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# Network analysis approach to the analysis of event sequences

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IMFM, UP IAM, FDV, Oštro

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# Outline

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**Current version of slides (July 15, 2024 at 10:23):** [slides PDF](#)

<https://github.com/bavla/TQ/tree/master/trajectories>



# Oštro, Zvezoskop, data

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*Oštro* is the Center for Investigative Journalism in the Adriatic region and cultivates investigative and data journalism. Colleagues from

Oštro have developed the *Zvezoskop* project, which allows the public to independently research the connections between current ministers, state secretaries, and members of parliament, and their educational and career paths. Based on their CVs, the careers of 160 current politicians are included in Zvezoskop.



## References

```

person_id,person_name,part_of_cv,show_in_network,start_day,start_month,
start_year,institution_si,institution_standardized_si,institution_department_si,
affiliation_type_si,position_si,end_day,end_month,end_year,notes_institution_si,notes_position_si
...
2241,112,Matej Tonin,izobraževanje,True,,9,1998,gimnazija in srednja šola rudolfa maistra kamnik
2242,112,Matej Tonin,izobraževanje,True,,10,2002,ul fakulteta za družbene vede,,dodiplomski št
2243,112,Matej Tonin,izobraževanje,True,,10,2007,ul fakulteta za družbene vede,,magistrski št
2244,112,Matej Tonin,delovne izkušnje,True,16/4/2007,,2007,državni zbor,,poslanska skupina NSi,j
2245,112,Matej Tonin,strankarska pozicija,True,,2006,nsi,,občinski odbor Kamnik,,predsednik,,2
2246,112,Matej Tonin,strankarska pozicija,True,10/9/2010,,2010,nsi,,,kandidat za župana v obč
2247,112,Matej Tonin,delovne izkušnje,True,29/11/2006,,2006,občina kamnik,,politik,občinski sve
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2255,112,Matej Tonin,strankarska pozicija,True,22/8/2008,,2008,nsi,,,kandidat za poslanca,21/9/
2256,112,Matej Tonin,delovne izkušnje,True,13/3/2020,,2020,ministrstvo za obrambo,,politik,mini
2257,112,Matej Tonin,delovne izkušnje,True,13/3/2020,,2020,vlada,,politik,podpredsednik,1/6/202
2258,112,Matej Tonin,strankarska pozicija,True,1/2/2018,,2018,nsi,,,v d predsednika ,20/4/2018,
2259,112,Matej Tonin,strankarska pozicija,False,21/4/2018,,2018,nsi,,,predsednik,,2100,,
2260,112,Matej Tonin,svetovalne in nadzorne funkcije etc,True,,2015,inštitut dr janeza evangel
2261,112,Matej Tonin,pritožne aktivnosti,True,27/11/2006,,2006,sportno društvo tuhinj,,,pred
2262,112,Matej Tonin,strankarska pozicija,False,,12,2001,nsi,,,član,,2100,,
2263,112,Matej Tonin,strankarska pozicija,False,1/2/2018,,2018,nsi,,,izvršilni odbor,,predsednik,

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# Reduced data

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A person  $X$ 's CV,  $CV_X = (e_1, e_2, \dots, e_{k_x})$ , consists of a sequence of events  $e_i$ . For an event  $e_i = (s_i, f_i, R_i, S_i, \dots)$  we at least know its start date  $s_i$ , its end (finish) date  $f_i$ , the type  $R_i$  of the event, the state (location)  $S_i$  of the event, and maybe something more.

The cleaned data table was first reduced to variables considered in the analysis.

- R – row (event) number (index)
- ID – person\_name: person's name
- s – start\_day|month|year: start date
- f – end\_day|month|year: finish date
- S – part\_of\_cv: type of activity  $R_i$  (work, education, free time, political party, counseling and supervision)
- T – institution\_si  $S_i$  : location (institution, party, organization, etc.)

# Co-presence network

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We decided to base our analysis on the corresponding *co-presence network*  $N = (V, L, w, t)$  – a weighted (number of days of co-presence on a link) multi-relational (5 areas) temporal network. The set of nodes  $V$  consists of 160 politicians.

