Signed Graph Analysis for the Interpretation of Voting Behavior

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Outline

Context

- Partitioning European Parliament (EP) vote networks
  - Extracting signed networks
  - Partitioning signed networks

Our previous works	Limitations	How to deal with?

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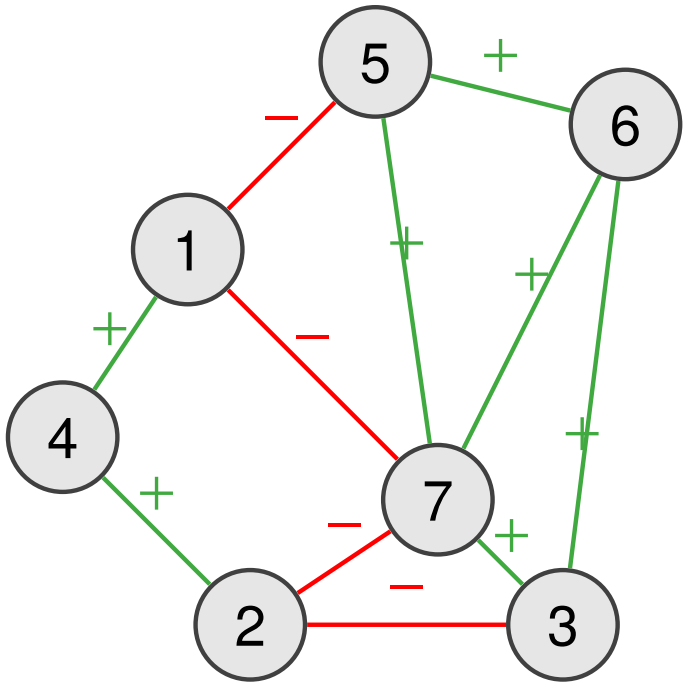
2. Brazilian Congress structural balance analysis [Levorato and Frota, 2017] 	• fully-connected networks  	• filtering step
	• interpretation problems  	• deeper analysis on selected cases

Structural Balance and Signed Graph Partitioning

- **Signed** graphs



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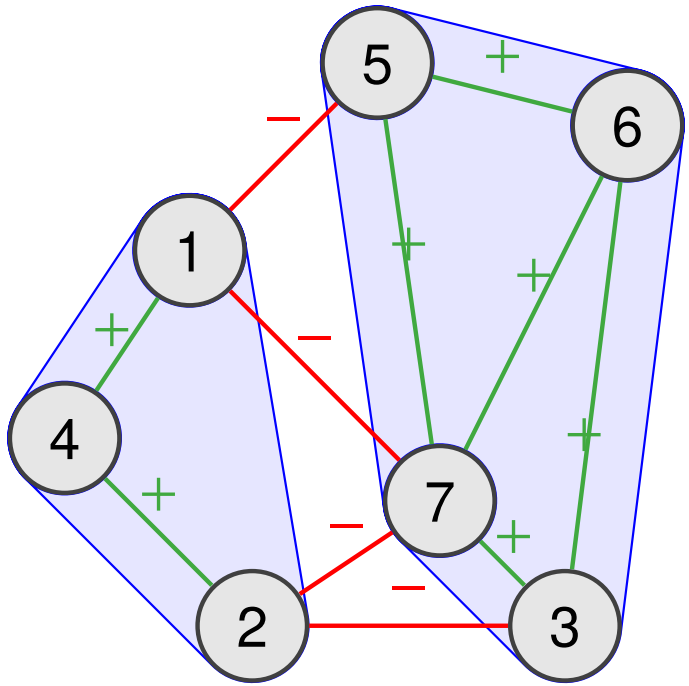
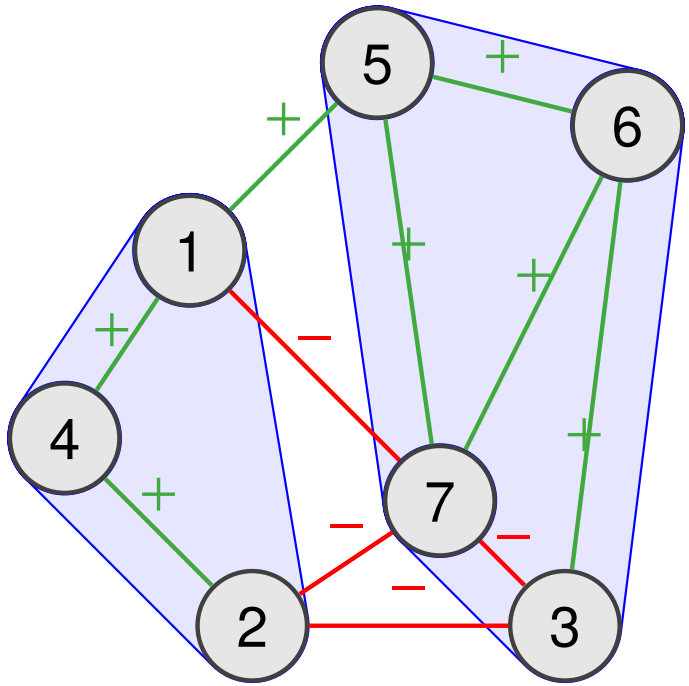
- **Structural Balance**: Partitioning into two [Heider, 1946] or more [Davis, 1967] mutually hostile subgroups each having internal solidarity



Structural Balance and Signed Graph Partitioning

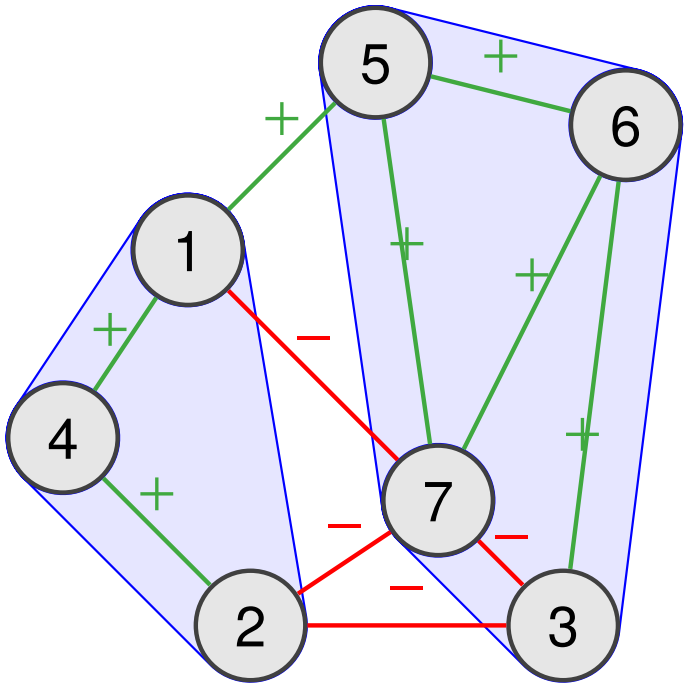
- **Signed** graphs
- **Structural Balance**: Partitioning into two [Heider, 1946] or more [Davis, 1967] mutually hostile subgroups each having internal solidarity
- Most real networks are not structurally balanced → need to measure graph **imbalance**



Measuring imbalance - CC problem

Definition

Consider a signed graph $G = (V, E, s)$ with a nonnegative weight associated with each $e \in E$. The Correlation Clustering (CC) problem is the problem of finding a partition P of V such that the imbalance $I(P)$ is minimized.



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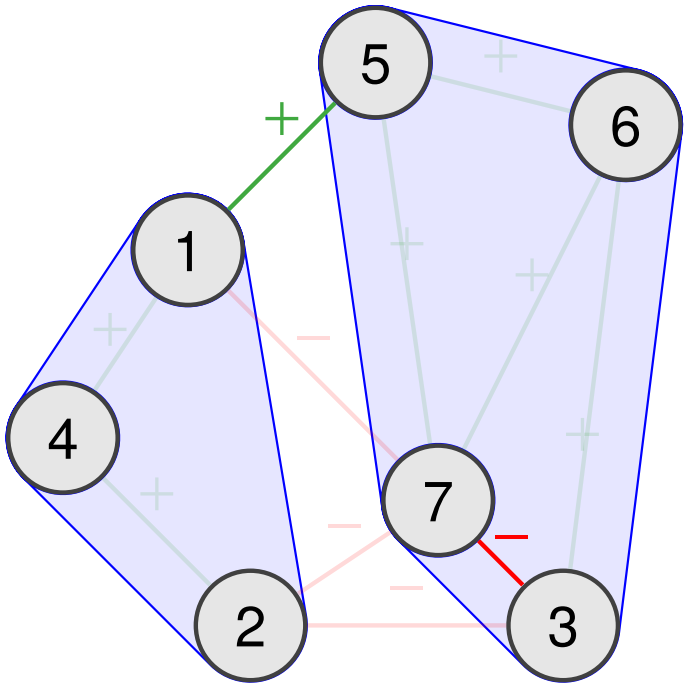

$$I(P) = 0 + 1 + 1 = 2$$

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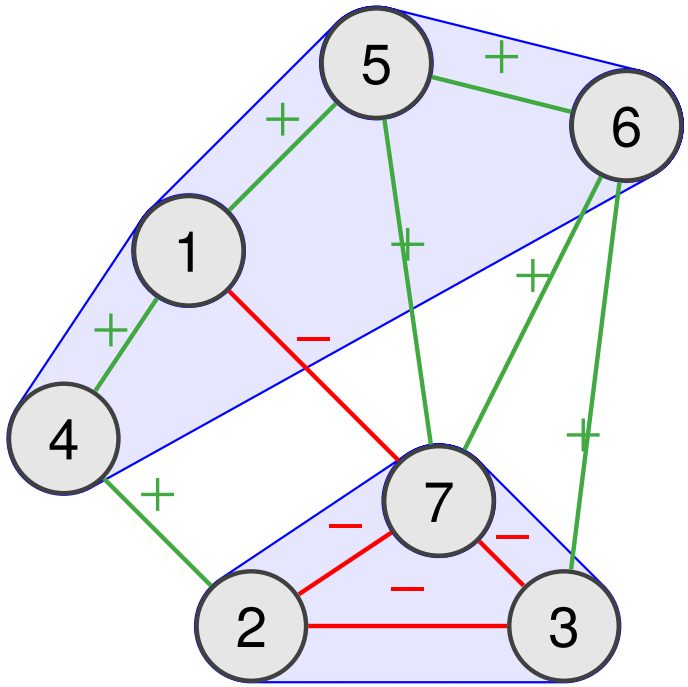

