



## Localization of hubs in complex networks with overlapping modular structure

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# Localization of hubs in complex networks with overlapping modular structure

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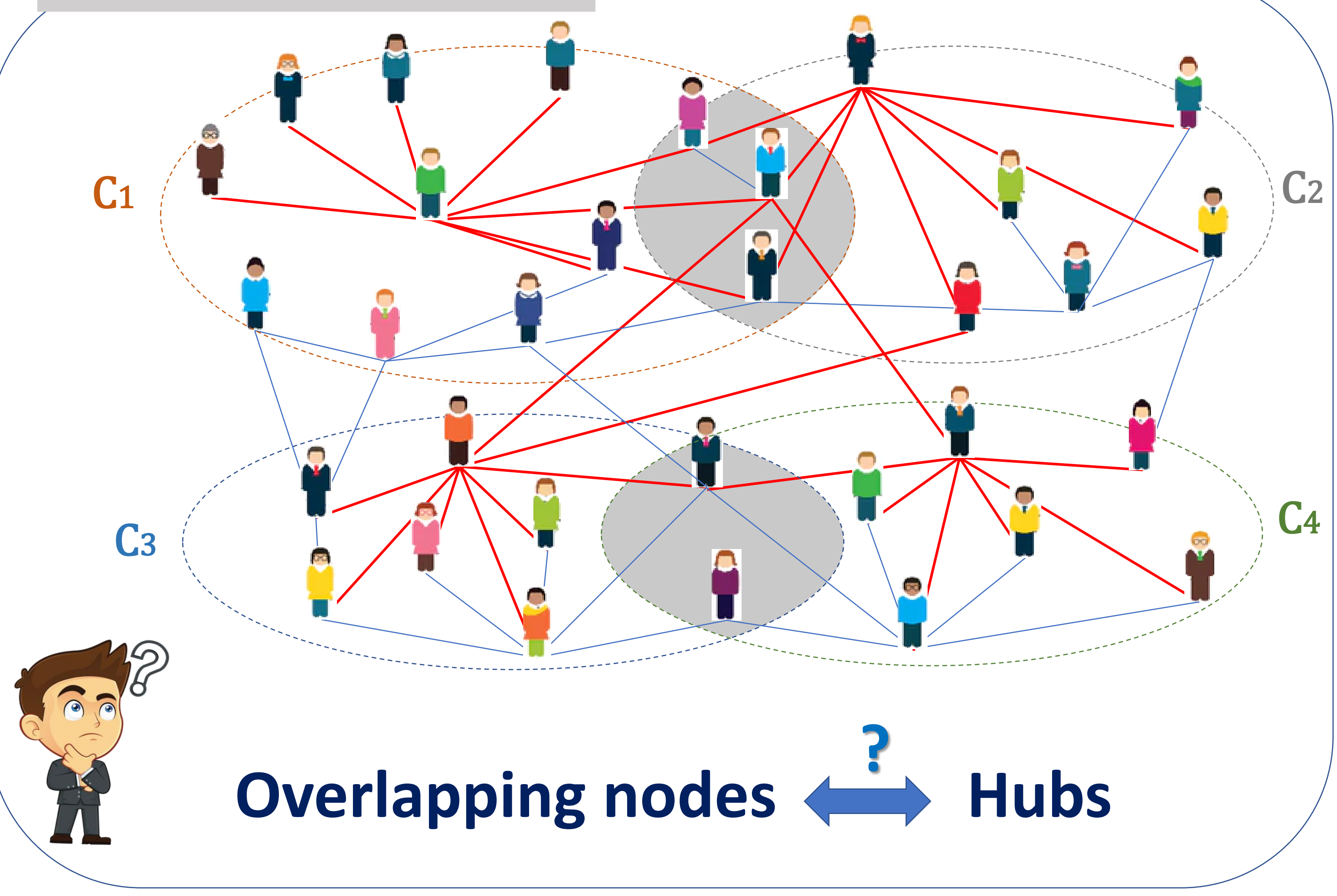
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University of Lyon 2 FRANCE

