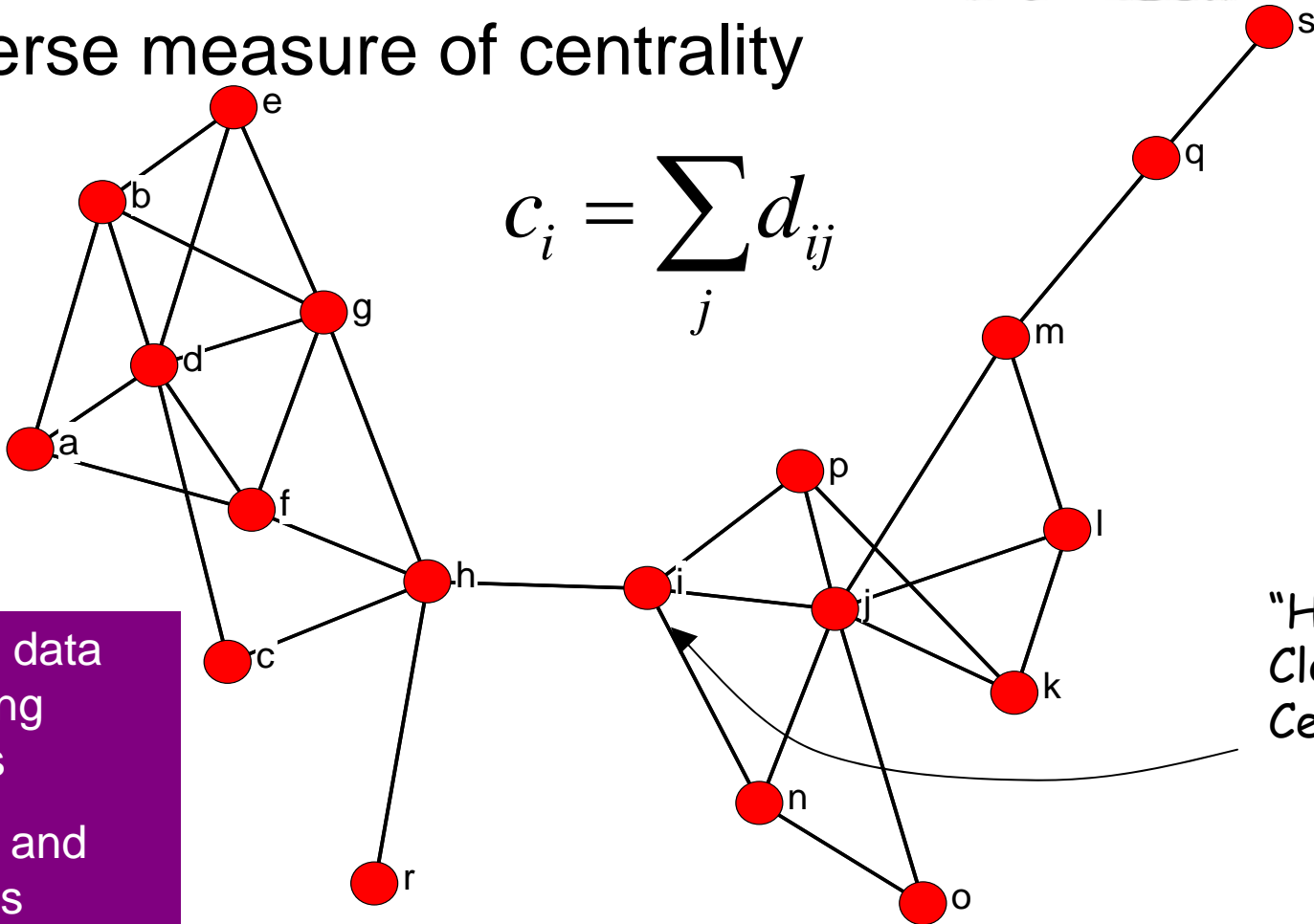


Red	= group 0
Blu	= group 1
Light green	= group 2
Turquoise	= group 3
Dark green	= group 4
Orange	= group 5
Yellow	= group 6
Violet	= group 7
Pink	= group 8
Brown	= group 9