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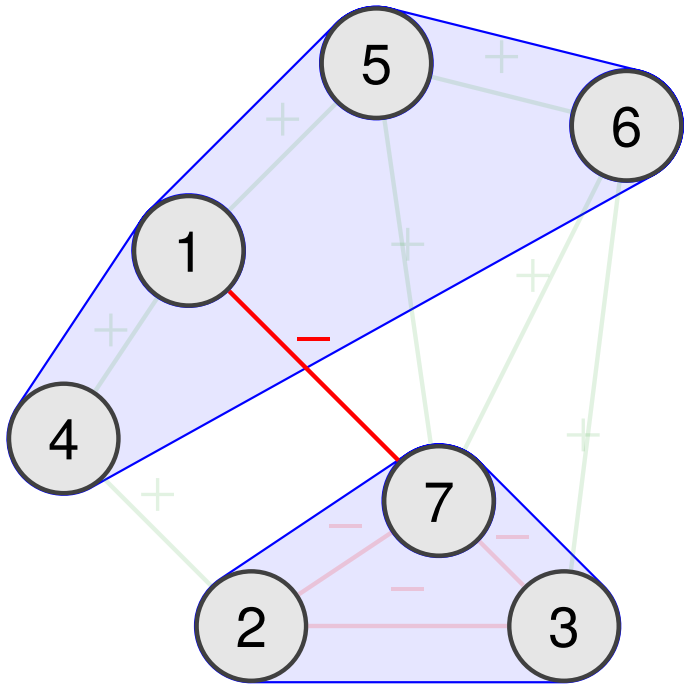

$$RI(P) = 0 + 0 + 1 = 1$$

Computational Experiments

- Dataset description, Construction of vote graphs and filtering step
- Evaluation of filtering step on graph structure and partitioning algorithms

Data Extraction

- Raw data (from itsyourparliament.eu):
  - Nature: Voting activity at the European Parliament
  - Period: 7^{th} term (June 2009–June 2014)
  - Size: 840 MEPs, 1426 documents, 21 topics

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  - Compares two MEPs

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- Networks:
  - Nodes: Members of the European Parliament (MEPs)
  - Weighted: VAI values (document-wise agreement averaged over all documents) → Ranges from −1 to +1
  - Dimensions: member country × EP political group × time × topics
    - For instance, documents voted by French MEPs on Agriculture in 2012-2013

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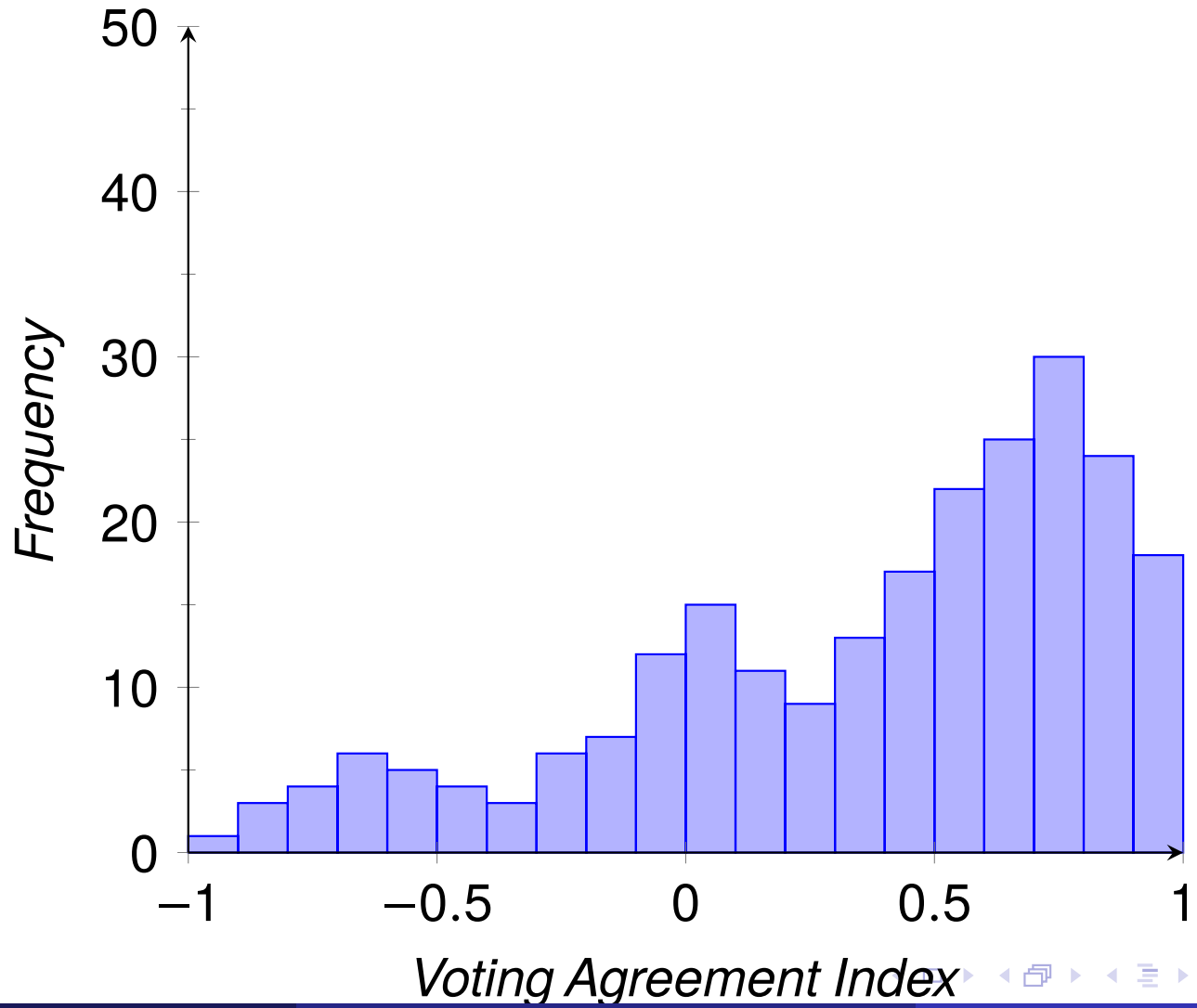
- Filtering step

France, AGRI, 2012–2013: Filtering Step

- Filtering step aims at ignoring the values too close to zero, deemed non-significant