MO Nova Gorica



# Co-presence network

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There is a *link* (edge)  $\ell = (u : v; R)$  of type (relation)  $R$  between persons  $u, v \in V$  iff there exist events  $e_u = (s_u, f_u, R_u, S_u)$  and  $e_v = (s_v, f_v, R_v, S_v)$  such that  $R_u = R_v = R$  and  $S_u = S_v$  and  $[s, f] = [s_u, f_u] \cap [s_v, f_v] \neq \emptyset$ . The weight of the link  $\ell \in L$  is  $w(\ell) = f - s$ , that is the length of the corresponding time interval  $[s, f]$ . The traditional sequence analysis deals mainly with the analysis of states (3). The co-presence network enables us to analyze groups of persons using network analysis methods such as cuts, cores, islands, network clustering and blockmodeling (1). The proposed approaches will be illustrated on the dataset Zvezoskop of Slovenian politicians (2).

# Co-presence network

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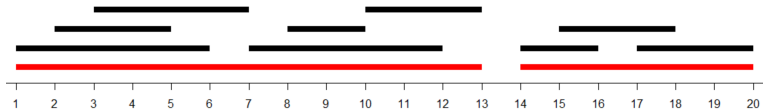
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In preliminary experiments, we found that parallel events of the same kind can greatly increase the similarity between persons. One way to reduce this influence is to count parallel events in the same institution between two persons only once.



All time intervals  $\{[s_i, f_i] : i \in 1 : k\}$  of edges between nodes  $u$  and  $v$  of kind  $S$  we replace with a single edge with weight

$$w(u, v; S) = \left| \bigcup_{i=1}^k [s_i, f_i] \right|$$





# Data – co-presence

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R	ID	s	f	S	T			
64	Igor Papič	1973-09-01	1981-08-01	education	oš v kočevju			
1116	Robert Golob	1979-09-01	1983-08-01	education	gim nova gorica			
65	Igor Papič	1981-09-01	1985-06-01	education	vegova ljubljana			
1068	Robert Golob	1983-10-01	1989-09-29	education	ul fe			
66	Igor Papič	1986-10-01	1992-01-01	education	ul fe			
1070	Robert Golob	1989-11-15	1994-11-14	work	ul fe			
1069	Robert Golob	1992-10-01	1994-10-17	education	ul fe			
67	Igor Papič	1992-10-01	1995-01-01	education	ul fe			
1115	Robert Golob	1994-01-01	1994-01-01	education	tu georgia atlanta us			
70	Igor Papič	1994-01-01	1996-01-01	work	siemens de			
1071	Robert Golob	1994-11-15	1995-10-31	work	ul fe			
69	Igor Papič	1993-03-01	1996-01-01	work	ul fe			
68	Igor Papič	1995-10-01	1998-01-01	education	ul fe			
1072	Robert Golob	1995-11-01	1997-09-30	work	ul fe			
1073	Robert Golob	1997-10-01	2001-06-30	work	ul fe			
1078	Robert Golob	1998-11-01	1999-08-31	work	min za gospodarstvo			
71	Igor Papič	1999-01-01	2007-01-01	work	ul fe			
96	Igor Papič	2000-01-01	2002-06-30	work	ul fe			
94	Igor Papič	2001-01-01	2002-12-31	work	ul fe			
...								
	u	v	s	f	rel	d	Ru	Rv
1	Robert Golob	Igor Papič	1986-10-01	1989-09-29	education	1094	1068	66
2	Robert Golob	Igor Papič	1993-03-01	1994-11-14	work	623	1070	69
3	Robert Golob	Igor Papič	1992-10-01	1994-10-17	education	746	1069	67
4	Igor Papič	Robert Golob	1994-11-15	1995-10-31	work	350	69	1071
5	Igor Papič	Robert Golob	1995-11-01	1996-01-01	work	61	69	1072
7	Robert Golob	Igor Papič	1999-01-01	2001-06-30	work	911	1073	71
10	Robert Golob	Igor Papič	2000-01-01	2001-06-30	work	546	1073	96
12	Robert Golob	Igor Papič	2001-01-01	2001-06-30	work	180	1073	94
...								
	u	v	s	f	d	rel	test	
1	Igor Papič	Robert Golob	1993-03-01	1996-01-01	1037	work	ul fe	
2	Igor Papič	Robert Golob	1999-01-01	2021-01-01	8037	work	ul fe	
3	Igor Papič	Robert Golob	1992-10-01	1994-10-17	747	education	ul fe	

Co-presence network was constructed for the time before the elections on April 24, 2022.