Closeness Centrality

- Sum of geodesic distances to all other nodes
- Inverse measure of centrality

$$c_i = \sum_j d_{ij}$$



For directed data
only on strong
components

Incloseness and
outcloseness

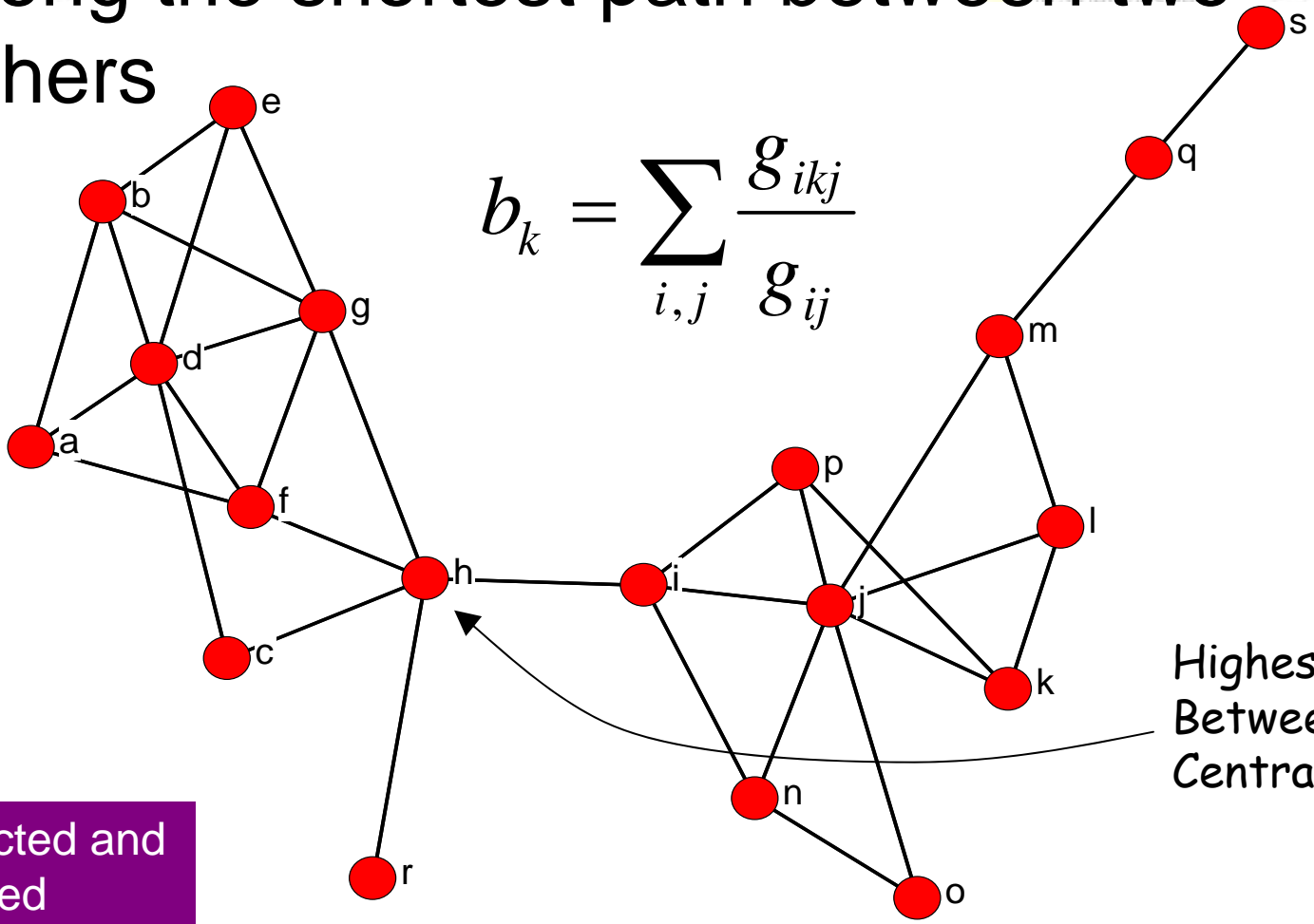
"Highest"
Closeness
Centrality

- group 0
- group 1
- group 2
- group 3
- group 4
- e = group 5
- v = group 6
- group 7
- group 8
- i = group 9

