

Automated Visualization of Sets and Networks Using Euler Diagrams and Graphs: Supplementary Material

Almas Baimagambetov¹, Gem Stapleton², John Howse¹, and Andrew Blake¹

¹ Centre for Secure, Intelligent and Usable Systems, University of Brighton, UK
`{a.baimagambetov, john.howse, a.l.blake}@brighton.ac.uk`

² University of Kent, UK
`g.stapleton@kent.ac.uk`

1 Introduction

This document is the supplementary material to the “Automated Visualization of Sets and Networks Using Euler Diagrams and Graphs” paper. It contains the GroupNet technique description, data used in the evaluation and how it was obtained, and also contains, for each data set used in the evaluation:

1. the name of the SNAP data set (from which the data were derived),
2. the diagrams drawn by each of the four techniques, and
3. a table showing all violation counts by each technique per property, and runtime information.

The implementations of each technique can be obtained from the following links:

- SetNet: <http://www.eulerdiagrams.org/setnet/> (last accessed 16-December-2019)
- Bubble Sets: <https://github.com/JosuaKrause/Bubble-Sets> (last accessed 16-December-2019)
- WebCola: <https://ialab.it.monash.edu/webcola/> (last accessed 11-December-2019)
- GroupNet: <https://github.com/AlmasB/D2020> (last accessed 14-January-2020)

2 The GroupNet Technique

A textual description of a combined set and network data set can be represented as a set of Euler diagram zones, D , a set of graph vertices, V , and a set of graph edges, E . Given D , V and E , the full algorithm of GroupNet is as follows:

1. Component-decomposition:
 - (a) Start with a full binary rooted tree, where the root is D .
 - (b) Identify descriptions, D_1 and D_2 such that $D = D_1 +_{az_1} D_2$ (a known approach³) for some az_1 in D_1 and add D_1 and D_2 to the tree as children of D . Repeat this step for D_1 and D_2 , using D_1 and D_2 instead of D , and then for all children of D_1 , D_2 and so on until all tree leaves cannot be separated further in this way. The resulting tree has leaves D'_0 , D'_1 , ..., D'_n , each of which is a set of Euler diagram zones.
 2. Decomposition:
For each D'_i in D'_0 , D'_1 , ..., D'_n , decompose D'_i using the following strategy:
 - (a) Identify abstract zones, $\{az_1, az_2\}$, such that their symmetric difference contains one element and with the highest value of m , where m is the number of edges in E such that one incident vertex is located in az_1 and the other is located in az_2 .
 - (b) Remove the label that is in the symmetric difference of az_1 and az_2 .
 3. Curve drawing:
For each D'_i in D'_0 , D'_1 , ..., D'_n , draw the curves for D'_i using the order provided by the decomposition:
 - (a) Draw the first curve as a circle.
 - (b) Draw the next curve either as a circle or as a non-circular smoothed curve using a cycle in the modified dual graph, MED , of the diagram so far. The cycle is chosen using the following strategy:
 - i. Identify topologically adjacent zones (zones that are separated by a single curve), (z_1, z_2) , in d with the most edges in E such that one vertex is placed in z_1 and the other is placed in z_2 .
 - ii. Choose a shortest valid curve-adding cycle⁴, s , in MED such that the edge with end points v_1 and v_2 is not inside s , where v_1 and v_2 are MED vertices that arise from zones z_1 and z_2 respectively.
- Repeat this step until all curves are drawn.

³ Stapleton, G., Rodgers, P., Howse, J.: A general method for drawing area-proportional Euler diagrams. *J. of Visual Languages and Computing* **22**(6), 426 – 442 (2011).

⁴ Baimagambetov, A., Howse, J., Stapleton, G., Delaney, A.: Generating effective Euler diagrams. In: *Diagrams*. pp. 39–54. Springer (2018).

4. Combining diagrams:

For each diagram visualizing D'_0 , D'_1 , ..., D'_n , draw one diagram inside a specified zone of another to reflect the nested properties of D , resulting in the Euler diagram, d .

5. Graph drawing:

(a) Place each vertex in its correct zone of d , close to zone centre.

(b) For j iterations (we used $j = 250$):

i. For each vertex, v , in V :

- A. move v away from every other vertex,
- B. move v away from the closest point on the closest zone boundary,
- C. move v towards its assigned zone's centre.

ii. For each edge, e , in E between vertices v_1 and v_2 :

- A. move v_1 and v_2 closer to each other if both are in the same zone,
- B. for each vertex v (apart from v_1 and v_2): move v away from edge e if v touches e .

iii. If any vertex is outside of its correct zone, move the vertex to its last known position when it was in the correct zone.

(c) For each pair of vertices, v_1 and v_2 : if v_1 touches v_2 , move v_1 by a small amount to a position in the same zone not occupied by any other vertex.

Call the resulting graph g .

The combined Euler diagram, d , and the graph, g , visualize the given description of a combined set and network data set, D , V and E .

3 Data for Visualization

The following describes how the SNAP data was reduced and sampled. To reduce the number of vertices and edges in the SNAP data, firstly, we removed vertices with degree 0 as they do not affect any of the properties being counted because they can be re-introduced post-process after the diagram is drawn⁵. Secondly, we made an assumption that only one non-directed binary relation is considered. In other words, if two vertices have multiple edges between them, then the edges can be reduced to just one. So, we removed all occurrences of multiple edges between any pair of vertices since, in terms of visualizations, the edges would just be drawn on top of each other. We also removed loops (an edge whose incident vertices are the same vertex). Thirdly, we randomly removed vertices using an iterative approach, whilst ensuring that if this created any degree 0 vertices, they would be removed also. The random removal stopped when the number of vertices was in the given bounds. Finally, any produced data sets that had too few vertices or edges were removed from consideration (which can happen through the creation of a degree 0 vertex or removing a vertex with many incident edges).

The operations can be summarized as the following steps:

1. Remove vertices with degree 0.
2. Remove multiple edges.
3. Remove loops.
4. Randomly remove 20% of the vertices (and their incident edges). Remove vertices with degree 0. Repeat this step until the data set is within the bounds or has too few vertices or edges.

This process left us with a set of SNAP data sets, reduced in complexity, from which we randomly selected a sample for our evaluation.

We explain how we randomly selected data sets for the two-set case, with the other cases being similar. We computed the median numbers of zones, vertices and edges. These medians were used to sub-divide the two-set data sets into eight groups: those with a low number of zones, vertices and edges (i.e. their numbers were all less than or equal to the median numbers), those with a low number of zones and vertices, but a high number of edges (i.e. more edges than the median number of edges), those with a low number of zones and edges, but a high number of vertices, and so forth. From each of these eight sub-divisions, we randomly selected one data set for visualization. This gave us eight two-set data sets. As we are visualizing two-, four-, six-, and eight-set data sets, this gave us 32 data sets for visualization.

4 Visualizing Data Using the Techniques

Each of the 32 data sets had to be visualized with each of the techniques in order for us to count violations of the accuracy and effectiveness properties. For each technique, we had to make some choices about how this was to be achieved. Focusing first on SetNet, it cannot visualize vertices that are outside of all curves. To overcome this limitation, we added a 'dummy' set, called U (for universal set) to the data: each data item was defined to be inside U . These altered data sets were supplied to SetNet (only), so a circle for U was drawn. This circle was subsequently deleted, since its presence was only necessary to achieve a layout, before we counted the properties. Bubble Sets requires an already drawn graph over which it lays out the closed curves; it does

⁵ We acknowledge that the techniques do not work in this way and these vertices could have a profound impact on the layouts.

not have an integrated graph layout algorithm. The graphs for Bubble Sets were drawn using the ForceAtlas2 layout algorithm to be consistent with the literature. For WebCola, the size of the vertices needs to be specified: we used the vertex size settings provided on the software website. It is important to note that different choices, such as a different graph layout algorithm or vertex size, could impact the properties possessed by the visualizations.

Given these choices, we attempted to draw each of the 32 data sets using the four techniques. In one case, for the data set with 8 sets, a high number of zones, a low number of vertices and a high number of edges, SetNet could not draw the selected data set. No SNAP data set could be reduced to match the given combination of the number of sets, zones, vertices and edges to replace that data set. Hence, the evaluation we present is based on the remaining 31 data sets.

5 Threats to Validity

The results we obtained are valid within the study constraints. In this section, we consider the threats to the validity of these results and discuss properties of diagrams that cannot be counted, which is why there were not part of our evaluation.

An important factor to consider is that the evaluated theoretical properties act as a proxy to diagram effectiveness. Therefore, the results can only provide a relative effectiveness of the techniques with respect to these properties. We should be mindful that these properties, when possessed by diagrams, do not necessarily ensure effectiveness. However, it is known that violating these properties leads to poor comprehension. Thus, it is important to rank visualization techniques with respect to how well they meet the effectiveness properties, which we have done in this evaluation.

Another important factor to consider is the number and the complexity of selected data sets used in the evaluation. A larger number of data sets, or the original complexity of the network (up to 68413 vertices and up to 1685163 edges) may have produced a different set of results. As explained earlier, it was not sensible to include all data sets with the original network complexity seen in SNAP data sets since the diagrams were to be produced and evaluated manually. So, we used a stratified random sampling method to reduce the number of data sets and we randomly removed vertices to manage the network complexity.

The validity of the results is also limited to the software implementations of techniques we used in the evaluation. Software implementations can use different rendering details, such as vertex sizes, and different heuristics when producing algorithms from theory. Therefore, these alterations can impact the evaluation criteria presented in this evaluation. For example, changing the graph algorithm used for Bubble Sets, or the vertex sizes in WebCola, will likely affect the accuracy and effectiveness properties that arise from graphs.

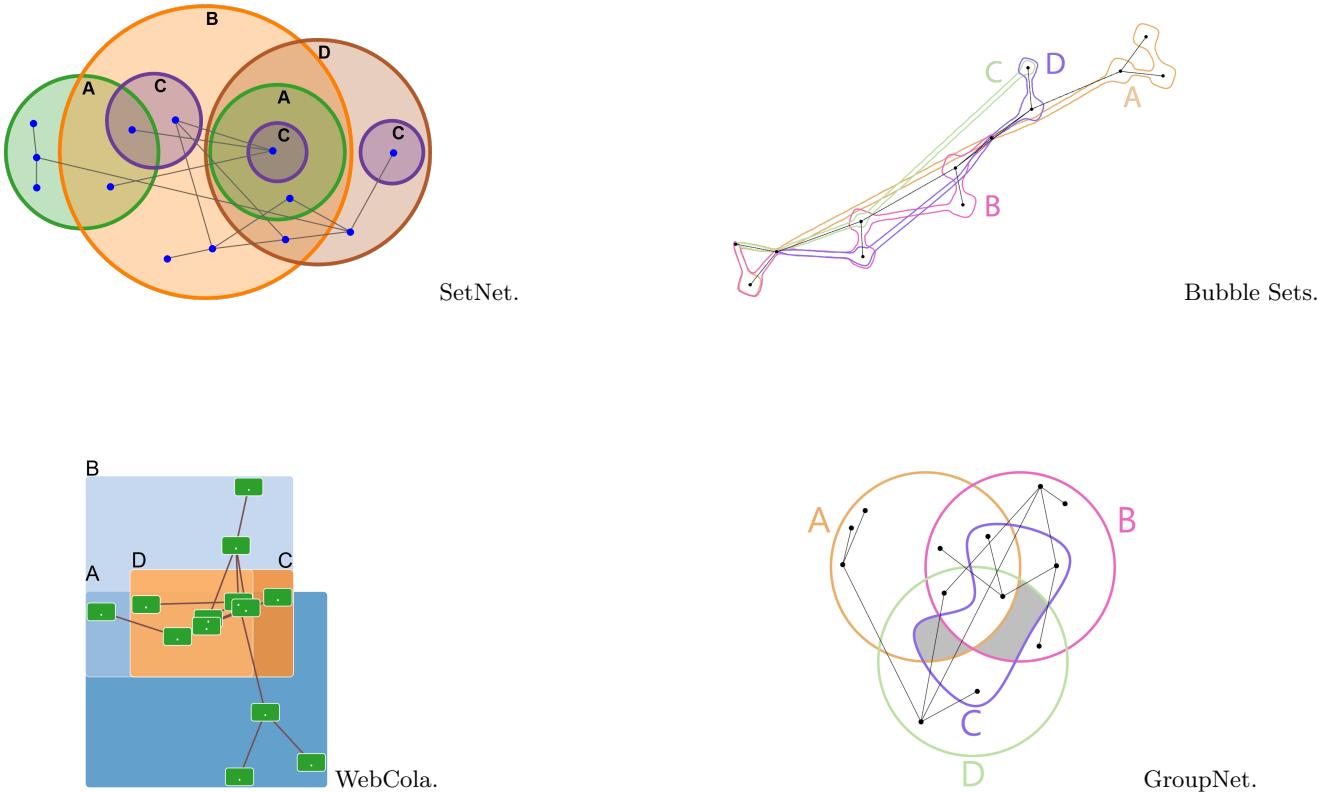


Fig. 1. Properties possessed by grouped network diagrams drawn by different techniques.

Our evaluation focused on accuracy and effectiveness properties whose violations can be counted, and runtime. It is known that other criteria can also impact effectiveness. With regard to Euler diagrams, properties such as zone areas, curve-edge closeness and curve smoothness all impact effectiveness but cannot be easily measured. Illustrative examples featuring these

properties are given in Fig. 1 to indicate potential differences in the effectiveness of the layouts produced. The same description was used to produce the diagrams by the techniques. The properties seen in these diagrams typify the techniques by which they were drawn. We can see that zones in Bubble Sets and WebCola diagrams do not have similar areas, whereas relatively, zones in GroupNet and SetNet do. Also, in GroupNet and SetNet the curves do not run closely for large sections and so with regard to curve-edge closeness, they are superior to Bubble Sets and WebCola. All four techniques use smooth curves to a varying degree: SetNet always uses circles, GroupNet uses circles whenever possible, whilst the non-circular curves are smoothed to C^2 continuity, WebCola uses rectangles with rounded corners and in Bubble Sets, smoothness does not appear to be consistent, as can be seen in Fig. 1. Overall, when it comes to these three closed-curve-based properties, it is unsurprising for the techniques that draw the curves first to be superior to the techniques that draw the graph first.

As for graphs, properties like angles, orthogonal layout and symmetry cannot be counted, yet they can also impact effectiveness of diagrams. The graphs in Bubble Sets seem to have a sufficiently large angle between edges leaving vertices. In SetNet and GroupNet, smaller angles between edges can be explained by the constraints imposed by the curves: vertices must be located in their assigned zones. Interestingly, WebCola does not appear to consider the angles property despite drawing the graph first. One can argue that Bubble Sets graphs follow a grid-based placement compared to the other three techniques. As for symmetry, Bubble Sets and WebCola graphs appear to be more symmetrical than those drawn by the other two techniques. This is likely because the graph layout is produced first by the former techniques. With these three graph properties we can see that the techniques that draw the graph first tend to come out on top.

6 Counting Property Violations

We now explain how the property violations were counted. We note that for the concurrent curves and triple points properties our counting approach differs from existing literature⁶. There the authors use the Euler diagram to construct a graph whose features are used to count these two properties. As this is done manually and given we have 124 diagrams for the evaluation, it is not practical to count occurrences of these two properties in this way. For this reason we adopted a practical approach for counting concurrent curves and triple points, as detailed below.

- *Edge-vertex intersections*: for each edge, each intersection with a non-incident vertex was counted.
- *Vertex-vertex intersections*: each pair of vertices that intersected was counted. For example, if there are three vertices (v_1, v_2, v_3) placed on top of each other, it is counted as: v_1 intersects v_2 , v_1 intersects v_3 and v_2 intersects v_3 . So the count is 3.
- *Vertices in incorrect zones*: each vertex that was either on a curve or not in its assigned zone was counted.
- *Omitted zones*: each omitted zone was counted.
- *Non-unique labels*: for each curve label, we counted the number of ‘extra’ times it was used on the basis that one curve per set is required. For example, in Fig. 2, the label *C* is used 2 times, so the count is 1. Each label that occurred more than once was made bold in the diagrams.
- *Disconnected zones*: for each disconnected zone we counted the number of extra minimal regions it comprised (i.e. one fewer than the number of minimal regions of which the zone comprised) on the basis that one minimal region per zone is required. For example, in Fig. 3, the zone *A* consists of two minimal regions (labelled *a*), thus adding 1 to the count, and the zone *B* consists of two minimal regions (labelled *b*), thus adding another 1 to the count. So the count is 2. If a zone has more than one region then each region is labelled.
- *Concurrent curves*: we counted the number of (maximal) paths that formed part of two or more curves, including self-concurrency. In Fig. 4, there is a segment of the curve *R* that runs concurrently with the curve *P*, contributing 1 to the count and there is a segment of the curve *R* that runs concurrently with the curve *Q*, also contributing 1 to the count. So the count is 2. In Fig. 5, there is a concurrent path between *P* and *Q* but not *R*, which contributes 1 to the count. There is also a concurrent path shared by all *P*, *Q* and *R*, which also contributes 1 to the count. So the count is 2.
- *Triple points*: each point passed through at least three times by the curves was counted, where at least one of the curves did not run concurrently in a small disc around the point. For example, in Fig. 6, there are two points that are passed through by the curves *A*, *B* and *D* where the curve *D* does not run concurrently in a small disc around the point. These two points are enclosed with red ellipses.
- *Non-simple curves*: for each curve, each self-intersection was counted. For example, in Fig 7, the curve *R* self-intersects twice, so the count is 2.
- *Non-circular curves*: each non-circular curve was counted. In Fig. 8, only *S* is non-circular, so the count is 1.
- *Extra zones*: each extra zone was counted. In Fig. 8, the count is 1.
- *Edge crossings*: each pair of edges that crossed was counted.
- *Extra edge-curve crossings*: we counted each ‘extra point’ on a curve passed through by an edge. Given an edge, *e*, with incident vertices v_1 and v_2 , an *extra point* is one that lies on a curve, *c*, such that either both vertices are inside *c* or both vertices are outside *c*.