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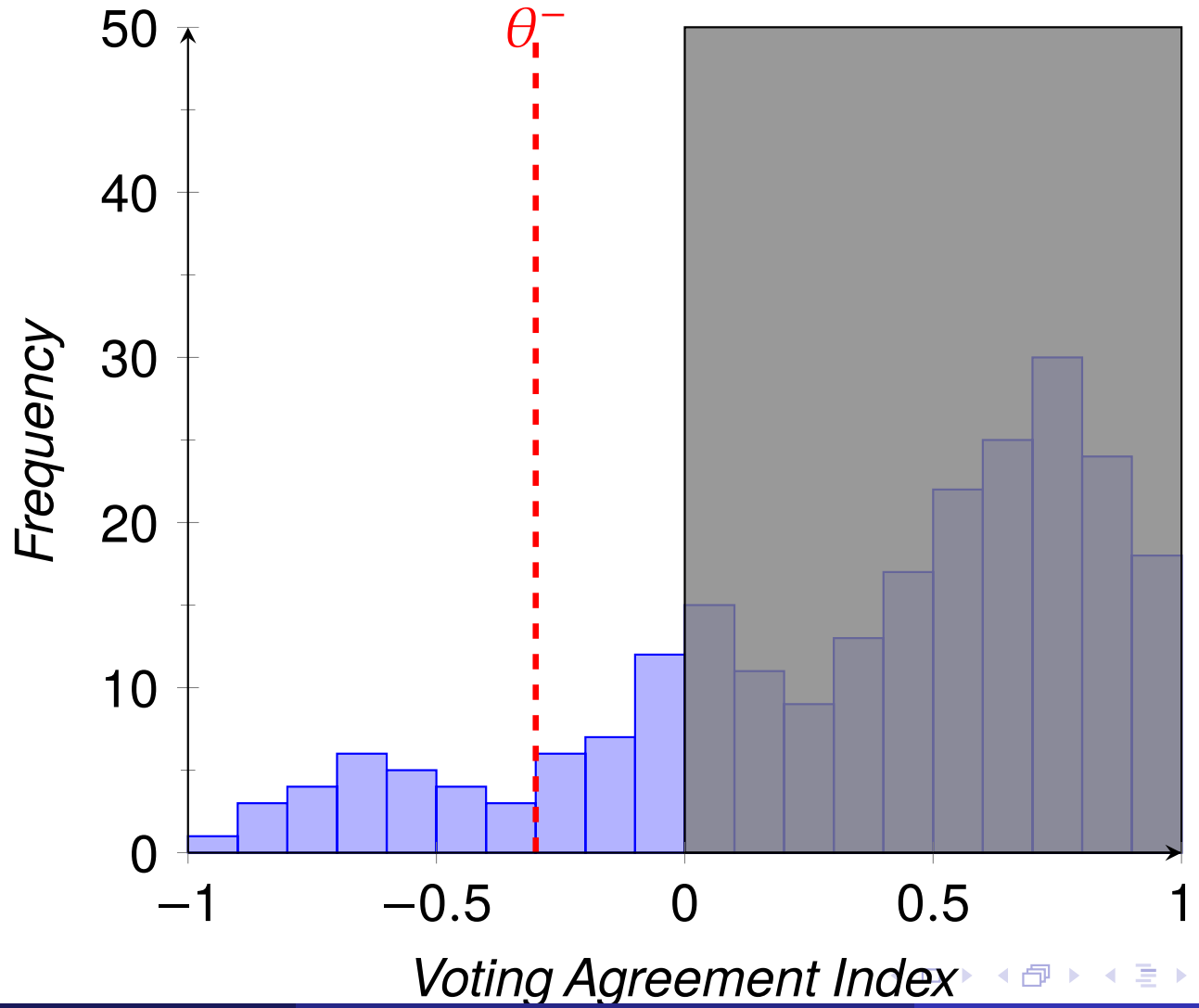

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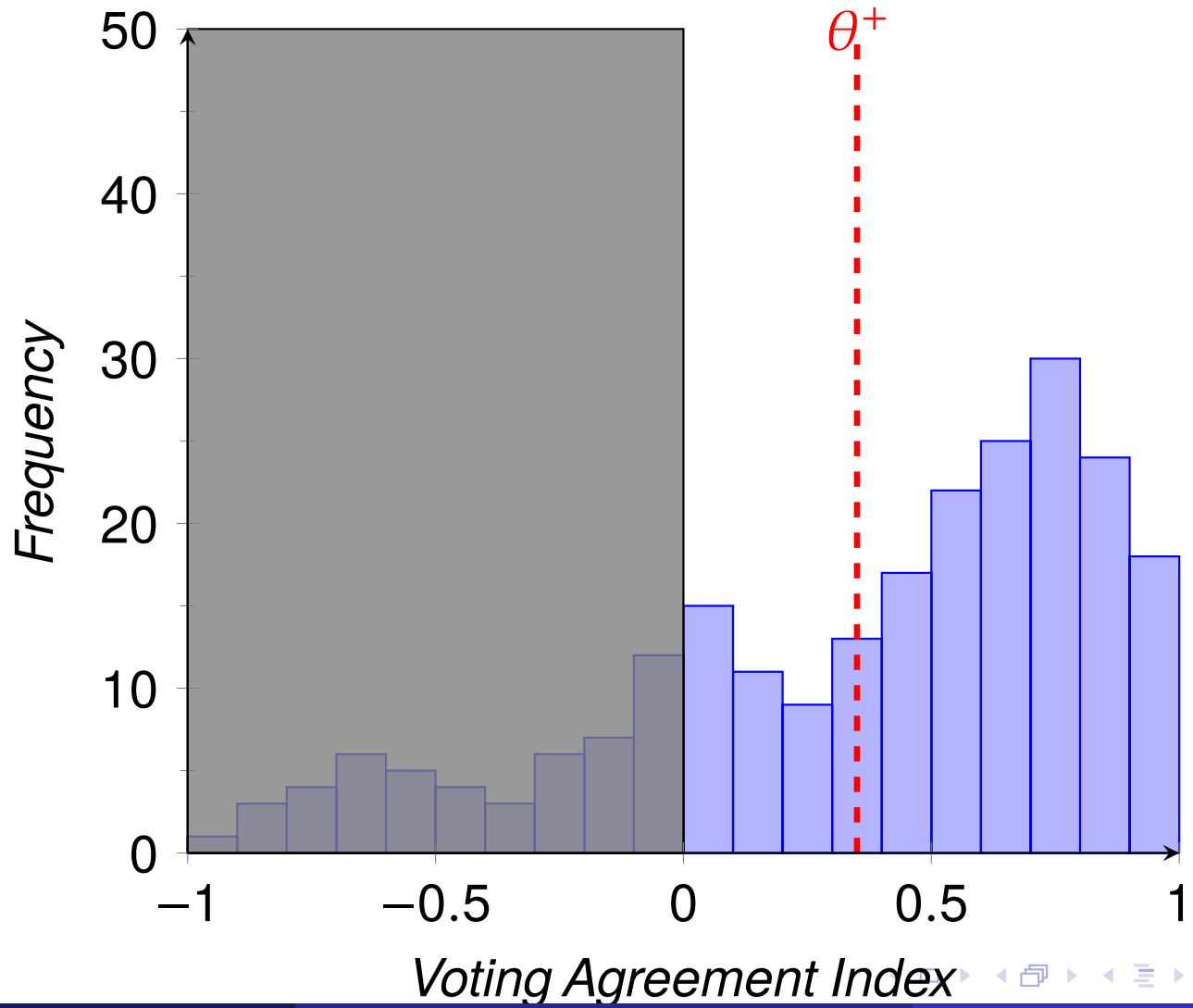

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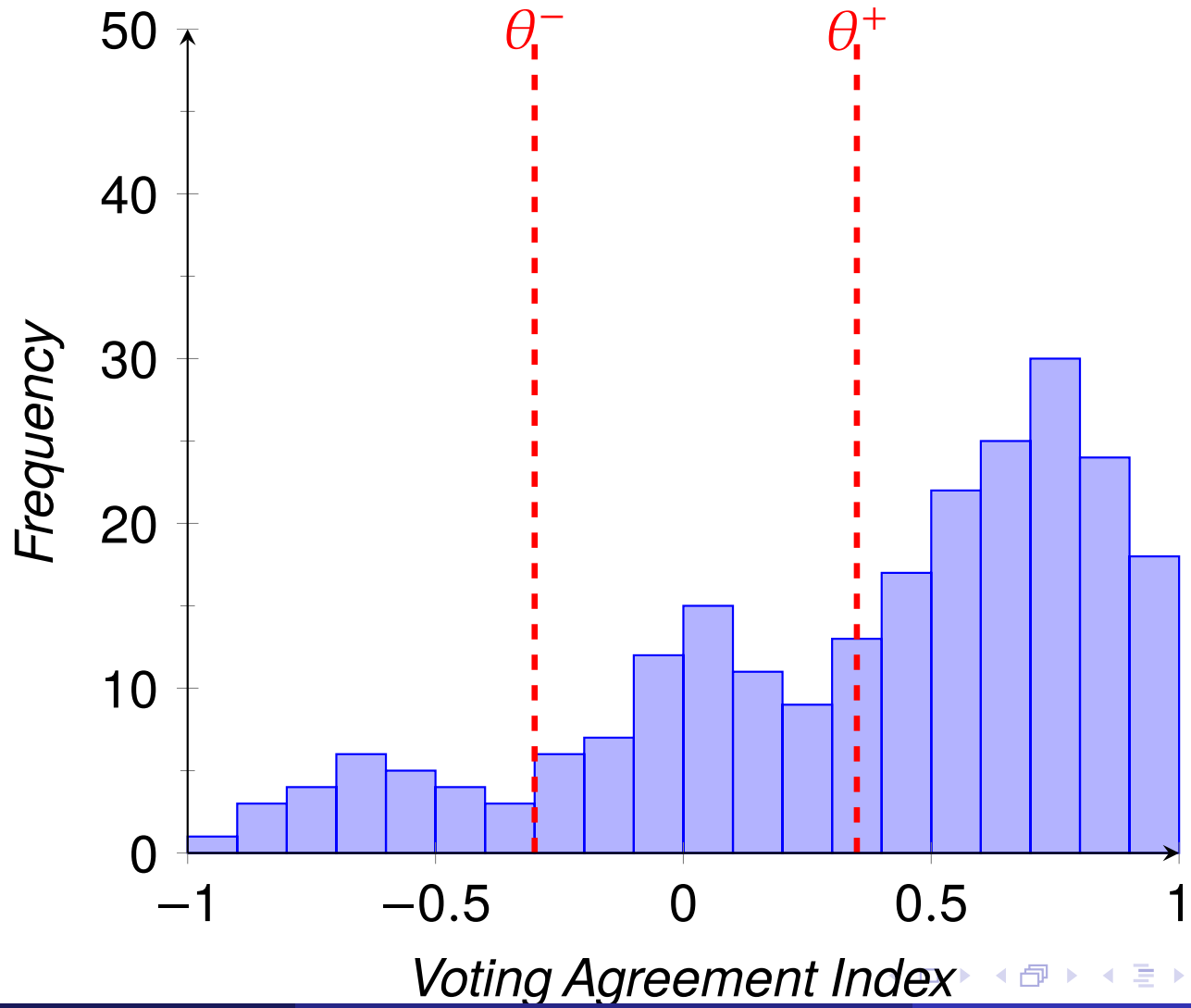