Betweenness Centrality

- Loosely: number of times that a node lies along the shortest path between two others

$$b_k = \sum_{i,j} \frac{g_{ikj}}{g_{ij}}$$



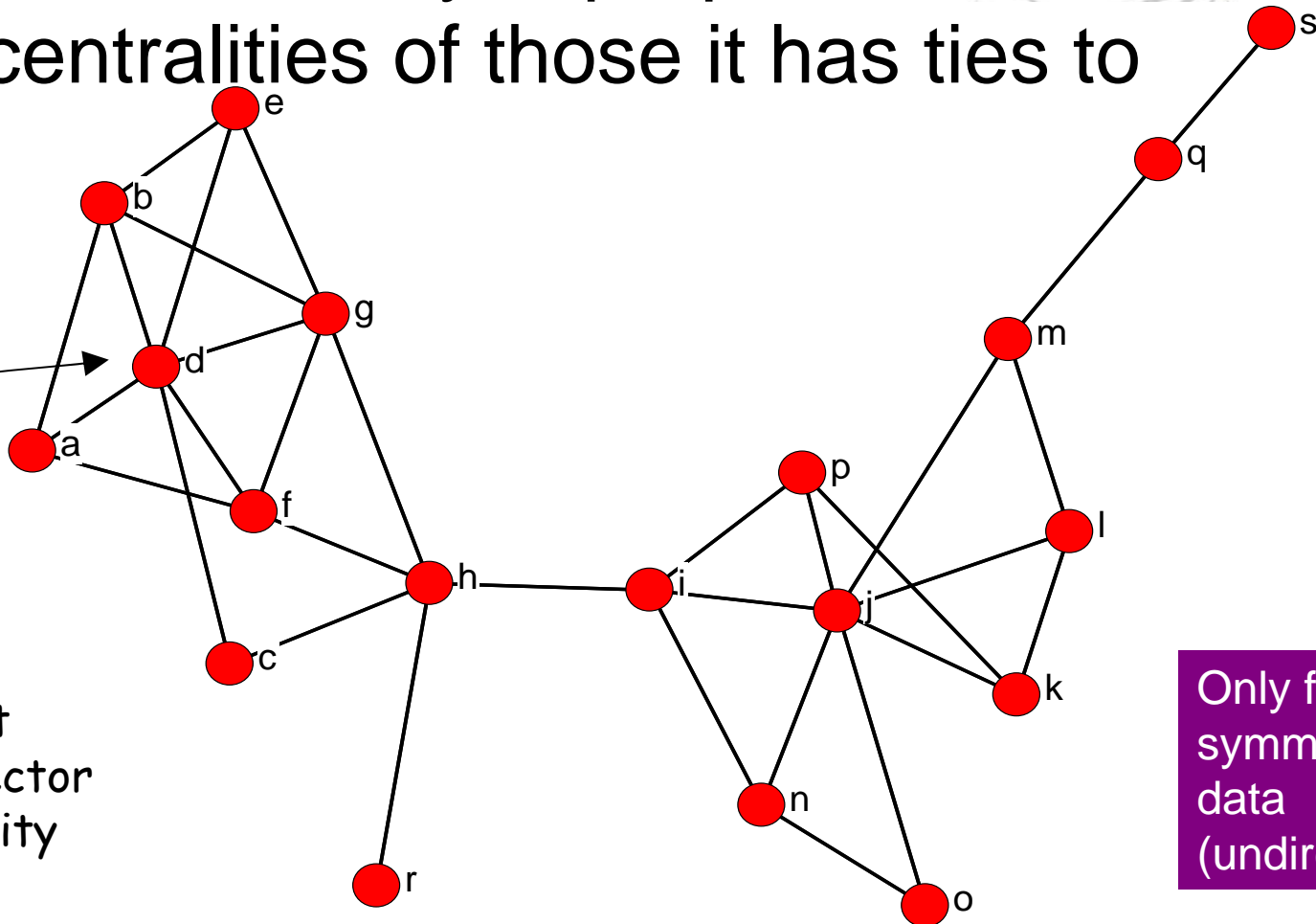
Highest Betweenness Centrality

For directed and undirected

- ed = group 0
- la = group 1
- group 2
- group 3
- group 4
- group 5
- group 6
- group 7
- group 8
- group 9