⁶ Stapleton, G., Howse, J., & Rodgers, P. (2010). A graph theoretic approach to general Euler diagram drawing. *Theoretical Computer Science*, 411(1), 91-112.

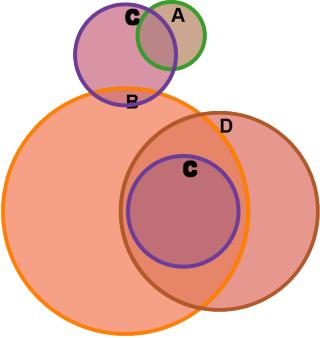


Fig. 2. SetNet: a non-unique label.

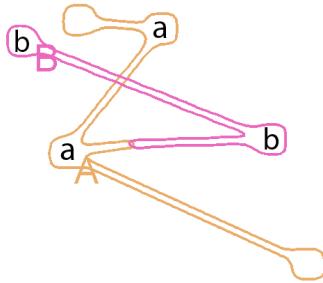


Fig. 3. Bubble Sets: disconnected zones.

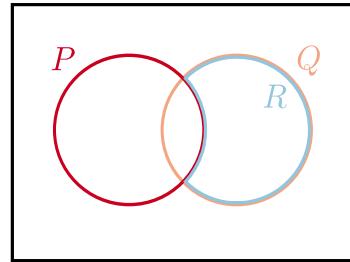


Fig. 4. Concurrency.

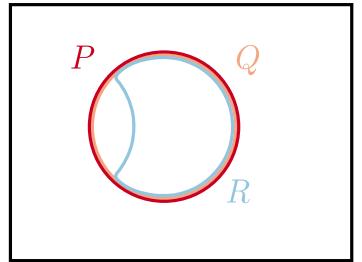


Fig. 5. Concurrency.

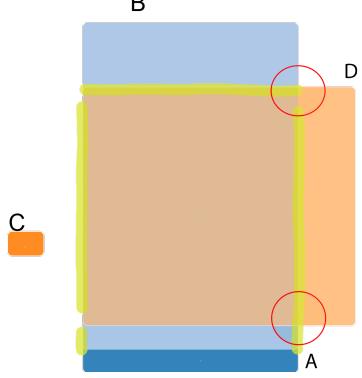


Fig. 6. WebCola: triple points.

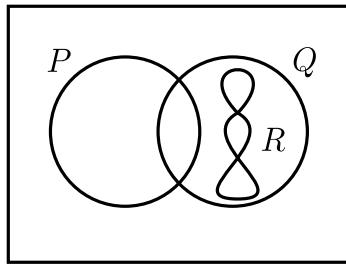


Fig. 7. A non-simple curve R.

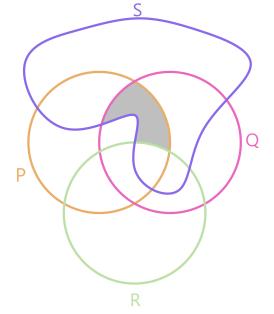


Fig. 8. GroupNet: an extra zone.

In the next section we provide, for each data set, two diagrams for SetNet, Bubble Sets and WebCola: one with the graph omitted and the other with the graph included. The markings for the Euler diagram properties are shown on the diagram without the graph for clarity. There was no need to omit the graph for GroupNet diagrams to count Euler diagram property violations, since GroupNet can only violate non-circular curves and extra zones and these are counted by the software. The graph property violations were automatically counted by each technique’s software.

7 Produced Diagrams and Results

In what follows, the format is for each data set (as explained in the paper there are 31 data sets):

1. Data set information, including *original* SNAP ID and the *derived* numbers of sets, zones, nodes and edges. To clarify, the original SNAP data set IDs are given, but the numbers of sets, zones, nodes and edges are shown for the derived (reduced) data set.
2. The marked diagram drawn by SetNet, with the graph omitted.
3. The unmarked diagram drawn by SetNet, with the graph.
4. The marked diagram drawn by Bubble Sets, with the graph omitted.
5. The unmarked diagram drawn by Bubble Sets, with the graph.
6. The marked diagram drawn by WebCola, with the graph omitted.
7. The unmarked diagram drawn by WebCola, with the graph.
8. The diagram drawn by GroupNet. As indicated above, there was no need to omit the graph for GroupNet diagrams.

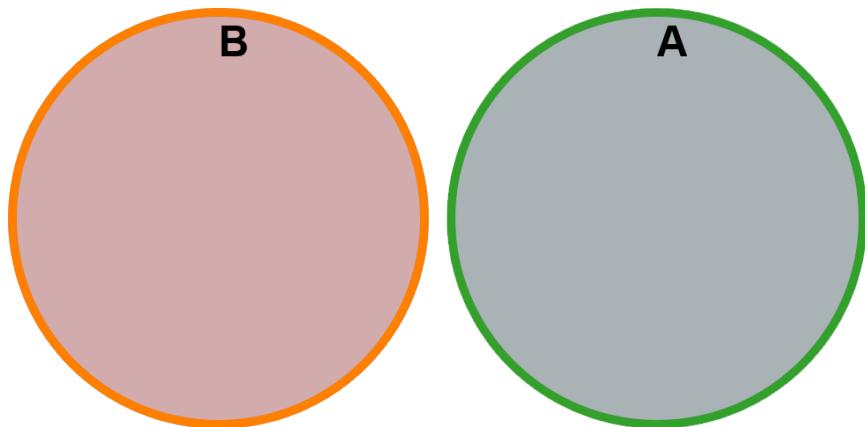
There was no occurrence of non-simple curves in any of the produced diagrams. Therefore, to avoid clutter, the entry for non-simple curves is omitted from the following tables.

2-set data set 1 : SNAP ID: 64619842

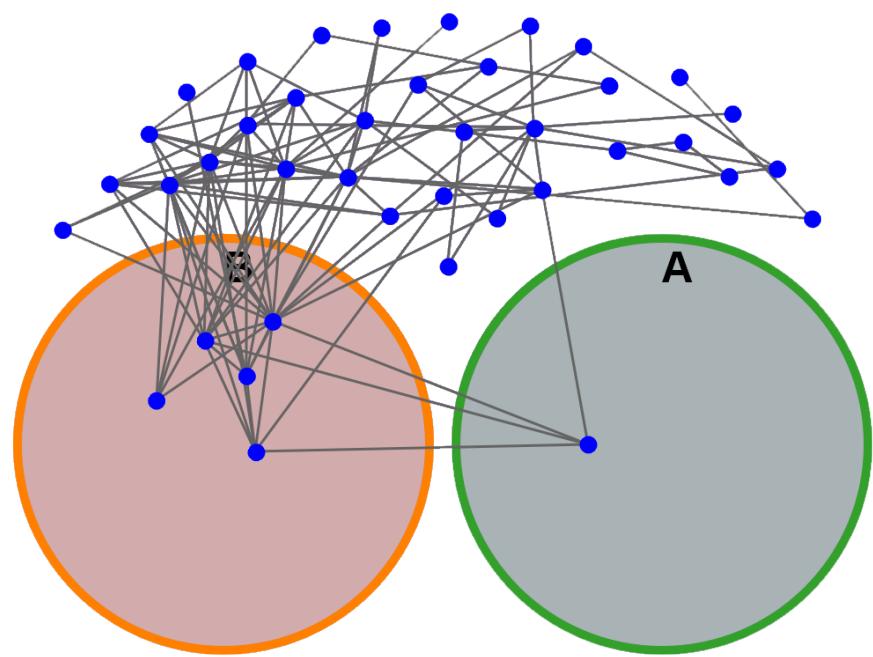
Number of Sets: 2
Number of Zones: 3
Number of Nodes: 40
Number of Edges: 110
Zones high: no
Nodes high: no
Edges high: no

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	28	4	126	4
Vertex-vertex intersections	0	0	0	0
Vertices in incorrect zones	0	0	0	0
Omitted zones	0	0	0	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	0	0	0
Concurrent curves	0	0	0	0
Triple points	0	0	0	0
Non-circles	0	2	2	0
Extra zones	0	0	0	0
Edge crossings	519	236	591	712
Extra edge-curve crossings	0	52	56	0
Runtime (in sec)	1.769	0.685	6.615	4.289

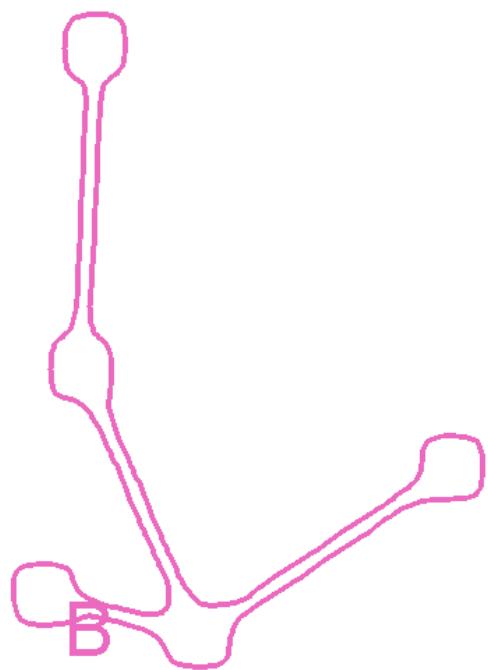
SetNet (without graph)



SetNet (with graph)

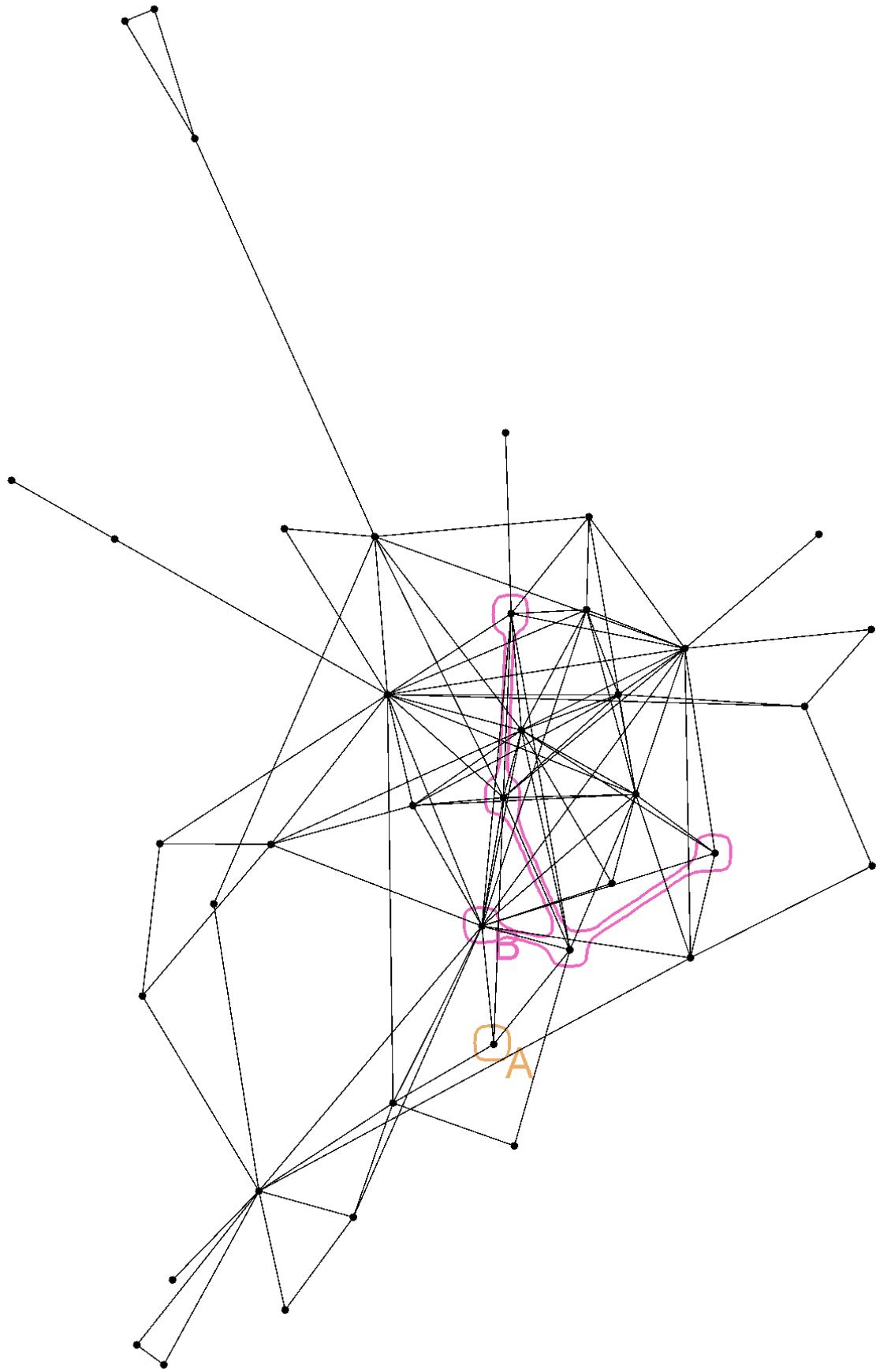


BubbleSets (without graph)