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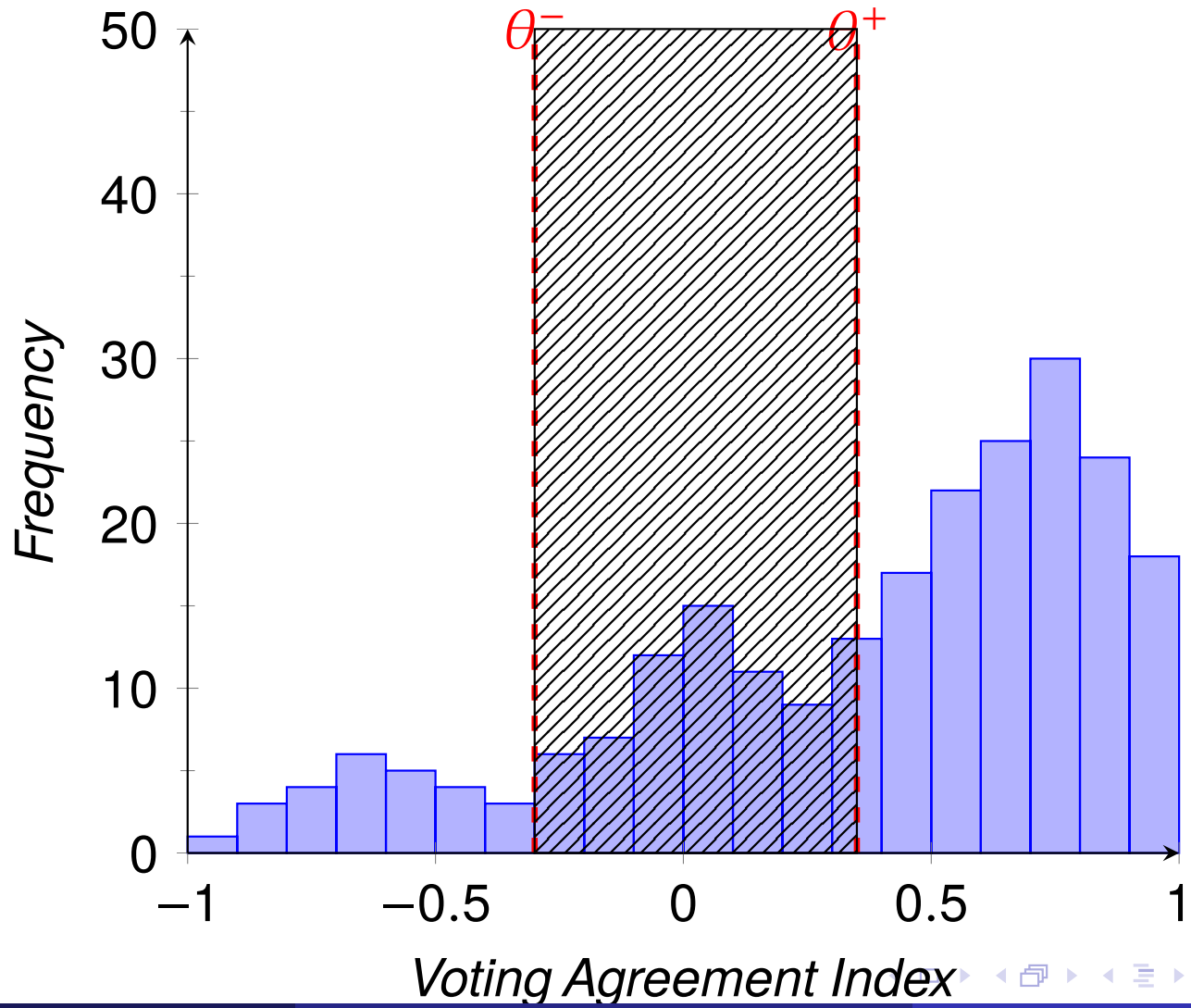
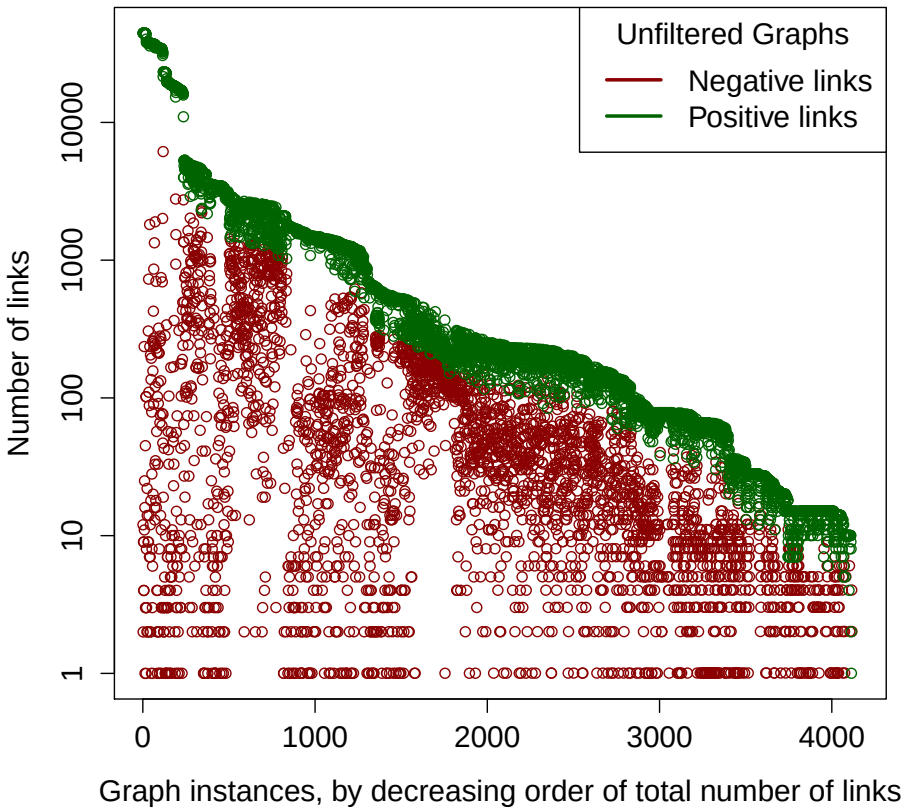
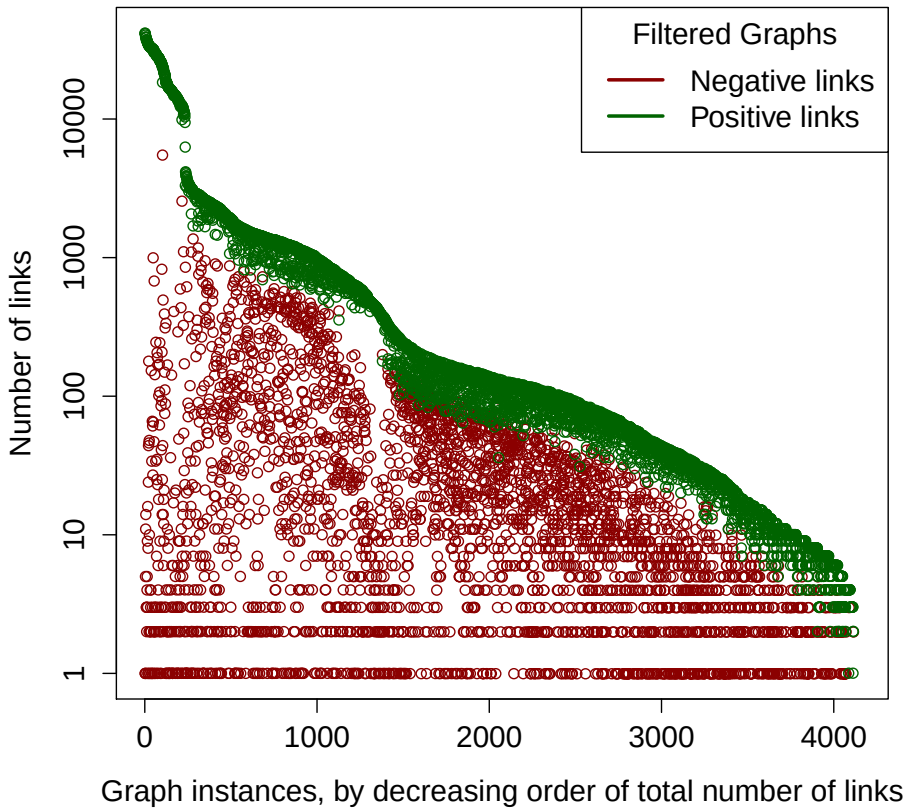


