

# DYNAMIC NETWORK ANALYSIS OF COVID-19 RELATED DISINFORMATION ECOSYSTEM IN CROATIA

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REPORT

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## Pro-fact

Research, education, fact-check and  
debunk COVID-19 related disinforma-  
tion narratives in Croatia

## Coordinator of the Pro-Fact

Gong

## Partners

Faculty of Political Science in Zagreb,  
University of Dubrovnik, Faculty of Ele-  
ctrical Engineering and Computing and  
Faktograf.hr.

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# MAPPING COVID-19 DISINFORMATION ECOSYSTEM IN CROATIA

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PRO-FACT

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## SUMMARY

This report is part of the research activities conducted under the project “Pro-fact: Research, education, fact-check and debunk Covid-19 related disinformation narratives in Croatia”, financed by EU grants for small-scale online media. The aim was to create the dynamic visualizations of disinformation propagation over time through the initial web source. Additionally, the aim was to provide insights about interconnectedness between actors of disinformation and to study change phenomena.

### Key findings:

Pioneer vertices on topic Covid-19 later situated in center of disinformation clusters and facilitated forming of the community clusters

Even a single actor can influence the structure of the disinformation ecosystem

The Covid-19 disinformation ecosystem had relatively stable structure over the two years period, independently from external factors like mitigation strategies taken by platforms

The Covid-19 disinformation ecosystem has a superorganism characteristic that helps its resistance to mitigation techniques through various strategies

## INTRODUCTION

To better understand the phenomenon of disinformation spreading, we need to understand the dynamic behavior of actors of the disinformation ecosystem, especially in the form of structural changes over the time (Zaidi et al., 2014). Therefore, on data collected as part of social network analysis of Covid-19 disinformation ecosystem in Croatia (Brautović, 2022) we applied the dynamic network analysis (DNA), with aim of understanding how the ecosystem evolved through two years period, what kind of structural changes happened, who were influential actors that facilitate development of the system, and its survival characteristics during the observed time.

DNA represents a holistic approach of studying and analyzing interconnectedness networks which are evolving during the passage of time. These processes are an outcome of internal and external factors (Zaidi et al, 2014). In the case of the Covid-19 disinformation ecosystem, the internal factor that changed it could be the end of the pandemic or withdrawal of the actors. The external factors could be strategies and approaches taken by platforms (Facebook) to detect and restrict their activities.

## METHODOLOGY

The dynamic patterns can be analyzed through their properties (Burch et al., 2011) by visualizing the ecosystem over the time as a single (whole) static<sup>1</sup> network (Zaidi, 2014) and by dividing it into vertex<sup>2</sup> level (ego network) for better understanding actors' roles. For visualization we broke the Covid-19 disinformation network graph into time-steps graphs<sup>3</sup>, based on the four waves of Covid-19 pandemic in Croatia that occurred in these periods:

1<sup>st</sup> wave: February 29<sup>th</sup>, 2020 – September 30<sup>th</sup>, 2020

2<sup>nd</sup> wave: October 1<sup>st</sup>, 2020 – February 28<sup>th</sup>, 2021

3<sup>rd</sup> wave: March 1<sup>st</sup>, 2021 – July 31<sup>st</sup>, 2021

4<sup>th</sup> wave: August 1<sup>st</sup>, 2021 – December 31<sup>st</sup>, 2021

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- 1 Static network is network of interconnections during the whole analyzed period and dynamic network is network of interconnections during shorter periods that repeats (Udine et al, 2011).
  - 2 Vertex or node represents actors or purveyors of Covid-19 disinformation. In SNA it's visualized as a dot in the graph.
  - 3 Time-step represents the time period that covers the visualization and metrics on which the whole analyzed period is divided. Usually can be day, week, month or, as in our case, the pandemic wave.

Time window<sup>4</sup> used for aggregating each subgraph was different as it was based on the duration of the pandemic waves. The animated visualization of the Covid-19 disinformation ecosystem is available [here](#).

The dataset was collected using snowball method from the collection of the URLs found on Faktograf's<sup>5</sup> blog about Covid-19 disinformation<sup>6</sup>. A total of 540 factcheck URLs (N=540) were collected, for the disinformation which were published in the period from January 1, 2020 to December 31, 2021. Based on that URL list, the manual content analysis was conducted and original (still active) 253 disinformation URLs (N=253, 47%) were determined. Afterwards, we used CrowdTangle to collect Facebook data about URLs leading to fact checks and disinformation, resulting in a dataset containing 5128 edges (N=5128) and unique 1528 vertices (N=1528).

The visualization was created using the Harel-Koren Fast Multiscale algorithm<sup>7</sup>, clusters were colored with different colors and connections (shared URLs) were colored from orange to purple, depending on the weight of the relationship (number of shared URLs). The size of the vertice was scaled based on the betweenness centrality measure (measure of influence of vertice in dissemination of the information in social networks), and labels were added only to the most influential vertices (top 30 vertices). As the same sources (organizations or people) usually have multiple outlets like websites, Facebook pages and similar web spaces, we applied the same names/labels to reduce them to the same source, whenever it was possible to determine so. For example, Faktograf had both a website and Facebook page, which were labeled as Faktograf and used as a single vertice. Where it was hard to determine the relationship between outlets we left it as it was. For example, for the Facebook page Matrix and Youtube channel Matrix TV it was impossible to establish the connection.

Drawing on above mentioned, we developed the following research questions:

RQ1: Who were the actors of the Covid-19 disinformation ecosystem around which the main clusters of purveyors of Covid-19 disinformation were formed?

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- 4 Time window represents the time period of the time-step. In our case the time window is the pandemic wave.
  - 5 Faktograf.hr is the only Croatian fact-checking organization and part of the project consortium.
  - 6 <https://faktograf.hr/live-blog-dezinformacije-o-koronavirusu/>
  - 7 Algorithm used for visualization of SNA that forces closely connected vertices to be plotted near.

RQ2: What were the SNA metrics differences during the two-year period?

RQ3: How did the dynamic patterns evolve during the two-year period?

RQ4: How did the morphology of ego-networks of the most influential and super-spreaders purveyors of Covid-19 change during the time?

## RESULTS

The snapshot of the Covid-19 disinformation ecosystem taken in January 2020 revealed that main vertices, around which later the leading (dis)information clusters were formed, were older vertices Marija Stojaković, 2012 Transformacija svijesti, Logicno.com and Faktograf.hr. It is a case of “Matthew effect” where “...public figures and users with older accounts have a higher probability of acquiring and maintaining an influencer status on social media platforms” (Leal, ).

Figure 1: The first disinformation about Covid-19 spread in January 2020

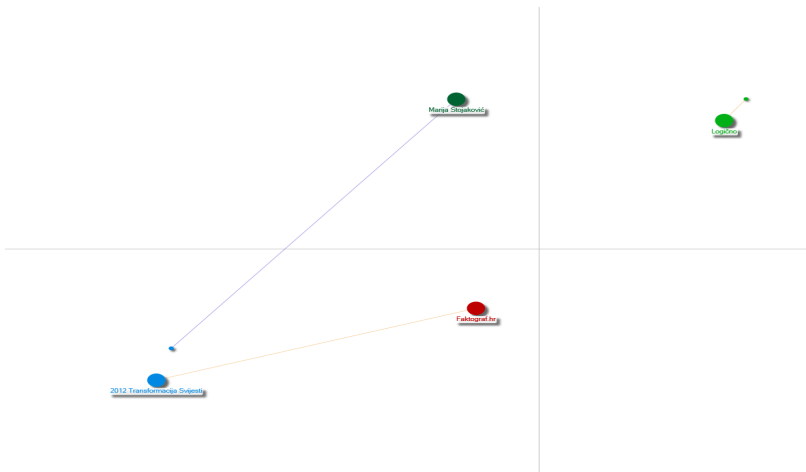


Table 1 shows that the number of vertices increased with the first case of Covid-19 in Croatia, introduction of lockdown and parliamentary elections. On the other hand, opening of the country after lockdown and end of the elections had a calming effect on the number of actors (vertices) and number of shared URLs (edges). During lockdown and parliamentary elections the ecosystem became more complex (average path length) as it involved

more actors who were sharing and creating more content (average degree). Creation of the clusters were more prominent in March 2020 and July 2020. We can speculate that it was the result of the involvement of political actors who found the Covid-19 narrative as a way of promoting their cause.

**Table 1: Evolution of Covid-19 disinformation ecosystem during 1st wave of pandemic**

	Vertices	Edges <sup>8</sup>	Average path length <sup>9</sup>	Average degree <sup>10</sup>	Average clustering coefficient <sup>11</sup>	Events
January 2020	6	5	0,5	0,667	0,000	The first reports about Covid-19
February 2020	39	46	1,706013	0,949	0,000	The first case of Covid-19 (February 25, 2020)
March 2020	121	200	3,192548	1,041	0,004	Lockdown (March 19, 2020- April 27, 2020)
April 2020	214	390	3,288583	1,248	0,000	
May 2020	78	120	3,068801	1	0,000	Opening
June 2020	183	298	2,942148	1,066	0,001	Campaign for parliament elections
July 2020	225	515	3,30334	1,511	0,026	Croatian parliament elections (July 5, 2020)
August 2020	108	179	2,963123	1,093	0,000	

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- 8 Edge represents connection or relationship between two vertices. In our case it is sharing someone's link.
  - 9 Average path length represents the average number of steps that a message needs to cross from one side of the network to the other side.
  - 10 Average degree represents the average number that someone shared the vertex's link.
  - 11 The measure of degree that vertices incline to group.

September 2020	188	311	3,475368	1,266	0,006	High number of the cases as result of taking down of all of the epidemical measures during the summer
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The number of involved vertices differ during four observed periods, with the highest number of the vertices in the 1<sup>st</sup> wave, and the smallest in the 3<sup>rd</sup> wave. Similar pattern was present in the total number of edges (connections). Beyond expectations, the most coherent structure of the disinformation ecosystem was during the 4<sup>th</sup> wave with the highest modularity (0,388575), and the smallest average geodesic distance (3,172014). It is probable that this last result was heavily influenced with the introduction of the cluster around the Marine Brekalo vertex.

