

Study of the European Parliament votes through the multiple partitioning of signed multiplex networks

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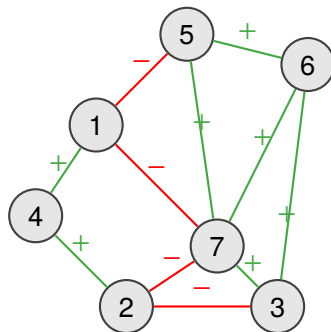
Avignon, OCT 17 - 19, 2018

- 1 Context
- 2 Structural Balance and Signed Graph Partitioning
- 3 Proposed Approach
- 4 Experiments
- 5 Conclusion & Further research

- **Objective:** Understanding the voting behaviors in European Parliament (EP)
- **Input:** Votes (legislative propositions) by members of EP (MEPs)
- **Model:** Signed graph
- **Analysis tool:** Partitioning (Structural Balance theory)

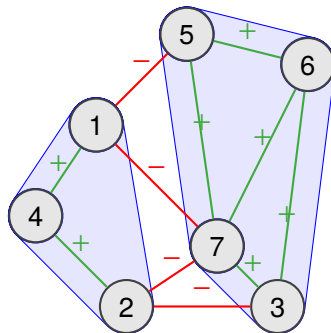
Structural Balance and Signed Graph Partitioning

- **Signed** graphs



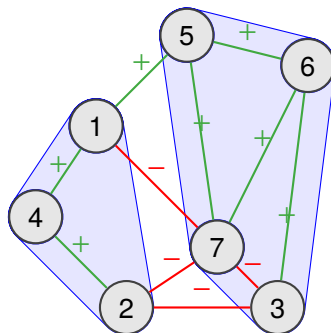
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- **Signed** graphs
- **Structural Balance:** Partitioning into two [Heider, 1946] or more [Davis, 1967] mutually hostile subgroups each having internal solidarity



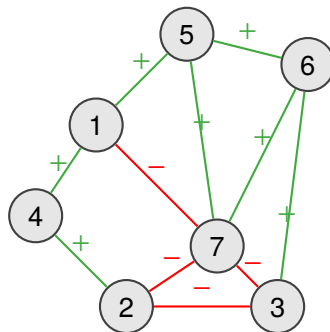
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- Most real networks are not structurally balanced → need to measure graph **imbalance**



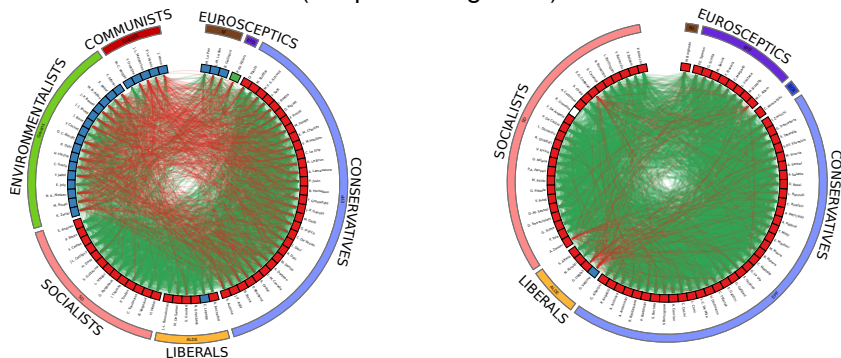
Structural Balance and Signed Graph Partitioning

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- Most real networks are not structurally balanced → need to measure graph **imbalance**
- We want to find the partition which minimizes the number of misplaced links



Proposed Approach: Motivation

France vs Italy, AGRI, 2012-13 [N. Arinik, 2017]
(temporal integration)



- Some associated subtopics: *Common Agricultural Policy (CAP)*, *Animal health and zootechnics* and so on

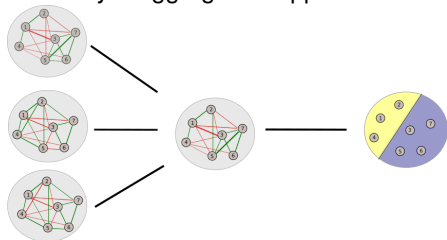
N. Arinik, R. Figueiredo, V. Labatut, "Signed graph analysis for the interpretation of voting behavior", International Conference on Knowledge Technologies and Data-driven Business - International Workshop on Social Network Analysis and Digital Humanities, Graz, AT, 2017.

