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Localization of hubs in complex networks with overlapping modular structure

Zakariya Ghalmane, Chantal Cherifi, Hocine Cherifi, Mohammed El Hassouni

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Localization of hubs in complex networks with overlapping modular structure

Zakariya Ghalmane

University Mohammed V MOROCCO
University of Burgundy FRANCE

Mohammed El Hassouni

University Mohammed V MOROCCO

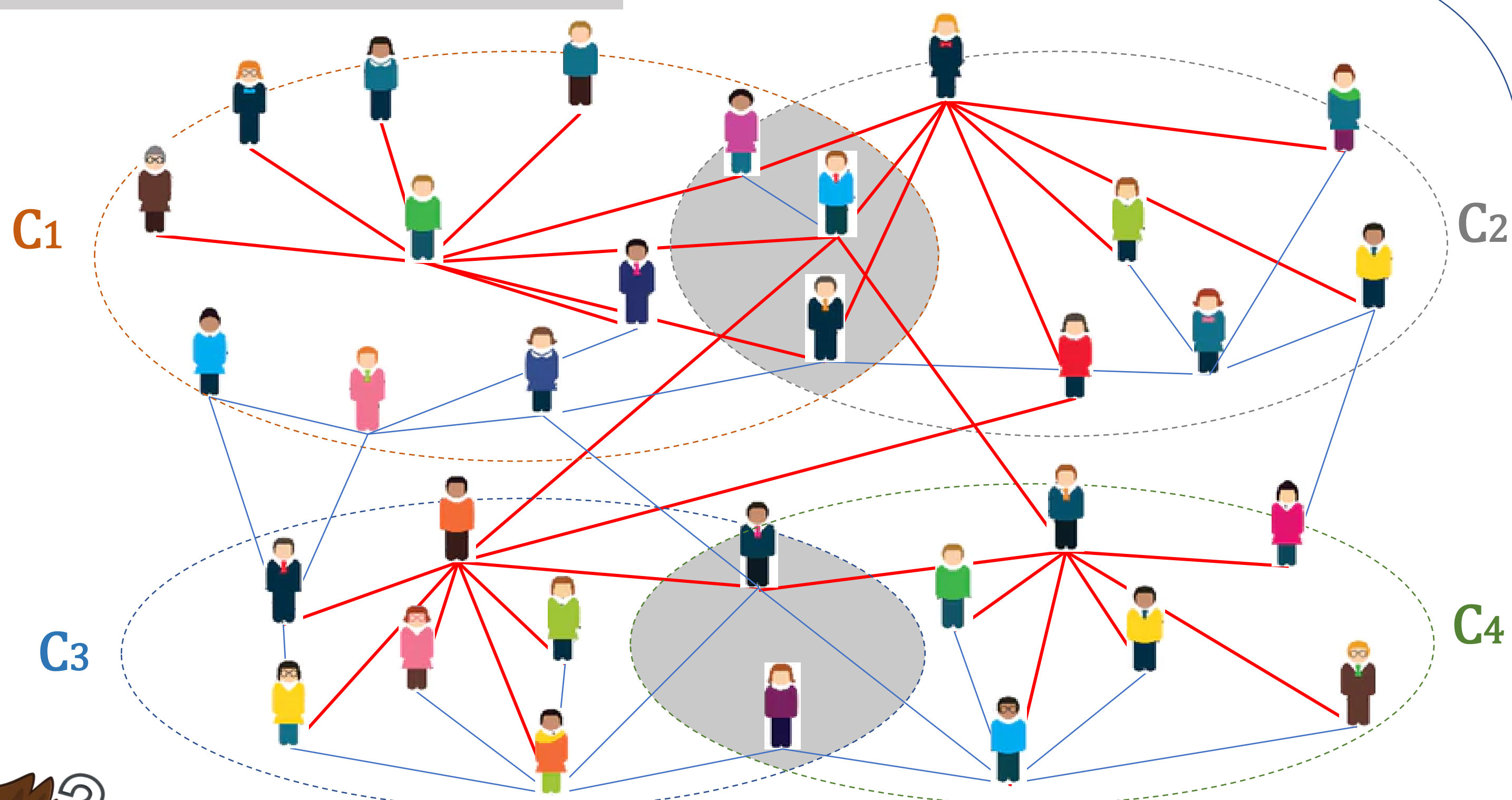
Chantal Cherifi

University of Lyon 2 FRANCE

Hocine Cherifi

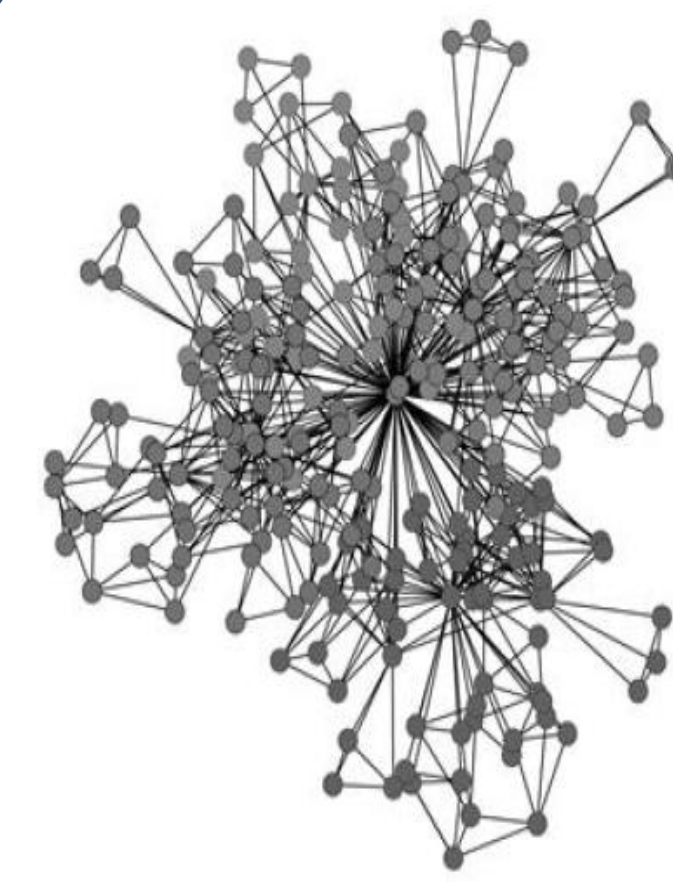