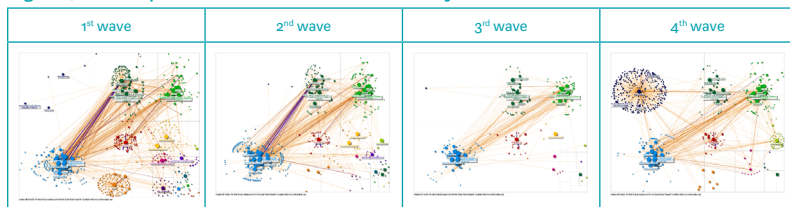
**Table 2: Comparison of SNA metrics through four Covid-19 waves**

	1 <sup>st</sup> wave	2 <sup>nd</sup> wave	3 <sup>rd</sup> wave	4 <sup>th</sup> wave
Vertices <sup>12</sup>	710	459	222	676
Unique Edges <sup>13</sup>	915	702	281	774
Edges With Duplicates	1098	570	208	530
Total Edges	2013	1272	489	1304
Self-Loops <sup>14</sup>	246	144	88	129
Maximum Geodesic Distance (Diameter) <sup>15</sup>	9	8	8	8
Average path length	3,478436	3,464873	3,728807	3,172014
Graph Density <sup>16</sup>	0,002308	0,004024	0,006502	0,001972
Modularity <sup>17</sup>	0,325377	0,286025	0,277968	0,388575

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- 12 Vertex or node represents the actors in the network.
  - 13 Edge represents a connection or relationship between two vertices.
  - 14 Number of the times that vertex shared its own link.
  - 15 Maximal distance between two vertices in the network.
  - 16 Ration between the number of edges in the network and maximum possible considering the size of the network.
  - 17 Strength of division of a network into clusters.

Visualization in figure 3 was created as “Flipbook”<sup>18</sup> and showed that snapshots taken in different times during the two-year period had stable structure in the form of interconnectedness and organization of main clusters. The graph was only moderately changed in November 2021 with establishment of new vertex Marija Brekalo and clusters around her. Although the new vertices were established, the network structure and cluster organization stayed relatively stable.

Figure 3: Development of the disinformation ecosystem



Opposite to previous, on vertex level the data showed (Figure 4) that, except Faktograf.hr and Logicno.com, all other subsequent graphs had an unstable pattern. During the four waves of Covid-19 pandemic they changed the structure and showed trends of changing edge density and patterns. For example, the network of vertices around 2012 Transformacija svijesti in the first two waves had a tight community structure which was later reduced in the number of edges and complexity. Similarly, Marija Stojaković had broadcasting structure in the first two waves that changed later when her presence was almost not existent. Stojaković’s role was replaced by Marina Brekalo in the 4th wave, who formed a new broadcasting cluster around her. Similar to Stojaković, the super-spreaders Saznajmo istinu o Koroni and Glavna grupa stranke Ivana Pernara were silenced in 3rd and 4th wave. Opposite to them, super-spreaders Narodni Referendum and Istina.info.nova became more active after the first wave.

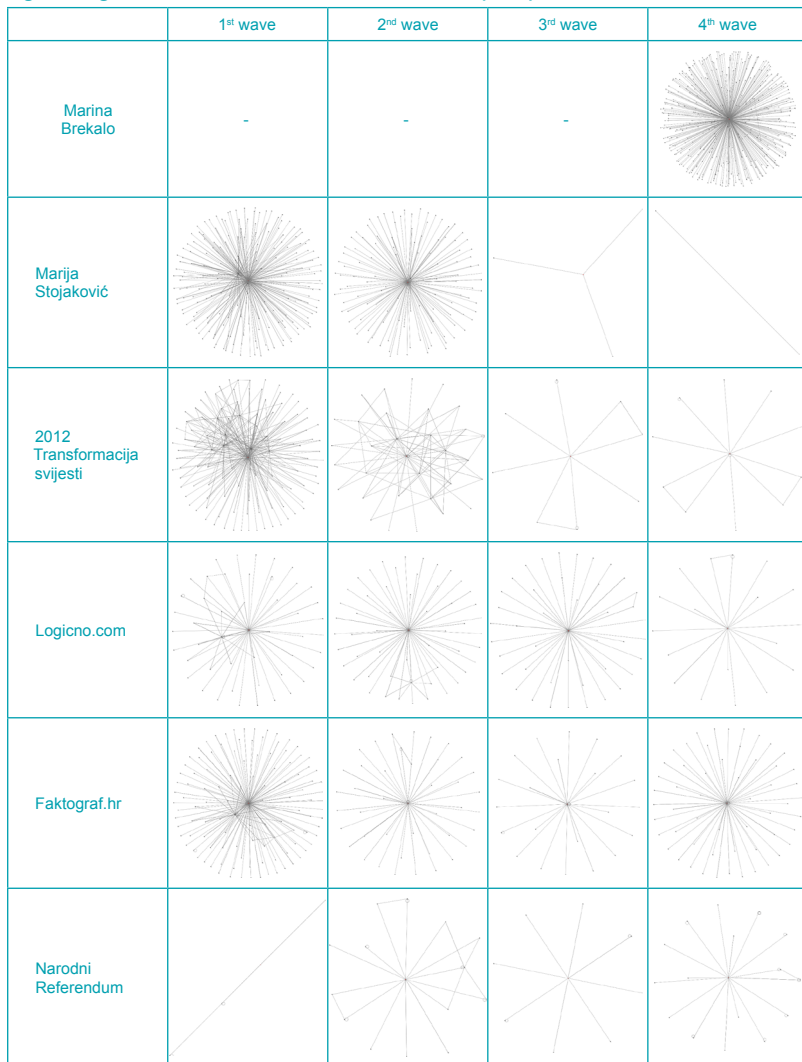
Although on the level of single vertex the Covid-19 disinformation network showed relatively high level of instability, the disinformation ecosystem possessed a dynamic morphing feature, acting as a superorganism<sup>19</sup> (term borrowed from biology), while attempts to survey strategies of mitigating techniques were performed by platforms and fact-checking organizations. The survival strategies, among others, include re-establishment/re-structuration of vertex (2012 Transformacija svijesti), late introdu-

18 Edges are dynamic while vertices maintain a fixed position (Zaidi et al, 2014).

19 The superorganisms are formed from many individual and different organisms and have functional organization that helps them to persist through the time.

ction of new vertex (Marina Brekalo), and morphing (Narodni Referendum, Istina.info.nova).

Figure 4: Ego-networks for the most influential and super-spreaders vertices



 **CLICK EACH IMAGE TO VIEW IN DETAIL**



CLICK EACH  
IMAGE TO VIEW  
IN DETAIL

Saznajmo istinu o Koroni				
Glavna grupa stranke Ivana Pernara				
Istina.info. nova				

## CONCLUSION

Application of the dynamic network analysis showed that pioneer vertices on Covid-19 disinformation were later situated in the center of disinformation clusters and facilitated forming of the community clusters around them. Additionally, it showed that even a single actor can influence the structure of the disinformation ecosystem. Probably the most interesting finding from DNA confirmed that Covid-19 disinformation ecosystem has a superorganism characteristic that enables it to survive mitigation techniques through various strategies like e-establishment/re-structuration of vertex, late introduction of new vertex, and morphing. On the single vertex level, Covid 19 ecosystem's actors were very unstable but shoaling to find the best surviving technique.

The limitations of the study are coming from the use of a static visualization approach that can be naïve in analyzing complex temporal systems and “...fails to exhibit relationship changes over a time period” (Zaidi et al. 2014).

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## ABOUT THE AUTHOR

Mato Brautović is a professor at the Department of Mass Communication at the University of Dubrovnik. He is an author and co-author of many books, book chapters, and scientific papers in professional journals in the field of his expertise – media and war, journalism, internet history, online disinformation, digital methods, and social media. Professor Brautovic has a long and rich experience with scraping, cleaning and analyzing big data, going back to 2006, when he conducted his first social network analysis (SNA).

## PRO-FACT

The Project ‘Pro-fact: Research, education, fact-check and debunk COVID-19 related disinformation narratives in Croatia’ is tackling disinformation related to COVID-19 on multiple levels by a multidisciplinary and intersectoral approach. Through research, awareness raising, and capacity-building methods, the project comprehensively approaches the social, political, and health problem of spreading disinformation campaigns related to COVID-19. Through its activities, it aims to effectively expose COVID-19 related disinformation campaigns in Croatia, strengthen the Croatian multidisciplinary team capacities for detecting and combatting disinformation campaigns, and to increase media literacy competencies of Croatia journalists and the general public.

The coordinator of the project is Gong, while the partner organisations are: the Faculty of Political Science in Zagreb, The University of Dubrovnik, Faktograf.hr, and the Faculty of Electrical Engineering and Computing.