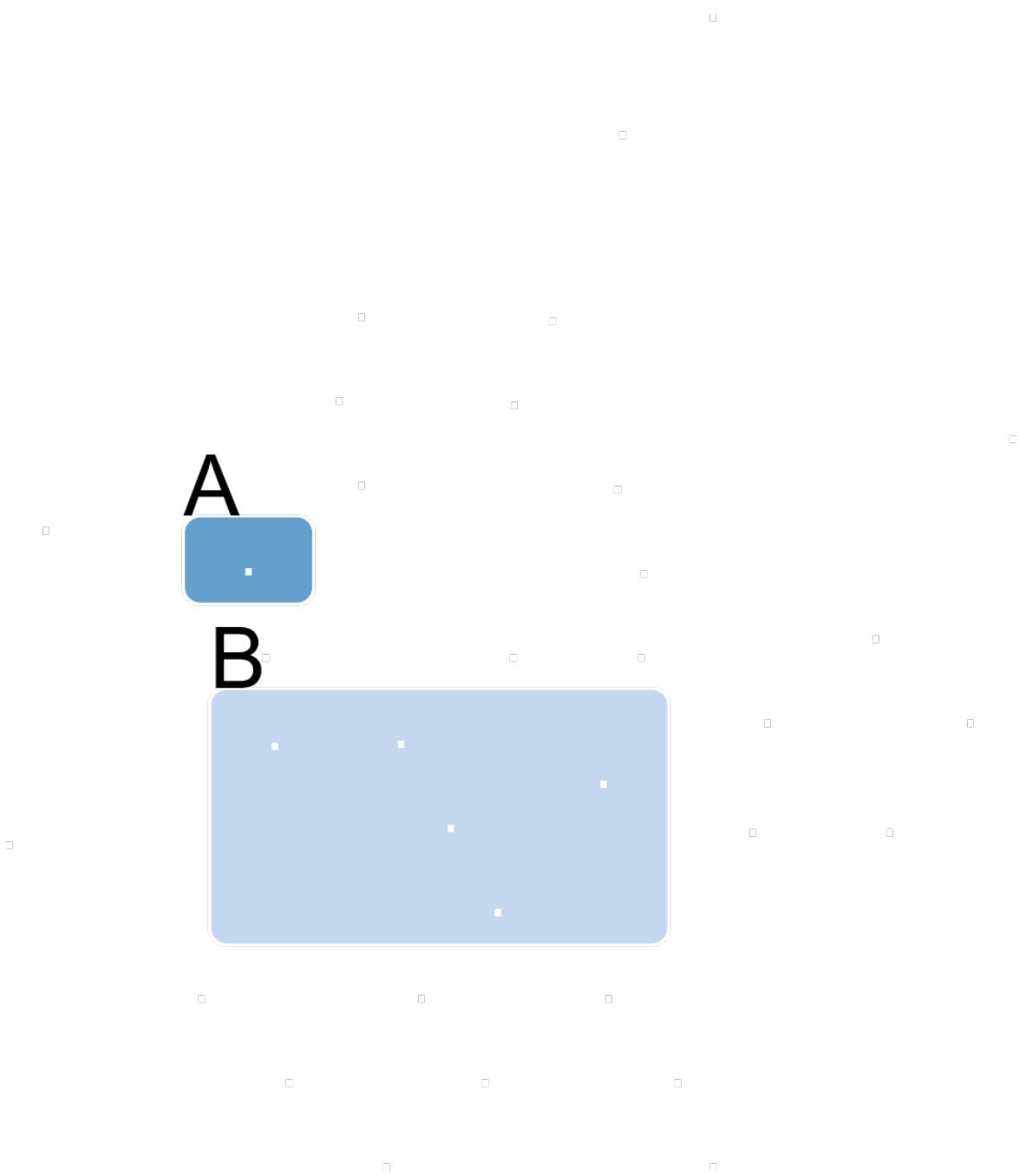


O_A

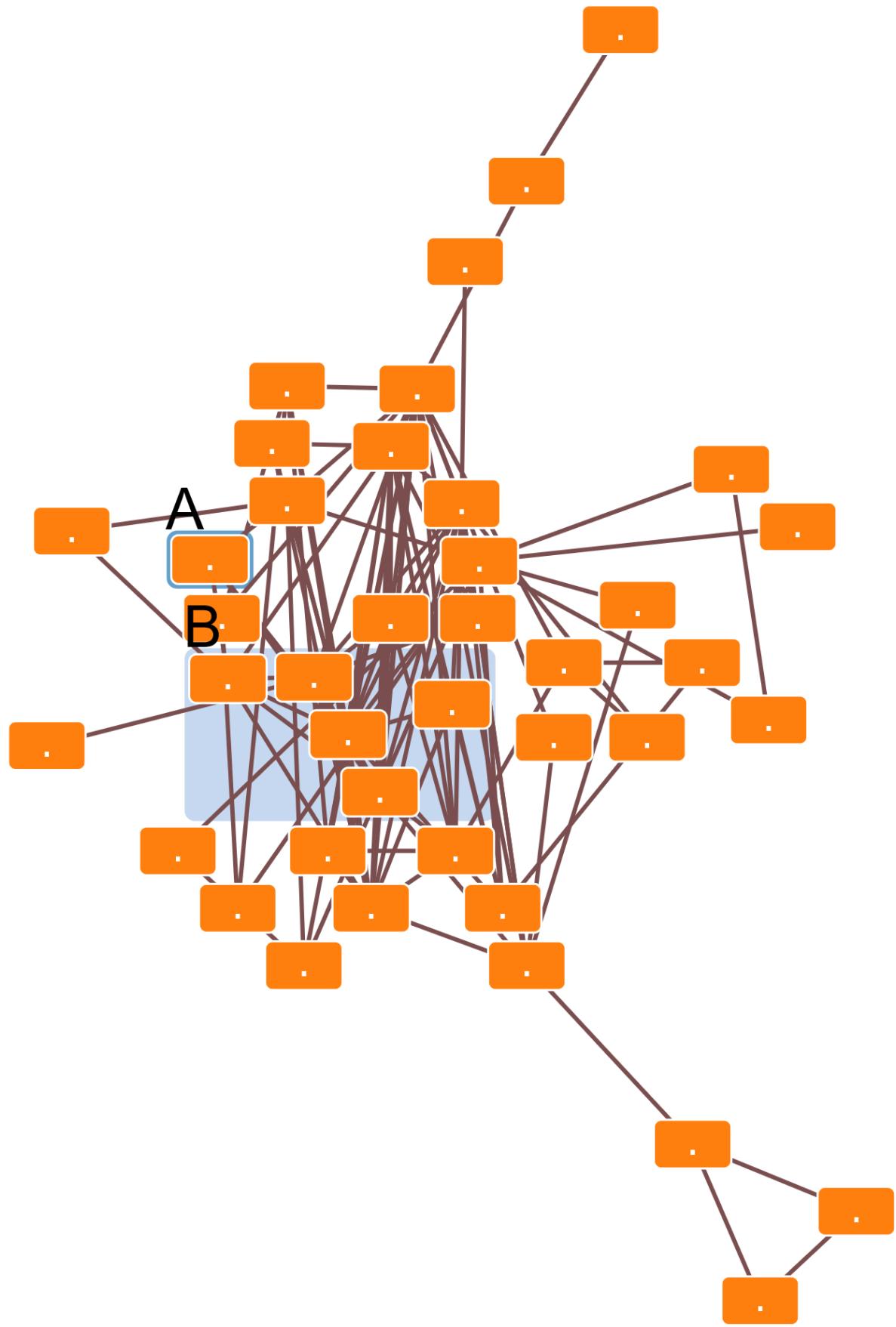
BubbleSets (with graph)



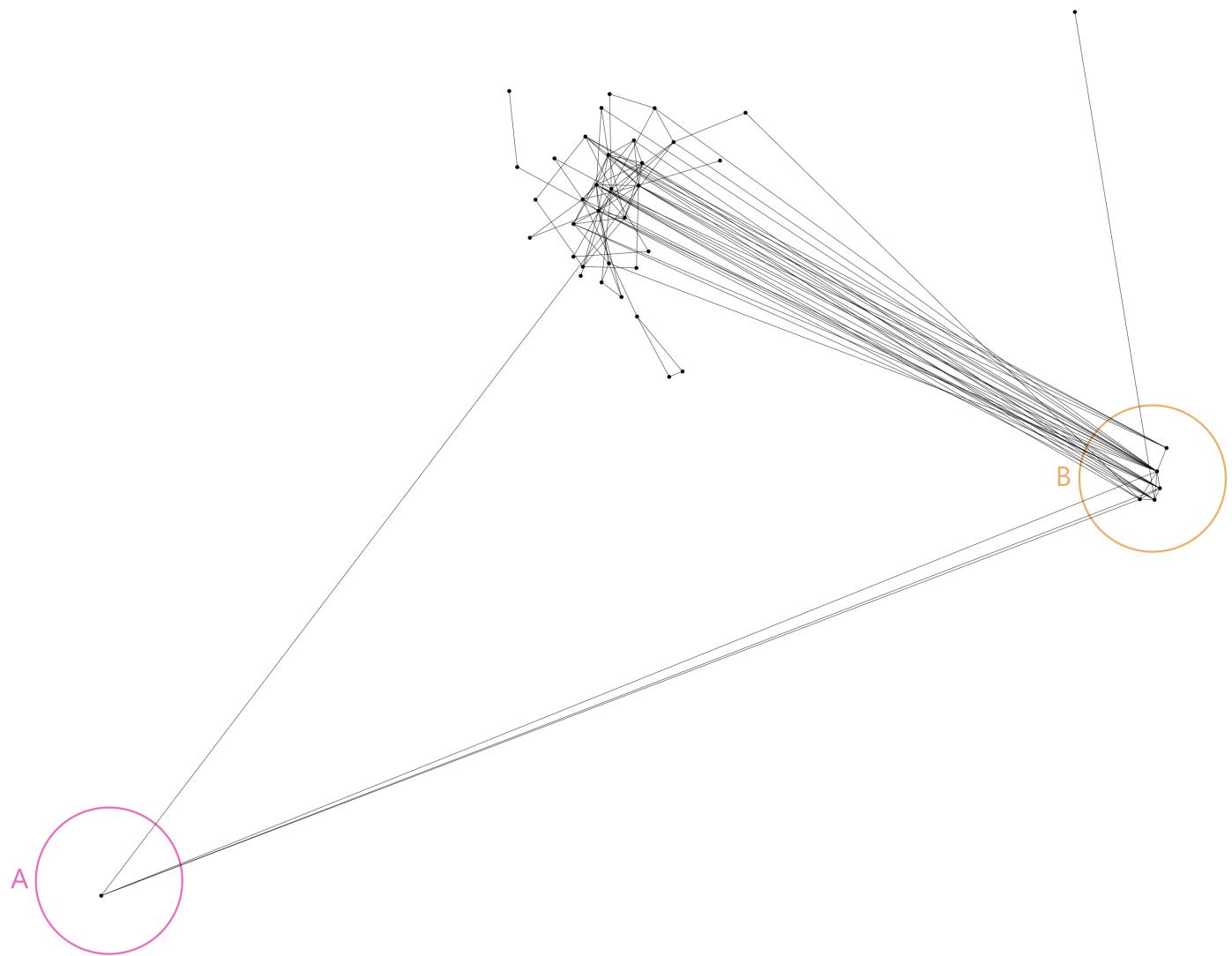
WebCola (without graph)



WebCola (with graph)



GroupNet

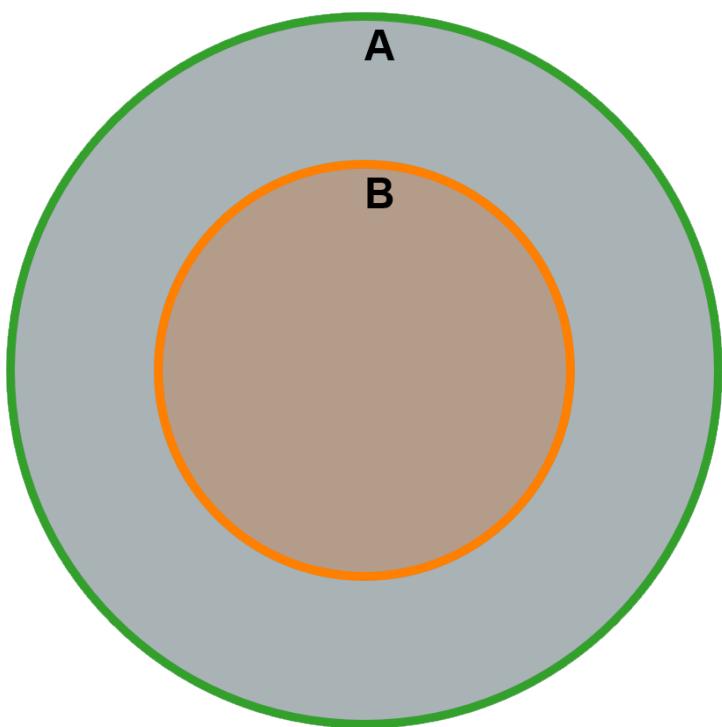


2-set data set 2 : SNAP ID: 143661263

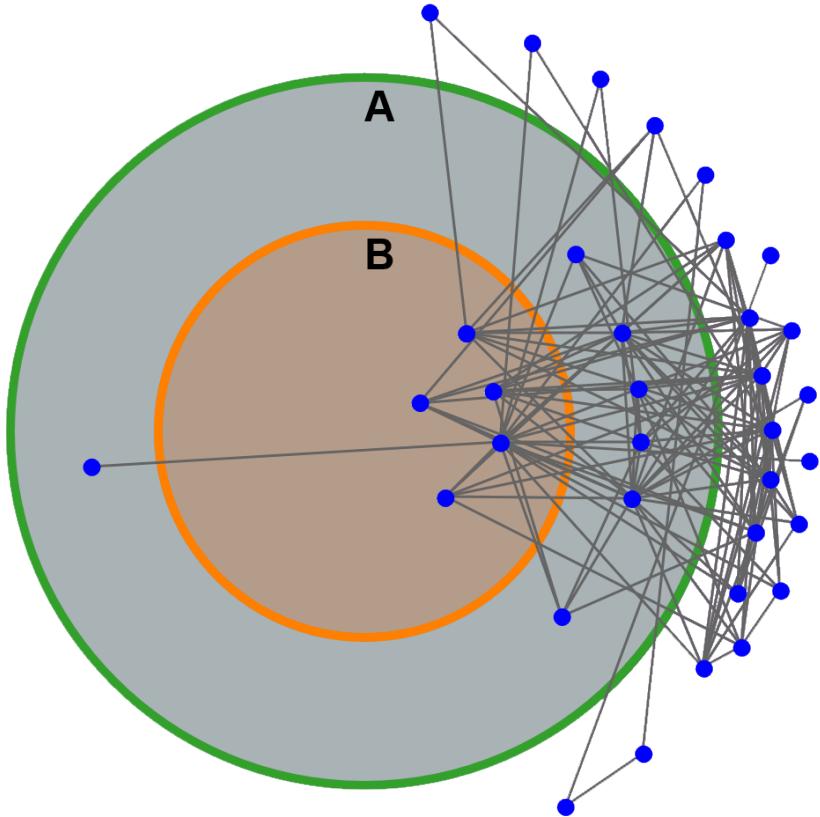
Number of Sets: 2
 Number of Zones: 3
 Number of Nodes: 34
 Number of Edges: 133
 Zones high: no
 Nodes high: no
 Edges high: yes

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	39	11	184	12
Vertex-vertex intersections	0	0	0	0
Vertices in incorrect zones	0	0	2	0
Omitted zones	0	0	0	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	4	0	0
Concurrent curves	0	0	1	0
Triple points	0	0	0	0
Non-circles	0	2	2	0
Extra zones	0	6	0	0
Edge crossings	1430	680	1309	1464
Extra edge-curve crossings	4	268	35	60
Runtime (in sec)	1.875	0.754	6.586	19.041

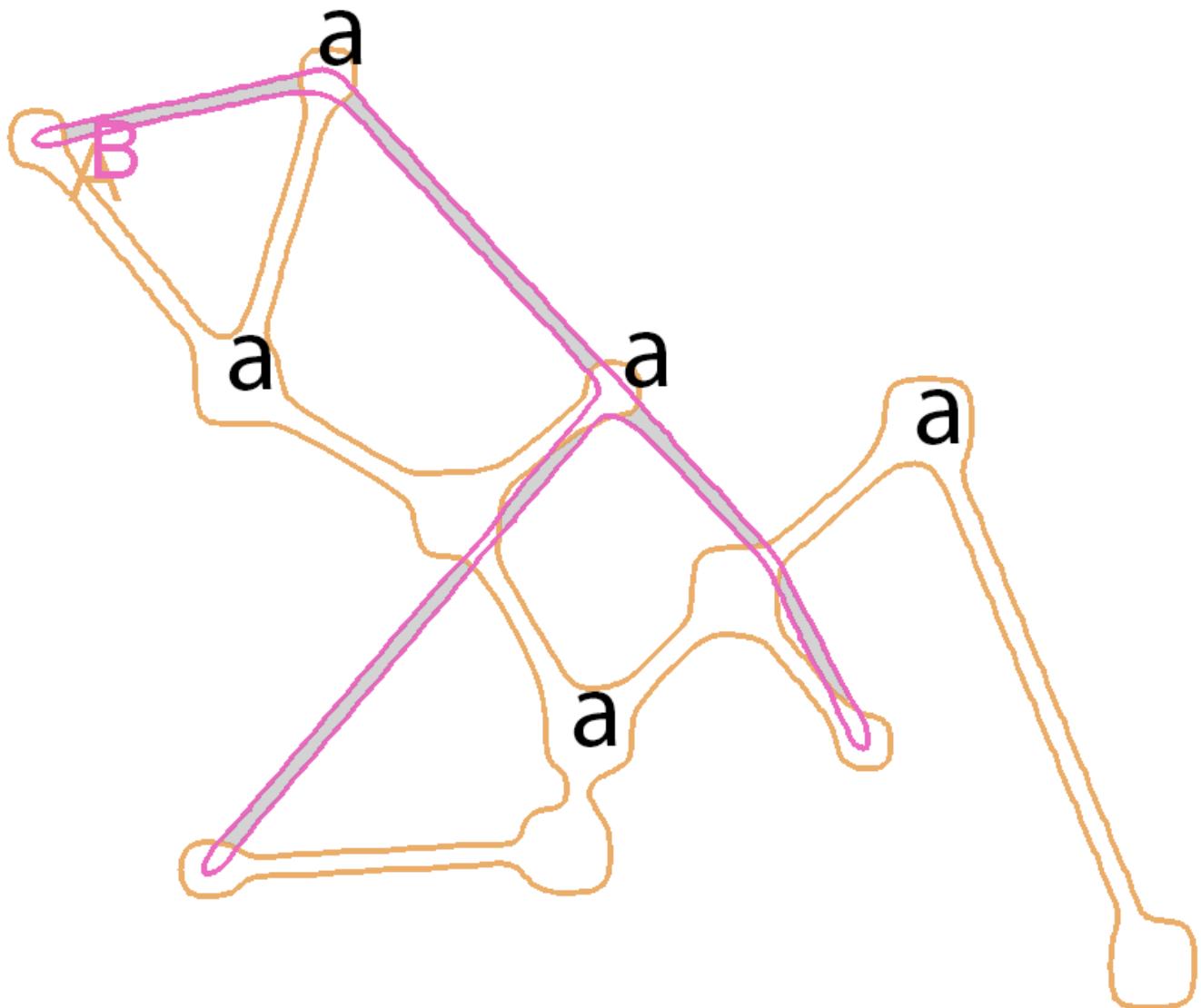
SetNet (without graph)