University of Burgundy FRANCE

Problematic

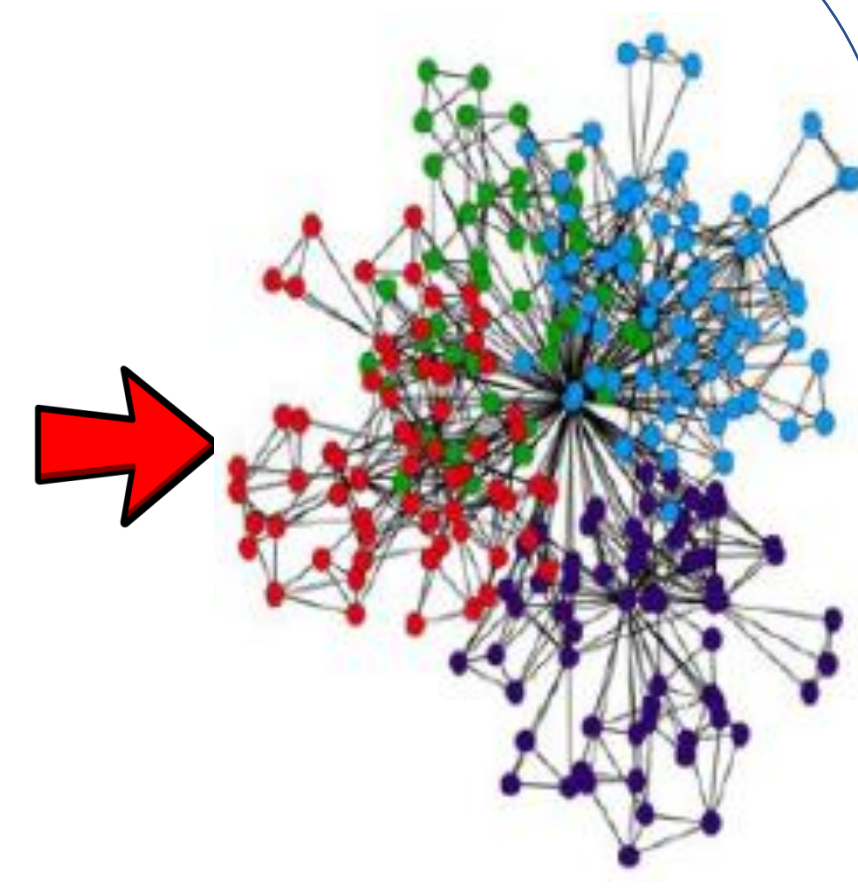


Overlapping nodes ↔ Hubs

Methodology



Community detection



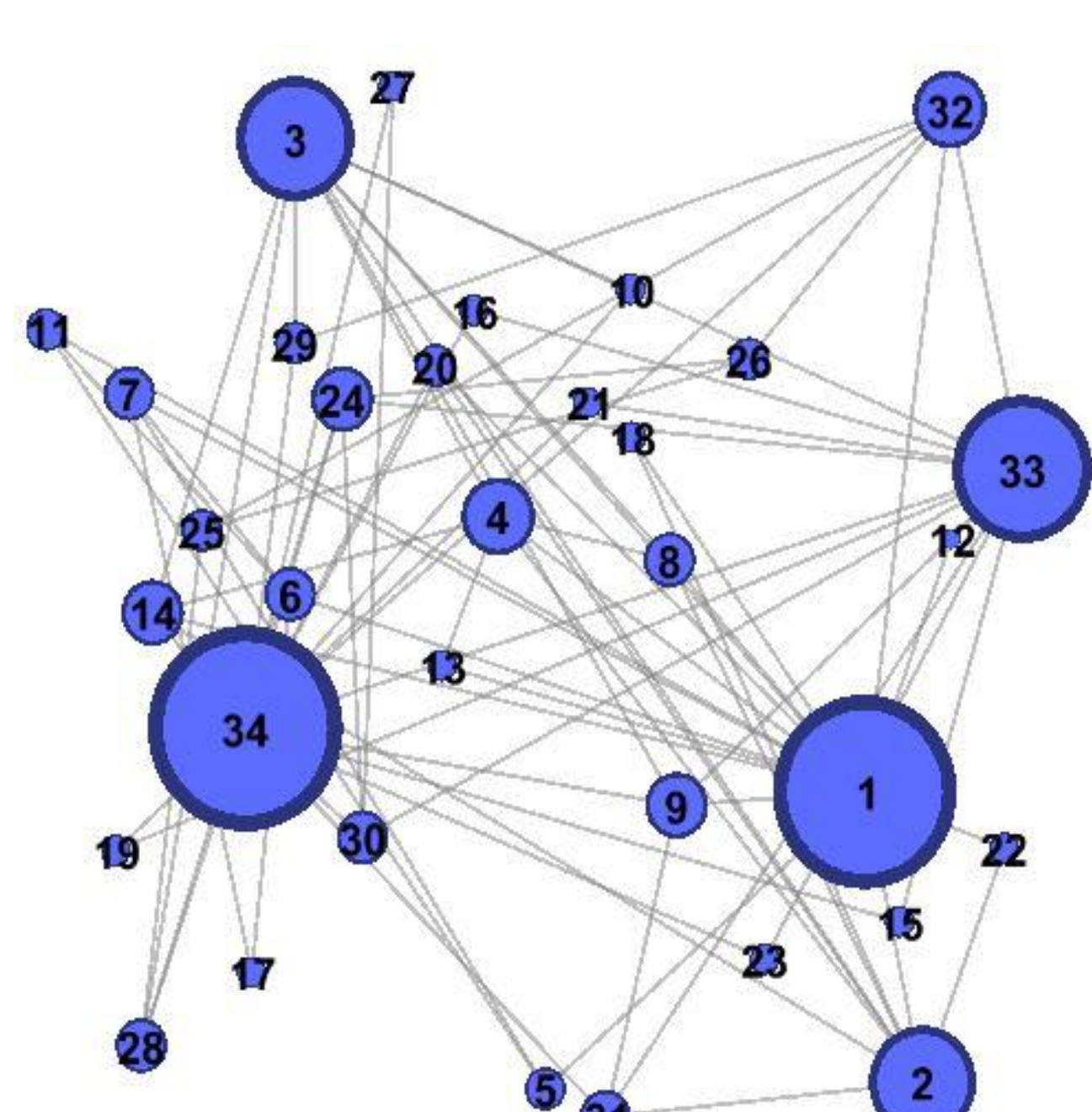
Evaluation measures

Proportion of hubs
Rank-biased overlap
Correlation
Degree distribution