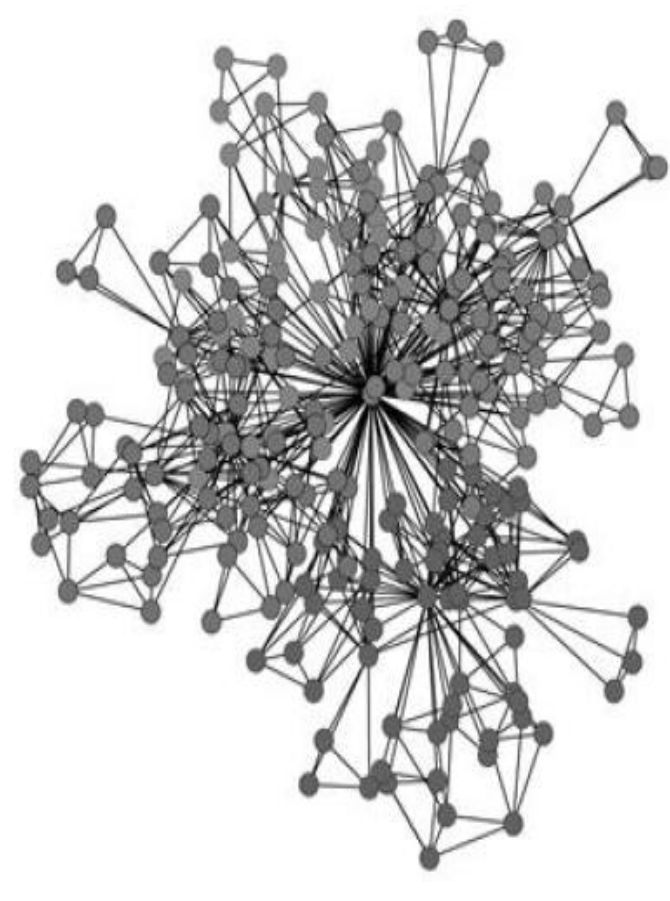
Hocine Cherifi

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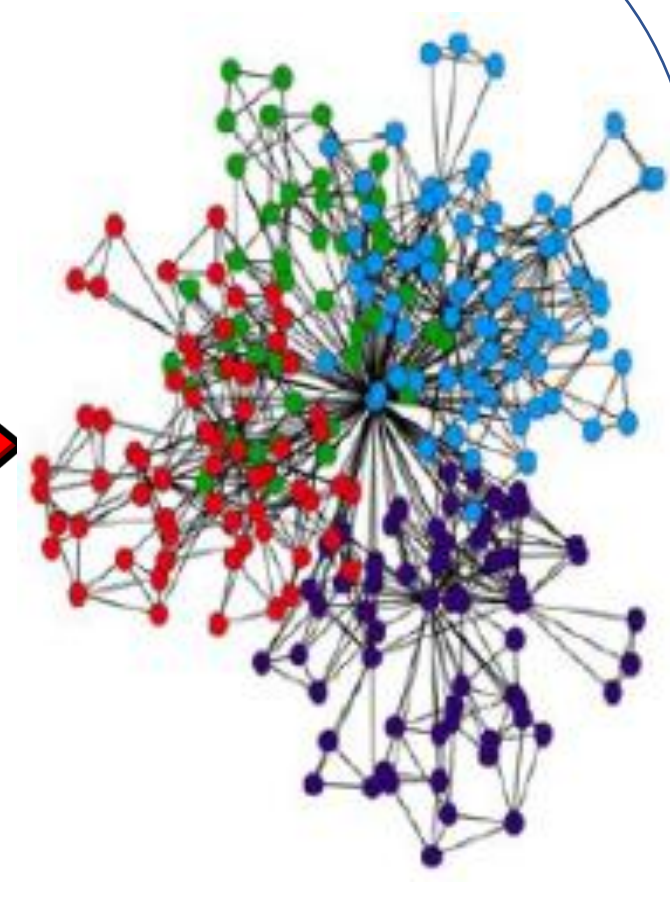
## Problematic