Proposed Approach: Multiple Partitioning of Multiplex Signed Networks



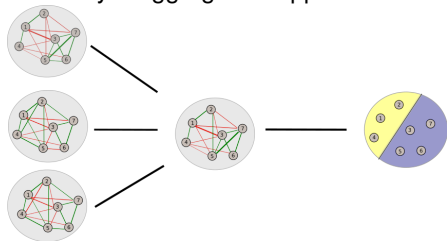
Proposed Approach: Multiple Partitioning of Multiplex Signed Networks

Layer aggregation approach

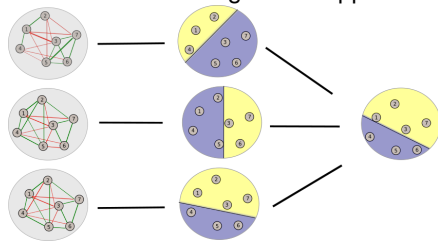


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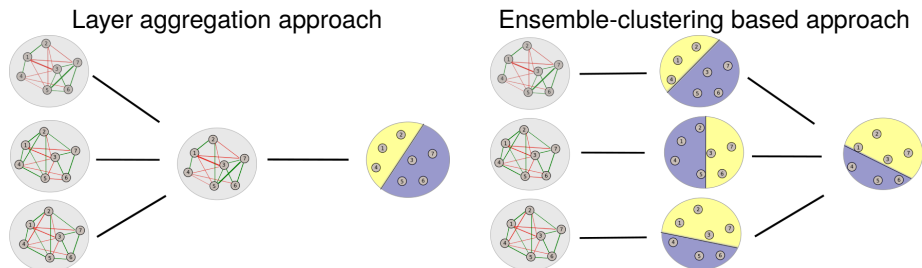
Layer aggregation approach



Ensemble-clustering based approach

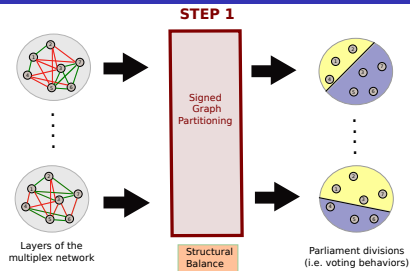


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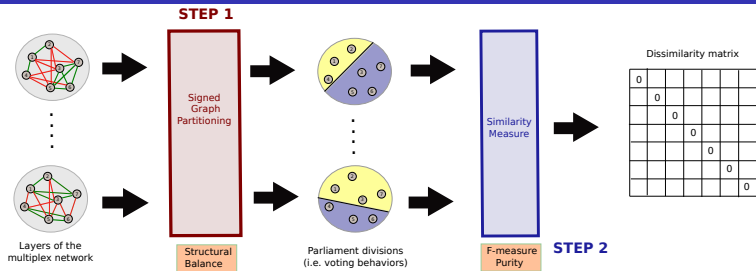


- In literature, existing methods result in single partition.
- But, we want to obtain **multiple** partitions