Ego-network of overlapping nodes & List of Hubs

Empirical Networks

Small Network



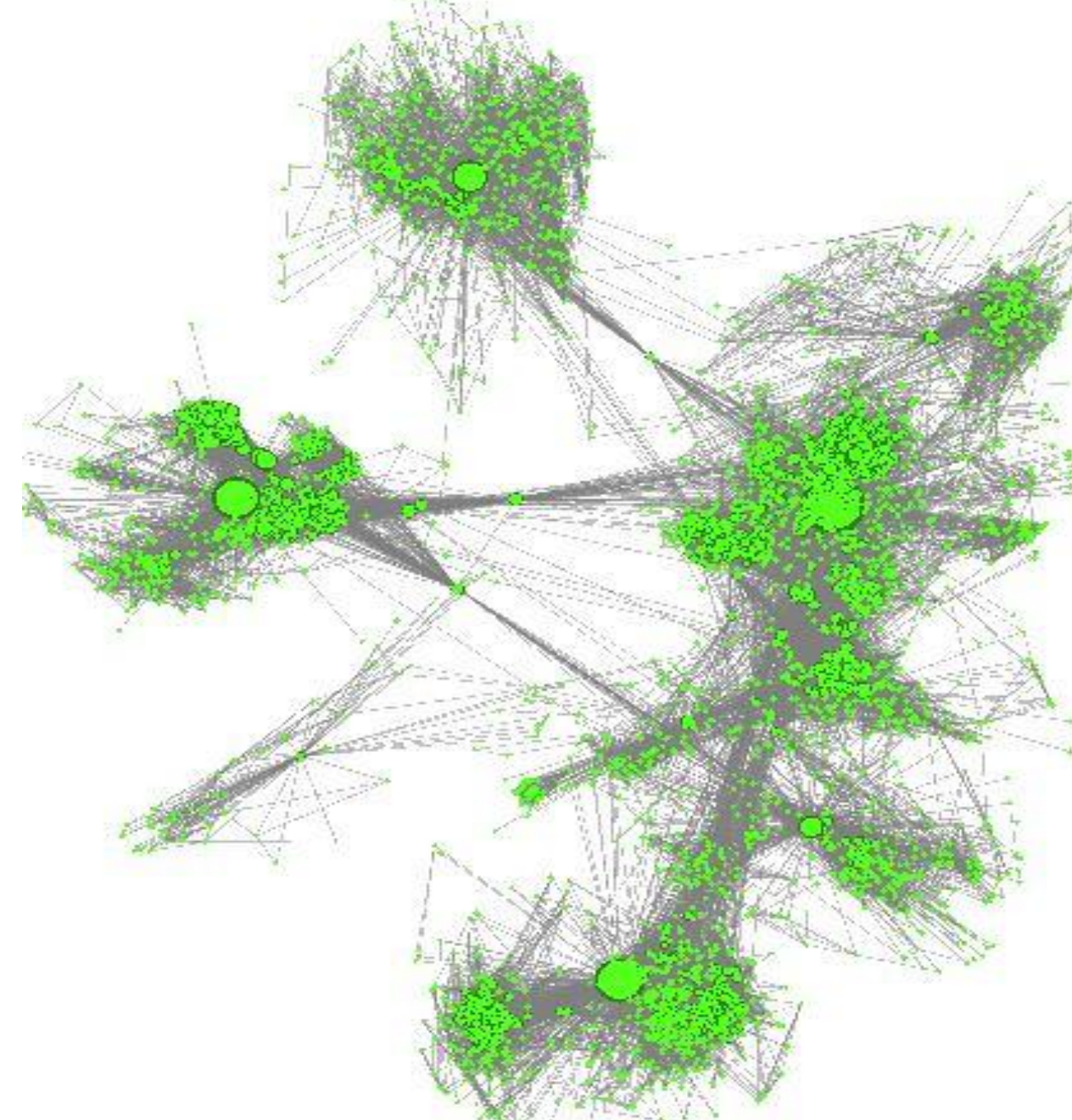
Social network

N 34
E 78

Relatively high density
Non Assortative

Karate network

Medium Network



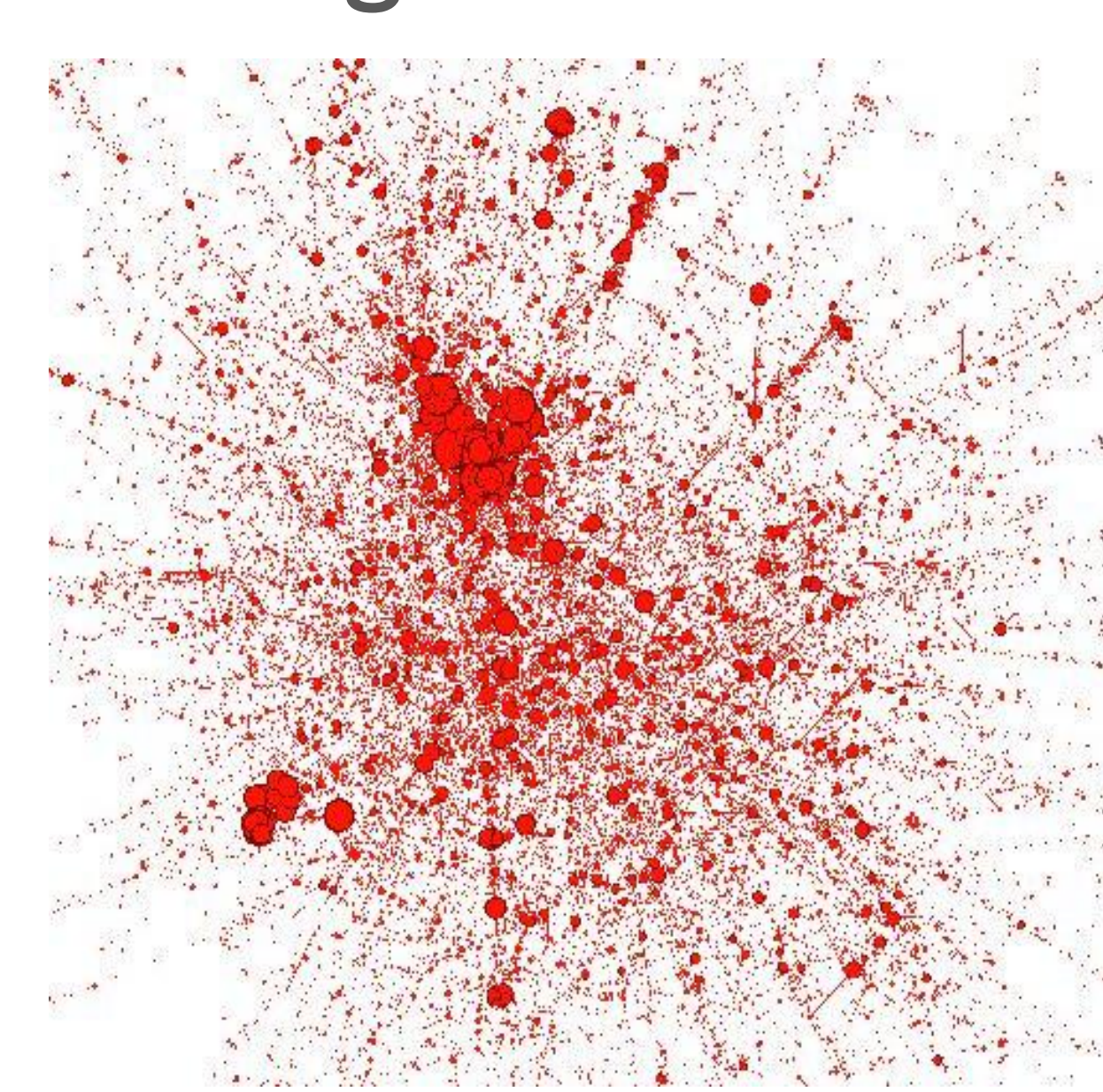
Social network

N 4039