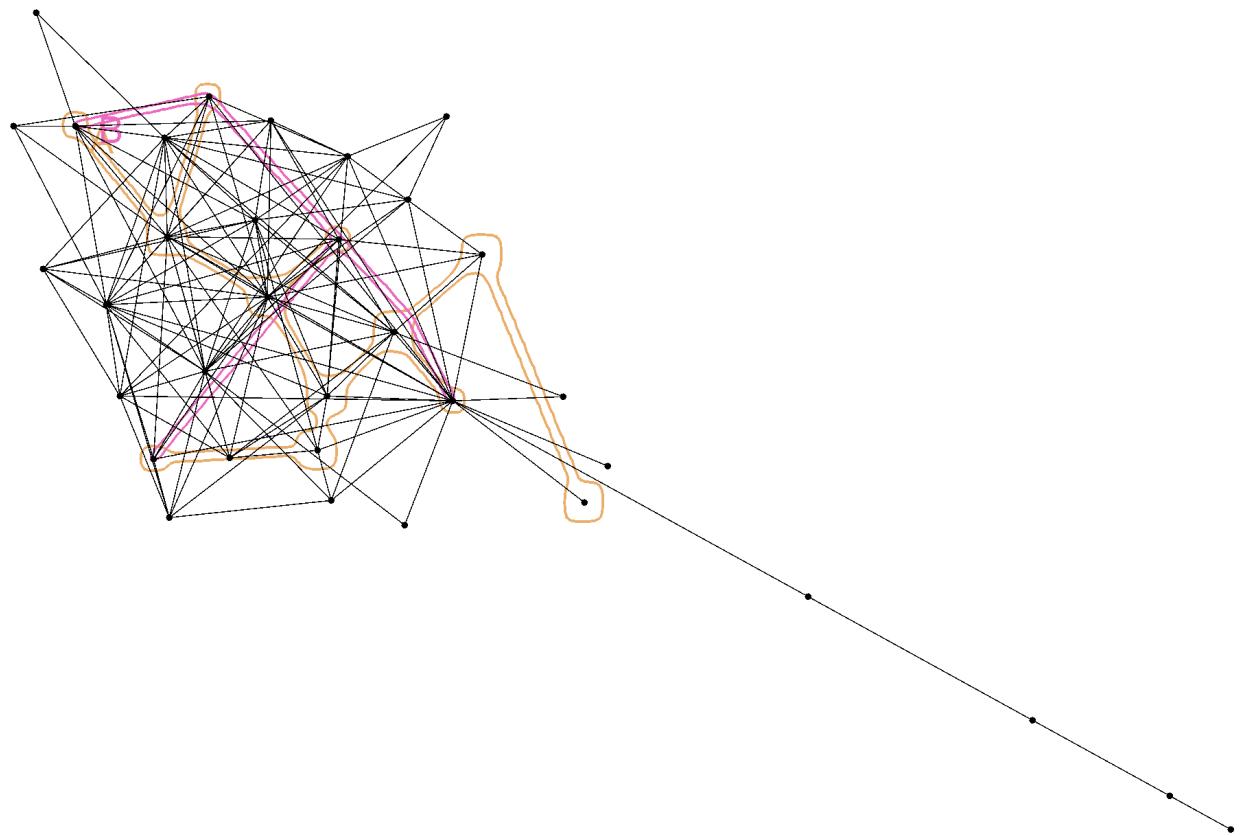
SetNet (with graph)



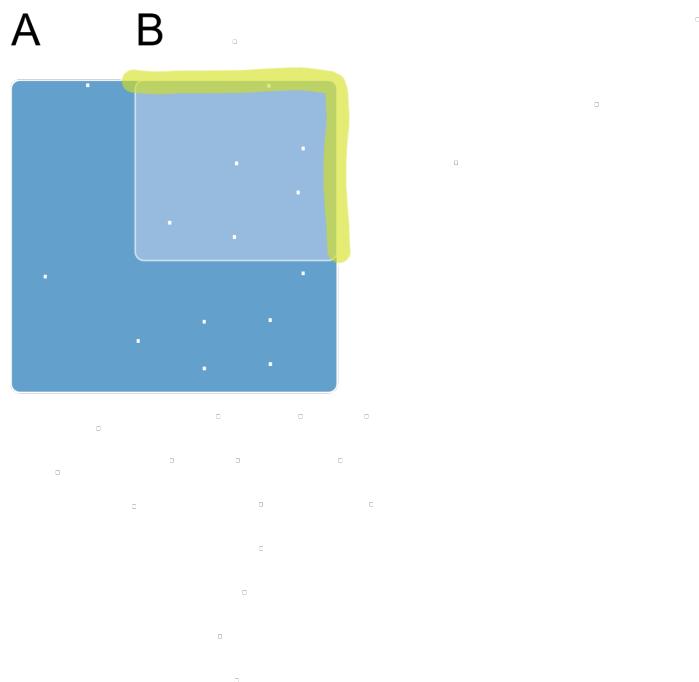
BubbleSets (without graph)



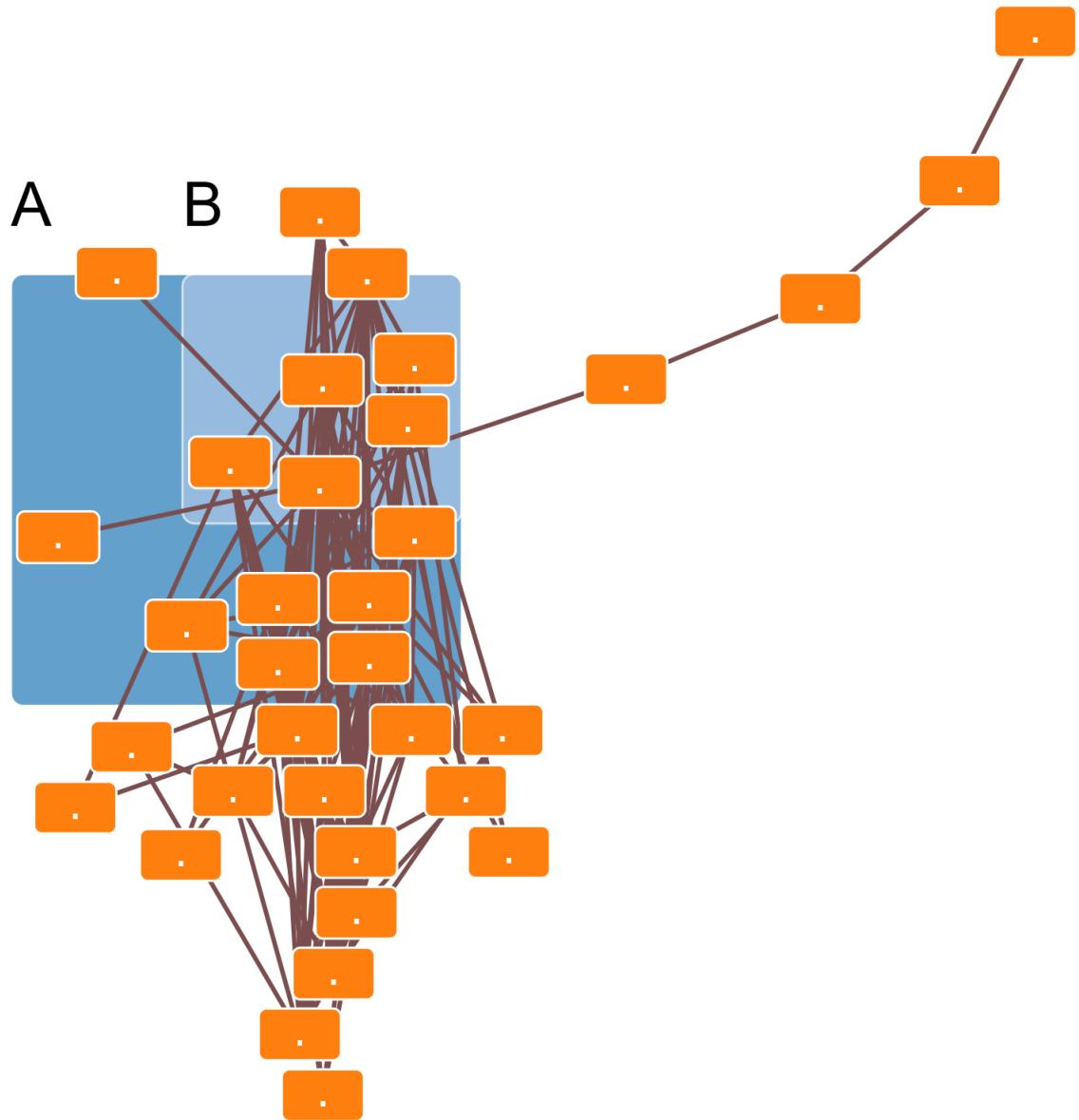
BubbleSets (with graph)



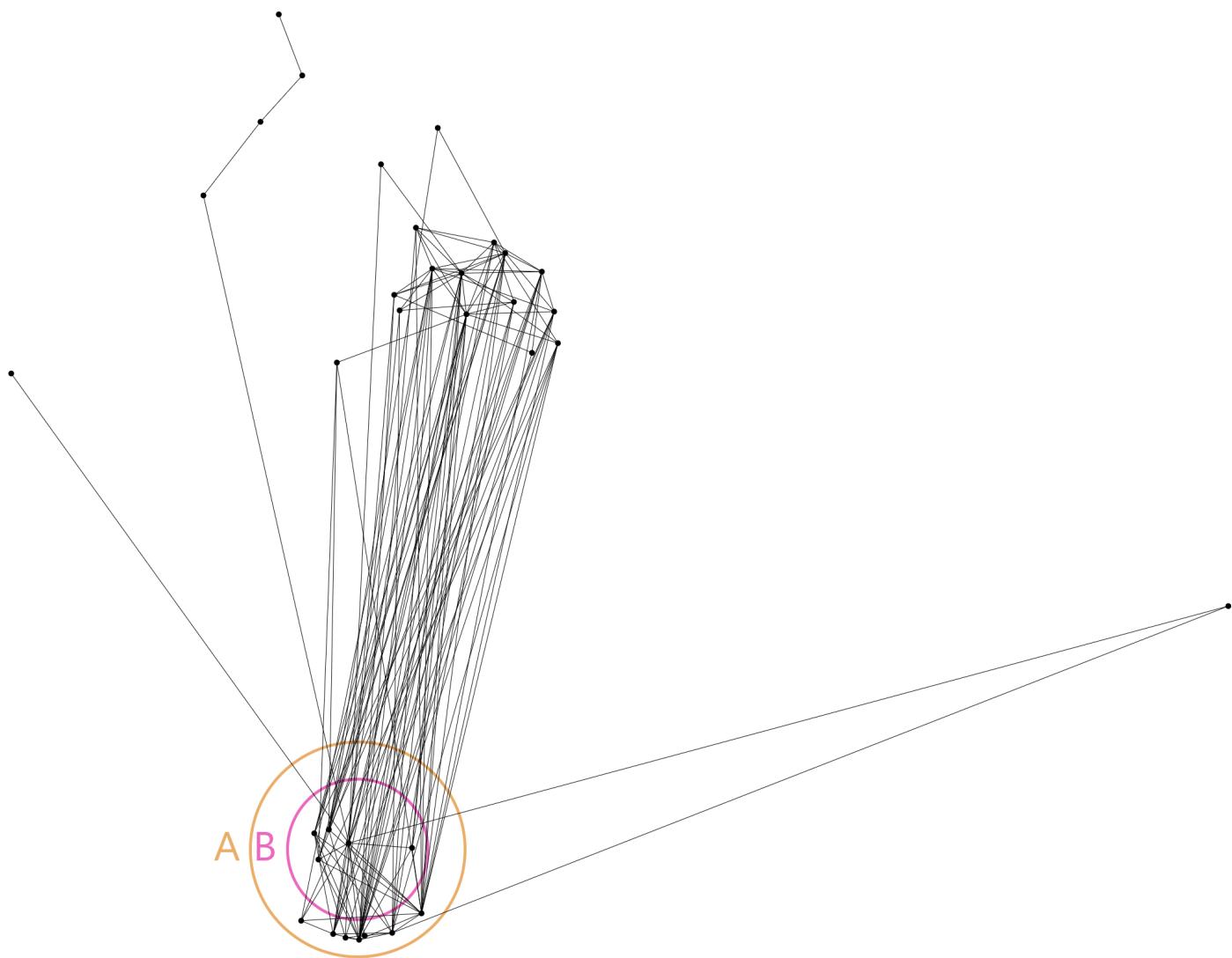
WebCola (without graph)



WebCola (with graph)



GroupNet

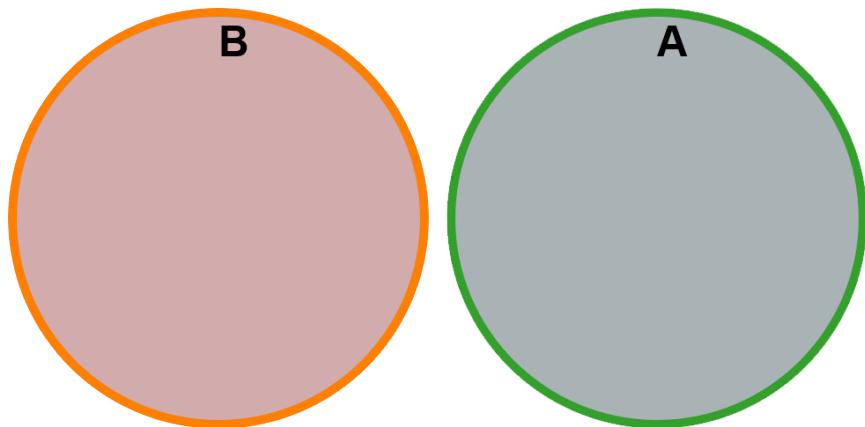


2-set data set 3 : SNAP ID: 15938936

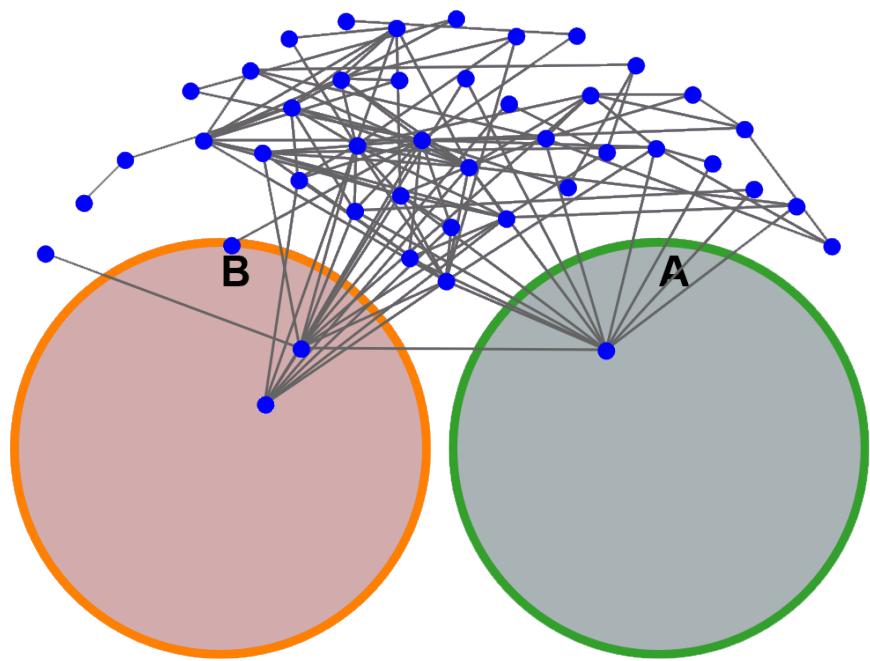
Number of Sets: 2
 Number of Zones: 3
 Number of Nodes: 44
 Number of Edges: 120
 Zones high: no
 Nodes high: yes
 Edges high: no

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	48	5	111	4
Vertex-vertex intersections	0	0	0	0
Vertices in incorrect zones	1	0	0	0
Omitted zones	0	0	0	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	0	0	0
Concurrent curves	0	0	1	0
Triple points	0	0	0	0
Non-circles	0	2	2	0
Extra zones	0	0	0	0
Edge crossings	638	320	687	560
Extra edge-curve crossings	1	16	36	18
Runtime (in sec)	2.069	0.503	6.609	4.228