## Methodology



**Community detection**



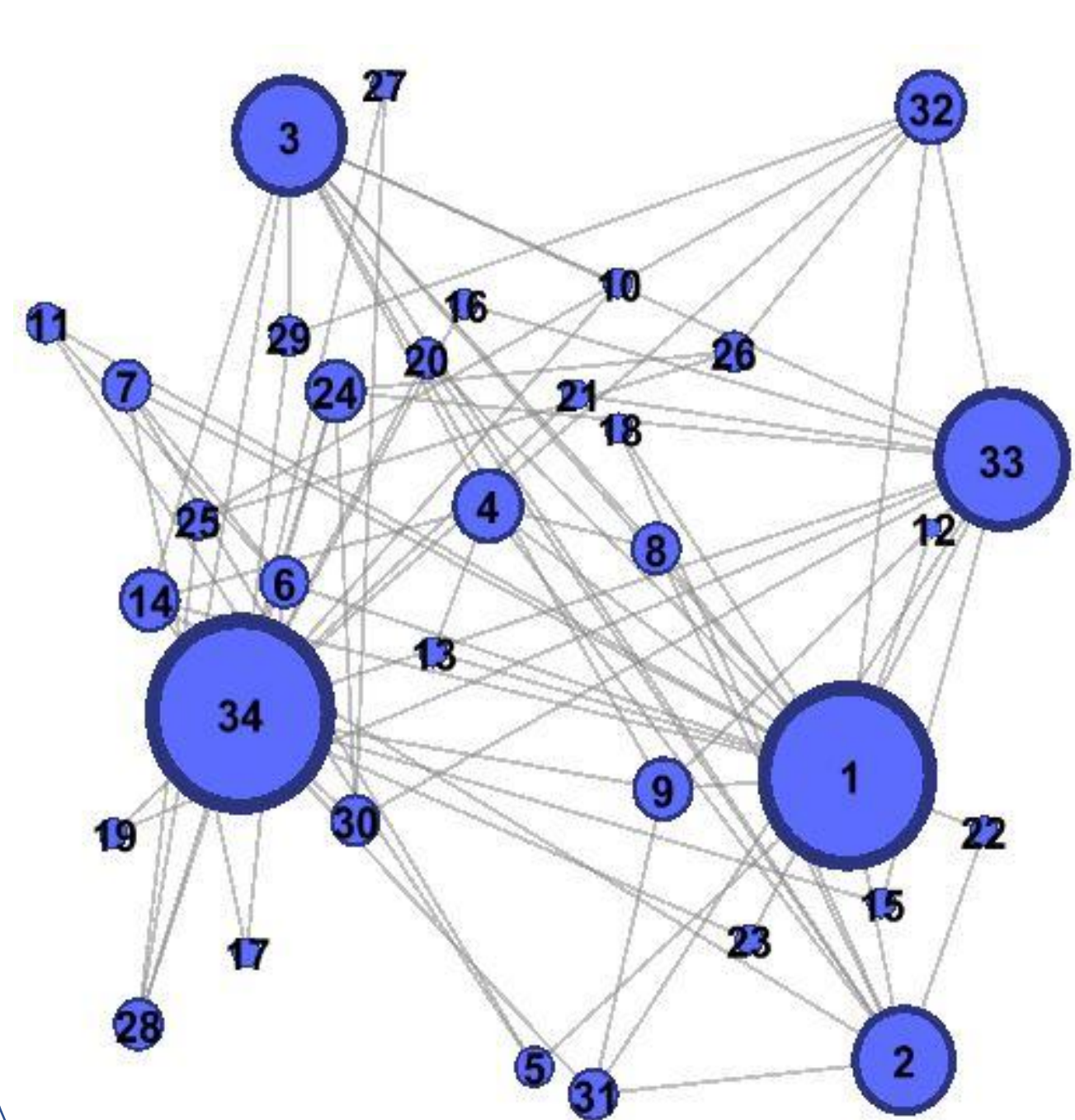
**Evaluation measures**

Proportion of hubs  
Rank-biased overlap  
Correlation  
Degree distribution