E 88234

Small density
Assortative

Ego-Facebook network

Large Network



Collaboration network

N 23133
E 93497

Very small density
Assortative

Condense Matter network

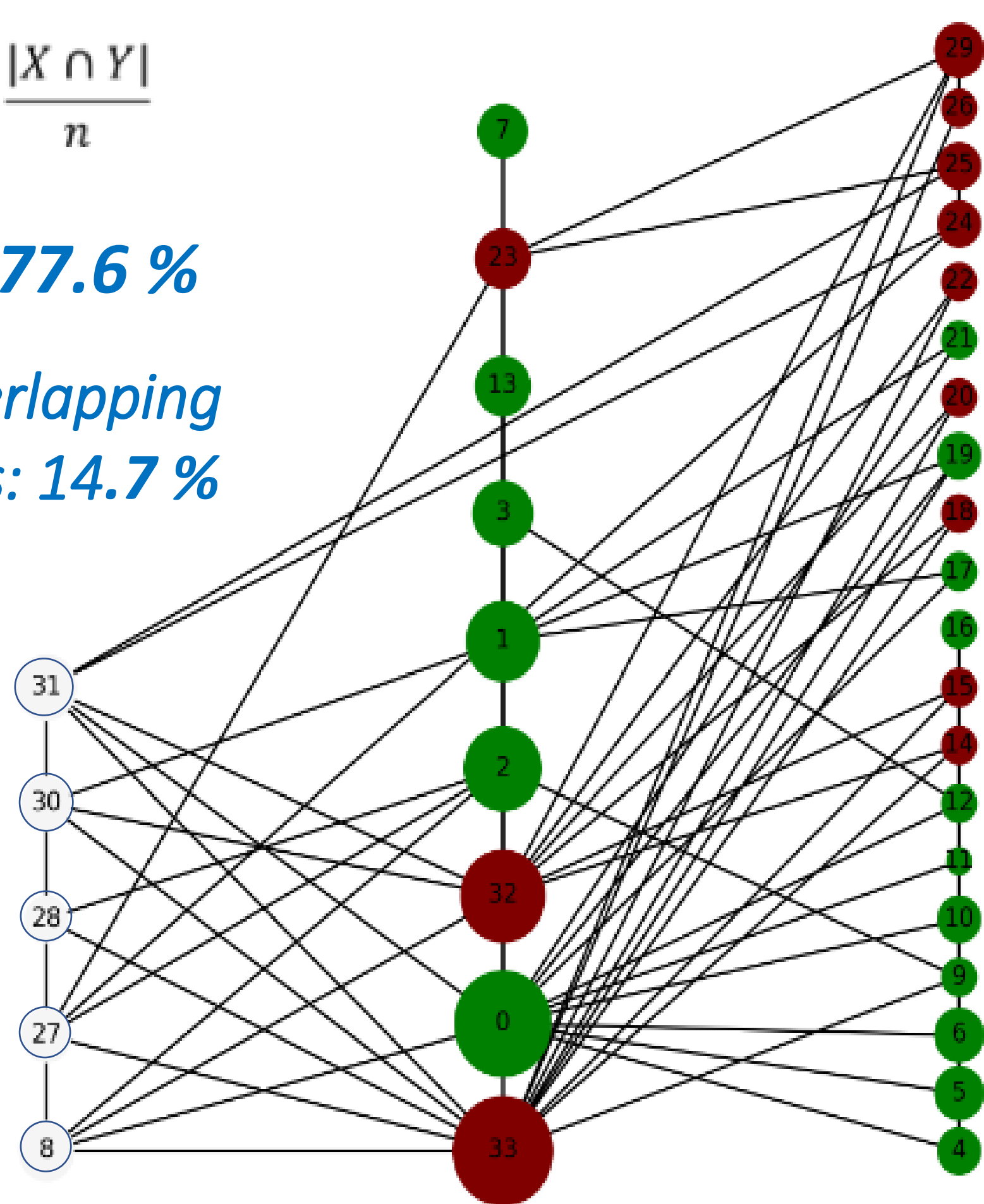
Results

Proportion of hubs

$$p = \frac{|X \cap Y|}{n}$$

$p = 77.6\%$

$P. overlapping nodes: 14.7\%$



Overlapping nodes

Hubs

Rank-biased overlap

$$RBO(X,Y) = \sum_d w_d A_d$$

$$A_d = \frac{|X_{1:d} \cap Y_{1:d}|}{d}$$

$$w_d = (1-p) * p^{d-1}$$

Network	RBO		
	$p=0.5$	$p=0.8$	$p=0.98$
Karate club	0.998	0.952	0.844
Ego-facebook	0.998	0.952	0.844
ca-CondMat	1	0.999	0.999