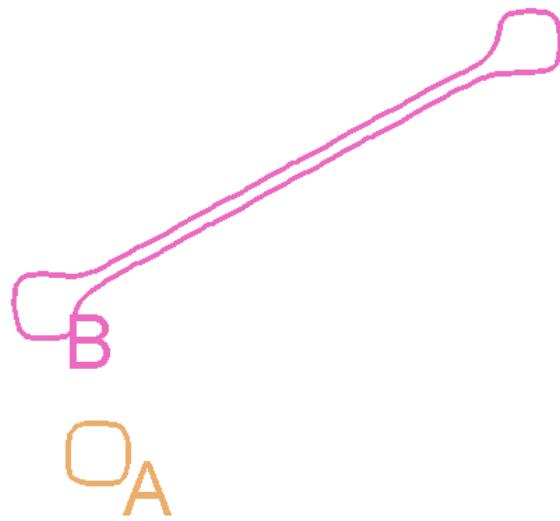
SetNet (without graph)



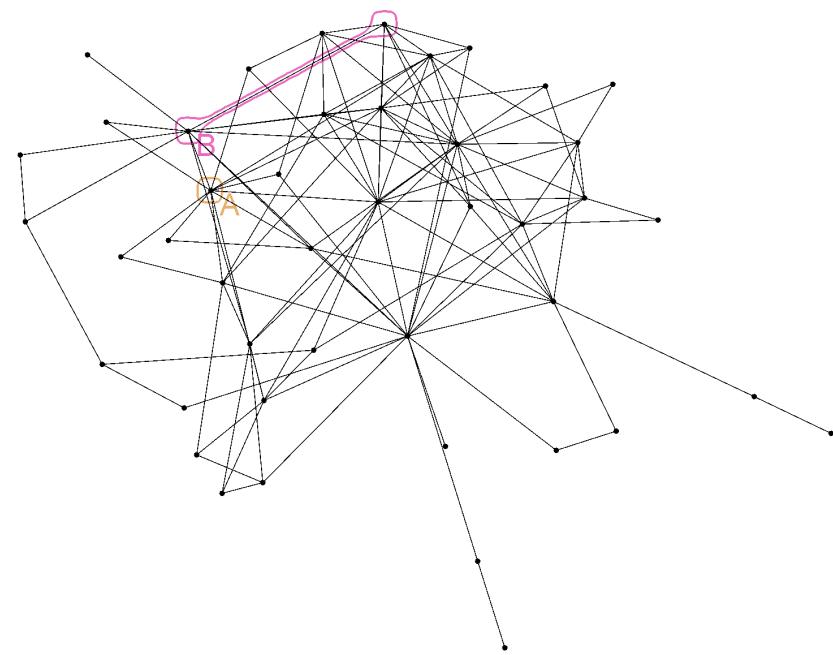
SetNet (with graph)



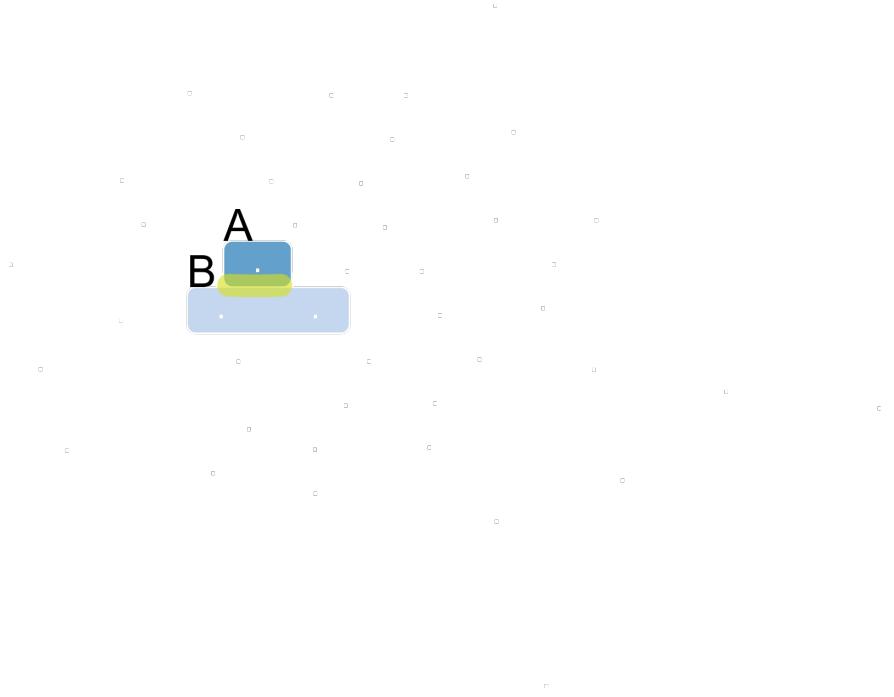
BubbleSets (without graph)



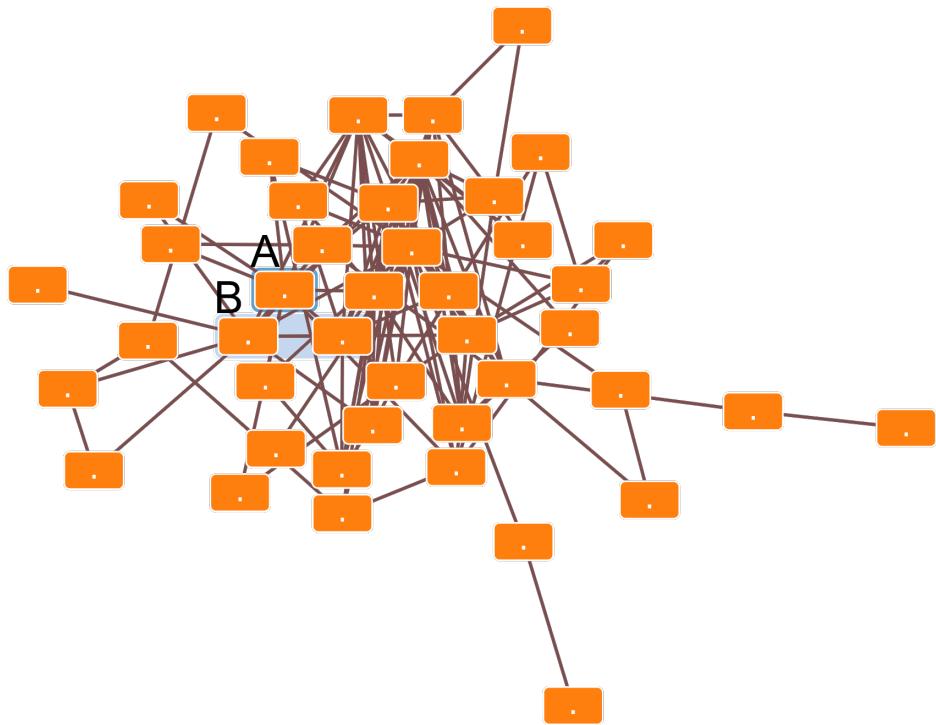
BubbleSets (with graph)



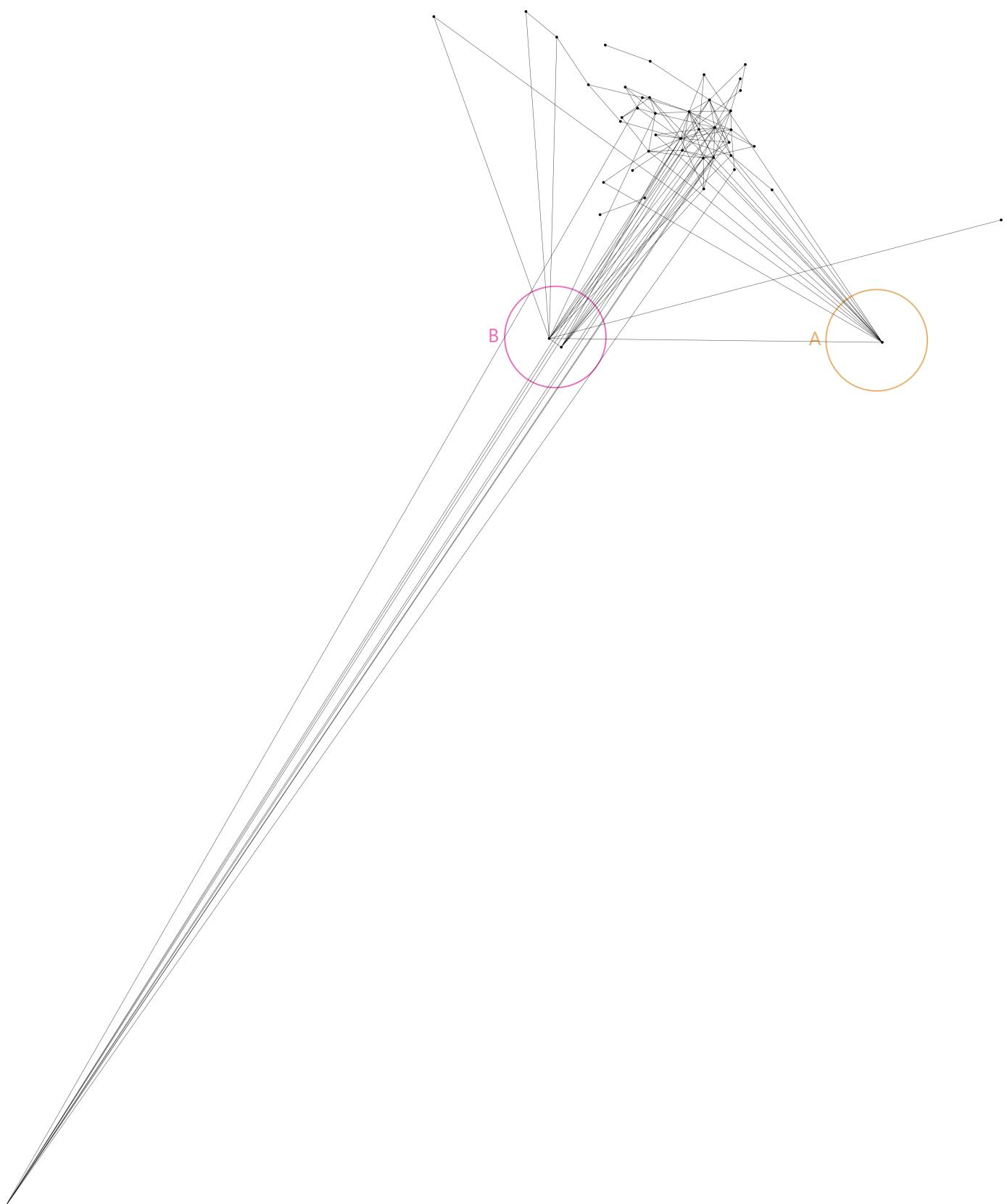
WebCola (without graph)



WebCola (with graph)



GroupNet

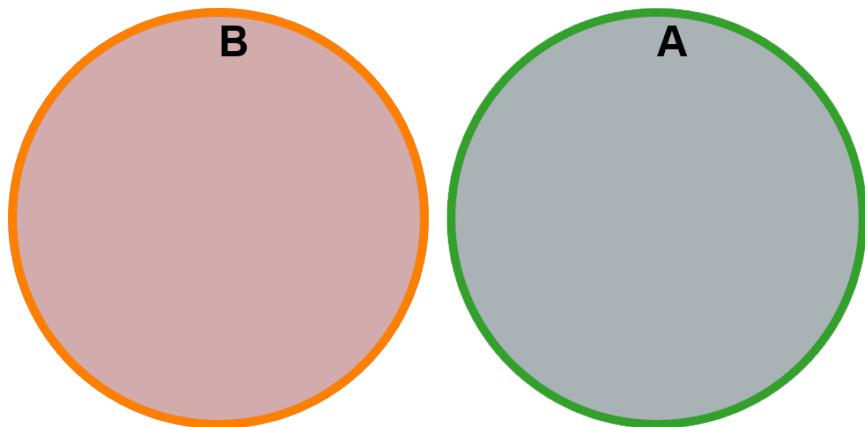


2-set data set 4 : SNAP ID: 15507297

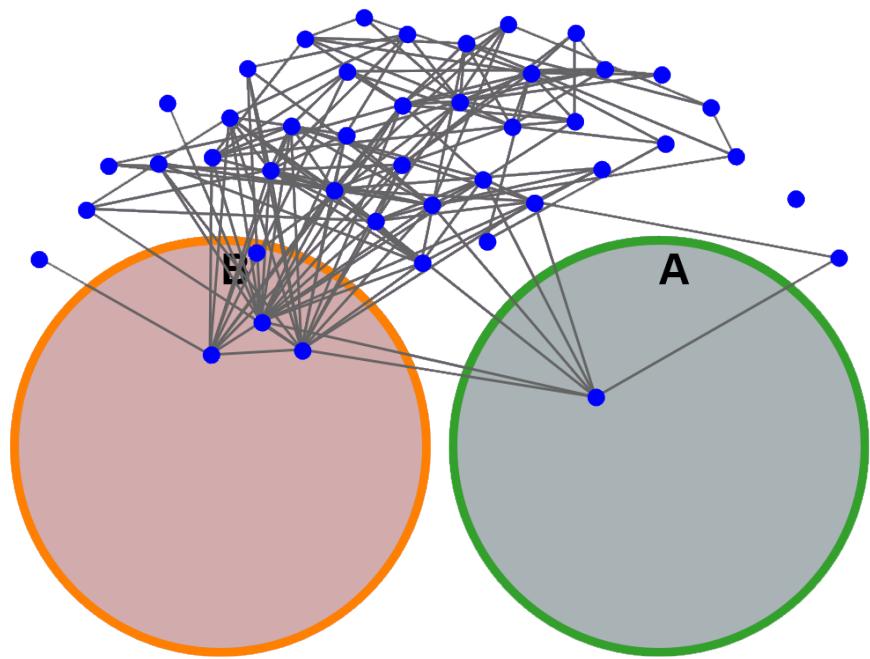
Number of Sets: 2
 Number of Zones: 3
 Number of Nodes: 45
 Number of Edges: 163
 Zones high: no
 Nodes high: yes
 Edges high: yes

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	58	11	230	19
Vertex-vertex intersections	1	0	0	0
Vertices in incorrect zones	1	0	0	0
Omitted zones	0	0	0	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	0	0	0
Concurrent curves	0	0	0	0
Triple points	0	0	0	0
Non-circles	0	2	2	0
Extra zones	0	0	0	0
Edge crossings	1247	638	1049	1345
Extra edge-curve crossings	1	62	66	2
Runtime (in sec)	2.774	0.685	6.068	4.152

SetNet (without graph)

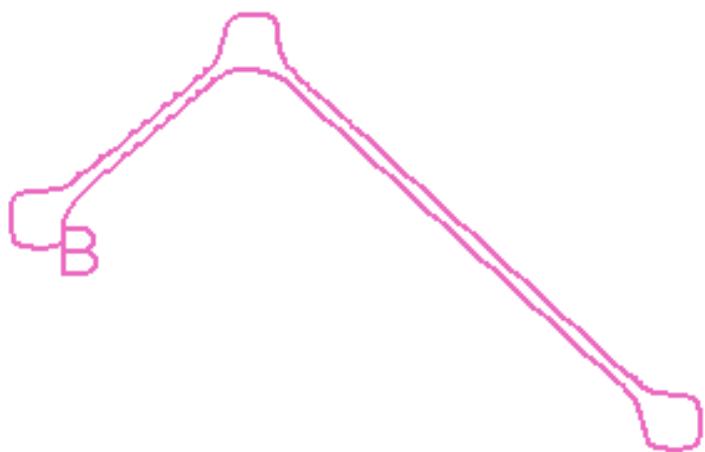


SetNet (with graph)