**Ego-network of overlapping nodes & List of Hubs**

## Empirical Networks

### Small Network



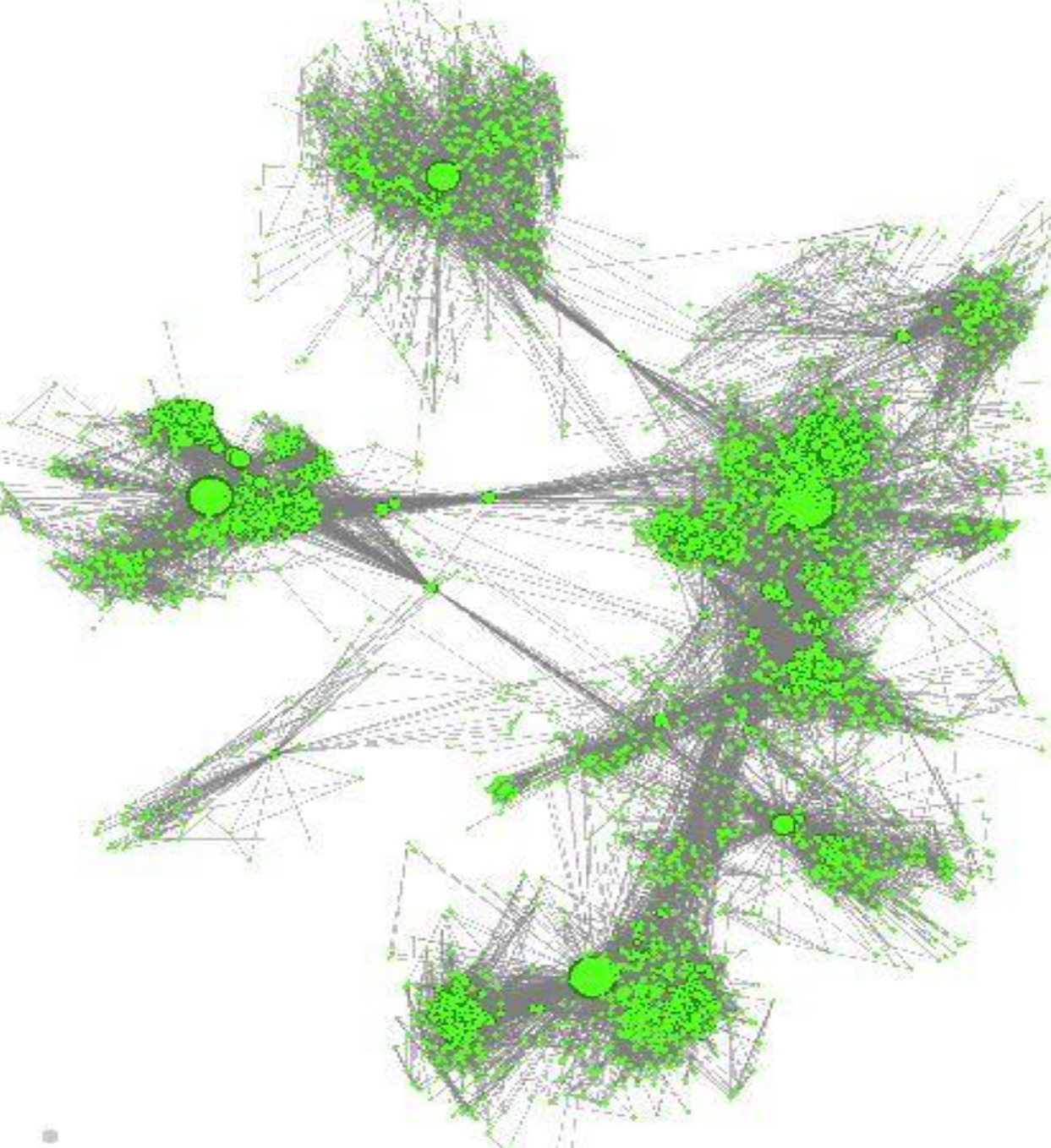
Social network

N 34  
E 78

Relatively high density  