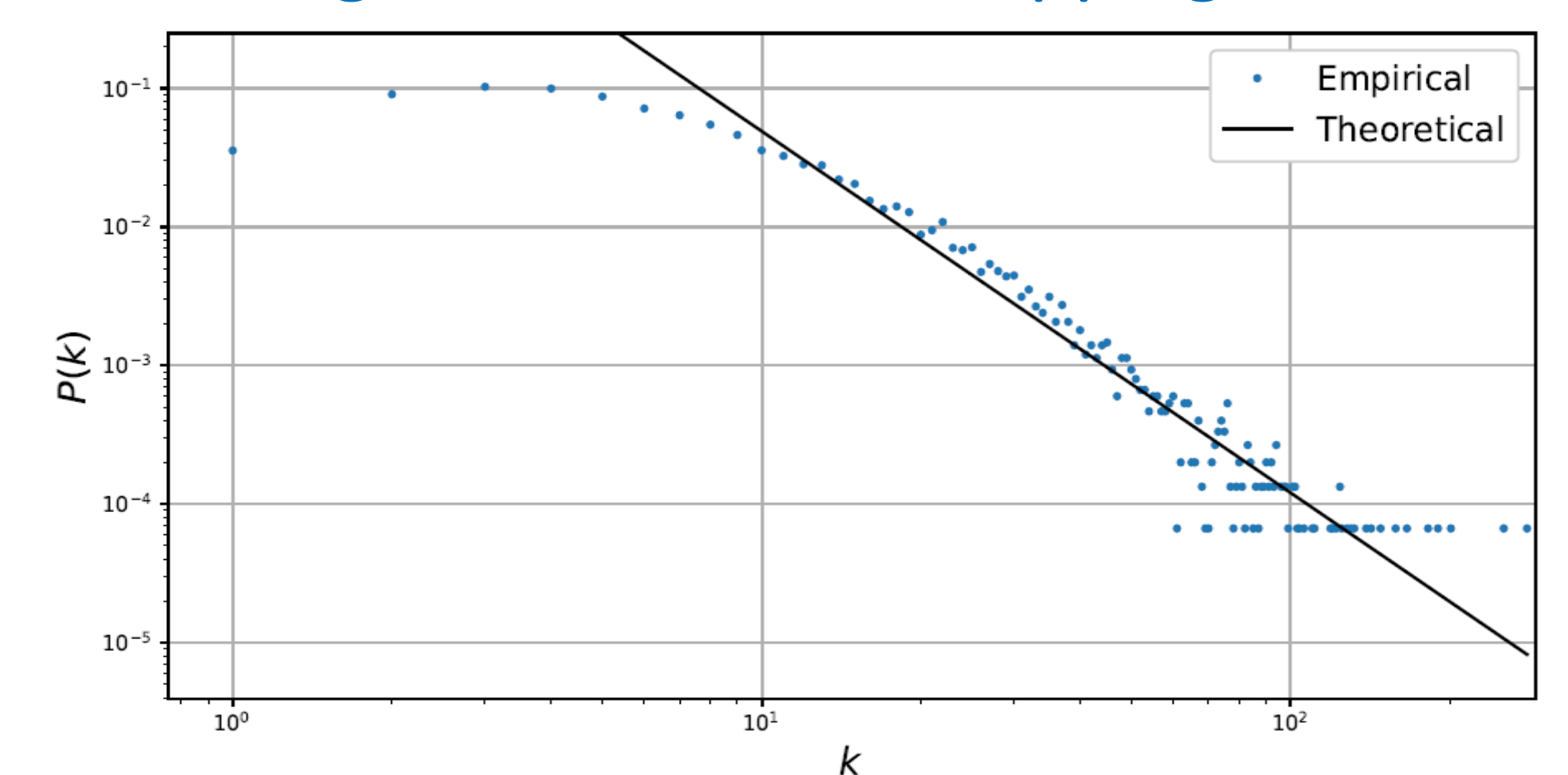
Correlation

Network	$P. overlapping nodes (%)$	Proportion of hubs (%)
ego-Facebook	3.1	59.25
ca-CondMat	2.1	79.57