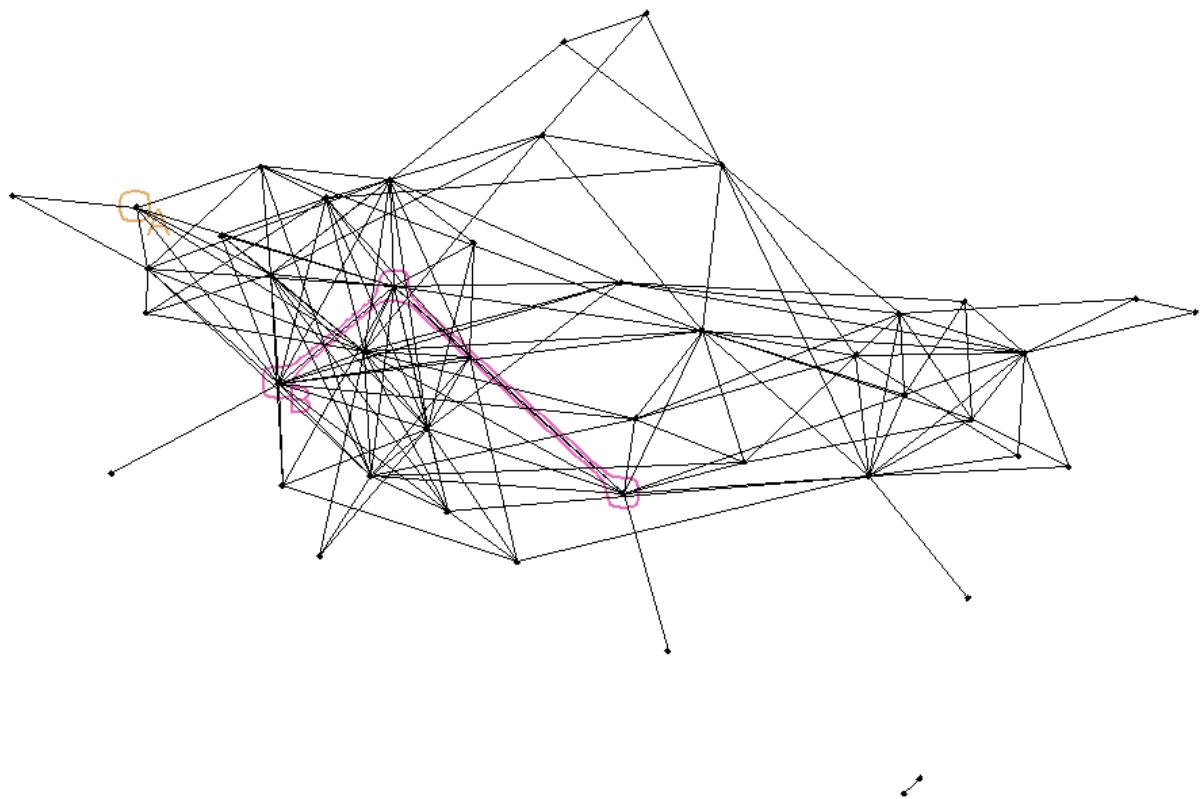


BubbleSets (without graph)

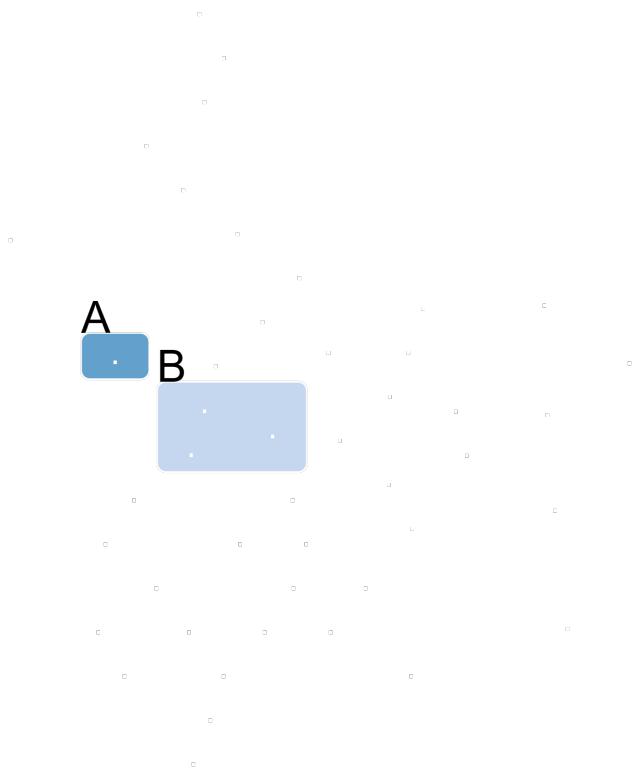
Q_A



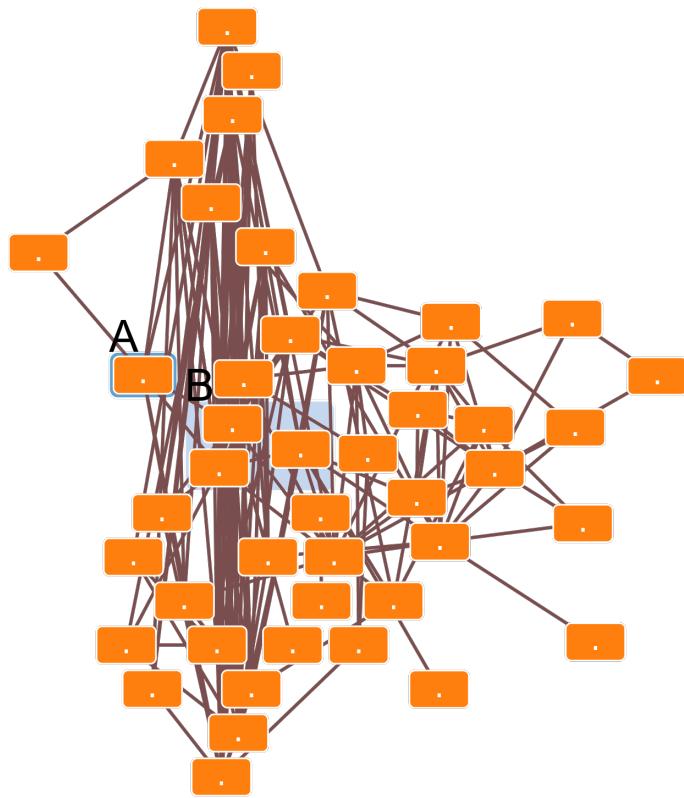
BubbleSets (with graph)



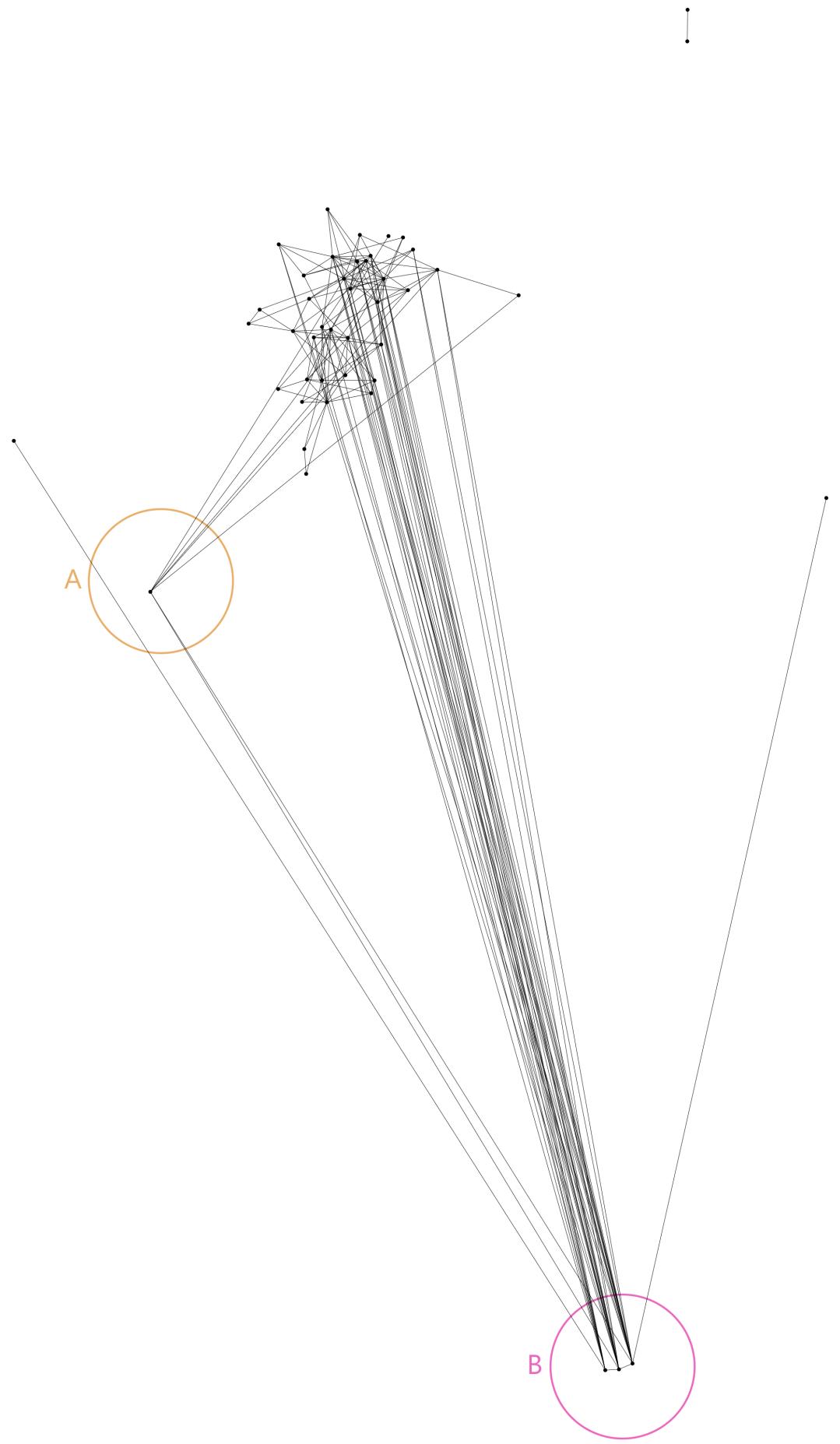
WebCola (without graph)



WebCola (with graph)



GroupNet

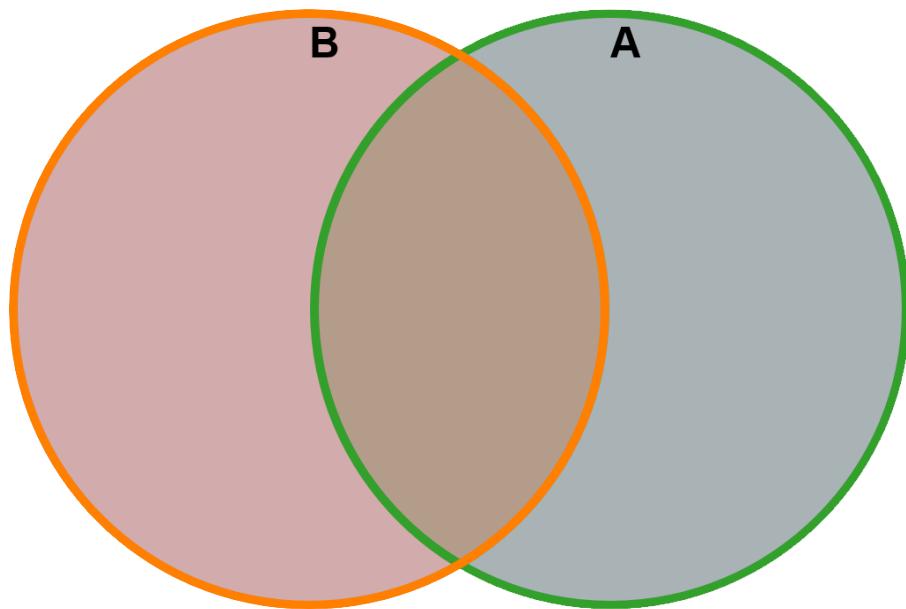


2-set data set 5 : SNAP ID: 20060293

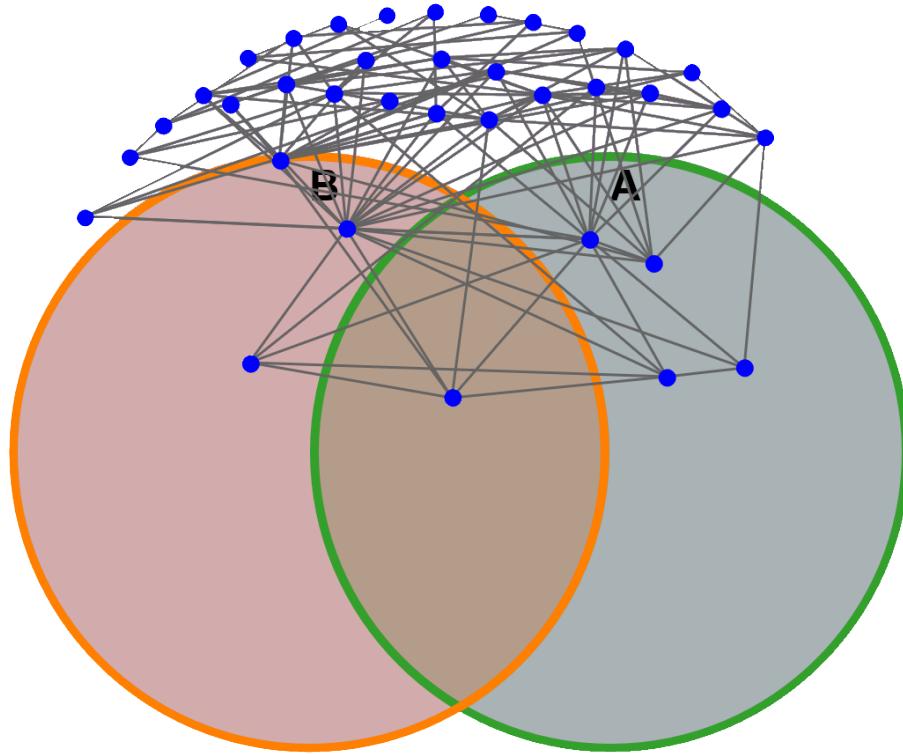
Number of Sets: 2
 Number of Zones: 4
 Number of Nodes: 36
 Number of Edges: 111
 Zones high: yes
 Nodes high: no
 Edges high: no

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	43	6	99	2
Vertex-vertex intersections	0	0	0	0
Vertices in incorrect zones	1	0	0	0
Omitted zones	0	0	0	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	2	0	0
Concurrent curves	0	0	0	0
Triple points	0	0	0	0
Non-circles	0	2	2	0
Extra zones	0	0	0	0
Edge crossings	633	235	621	472
Extra edge-curve crossings	20	70	106	0
Runtime (in sec)	1.745	0.506	6.631	8.899

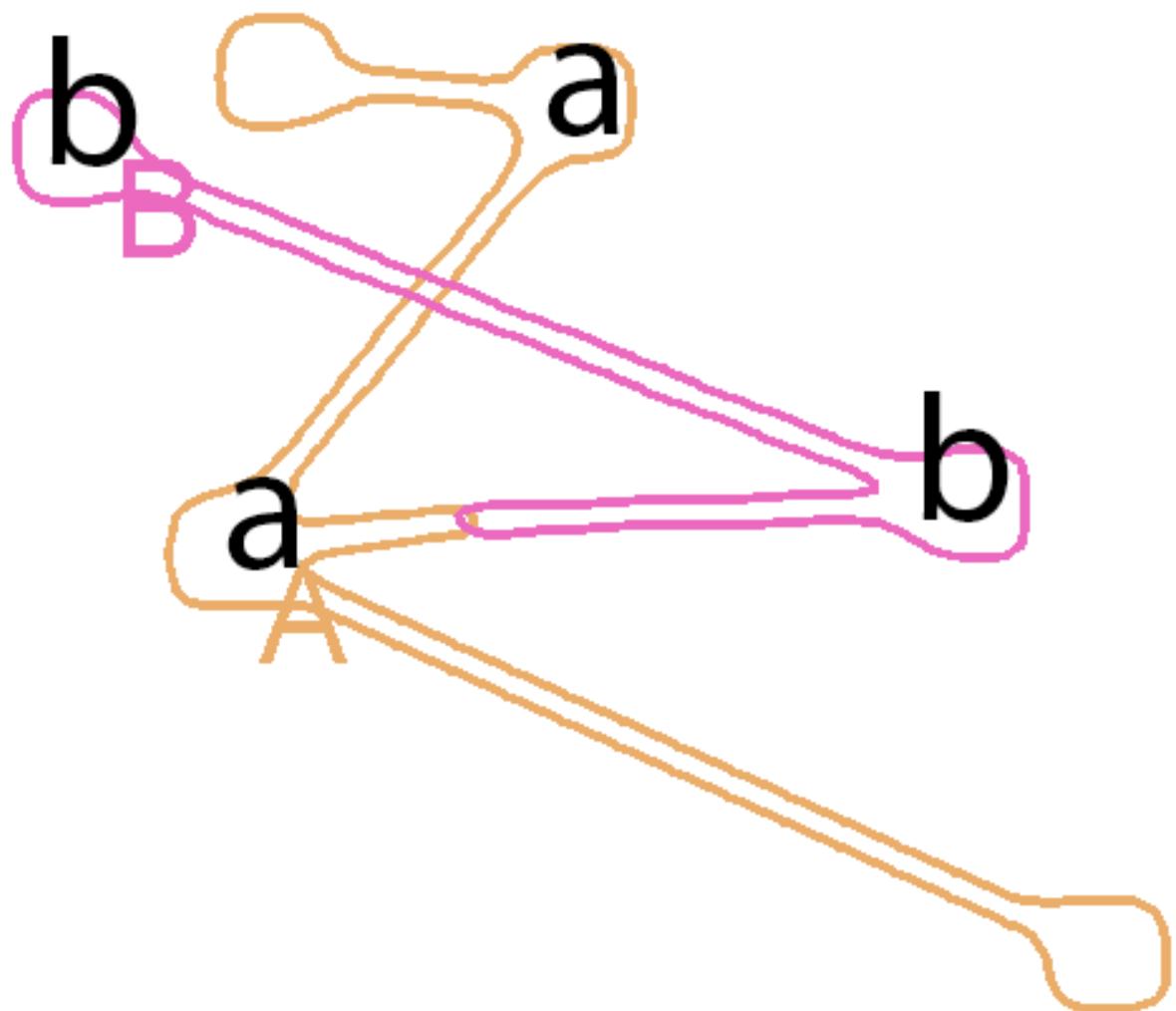
SetNet (without graph)