Non Assortative

Karate network

### Medium Network



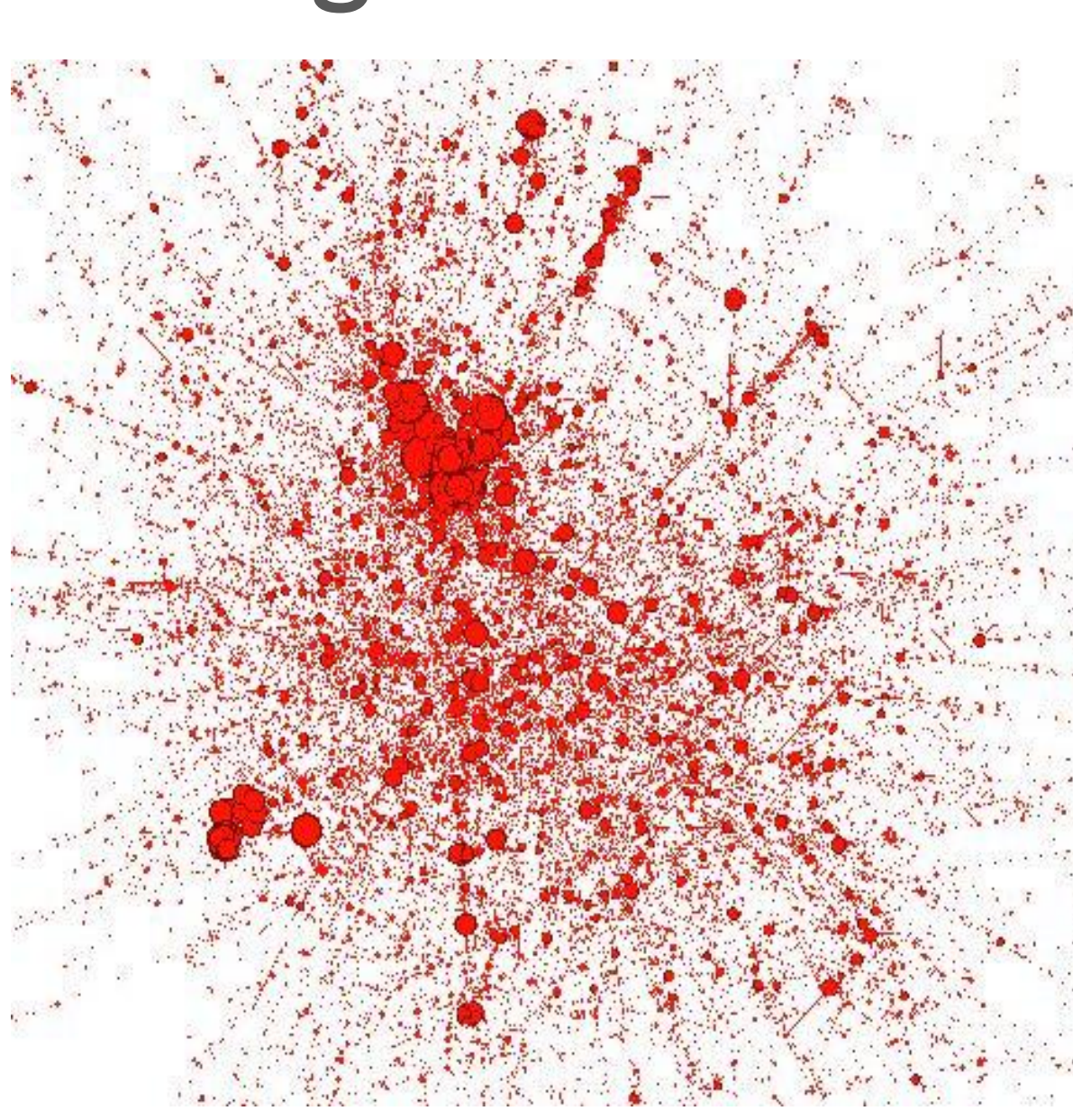
Social network

N 4039  
E 88234

Small density  
Assortative

Ego-Facebook network