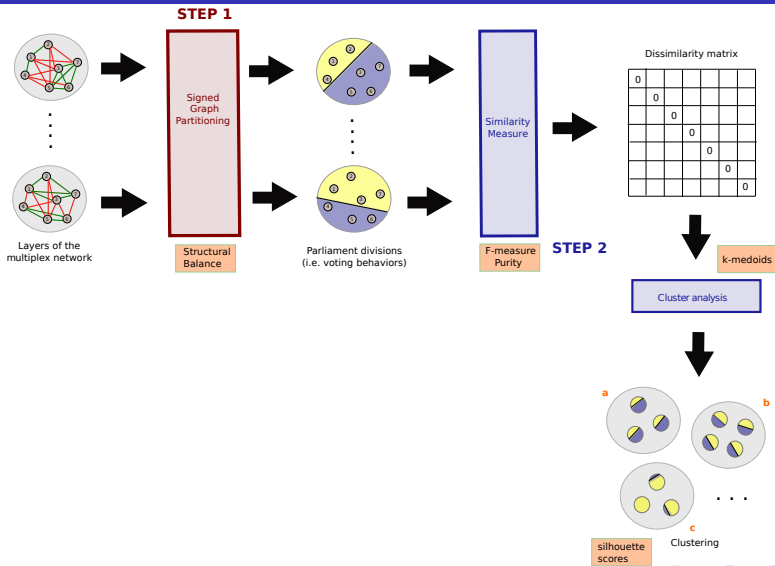
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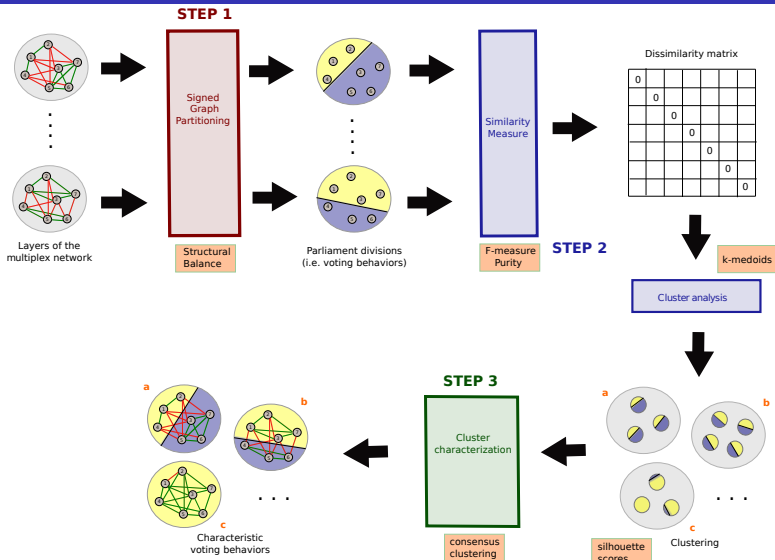
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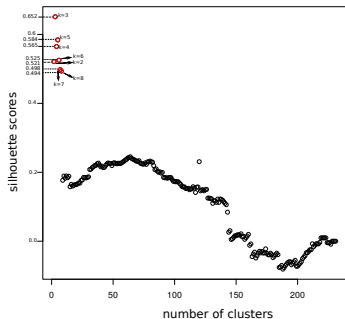
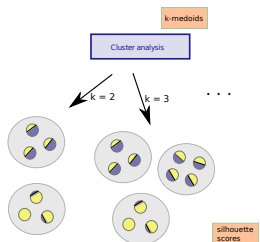


- Raw data (from itsyourparliament.eu):
 - Nature: Voting activity at the European Parliament
 - Period: 7th term (June 2009–June 2014)
 - Size: 840 MEPs, 1426 documents, 21 topics

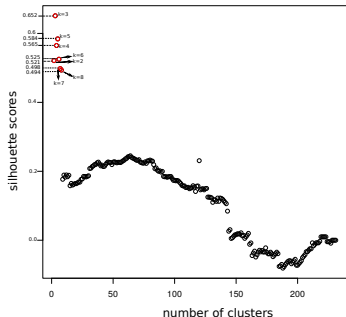
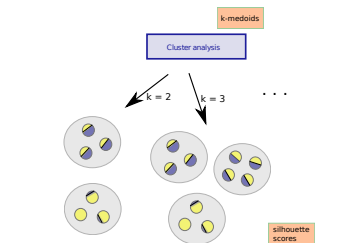
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- Legislative proposition networks:
 - Nodes: Members of the European Parliament (MEPs)
 - Edges: unweighted $\rightarrow -1$ or $+1$
 - Dimensions: country \times topic \times time period \times legislative proposition title
 - For instance, a legislative proposition voted by French MEPs on Agriculture in 2012-2013