Effect of the filtering on Graph Structure

- Filtering removes in average: 43% of the links, 26% of the network weight





Effect of the filtering on Graph Structure

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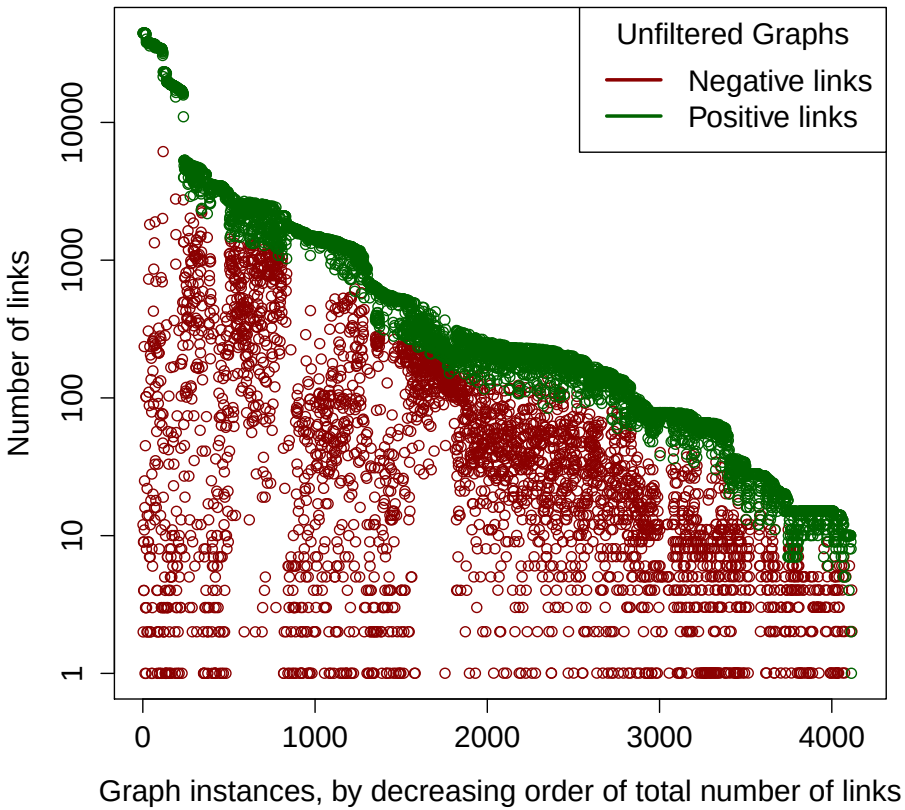
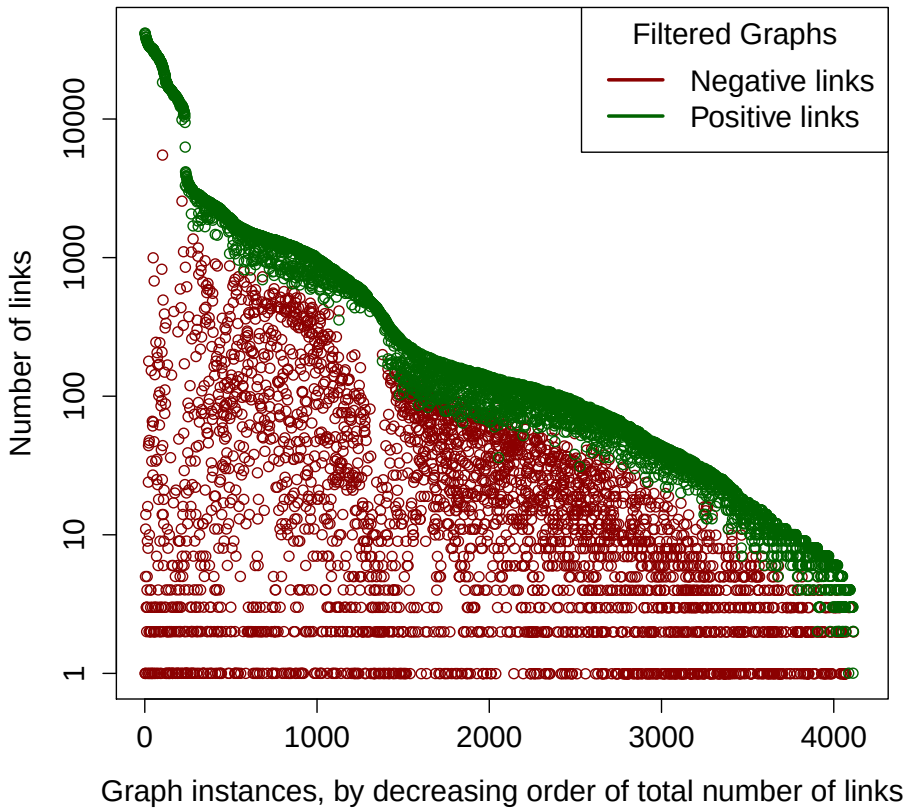
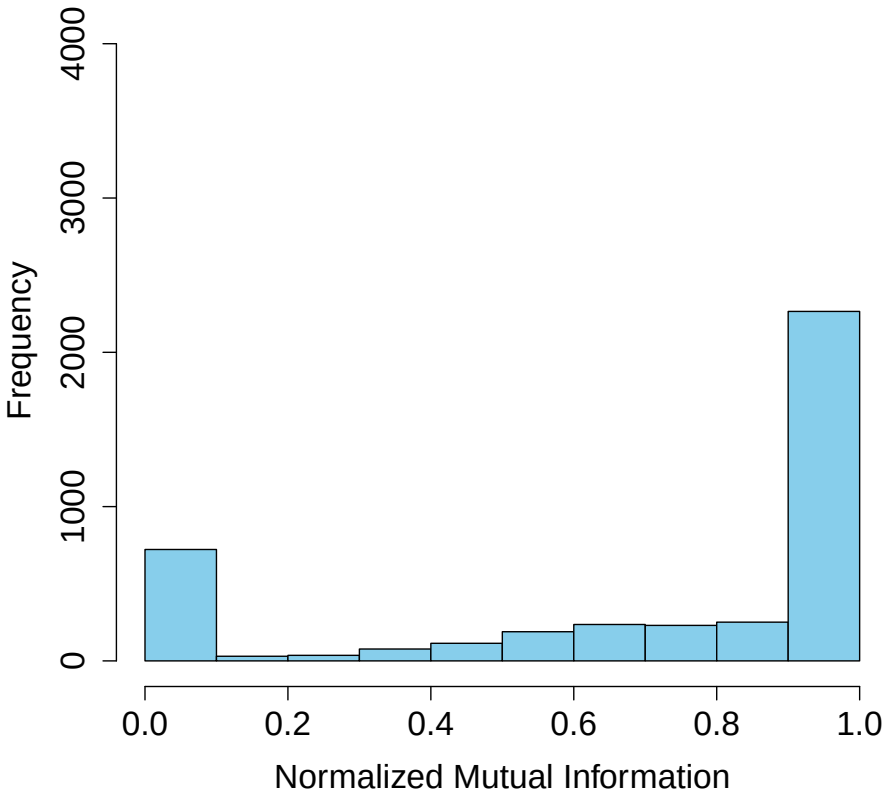
- Connectivity of filtered networks: 66% still connected, 23% divided into 2 components (but the giant component)