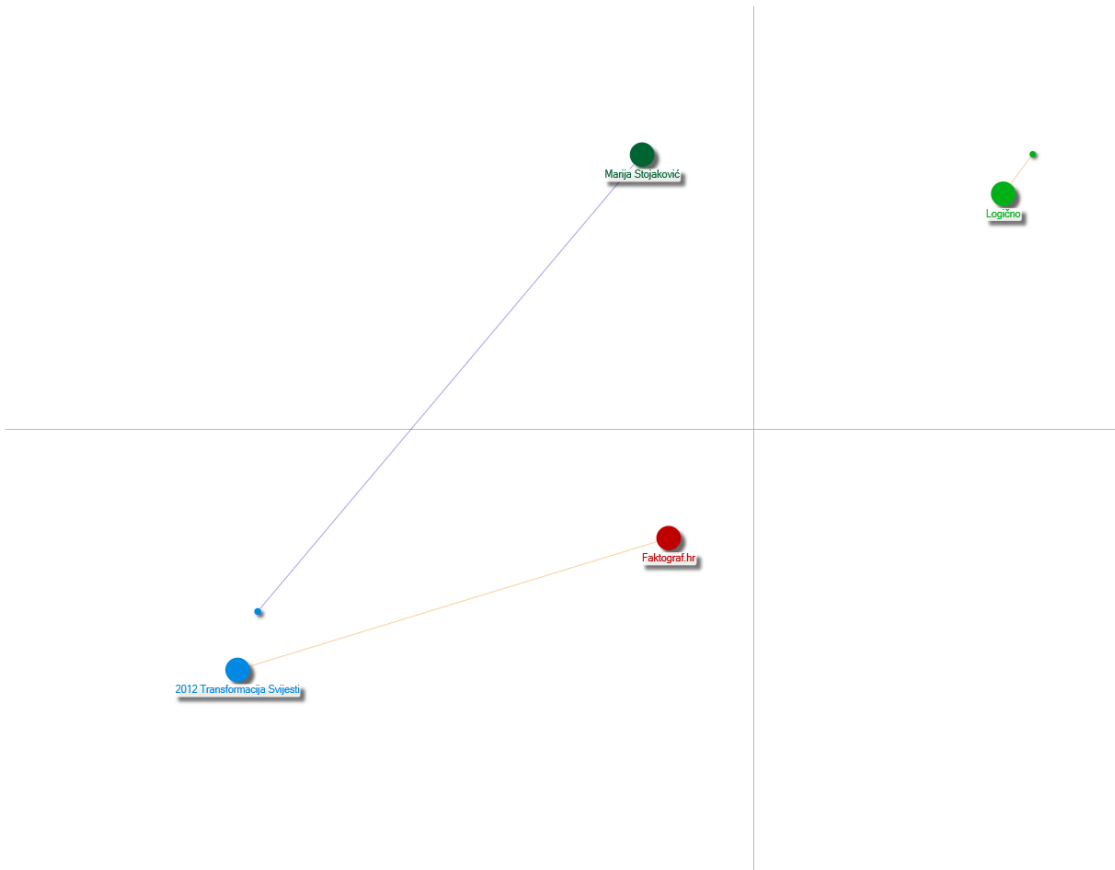
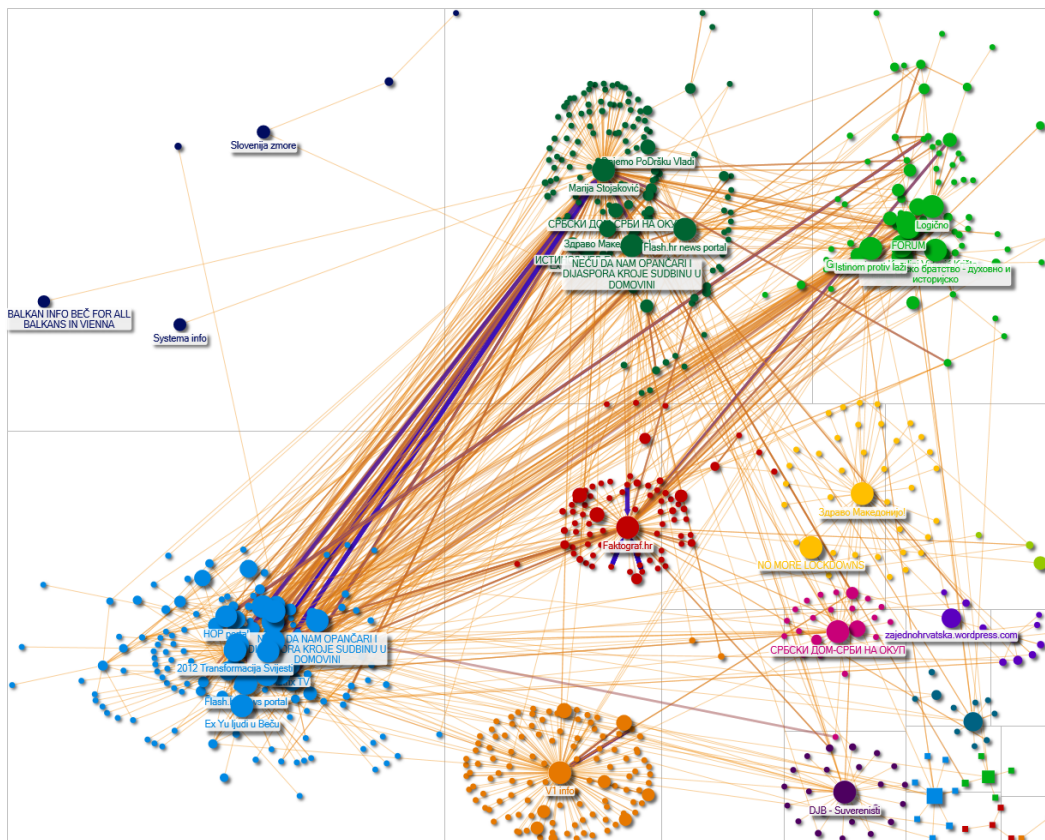
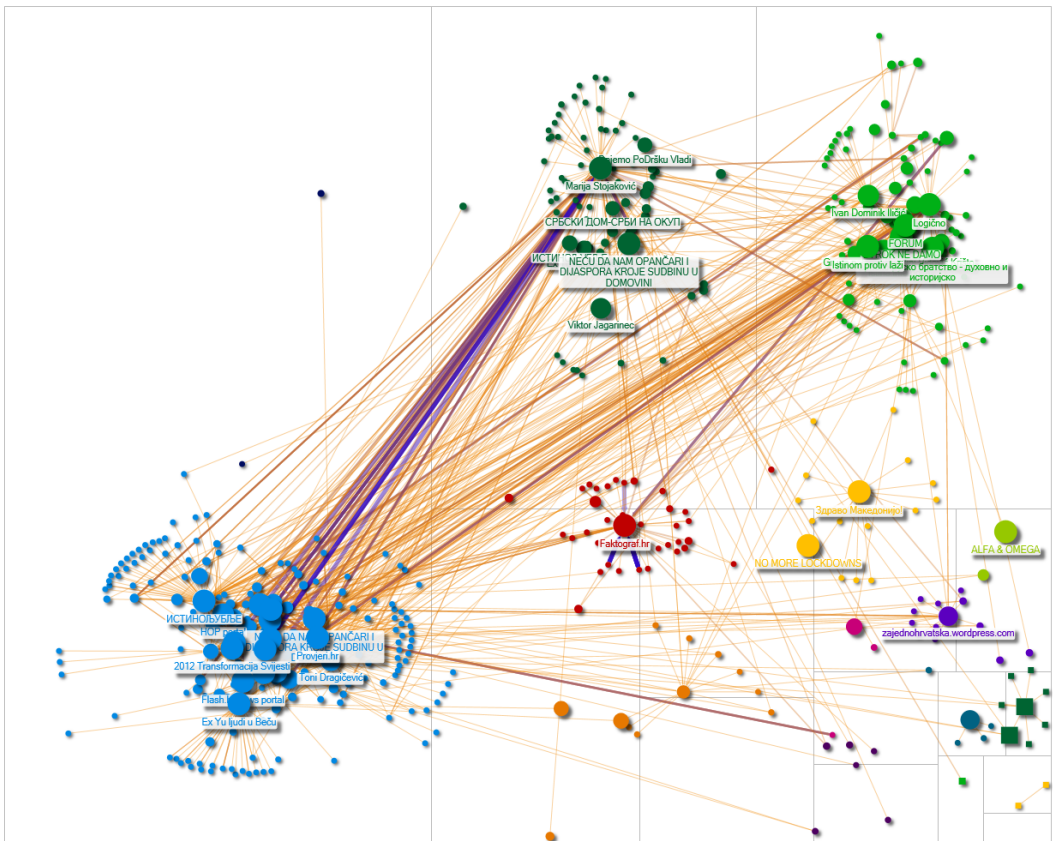