Eigenvector Centrality

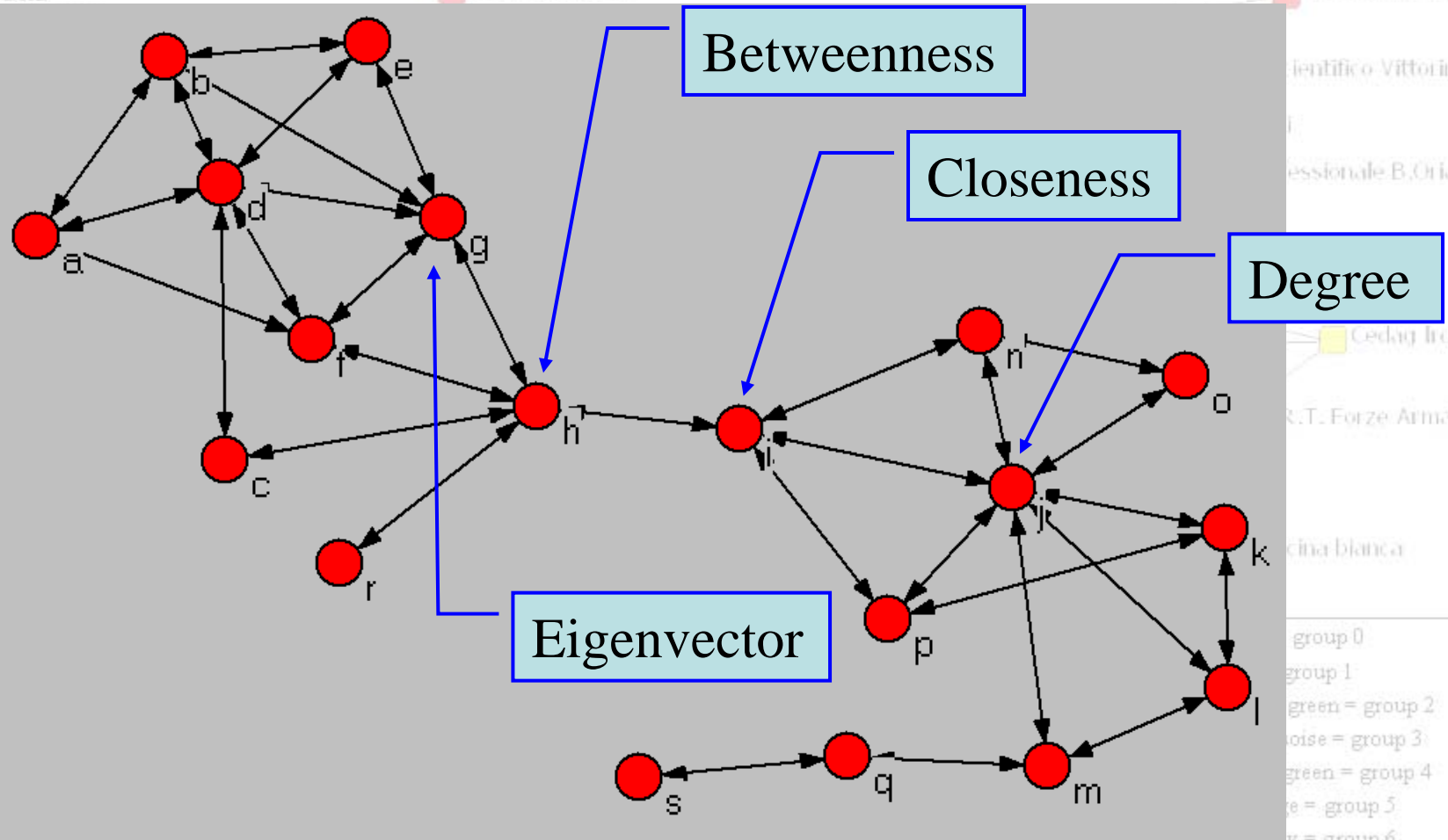
- Iterative version of degree centrality: a node's centrality is proportional to the sum of centralities of those it has ties to



Highest
eigenvector
Centrality

Only for
symmetric
data
(undirected)