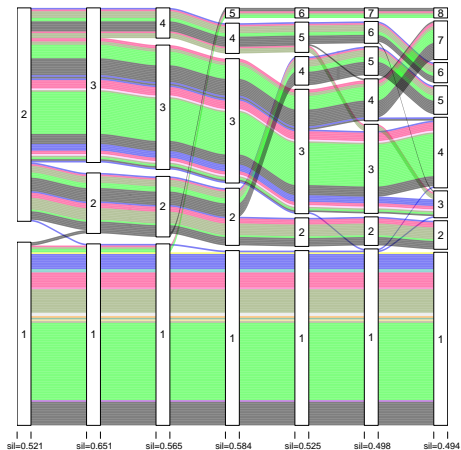
Choice of the number of cluster: France, AGRI, 2012-13



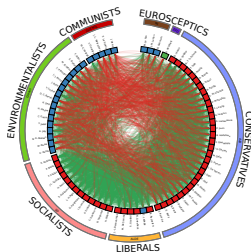
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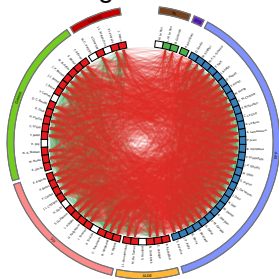
- The best silhouette score $\rightarrow k=3$
- Discarding the scores for $k > 8$



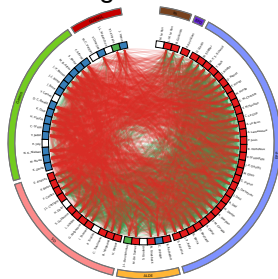
Temporal integration [N. Arinik, 2017]



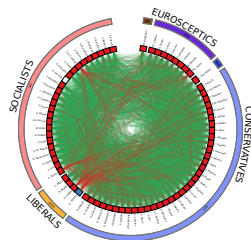
Voting behavior 1



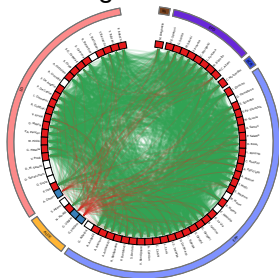
Voting behavior 2



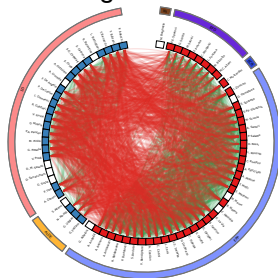
Temporal integration [N. Arinik, 2017]



Voting behavior 1



Voting behavior 2



Conclusion & Further research

- Avoided information loss
 - Discovery of characteristic voting behaviors → associated legislative propositions
 - Existence of unstable antagonistic situations
-
- Improving our system with textual content analysis of the voted legislative propositions
 - Applying our method more systematically to the whole EP dataset

Thank you for your attention!

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References:



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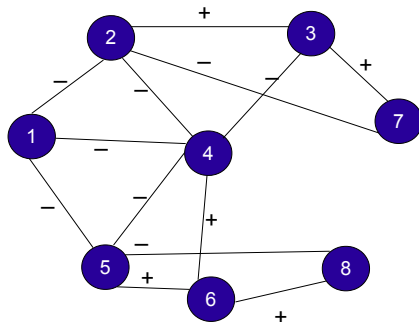
Iterated Local Search

It is comprised of 4 modules:

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

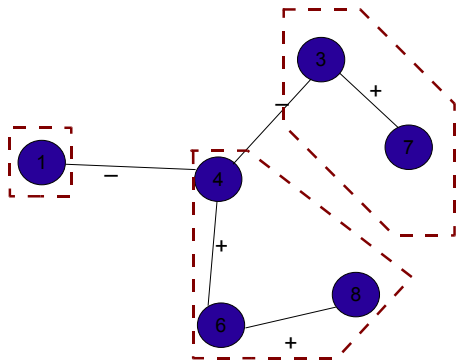
Measure \leftrightarrow Graph optimization problem

$|V|$ in a k balanced subgraph \leftrightarrow Maximum k -balanced subgraph Problem



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$|V|$ in a k balanced subgraph \leftrightarrow Maximum k -balanced subgraph Problem



Definition

Consider a signed graph $G = (V, E, s)$ and an integer value satisfying $1 \leq k \leq n$. The *Maximum k -Balanced Subgraph problem* is the problem of finding a subgraph $H = (V', E', s)$ of G such that H is k -balanced and maximizes the cardinality of the vertex set V' .