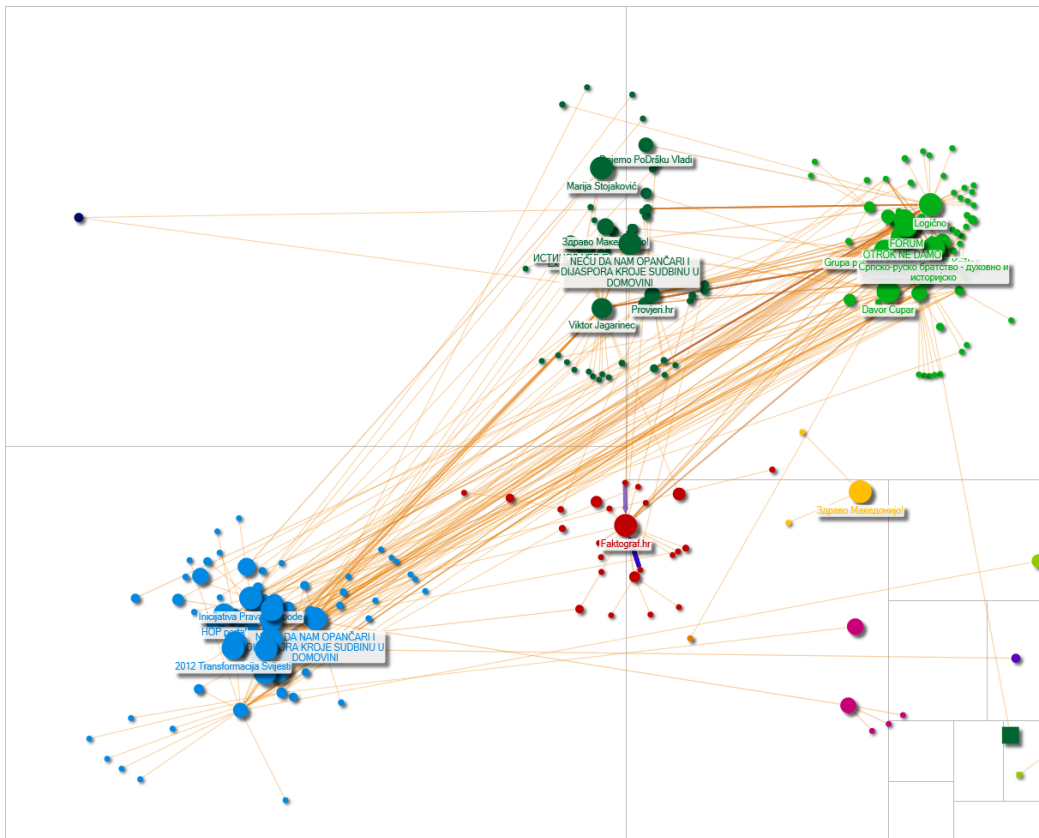
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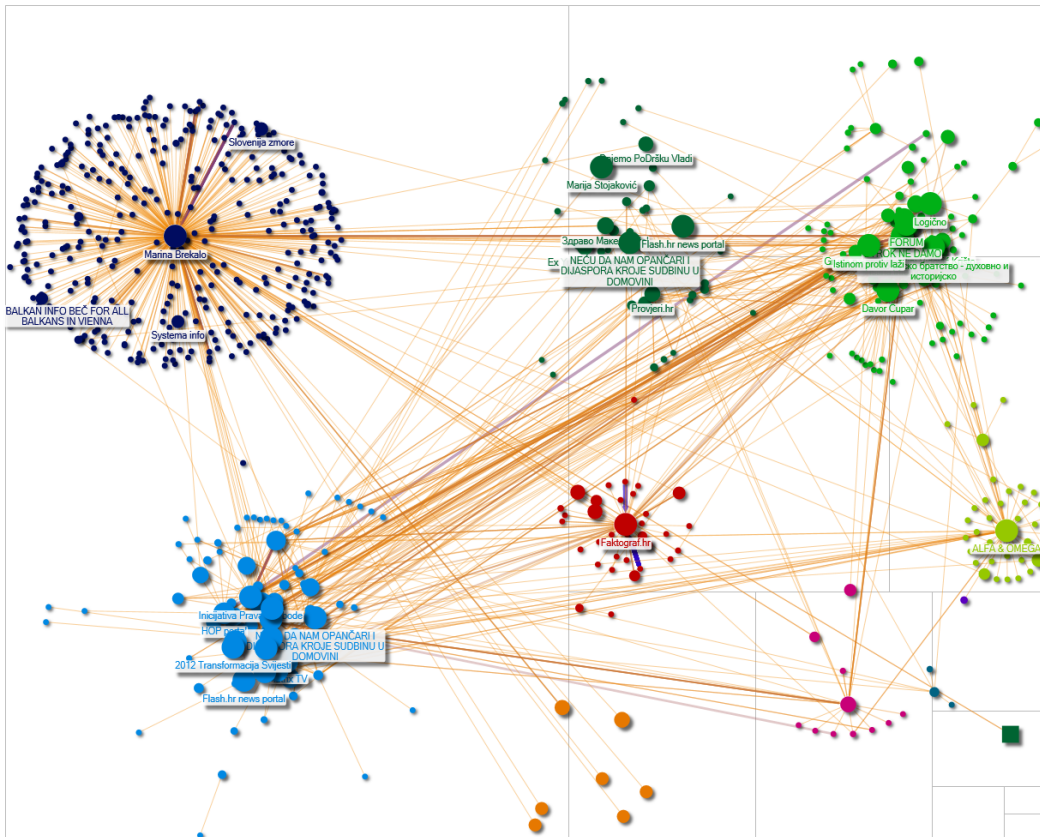
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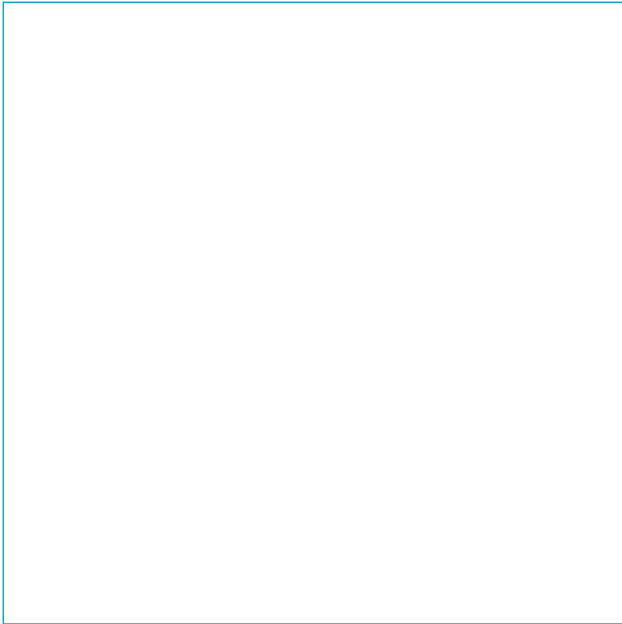
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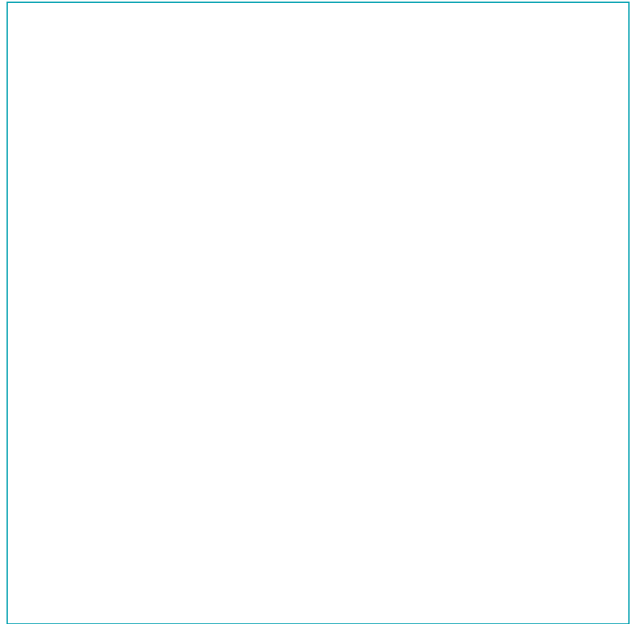
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**MARINA BREKALO**