4 Aspects of Centrality



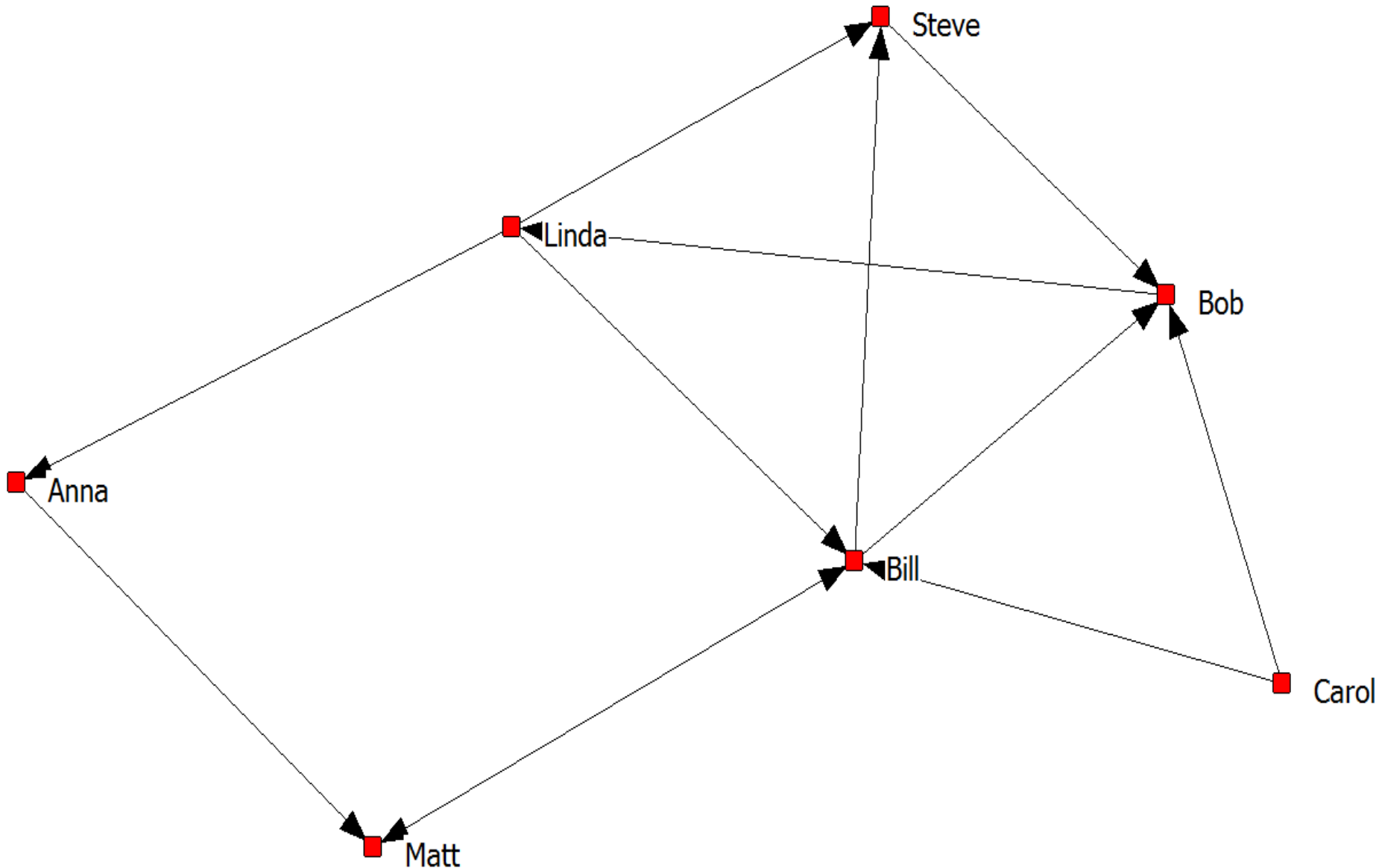
- Aqorà
- Amici della musica
- Arcimetromondo
- Arcobaleno
- Arcobaleno Danza
- Arno Stern
- Ass. Sportiva dilettantistica
- Atelier di pittura
- Atletico Milano
- Barona E. Satta
- Biblioteca L.
- C.P.B.A.
- C.P.S. Sode
- C.P.S. Vigili
- C.T.F.
- C.T.P.: S. P.
- C.T.P.: Zua
- Centro Con
- Centro pitt.
- Centro stud
- CFP - Paul
- Comunità A
- Cooperativa
- Cose dell'alt
- Don Orione
- Enaip Lomb
- Futsal
- Handicap: s
- Immacolat
- Istituto d'an
- Istituto Res
- L'impronta
- La Creta
- La Piazzett
- Le Tre Fon
- Liceo scient
- Mani Tese
- MB Sportell
- Mediazione
- Milano Spor
- Palauno
- Piscina Cardellino