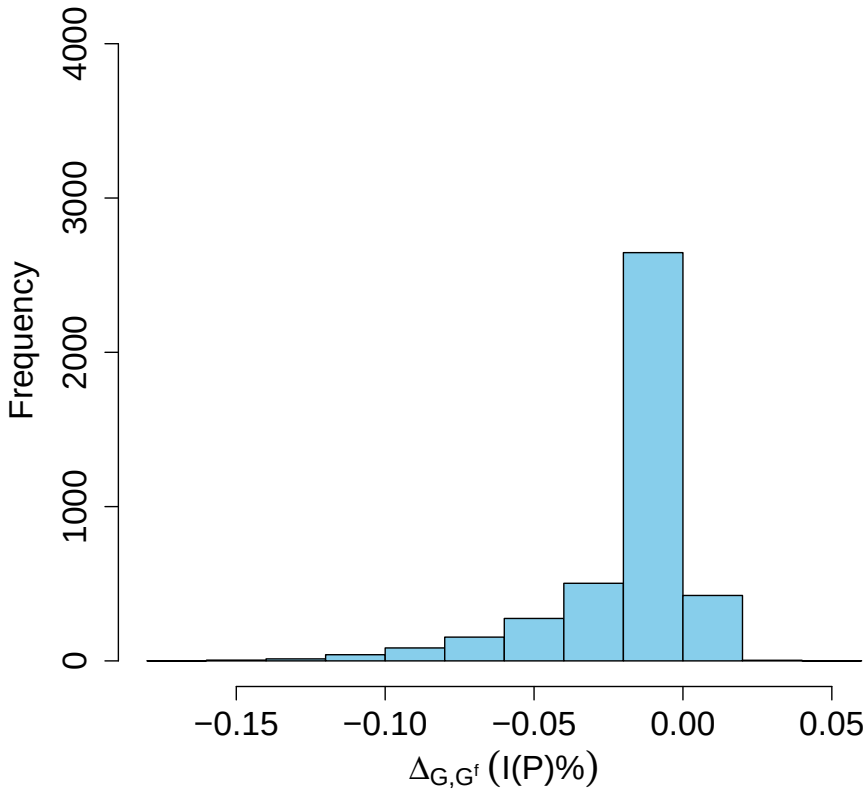




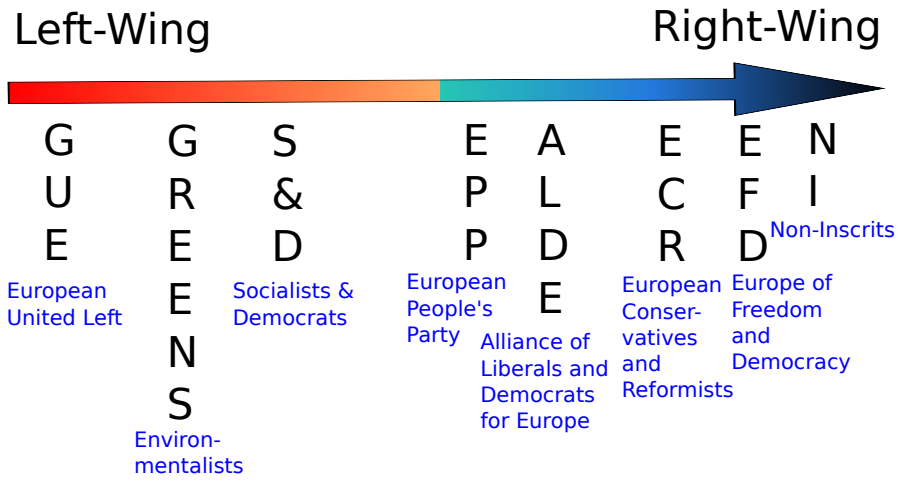
Effect of the filtering on Partitioning Algorithms

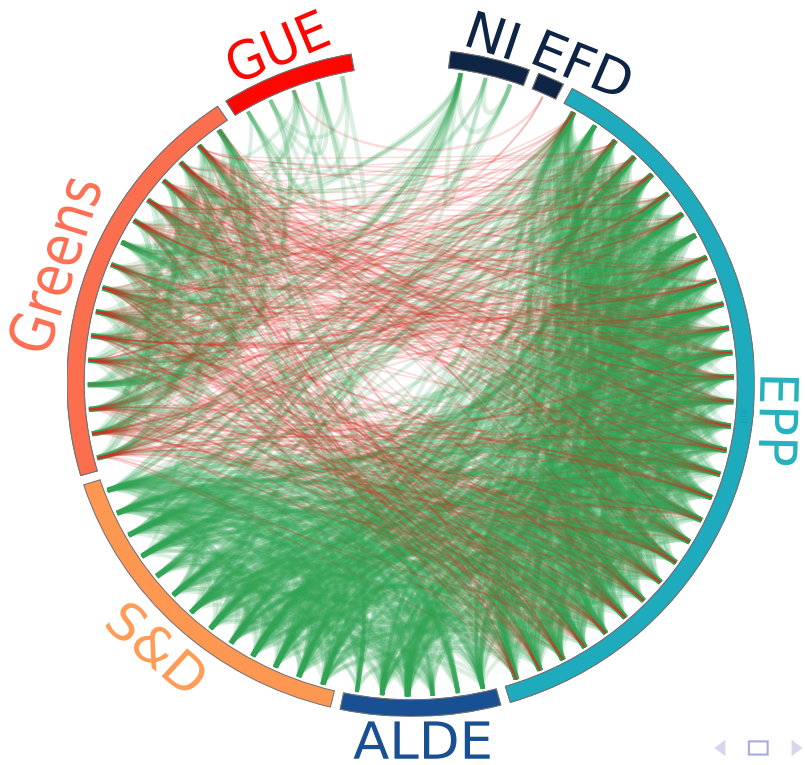
- Ex-CC before vs. after filtering
- The NMI is close to 1 for most instances ($\geq$0.8 for 61% of them)
- The quality in terms of I(P)% does not change much with filtering





Interpretation of a vote network: France, AGRI, 2012–13





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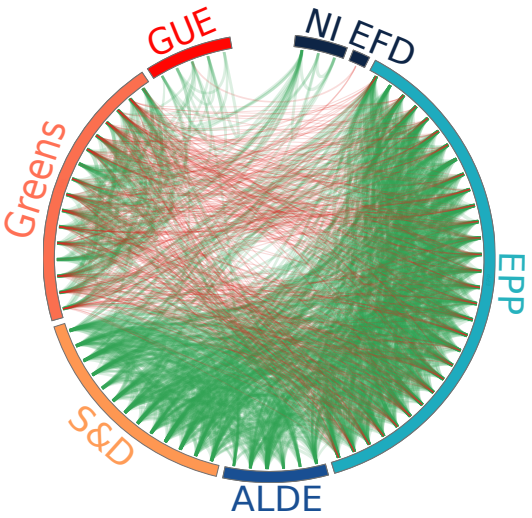

b) CC

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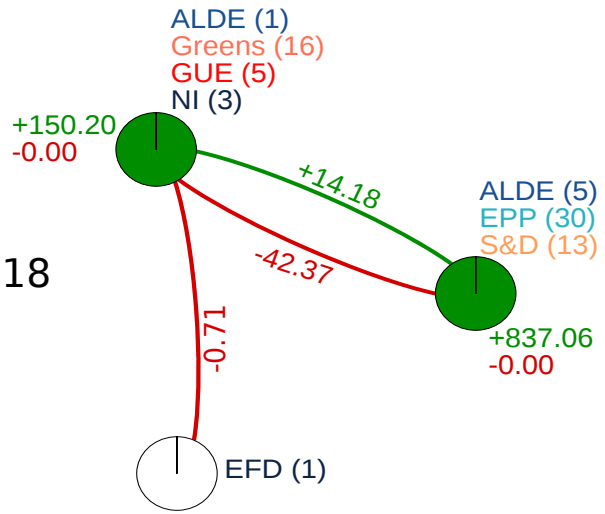

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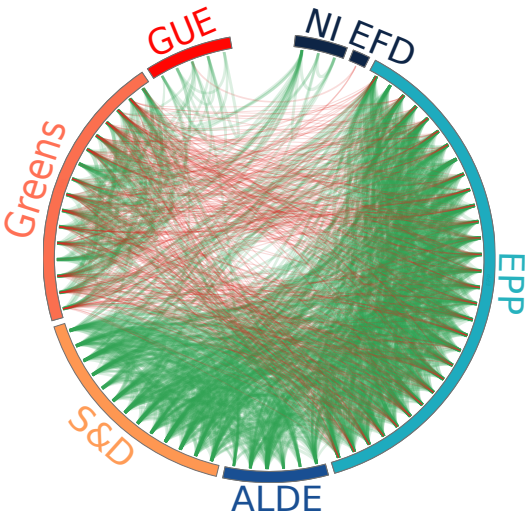

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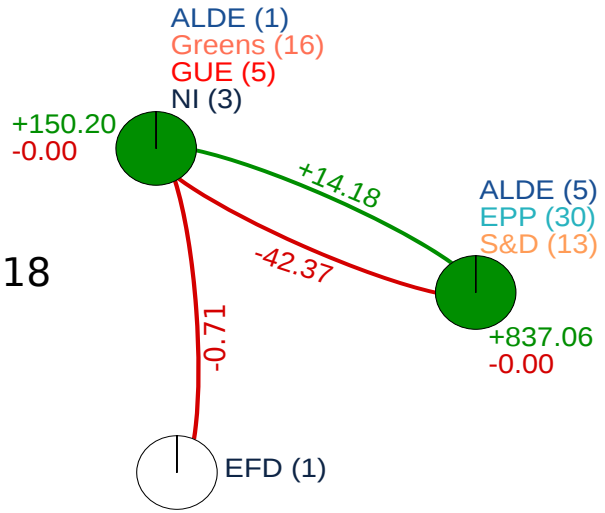

c) RCC with 3 clusters

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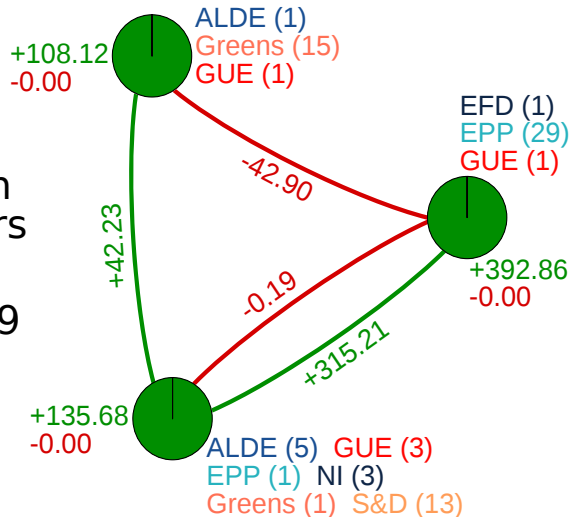