relation	apr22
1 work	1767
2 education	470
3 leisure activities	6
4 party	1086
5 counseling & supervision	10
total	3339
nodes	154

The link values in the network are in the interval  $[1, 3339]$ . Applying the square root we transform them into the interval  $[1, 58]$ . Another application of the square root gives the interval  $[1, 8]$ , which is used for the visualization.

The analysis was done using program Pajek

# Partitions

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In the data on persons, there are three partitions that describe the characteristics of an individual person: party (party membership), position (role in the country), and gender.

The party membership is displayed as the node color. The following bright colors denote political parties:

0	1	2	3	4
5	6	7	8	9

1: Undefined; 2: Freedom (Svoboda) Movement; 3: Left; 4: NSi;  
5: IT+HU; 6: SD; 7: SDS.

Their roles are presented by the following symbols:  – member of parliament,  – secretary,  – minister,  – prime minister; and their gender by colors: blue – male, red – female.

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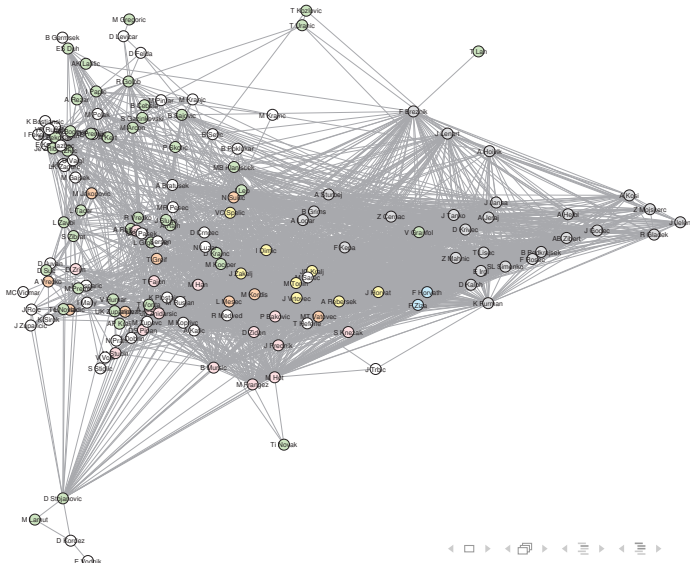
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# Skeletons