- A.S. Baiona
- Nuova Canottieri Olona
- Piscina Solari
- Canottieri Milano
- G.S.S. Ambrogio
- Istituto Cavalieri

- Cedag Irla
- K.T. Forze Armate
- cina bianca
- group 0
- group 1
- green = group 2
- noise = group 3
- green = group 4
- re = group 5
- group 6
- Violet = group 7
- Pink = group 8
- Brown = group 9

Centrality for directed data

- Agorà
- Amici della musica
- Arcimetromondo
- Arcobaleno
- Arcobaleno Danza



Brown = group 9

FREEMAN'S DEGREE CENTRALITY MEASURES

(The normalized degree centrality is the degree divided by the maximum possible degree expressed as a percentage; The share is the centrality measure of the actor divided by the sum of all the actor centralities in the network)

Diagonal valid? NO

Model: **ASYMMETRIC**

Input dataset: C:\Users\ELISA

BELLOTTI\Documents\università\MANCHESTER\workshop SNA\dati prova\directed

	1	2	3	4
	OutDegree	InDegree	NrmOutDeg	NrmInDeg
1 Bill	3.000	3.000	50.000	50.000
4 Linda	3.000	1.000	50.000	16.667
7 Carol	2.000	0.000	33.333	0.000
2 Bob	1.000	3.000	16.667	50.000
3 Anna	1.000	1.000	16.667	16.667
5 Matt	1.000	2.000	16.667	33.333
6 Steve	1.000	2.000	16.667	33.333

DESCRIPTIVE STATISTICS

	1	2	3	4
	OutDegree	InDegree	NrmOutDeg	NrmInDeg
1 Mean	1.714	1.714	28.571	28.571
2 Std Dev	0.881	1.030	14.677	17.169
3 Sum	12.000	12.000	200.000	200.000
4 Variance	0.776	1.061	215.420	294.785
5 SSQ	26.000	28.000	7222.222	7777.777
6 MCSSQ	5.429	7.429	1507.937	2063.492
7 Euc Norm	5.099	5.292	84.984	88.192
8 Minimum	1.000	0.000	16.667	0.000
9 Maximum	3.000	3.000	50.000	50.000

Network Centralization (Outdegree) = 25.000%

Network Centralization (Indegree) = 25.000%

Actor-by-centrality matrix saved as dataset FreemanDegree

- Red = group 0
- Blu = group 1
- Light green = group 2
- Turquoise = group 3
- Dark green = group 4
- Orange = group 5
- Yellow = group 6
- Violet = group 7
- Pink = group 8
- Brown = group 9

CLOSENESS CENTRALITY

Input dataset: C:\Users\ELISA BELLOTTI\Documents\università\MANCHESTER\workshop
 SNA\dati prova\directed
 Method: Geodesic paths only (Freeman Closeness)
 Output dataset: C:\Users\ELISA BELLOTTI\Documents\università\MANCHESTER\workshop
 SNA\dati prova\Closeness

**Note: Data not symmetric, therefore separate in-closeness & out-closeness computed.
 The network is not connected. Technically, closeness centrality cannot be computed, as there are infinite distances.**

Closeness Centrality Measures

		1	2	3	4
		inFarness	outFarness	inCloseness	outCloseness
1	Bill	10.000	15.000	60.000	40.000
2	Bob	10.000	17.000	60.000	35.294
6	Steve	11.000	20.000	54.545	30.000
5	Matt	13.000	19.000	46.154	31.579
4	Linda	14.000	14.000	42.857	42.857
3	Anna	16.000	20.000	37.500	30.000
7	Carol	42.000	11.000	14.286	54.545