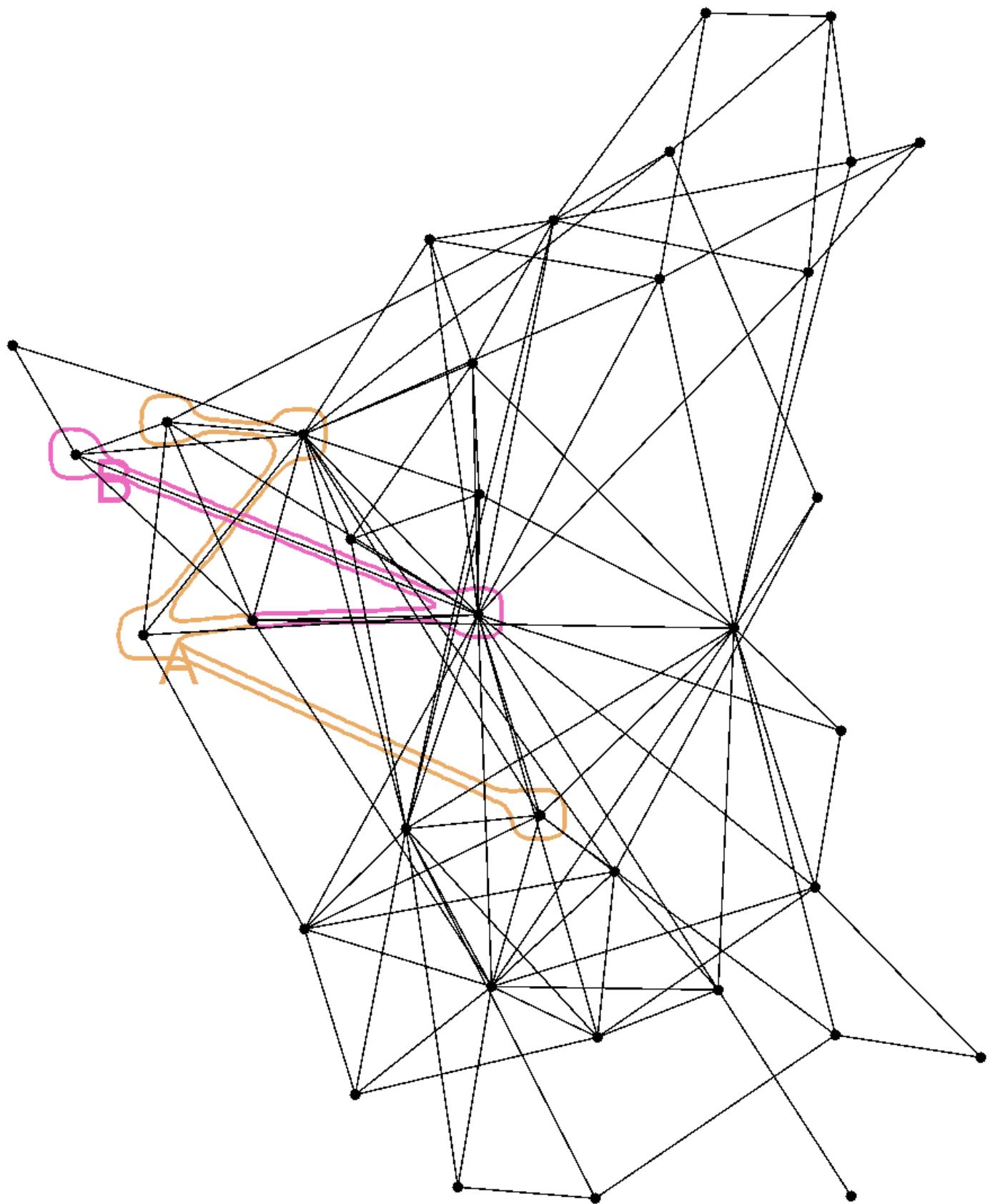
SetNet (with graph)



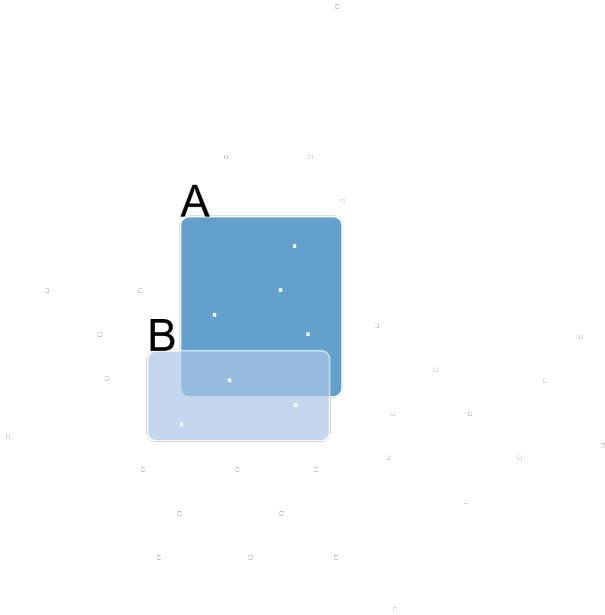
BubbleSets (without graph)



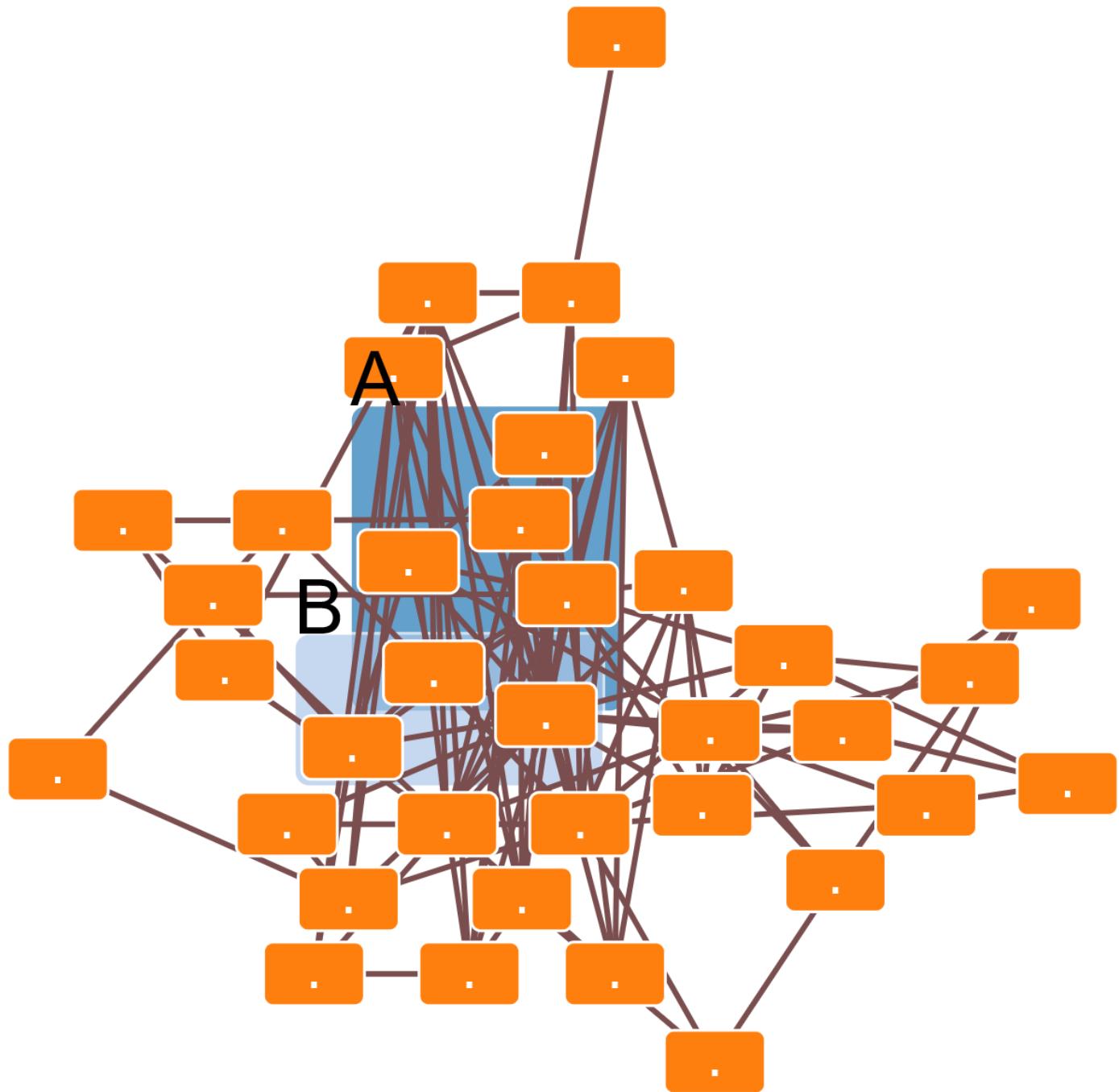
BubbleSets (with graph)



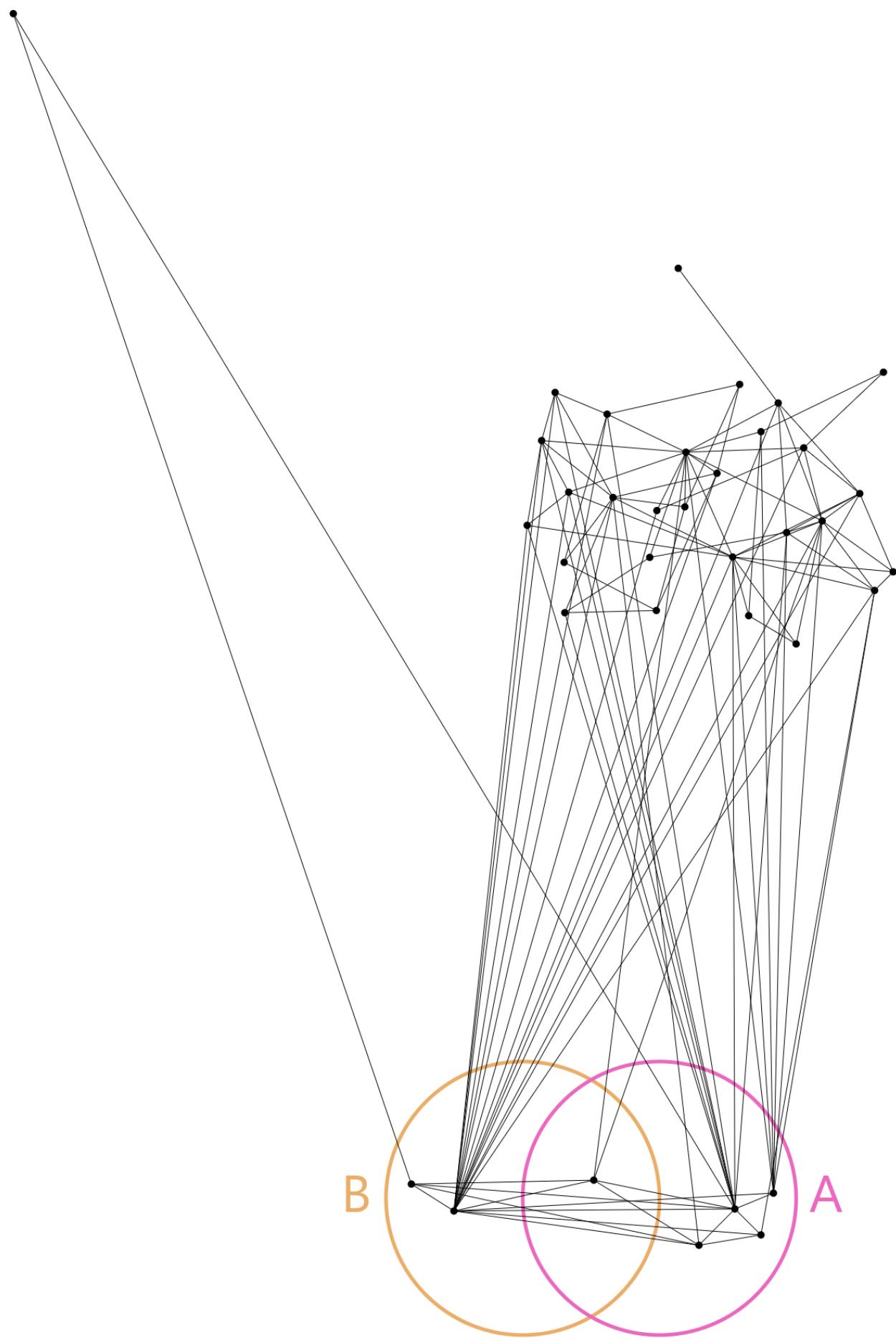
WebCola (without graph)



WebCola (with graph)



GroupNet

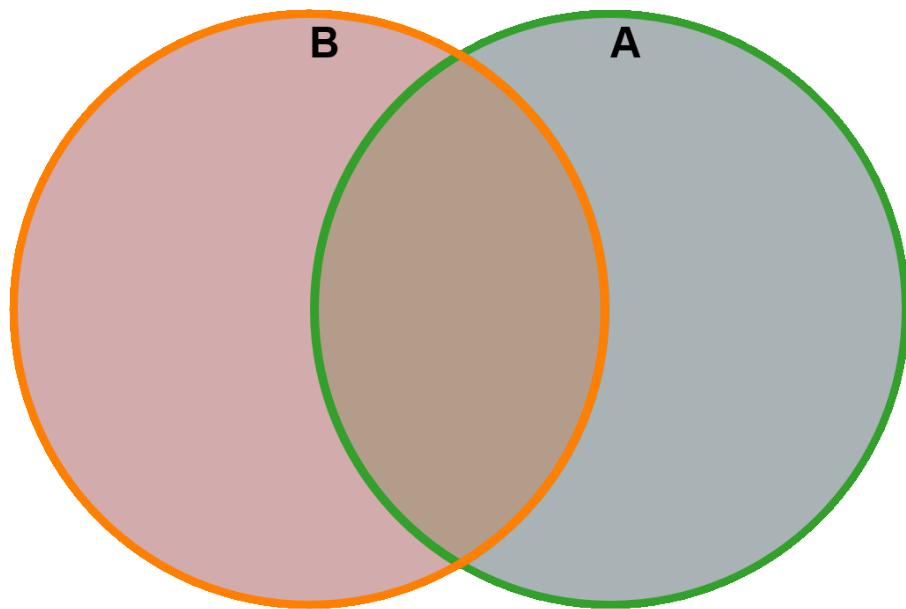


2-set data set 6 : SNAP ID: 242024994

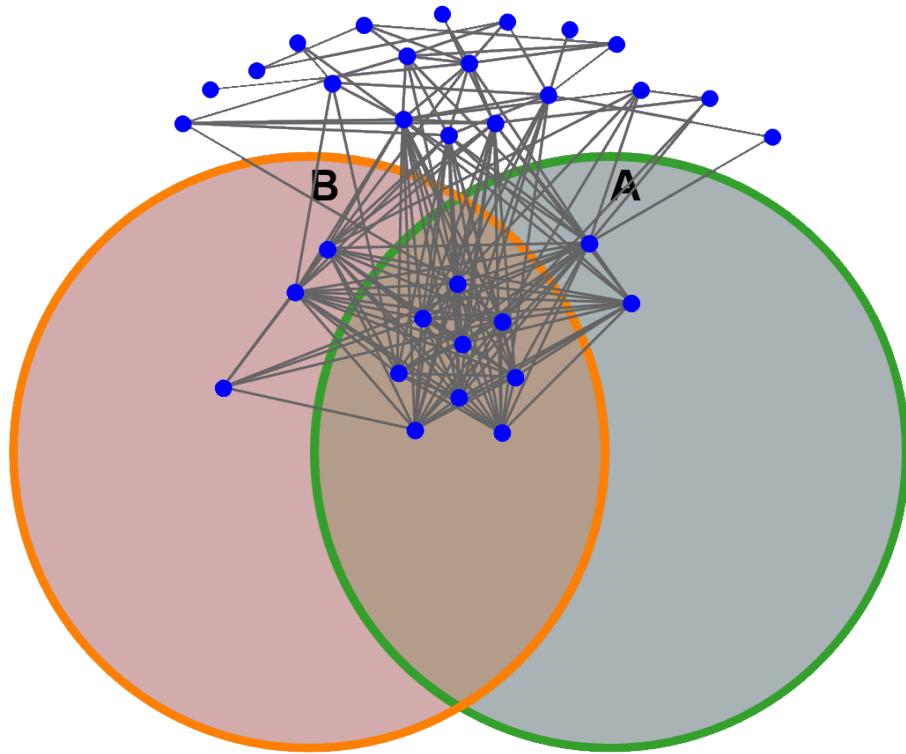
Number of Sets: 2
 Number of Zones: 4
 Number of Nodes: 33
 Number of Edges: 170
 Zones high: yes
 Nodes high: no
 Edges high: yes