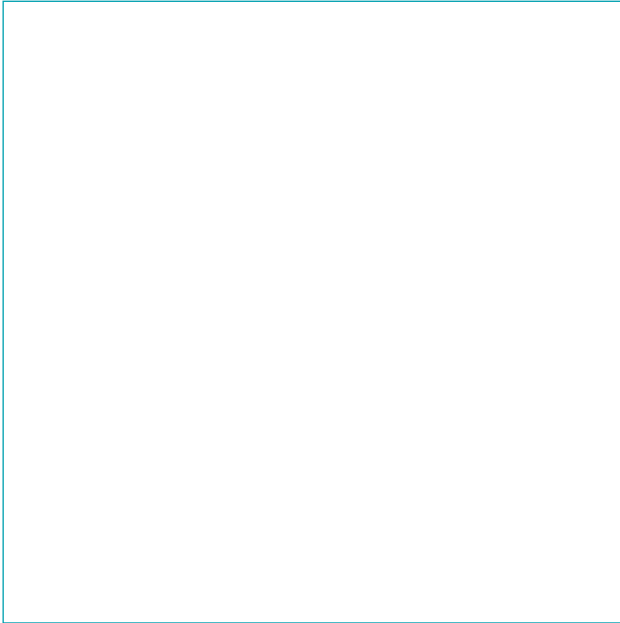
**1<sup>ST</sup> WAVE**



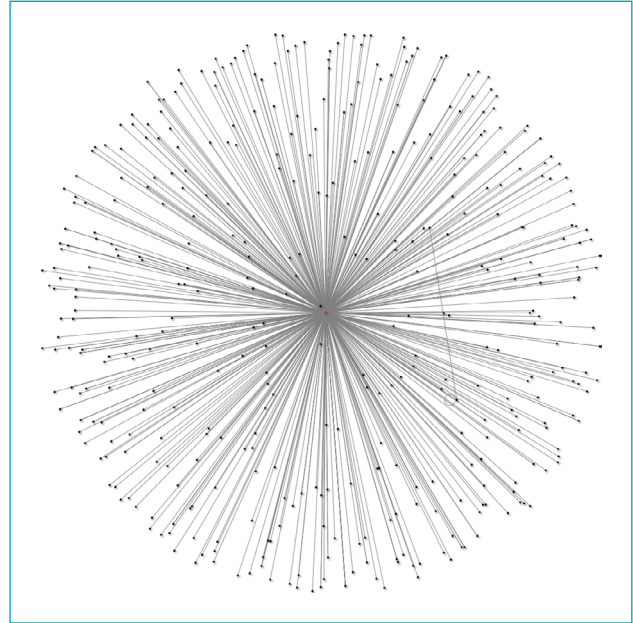
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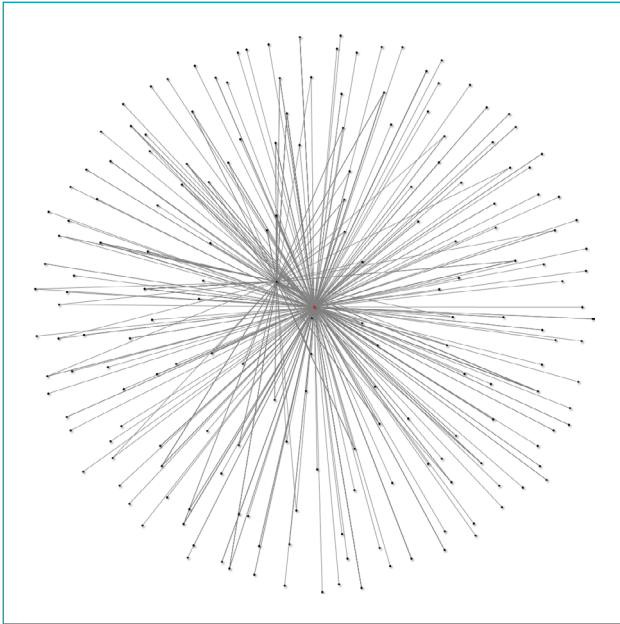
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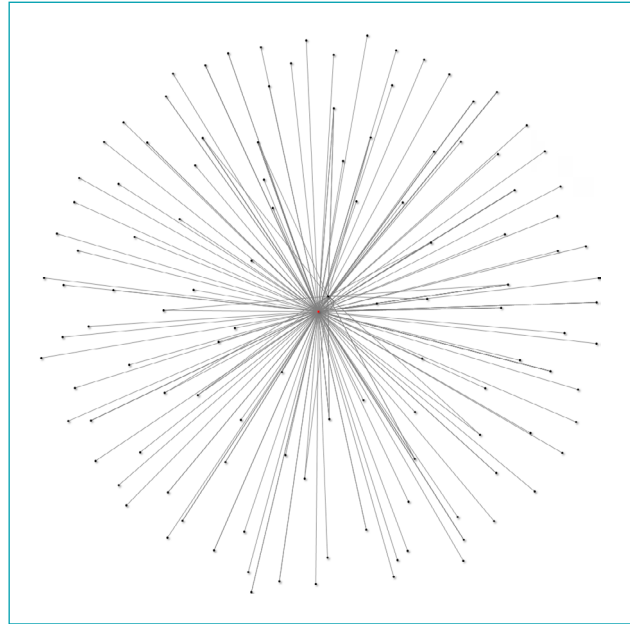
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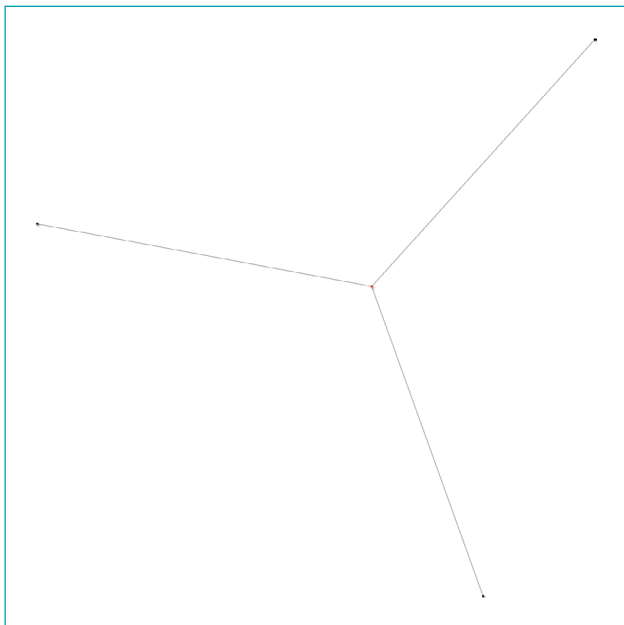
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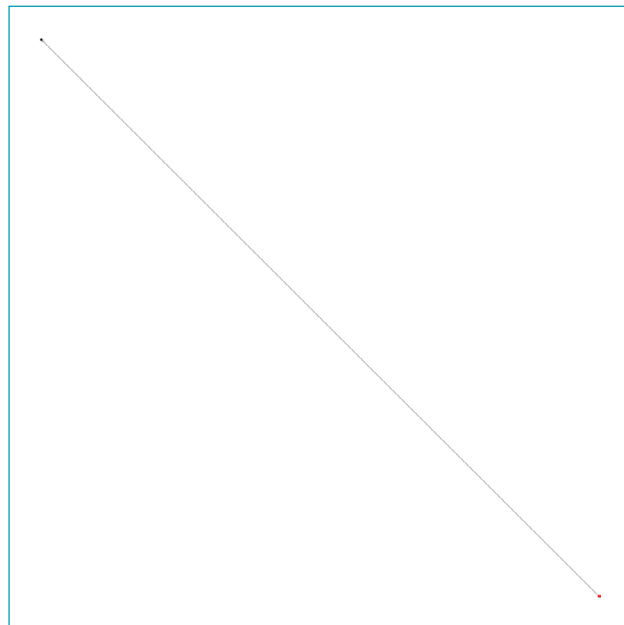
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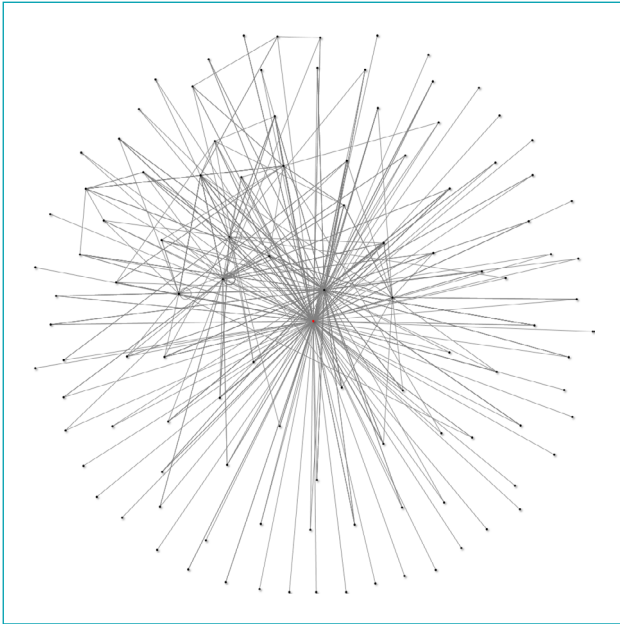


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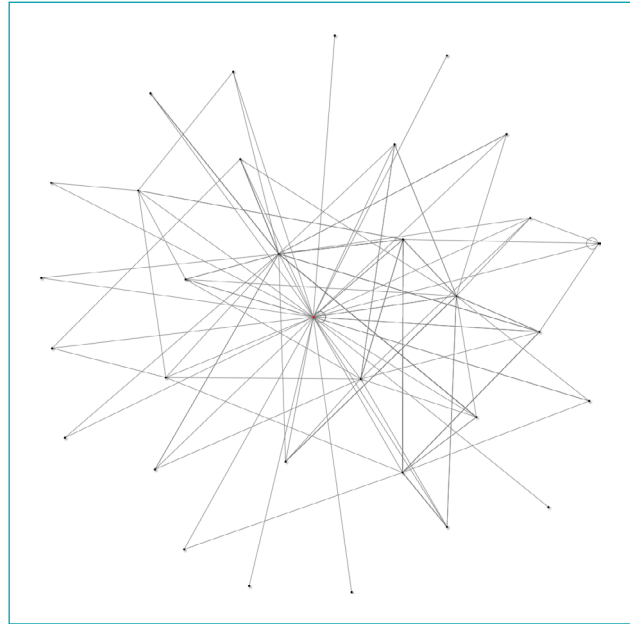