Statistics

		1	2	3	4
		inFarness	outFarness	inCloseness	outCloseness
1	Mean	16.571	16.571	45.049	37.754
2	Std Dev	10.581	3.156	14.864	8.259
3	Sum	116.000	116.000	315.342	264.276
4	Variance	111.959	9.959	220.949	68.210
5	SSQ	2706.000	1992.000	15752.451	10454.846
6	MCSSQ	783.714	69.714	1546.640	477.471
7	Euc Norm	52.019	44.632	125.509	102.249
8	Minimum	10.000	11.000	14.286	30.000
9	Maximum	42.000	20.000	60.000	54.545

Red = group 0
 Blu = group 1
 Light green = group 2
 Turquoise = group 3
 Dark green = group 4
 Orange = group 5
 Yellow = group 6
 Violet = group 7
 Pink = group 8
 Brown = group 9

Network centralization not computed for unconnected graphs

Output actor-by-centrality measure matrix saved as dataset C:\Users\ELISA BELLOTTI\Documents\università\MANCHESTER\workshop SNA\dati prova\Closeness

FREEMAN BETWEENNESS CENTRALITY

Input dataset:

C:\Users\ELISA

BELLOTTI\Documents\università\MANCHESTER\workshop SNA\dati prova\directed

Important note: this routine binarizes but does NOT symmetrize.

Un-normalized centralization: 39.000

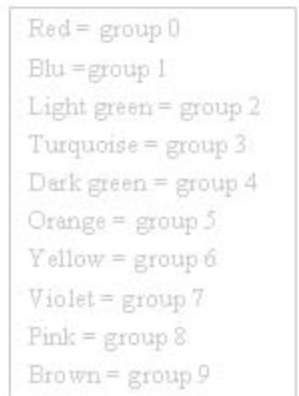
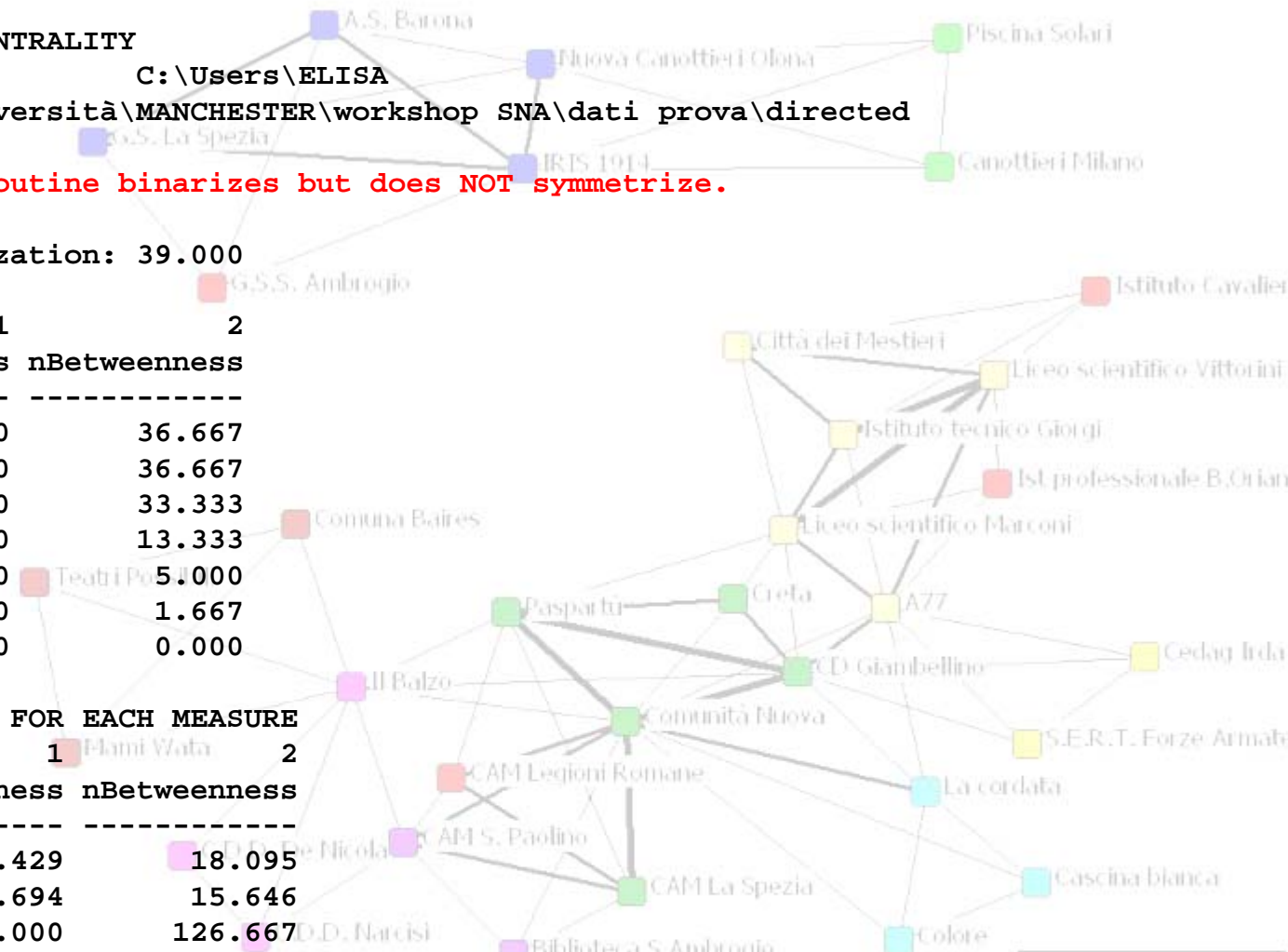
	1	2
	Betweenness	nBetweenness
	-----	-----
1 Bill	11.000	36.667
2 Bob	11.000	36.667
4 Linda	10.000	33.333
5 Matt	4.000	13.333
3 Anna	1.500	5.000
6 Steve	0.500	1.667
7 Carol	0.000	0.000