Measuring imbalance - CC problem

Definition

Consider a signed graph $G = (V, E, s)$ with a nonnegative weight for 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.

- Imbalance of a partition

$$P = \{S_1, S_2, \dots, S_l\} \text{ of } V$$

$$I(P) = \sum_{1 \leq i \leq l} \Omega^-(S_i, S_i) + \sum_{1 \leq i < j \leq l} \Omega^+(S_i, S_j).$$

where

$$\Omega^+(S_i, S_j) = \sum_{e \in E^+ \cap E[S_i:S_j]} w_e$$

$$\text{and } \Omega^-(S_i, S_j) = \sum_{e \in E^- \cap E[S_i:S_j]} w_e$$

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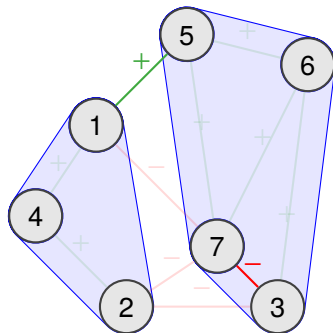
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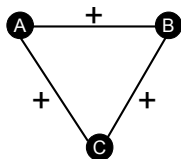


$$I(P) = 0 + 1 + 1 = 2$$

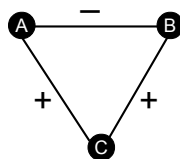
Structural Balance

[Heider, 1946]:

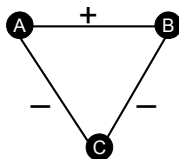
- People strive for cognitive balance in their network of likes and dislikes.



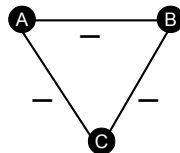
(a) Balanced



(b) Not balanced



(c) Balanced

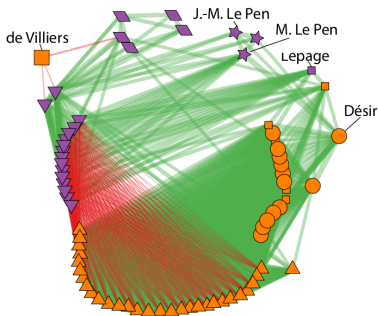


(d) Not balanced

Comparison between a community detection and signed graph partitioning methods

ILS-CC:

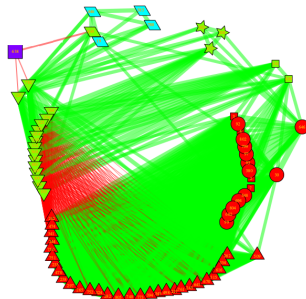
- Method designed for signed graphs
- Negative links taking into account



imbalance (count) = 14.18

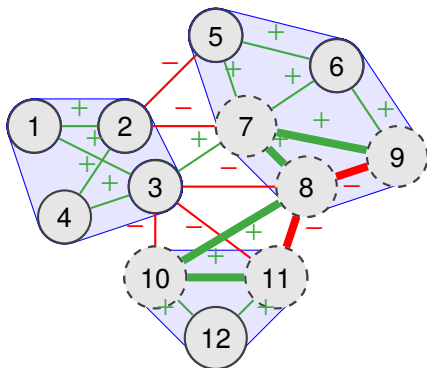
Infomap:

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

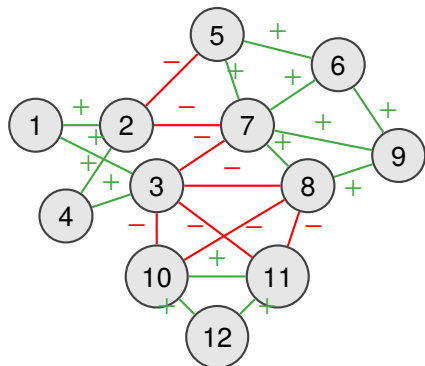


imbalance (count) = 21.70

Structural Balance (checking of local property)



An example of link prediction



An example of link prediction