### Large Network



Collaboration network

N 23133  
E 93497

Very small density  
Assortative

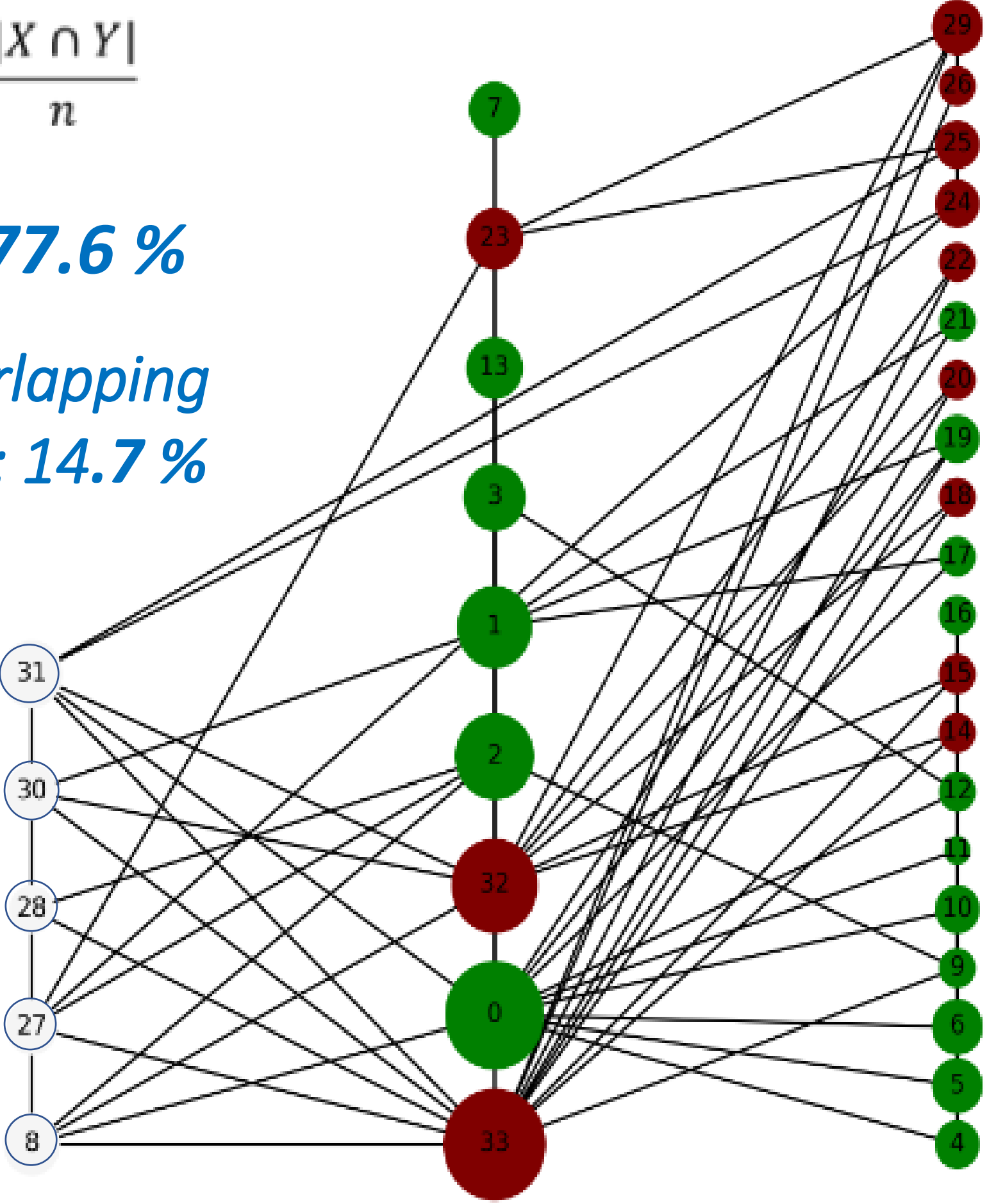
Condense Matter network

## 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