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For a quick inspection of the structure of weighted networks, we use various skeletons, in which less important elements (nodes, links) are discarded. An example of a skeleton is a link-cut or a node-cut at selected level. Another example is a *k-neighbors* network, in which we keep only the  $k$  most important neighbors (highest weights) in each node.

Most often we use 1-neighbors because of their tree like structure.

1-neighbors for party links February 2024

Whole network for party links February 2024 on the 1-neighbors nodes layout

# 1-neighbors / Parties February 2024 – relation Party

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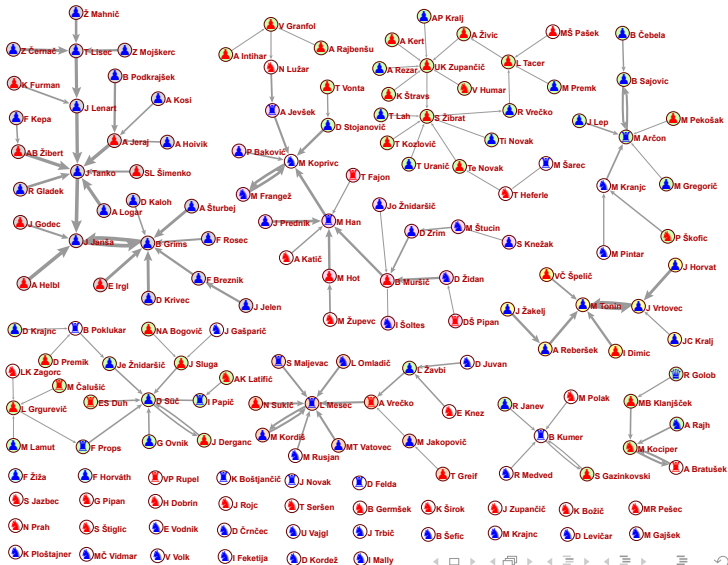
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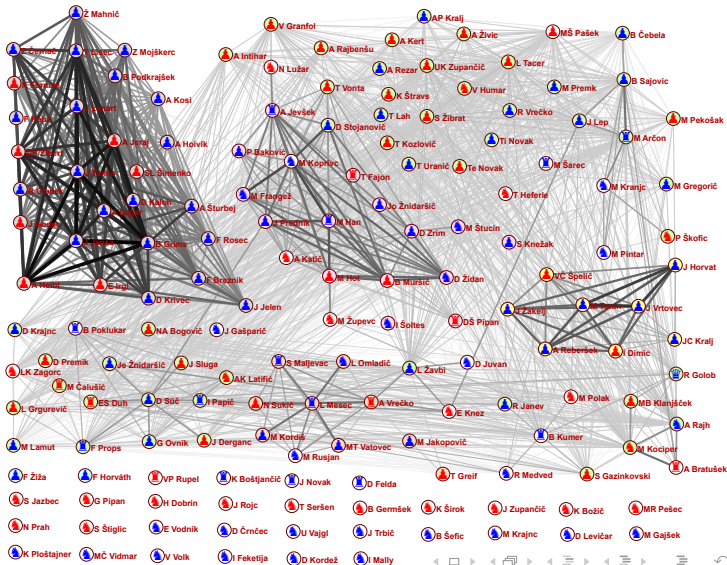
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The co-presence network is a weighted one. Therefore, we decided to use indirect blockmodeling approach, where

- dissimilarity between nodes was calculated by corrected eucliden distance

$$D[u, v] = \sqrt{(w[u, v] - w[v, u])^2 + (w[u, u] - w[v, v])^2 + \sum_{t: t \neq u, t \neq v} (w[u, t] - w[v, t])^2}$$

- Ward hierarchical agglomerative method was used as a clustering procedure

The obtained dendrogram is presented in the next slide.



# Dendrogram

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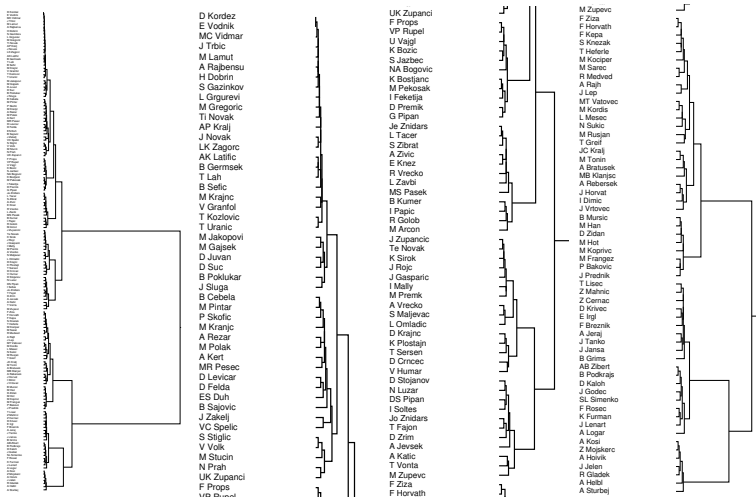
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According to the dendrogram 9 clusters of politicians were determined.