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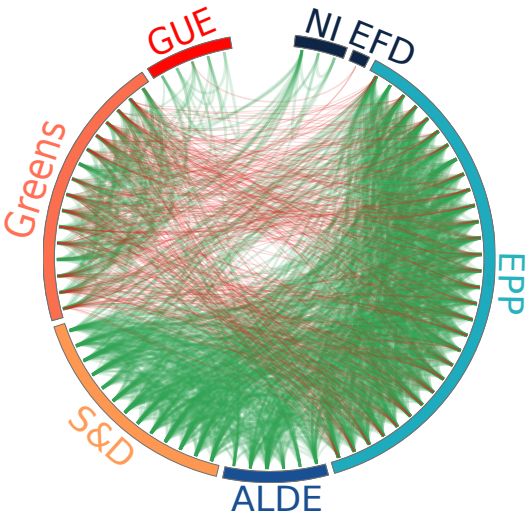

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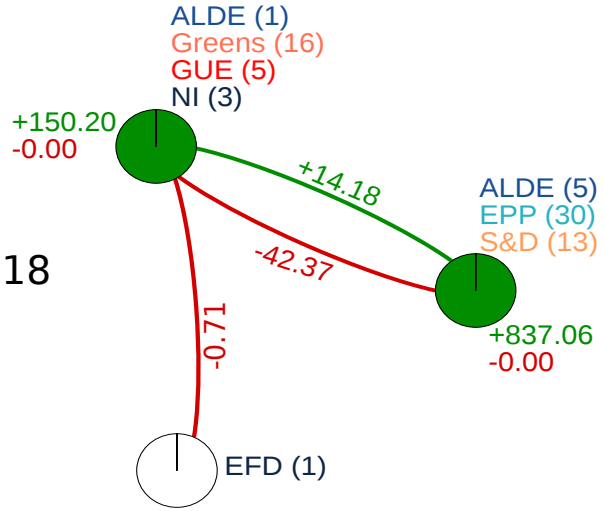

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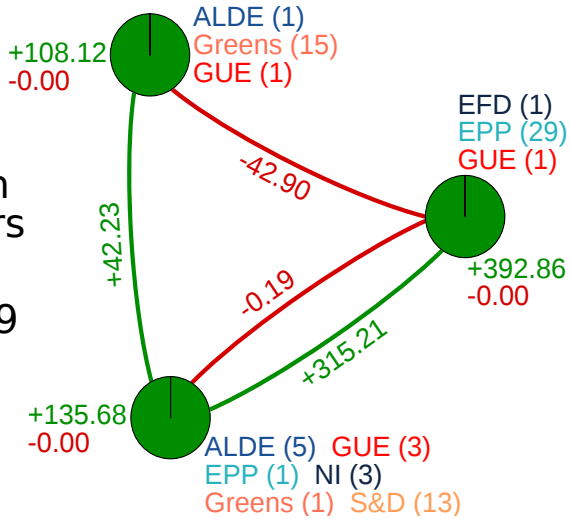
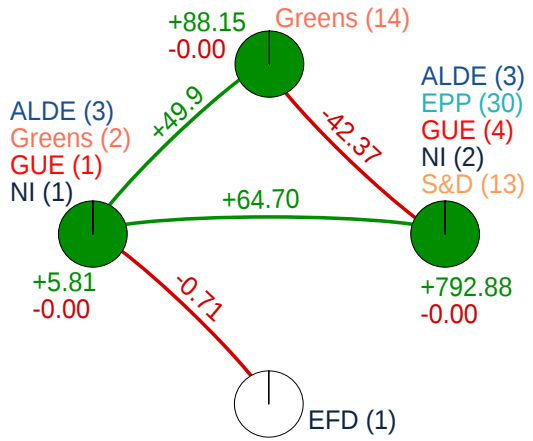


d) RCC with 4 clusters

RI(P)=0



Conclusion & Further research

- Methodological:
  - Other Structural Balance problems
  - Detailed experiments based on randomly generated signed networks
- Application:
  - More complete interpretations via Manifestos of EU parties and the parties' policy preferences $\longrightarrow$ Comparative Manifestos Project (CMP).

Thank you for your attention!

References:

Davis, J. (1967).

Clustering and structural balance in graphs.

Human Relations, 20:181–187.

Heider, F. (1946).

Attitudes and cognitive organization.

Journal of Psychology, 21:107–112.

Levorato, M. and Frota, Y. (2017).

Brazilian congress structural balance analysis.

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Mendonça, I., Figueiredo, R., Labatut, V., and Michelon, P. (2015).

Relevance of negative links in graph partitioning: A case study using votes from the european parliament.

In *2015 Second European Network Intelligence Conference, ENIC 2015, Karlskrona, Sweden, September 21-22, 2015*, pages 122–129.

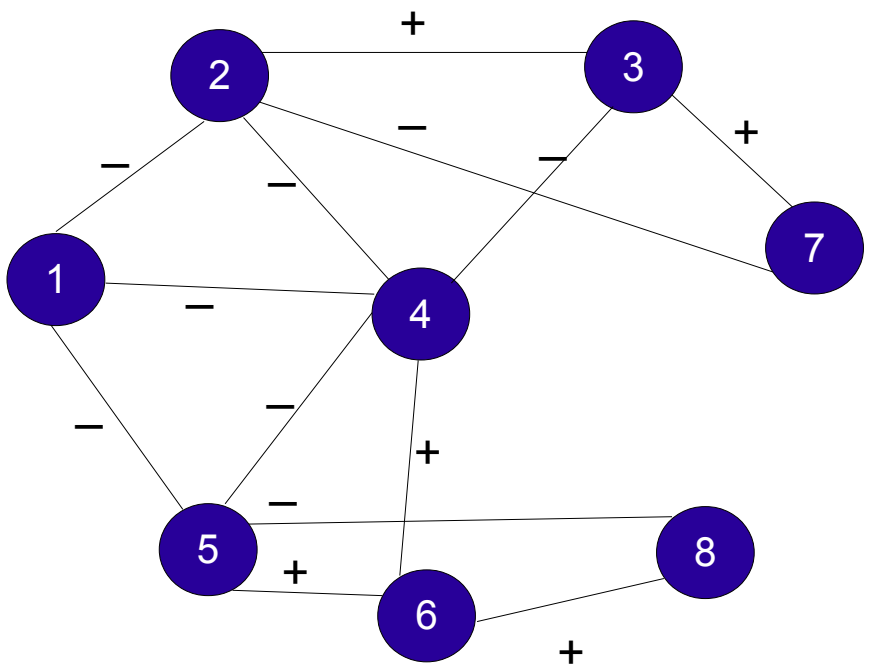
Iterated Local Search

It is comprised of 4 modules:

1. Constructive phase;
2. Local search;
3. Perturbation;
4. Acceptance criterion.

Measure ↔ Graph optimization problem

$|V|$ in a k balanced subgraph ↔ Maximum k-balanced subgraph Problem



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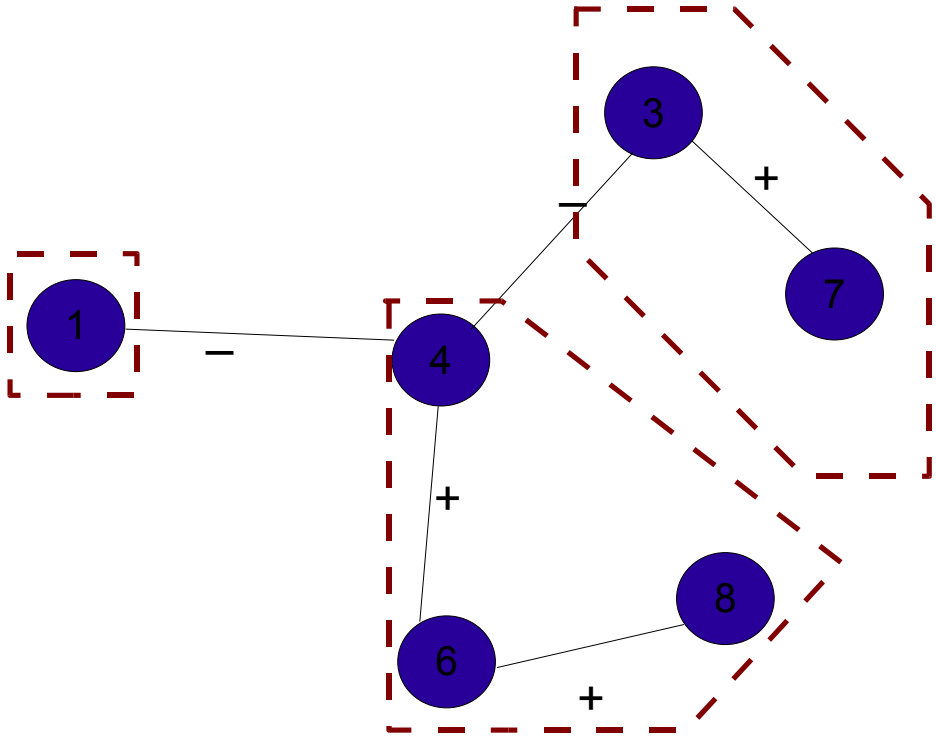

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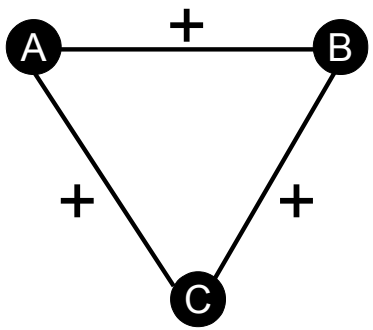
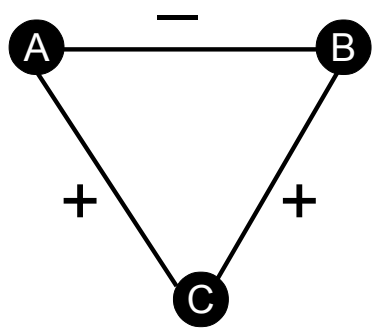
Structural Balance

[Heider, 1946]:

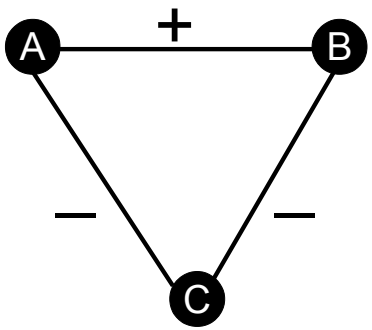
- People strive for cognitive balance in their network of likes and dislikes.