DESCRIPTIVE STATISTICS FOR EACH MEASURE

	1	2
	Betweenness	nBetweenness
	-----	-----
1 Mean	5.429	18.095
2 Std Dev	4.694	15.646
3 Sum	38.000	126.667
4 Variance	22.031	244.785
5 SSQ	360.500	4005.556
6 MCSSQ	154.214	1713.492
7 Euc Norm	18.987	63.289
8 Minimum	0.000	0.000
9 Maximum	11.000	36.667

Network Centralization Index = 21.67%

Output actor-by-centrality measure matrix saved as dataset FreemanBetweenness



BONACICH CENTRALITY

Method:

Slow

Input dataset:

C:\Users\ELISA

BELLOTTI\Documents\università\MANCHESTER\workshop SNA\dati prova\directed

WARNING: This version of the program cannot handle asymmetric data.

Matrix symmetrized by taking larger of Xij and Xji.

EIGENVALUES

FACTOR	VALUE	PERCENT	CUM %	RATIO
1:	3.513	34.6	34.6	3.186
2:	1.102	10.8	45.4	2.360
3:	0.467	4.6	50.0	
4:	-0.300	-3.0	47.0	
5:	-1.233	-12.1	34.9	
6:	-1.374	-13.5	21.4	
7:	-2.174	-21.4	0.0	

Bonacich Eigenvector Centralities

	1	2	
	Eigenvec	nEigenvec	
1	Bill	0.513	72.520
2	Bob	0.469	66.303
3	Anna	0.184	26.009
4	Linda	0.448	63.309
5	Matt	0.198	28.050
6	Steve	0.407	57.545
7	Carol	0.279	39.522

Descriptive Statistics

	1	2	
	Eigenvec	nEigenvec	
1	Mean	0.357	50.466
2	Std Dev	0.125	17.617
3	Sum	2.498	353.259
4	Variance	0.016	310.373
5	SSQ	1.000	20000.000
6	MCSSQ	0.109	2172.615
7	Euc Norm	1.000	141.421
8	Minimum	0.184	26.009
9	Maximum	0.513	72.520
10	N of Obs	7.000	7.000

Network centralization index = 43.48%

Centrality scores saved as dataset

C:\Users\ELISA

BELLOTTI\Documents\università\MANCHESTER\workshop SNA\dati prova\EigenvectorCentrality

- Red = group 0
- Blu = group 1
- Light green = group 2
- Turquoise = group 3
- Dark green = group 4
- Orange = group 5
- Yellow = group 6
- Violet = group 7
- Pink = group 8
- Brown = group 9