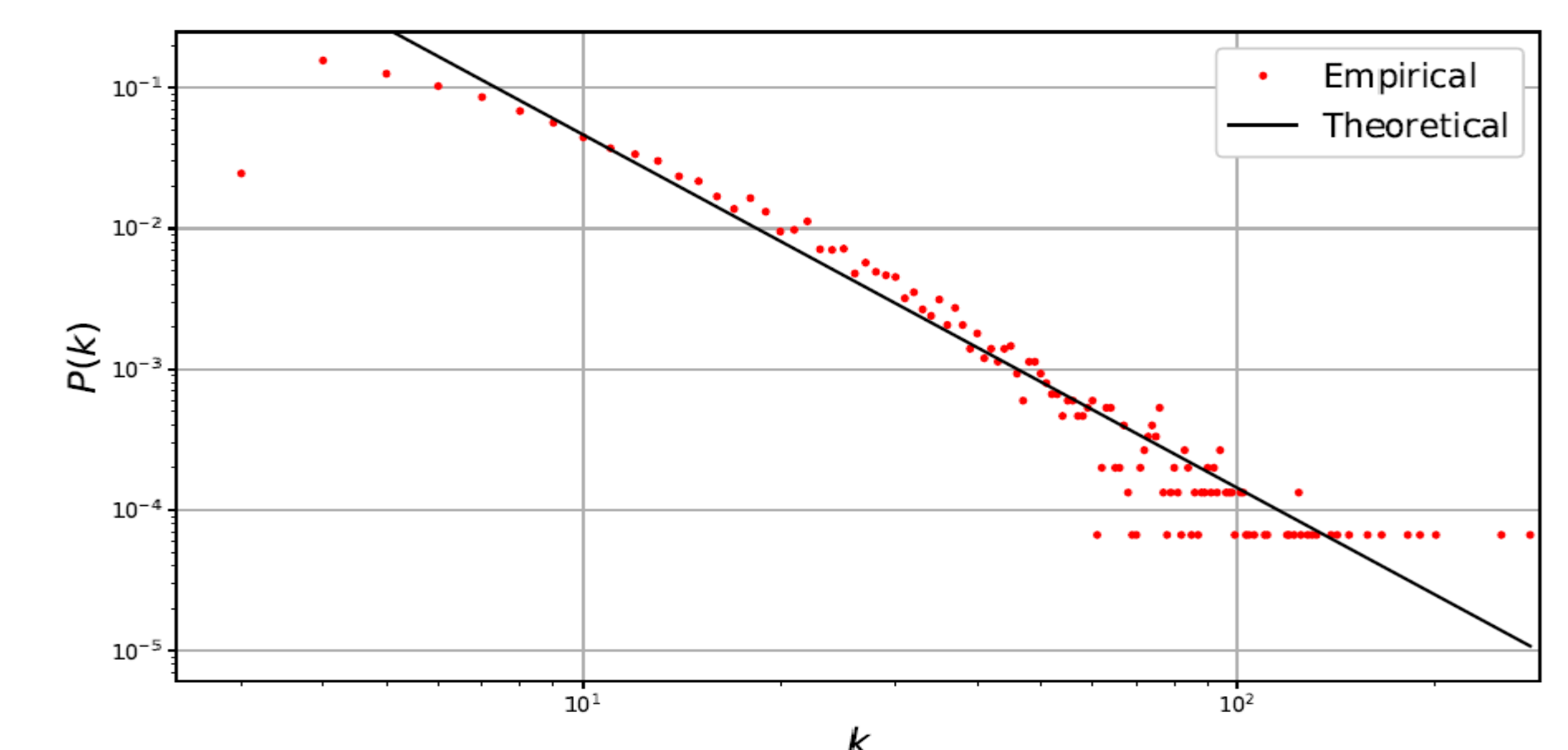
Network	Pearson Correlation	Spearman Correlation
Karate club	0.991	0.98
ego-Facebook	0.985	0.98
ca-CondMat	0.989	0.99

Degree distribution

Neighbors of the overlapping nodes



Hubs



Power law distribution