- 1 **'New' SDS MPs (7)**
- 2 **'Old' SDS MPs (19)**
- 3 **'Old' SD MPs (8)**
- 4 **MPs not members of SDS or SD (24)**
- 5 **'New' SD MPs (11)**
- 6 **Members of Gibanje Svoboda (Freedom) and Levica (Left) (15)**
- 7 **Members of Gibanje Svoboda (Freedom) (12)**
- 8 **Members of Gibanje Svoboda (Freedom) (11)**
- 9 **Isolated political office holders (47)**

# Reordered network matrix / $\sqrt{w}$

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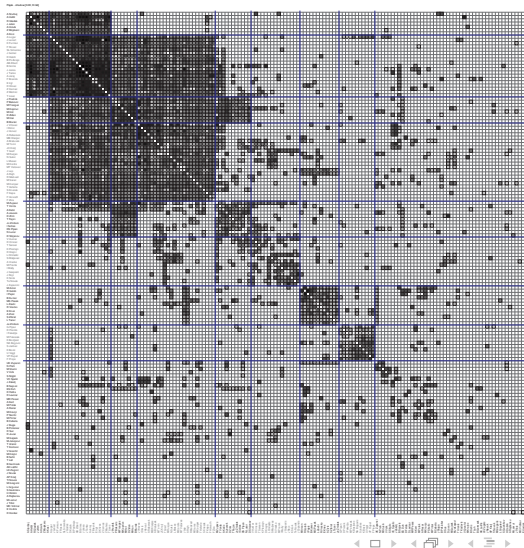
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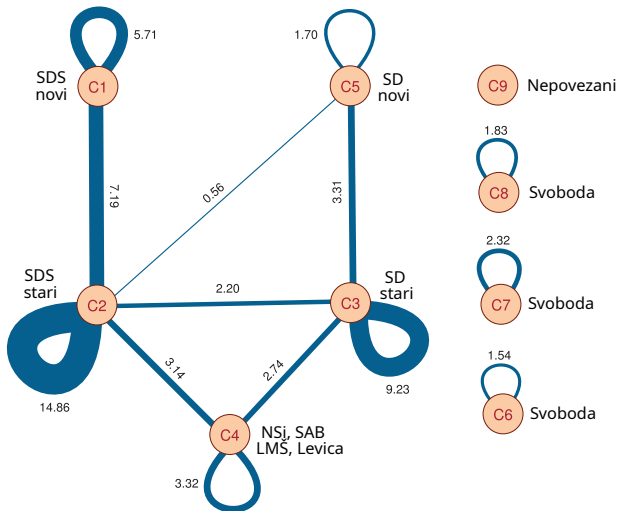
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# Blockmodel (weights in years)



# Some observations

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- The strongest co-presence is among members of the SDS party (among older members, almost 15 years on average). The members of the second oldest SD party (almost 10 years among the seniors) are also quite connected. The greatest co-presence is expected between the two SDS clusters (C1 and C2) (over seven years on average) and between the SD clusters (C3 and C5) with an average of just over three years.
- The fourth group (C4) consists of politicians who have been active for a long time, but are not members of SDS or SD. They are expected to be co-present together with older SDS members and older SD members (on average around three years).
- In the connected part of the blockmodel, politicians have been active for a longer time, including members of NSi and former SAB and LMŠ, but without members of Sloboda.
- Connections within and between the first five groups are mainly due to co-presence in the previous National Assemblies and the state administration.

## ... Some observations

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- The members of Svoboda mainly consist of two clusters (C7, C8) and, together with Levica, the cluster C6. These clusters are not co-present with each other, their members are co-present only within their own cluster.
- As expected, politicians within the three Svoboda clusters were co-present before the last parliamentary elections, each of them also includes ministers and their secretaries (e.g. the seventh most connected Svoboda cluster includes the Prime Minister and the persons who were co-present with him in the municipality of Nova Gorica, at the Faculty of Electrical Engineering, and at the company GENi; in the cluster C8 there are members of Svoboda who, on average, have collaborated for a little less than 2 years and work at the ministries of finance and public administration).
- The quite large cluster C9, which has negligible mutual co-presence, consists of politicians from different parties.
- The co-presence in education is interesting (Faculty of Electrical Engineering, Faculty of Social Sciences, Faculty of Economics, and Law) and play a strong role.



# Conclusions

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- 1 Traditional sequence analysis concentrate attention mainly to the states. Our network approach deals primary with units.
- 2 Apply traditional sequence analysis to Zvezoskop data.  
Extend the dataset at least to public officials from the previous government.  
Kinship!? Additional personal attributes. Homophily  $uE_a v \equiv a(u) = a(v)$ .
- 3 Find other interesting and well documented datasets.



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- [1] Batagelj, V., Doreian, P., Ferligoj, A. and Kejžar, N.: Understanding large temporal networks and spatial networks. (Vol. 2). John Wiley & Sons (2014)
- [2] Oštro center: Zvezoskop. <https://www.zvezoskop.si/en/> (accessed March 31, 2024)
- [3] Ritschard, G., Studer, M.: Sequence analysis and related approaches: Innovative methods and applications. Springer Nature (2018)