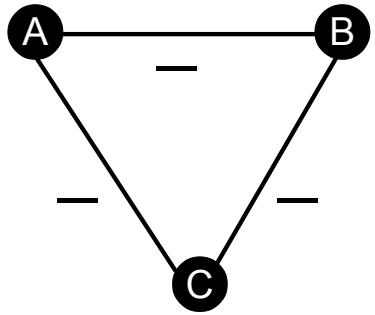
(a) Balanced



(b) Not balanced



(c) Balanced

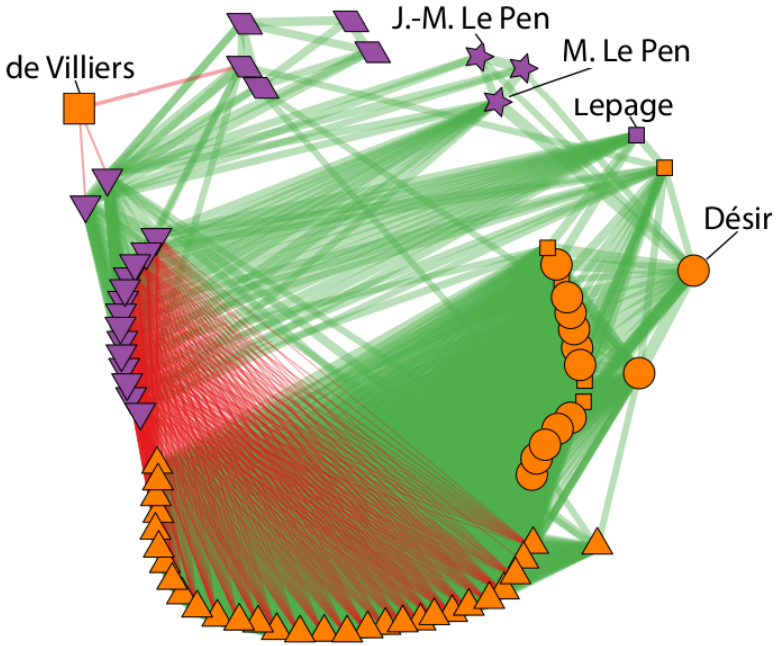


(d) Not balanced

Comparison between a community detection and signed graph partitioning methods

ILS-CC:

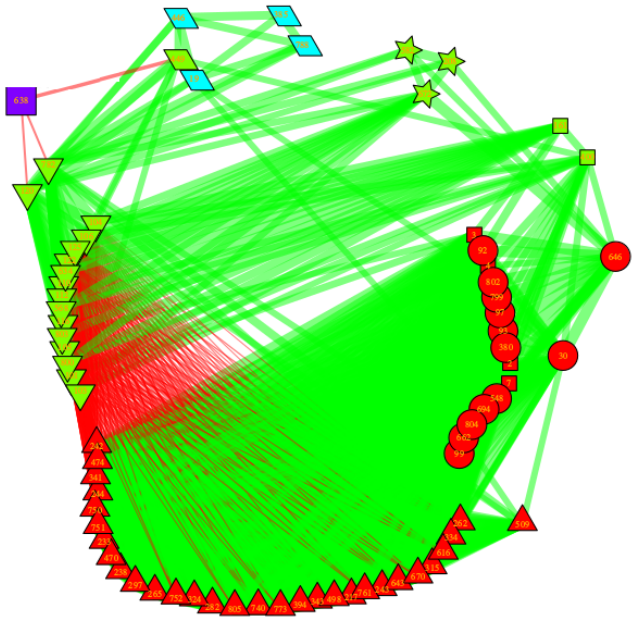
- Method designed for signed graphs
- Negative links taking into account



imbalance (count) = 14.18

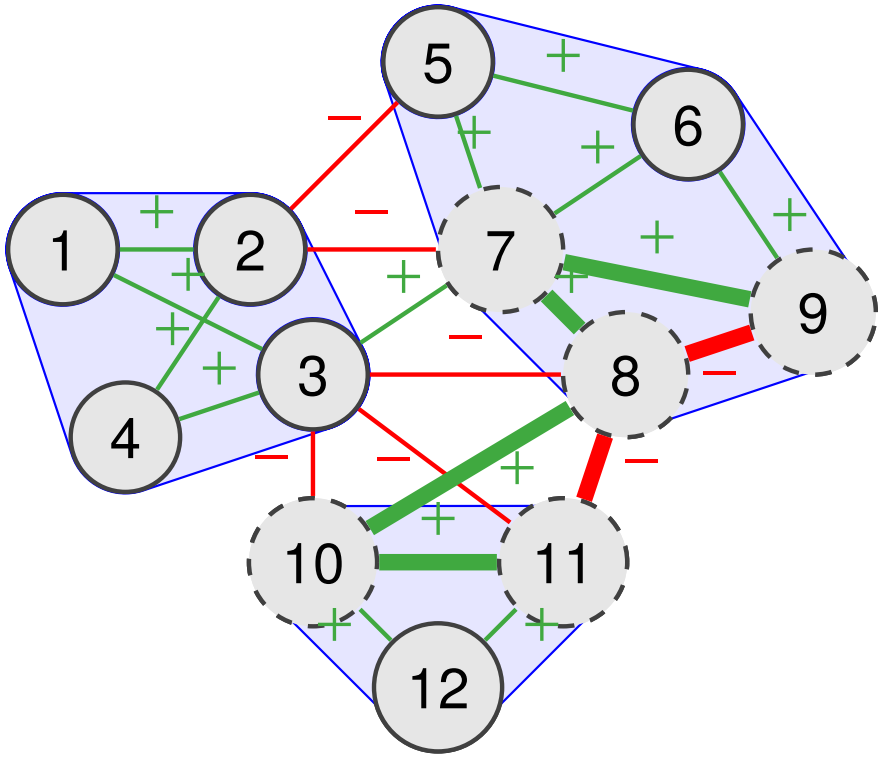
Infomap:

- Method designed for unsigned graphs
- Negative links not taking into account

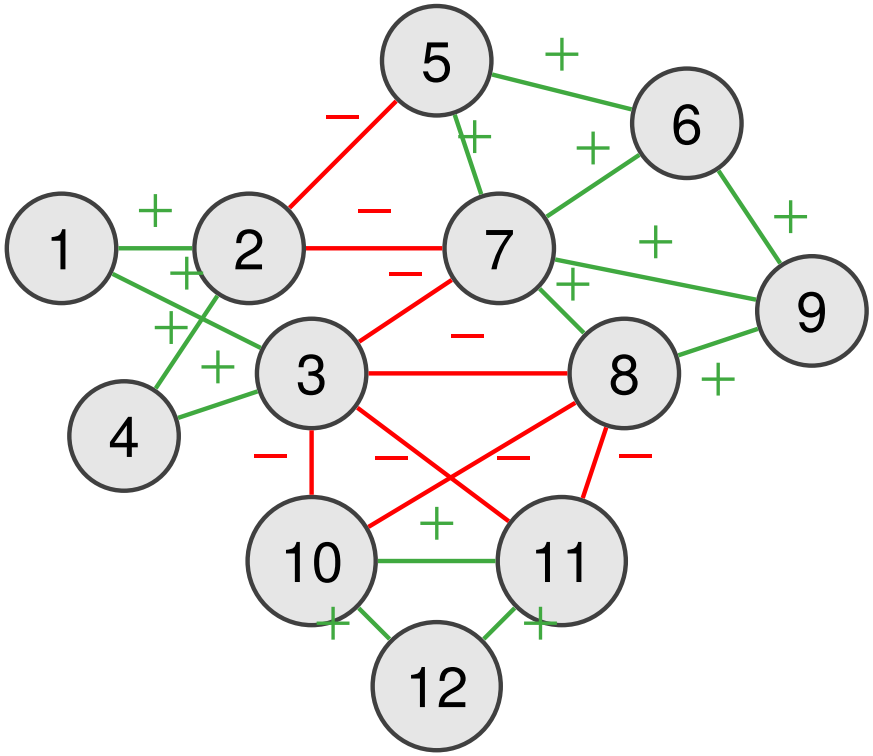


imbalance (count) = 21.70

Strucutural Balance (checking of local property)



An example of link prediction



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