## 2012 TRANSFORMACIJA SVIJESTI

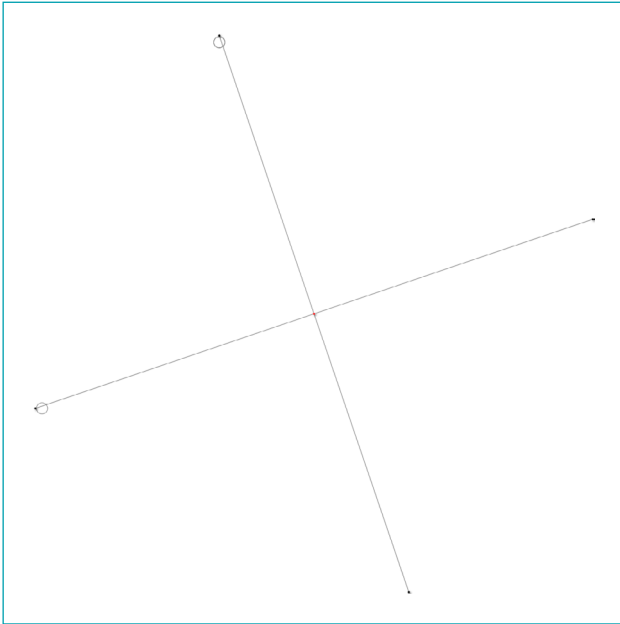
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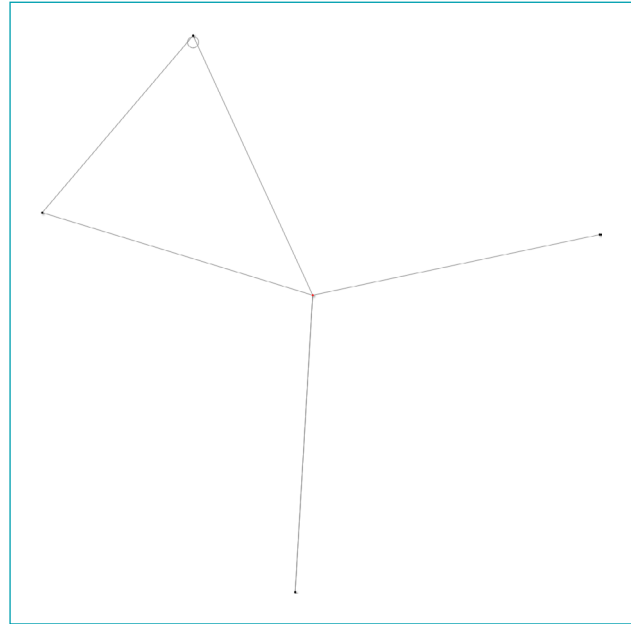
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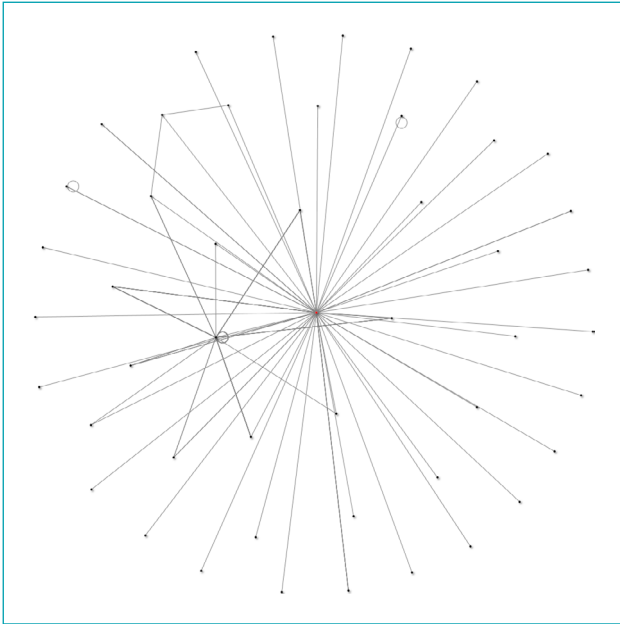
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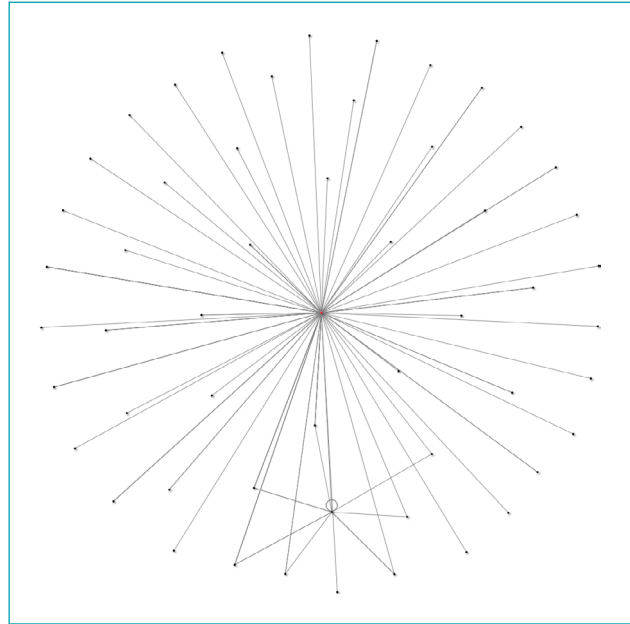
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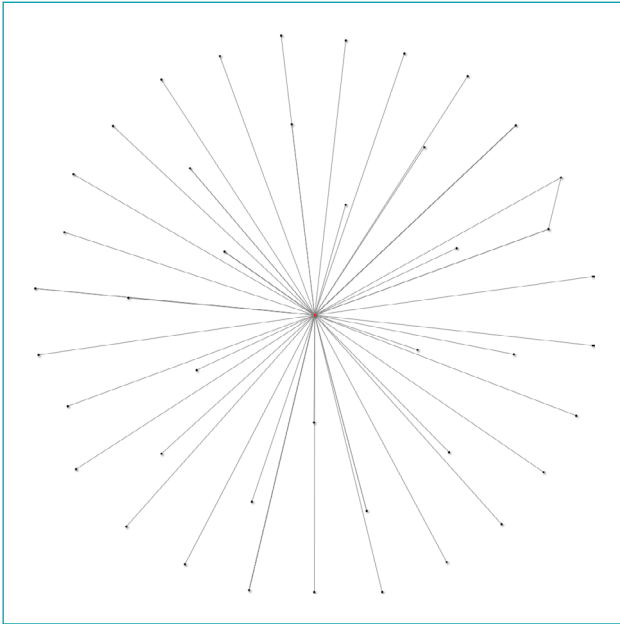
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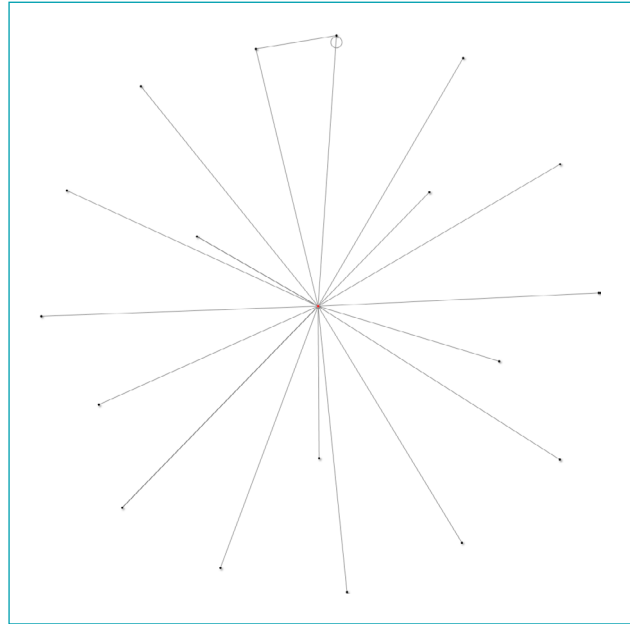
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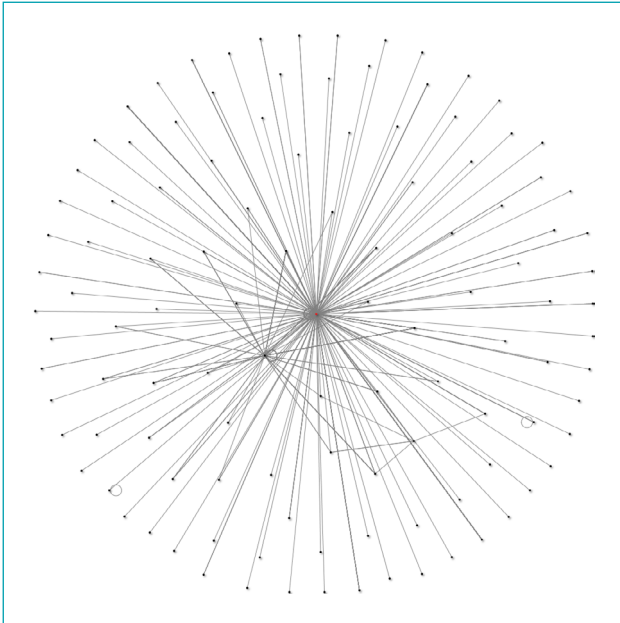
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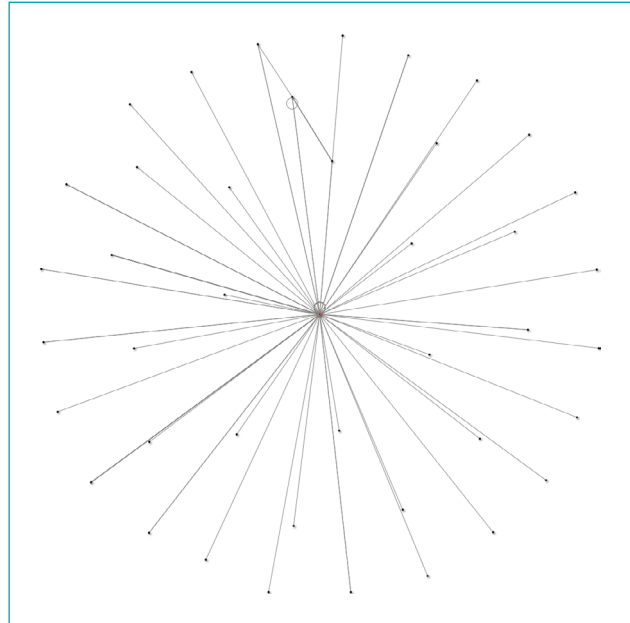
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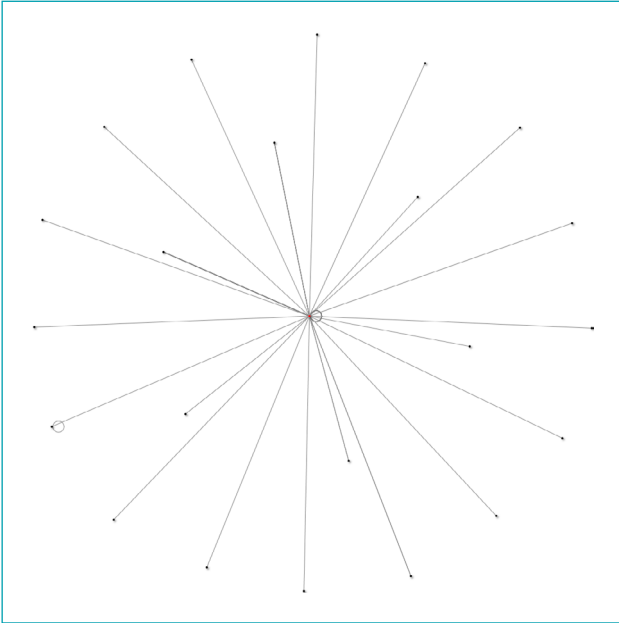
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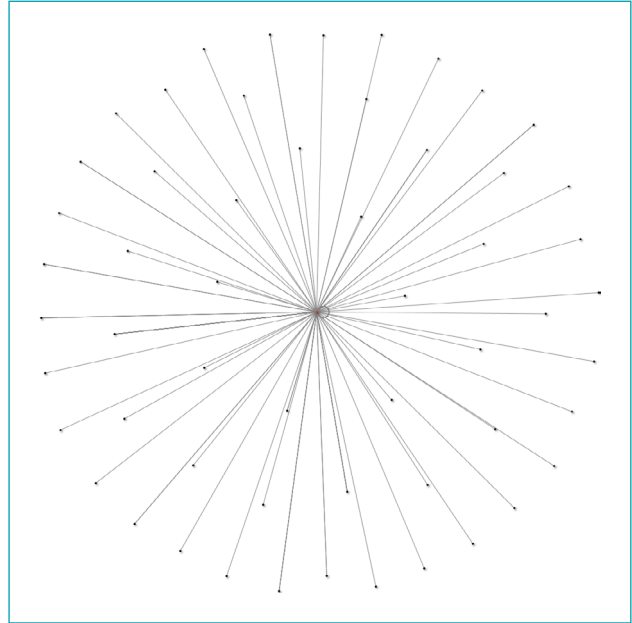
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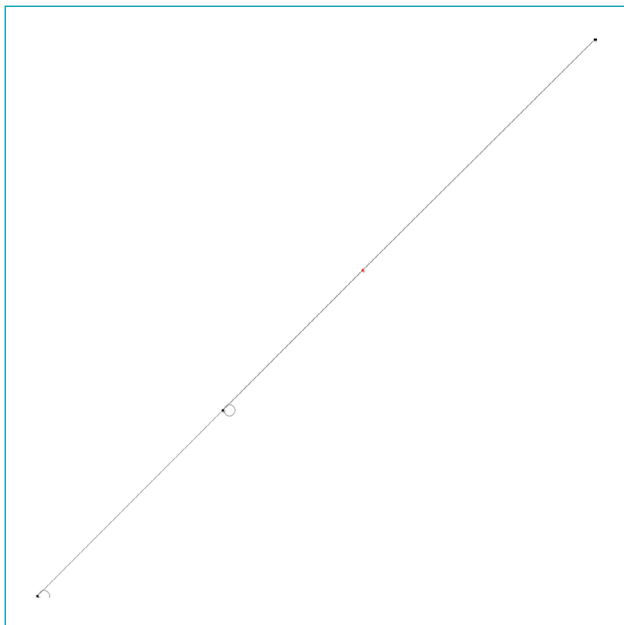