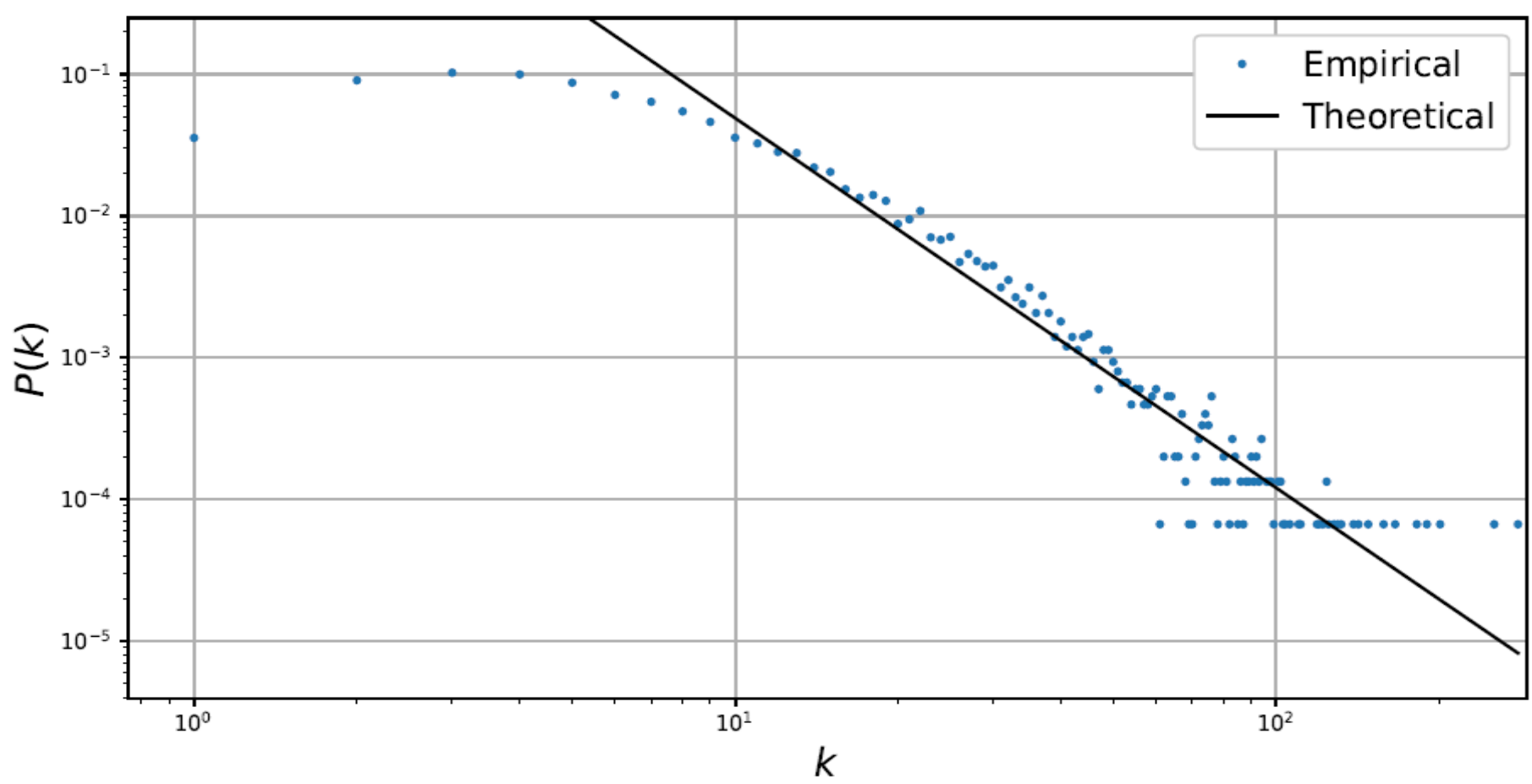
### Correlation

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

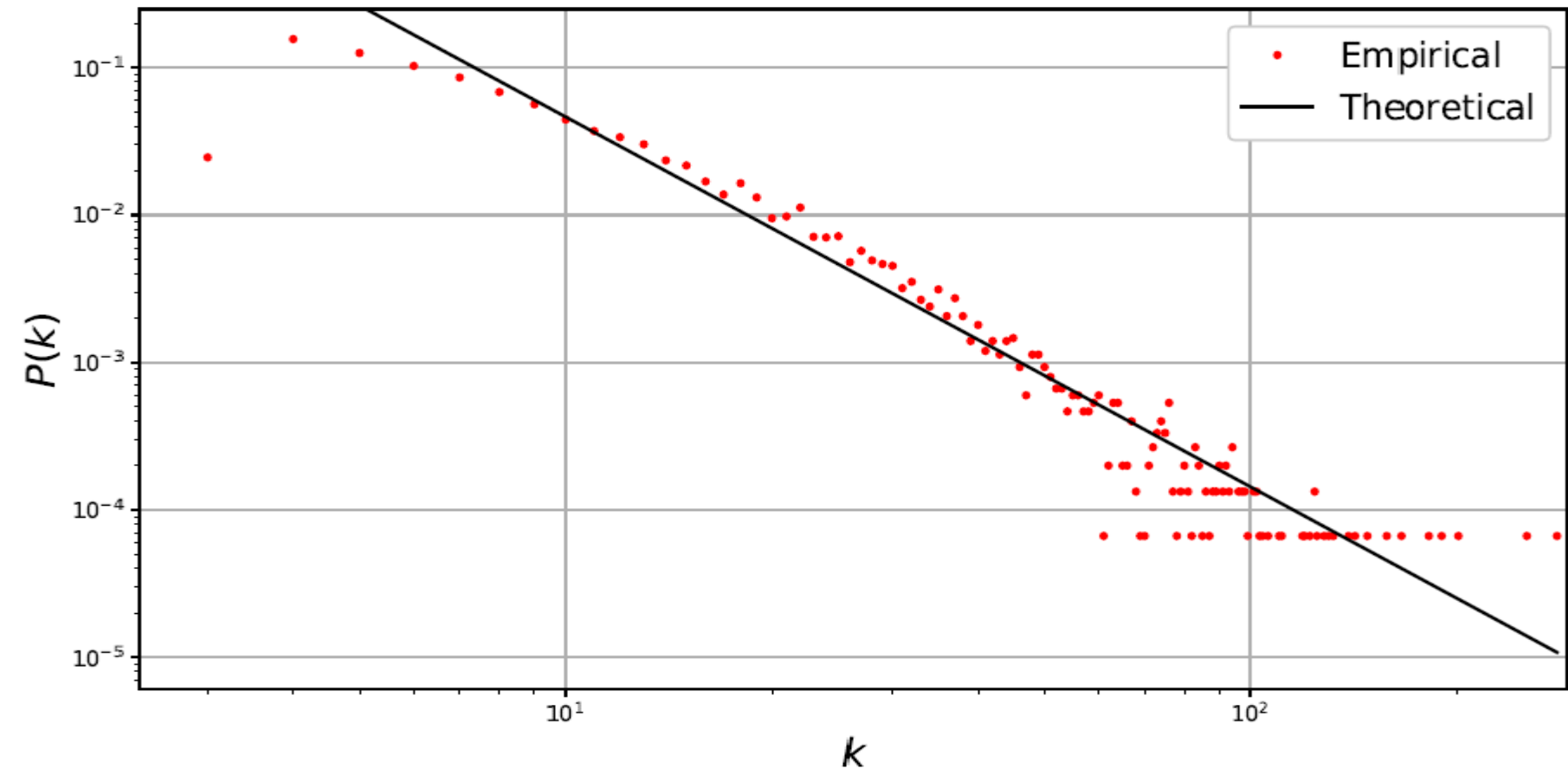
Network	Pearson Correlation	Spearman Correlation
Karate club	0.991	0.98
ego-Facebook	0.985	0.98
ca-CondMat	0.989	0.99

### Degree distribution

#### Neighbors of the overlapping nodes



#### Hubs



Power law distribution