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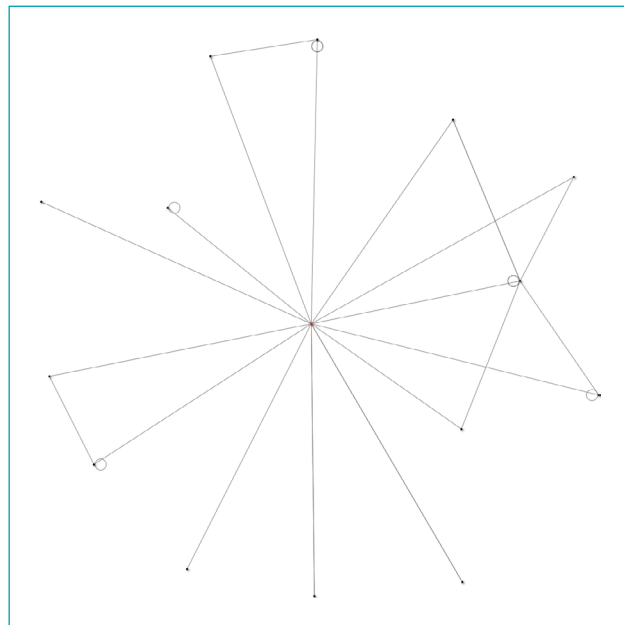


# NARODNI REFERENDUM

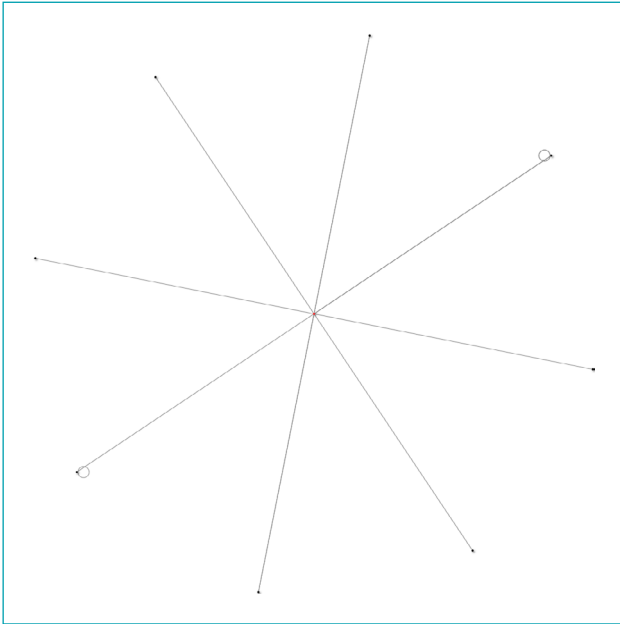
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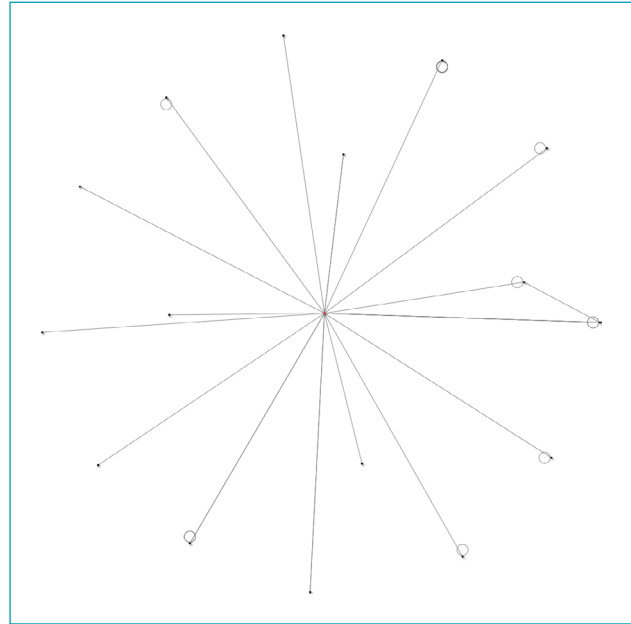
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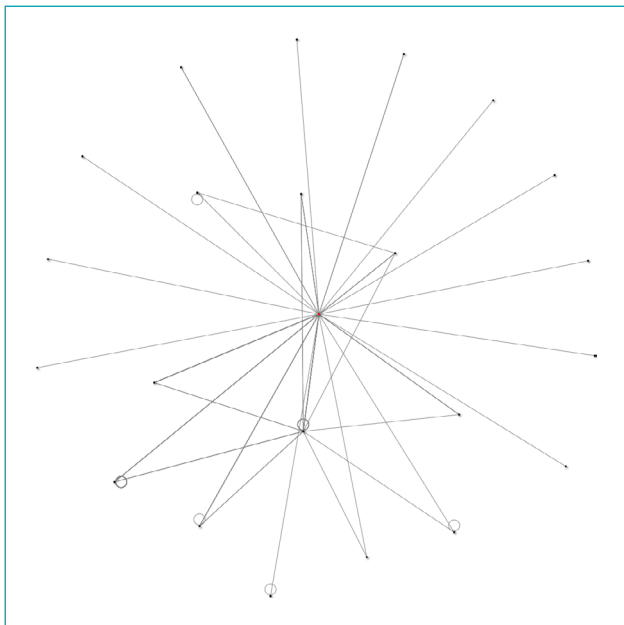


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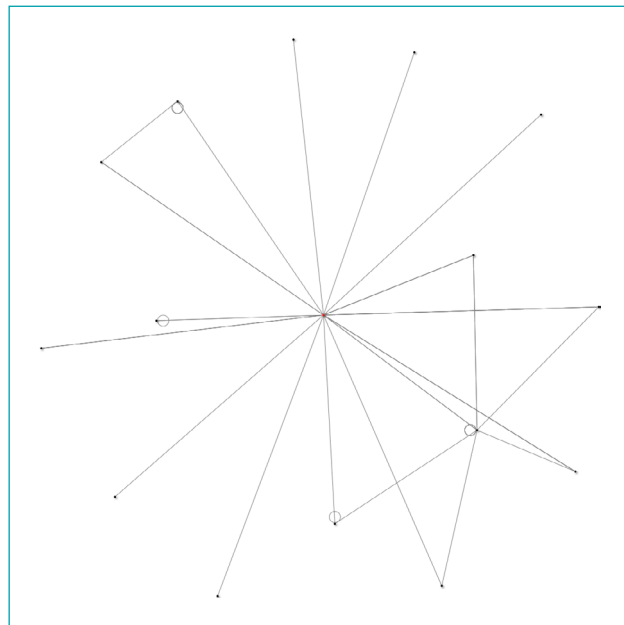


## SAZNAJMO ISTINU O KORONI

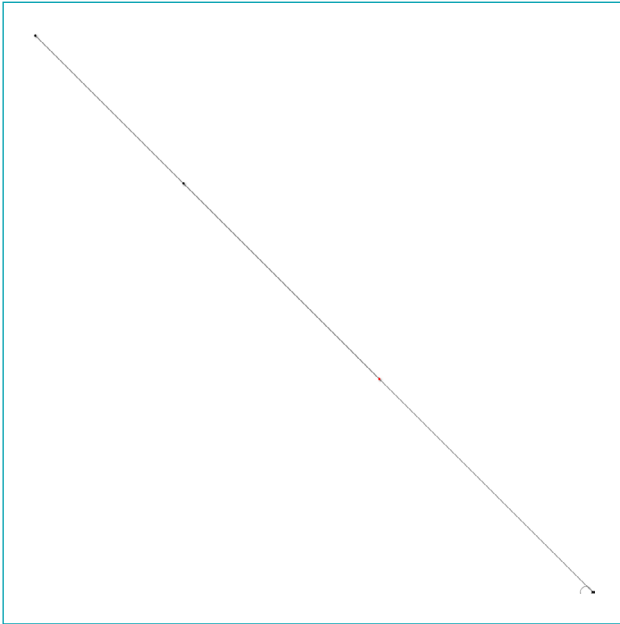
### 1<sup>ST</sup> WAVE



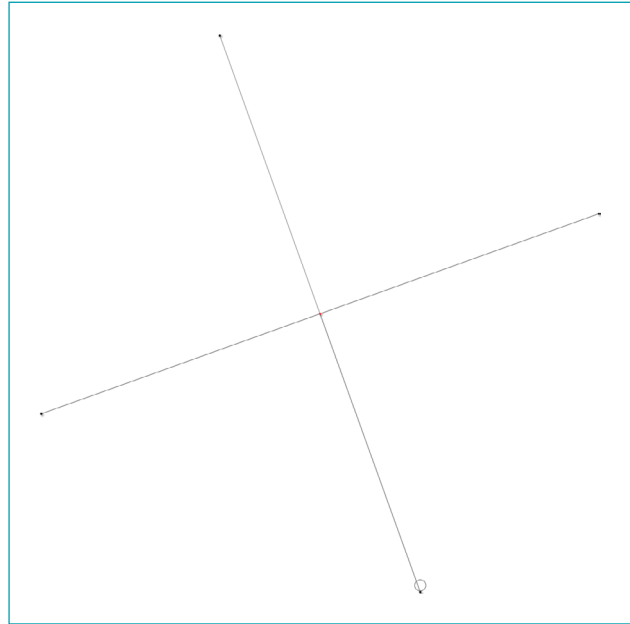
### 2<sup>ND</sup> WAVE



### 3<sup>RD</sup> WAVE

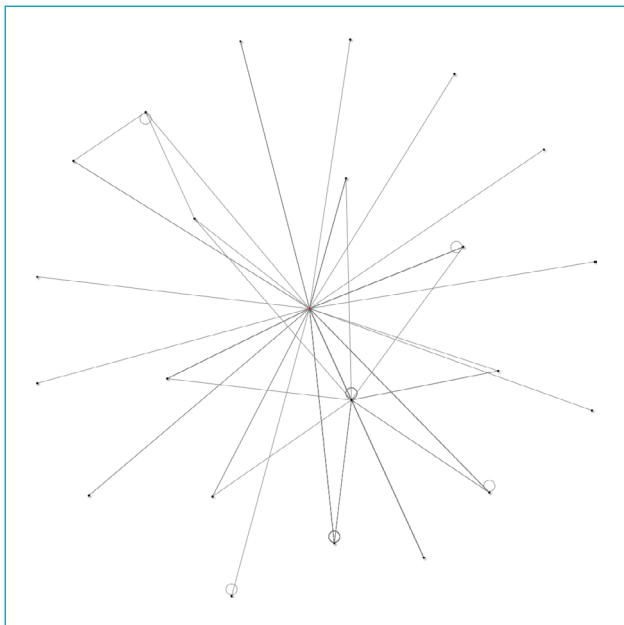


### 4<sup>TH</sup> WAVE

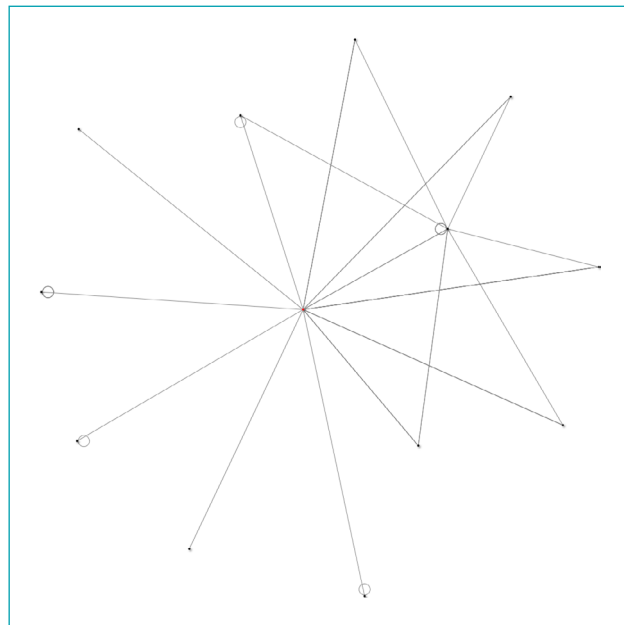


# GLAVNA GRUPA STRANKE IVANA PERNARA

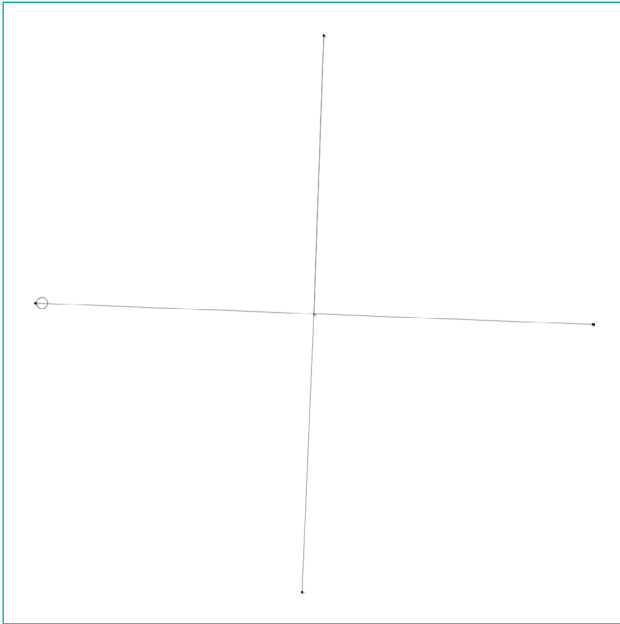
## 1<sup>ST</sup> WAVE



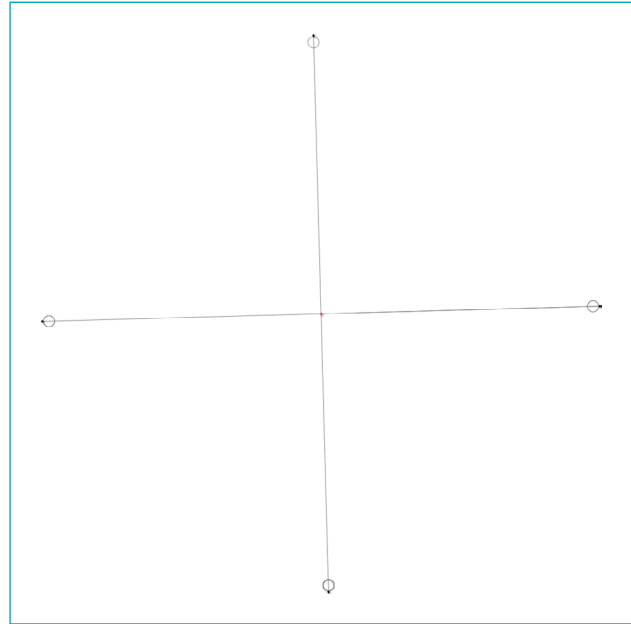
## 2<sup>ND</sup> WAVE



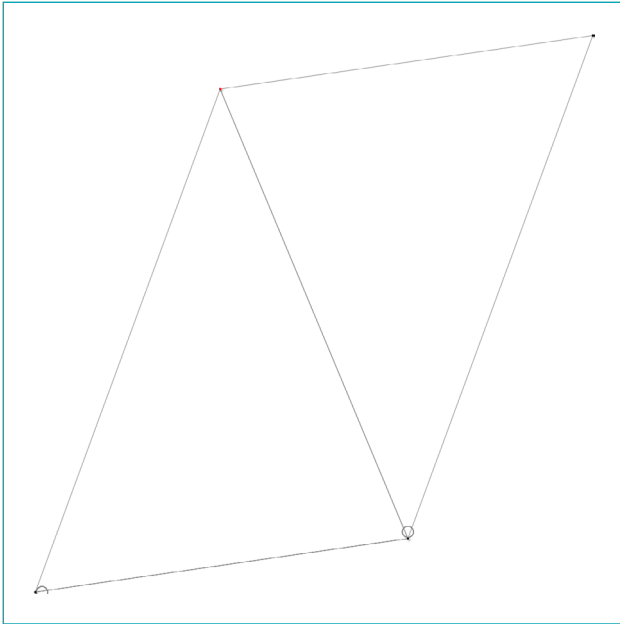
### 3<sup>RD</sup> WAVE



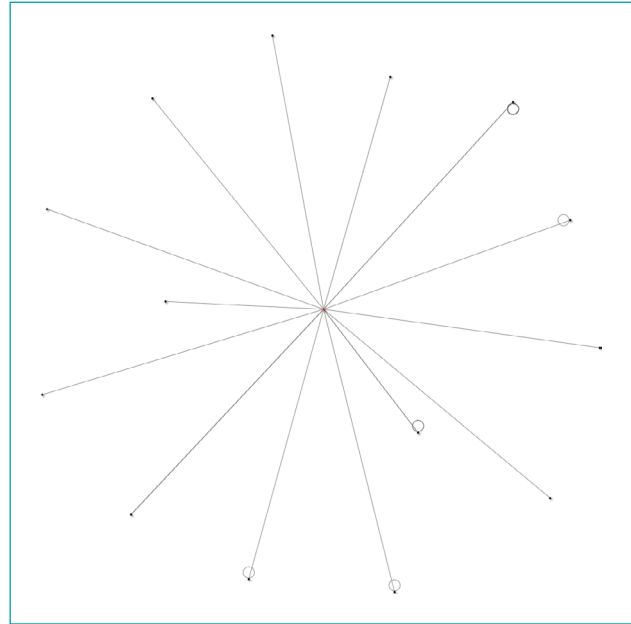
### 4<sup>TH</sup> WAVE



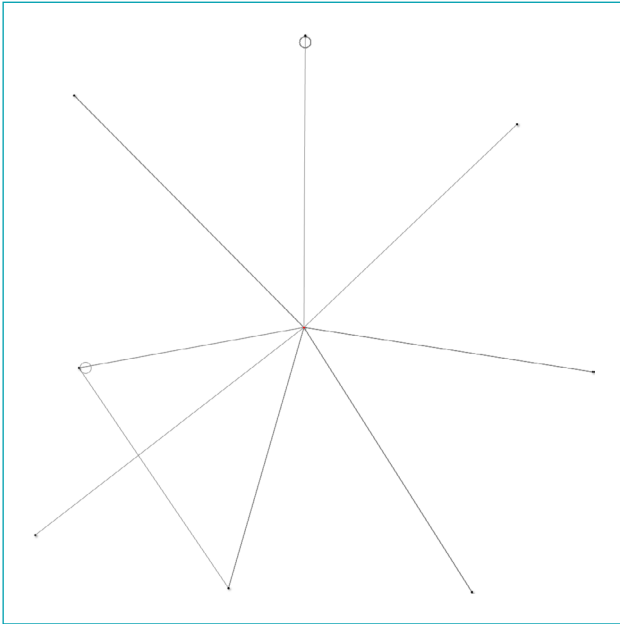
1<sup>ST</sup> WAVE



2<sup>ND</sup> WAVE



3<sup>RD</sup> WAVE



4<sup>TH</sup> WAVE