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	37	16	205	17
Vertex-vertex intersections	0	0	4	0
Vertices in incorrect zones	0	0	2	0
Omitted zones	0	0	1	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	15	0	0
Concurrent curves	0	2	1	0
Triple points	0	0	0	0
Non-circles	0	2	2	0
Extra zones	0	0	0	0
Edge crossings	1771	1407	1634	1995
Extra edge-curve crossings	0	478	33	0
Runtime (in sec)	2.446	0.525	7.071	9.732

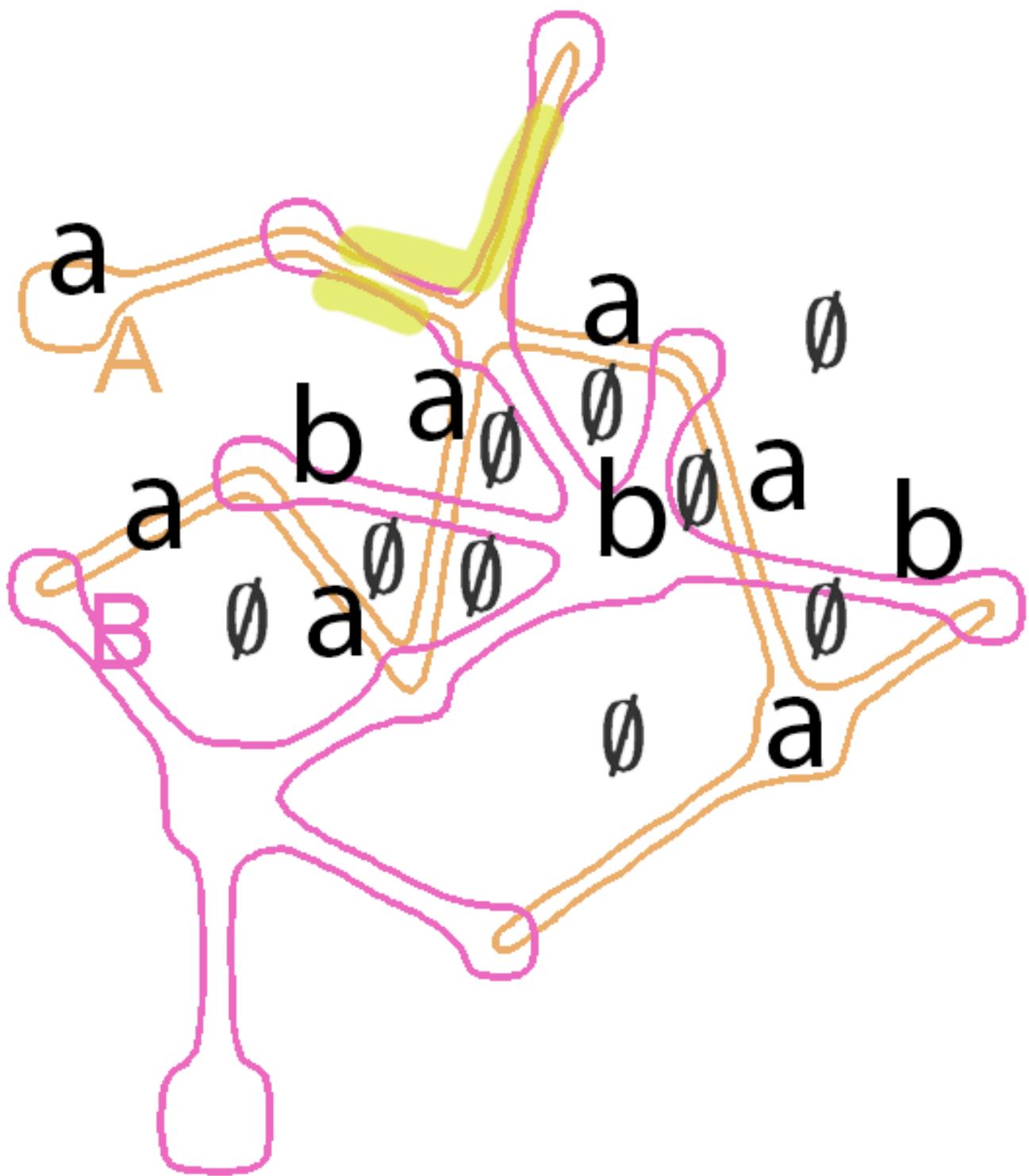
SetNet (without graph)



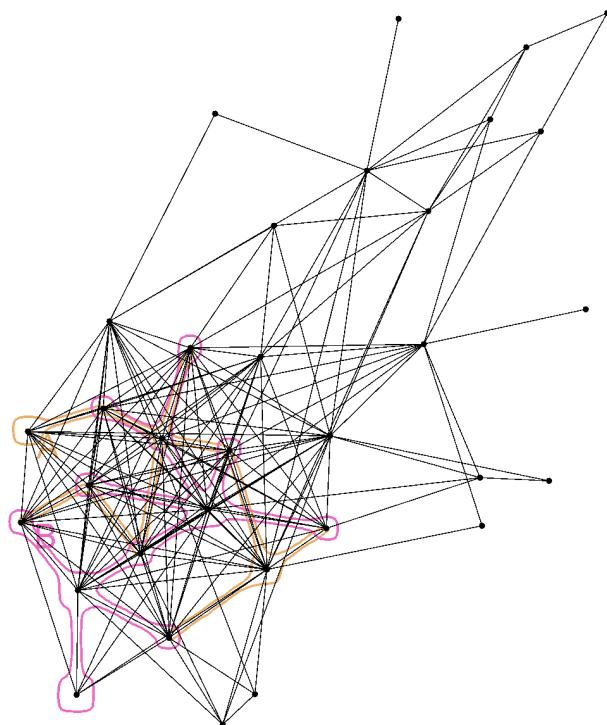
SetNet (with graph)



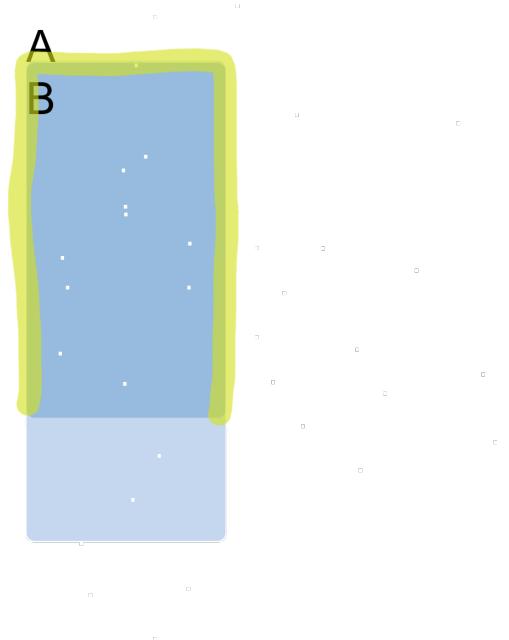
BubbleSets (without graph)



BubbleSets (with graph)

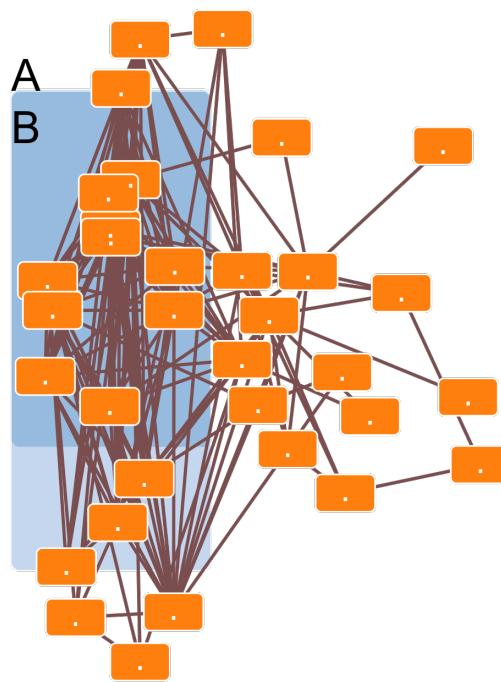


WebCola (without graph)

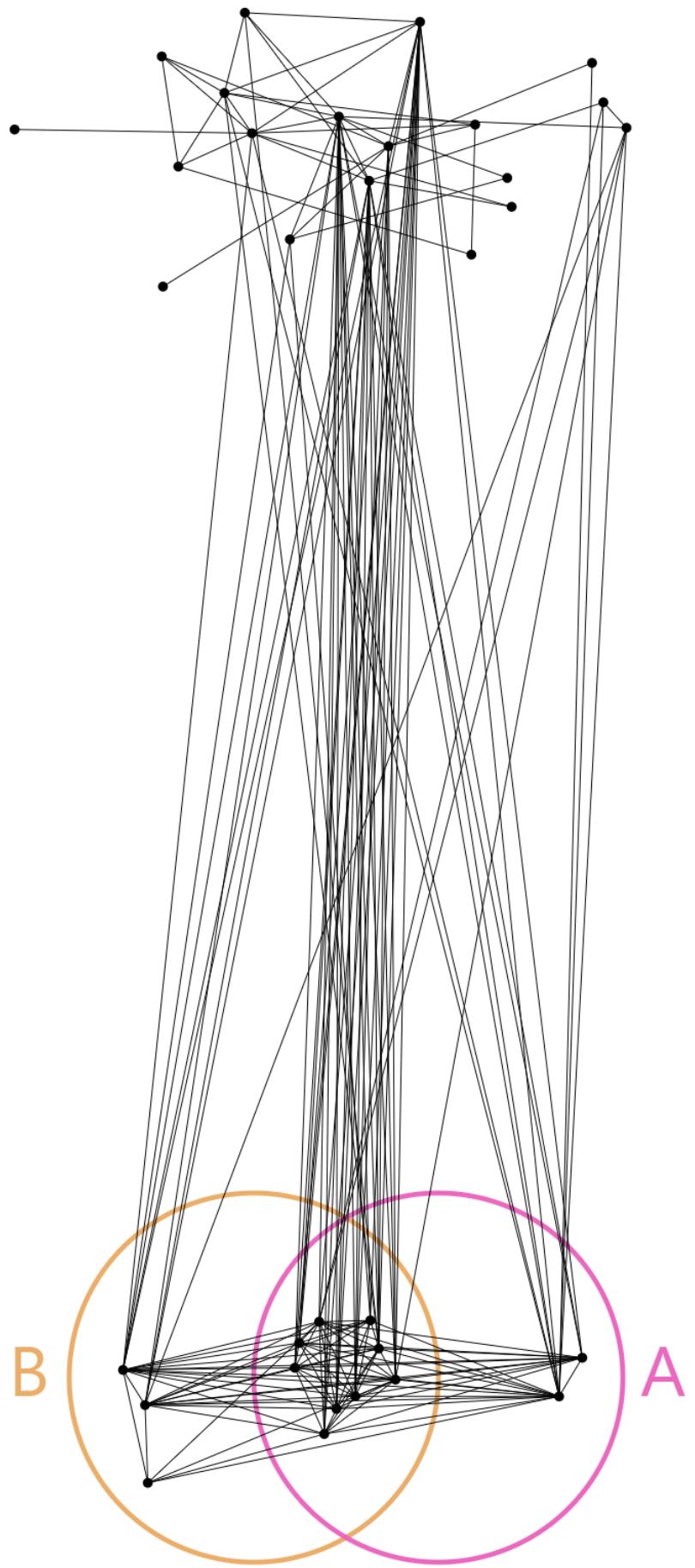


Omitted zone: A

WebCola (with graph)



GroupNet

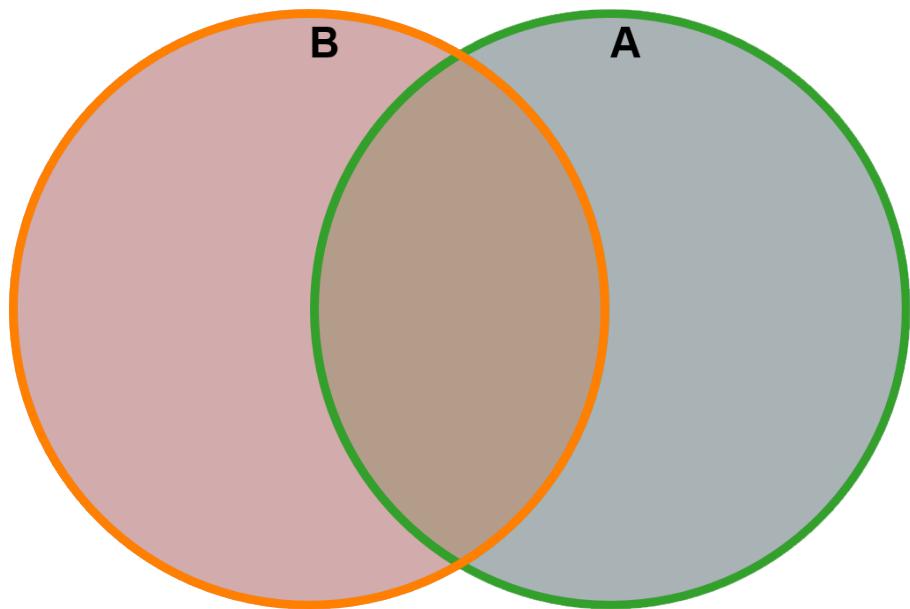


2-set data set 7 : SNAP ID: 22879382

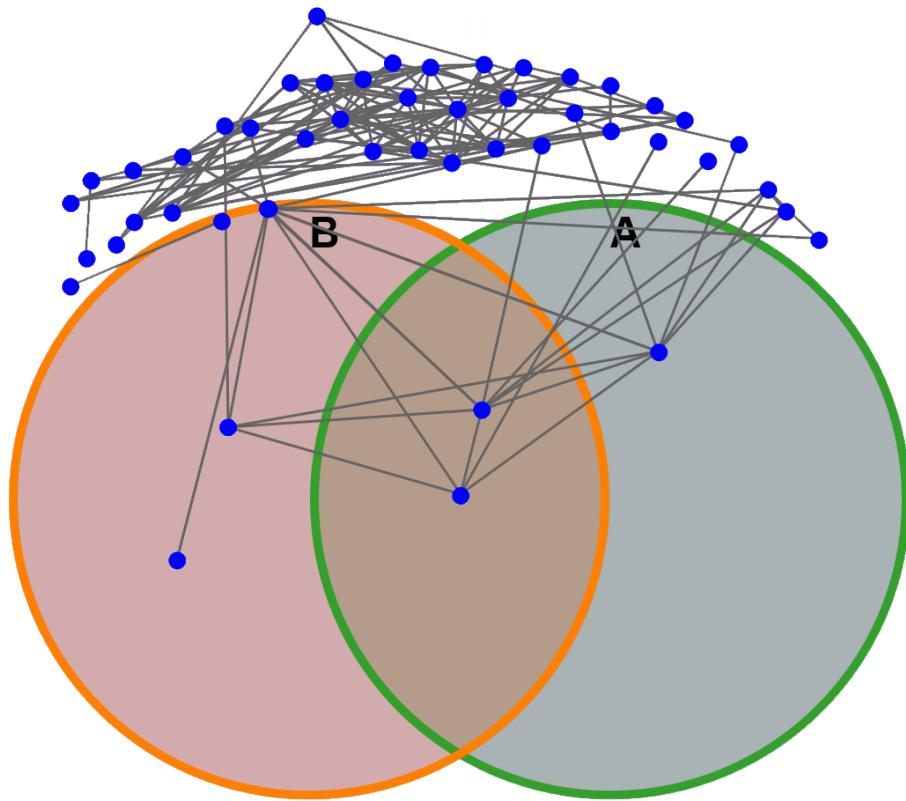
Number of Sets: 2
 Number of Zones: 4
 Number of Nodes: 49
 Number of Edges: 138
 Zones high: yes
 Nodes high: yes
 Edges high: no

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	92	9	137	12
Vertex-vertex intersections	1	0	0	0
Vertices in incorrect zones	2	0	0	0
Omitted zones	0	0	0	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	2	0	0
Concurrent curves	0	0	0	0
Triple points	0	0	0	0
Non-circles	0	2	2	0
Extra zones	0	0	0	0
Edge crossings	911	357	698	561
Extra edge-curve crossings	8	25	18	2
Runtime (in sec)	2.564	0.69	7.098	10.519

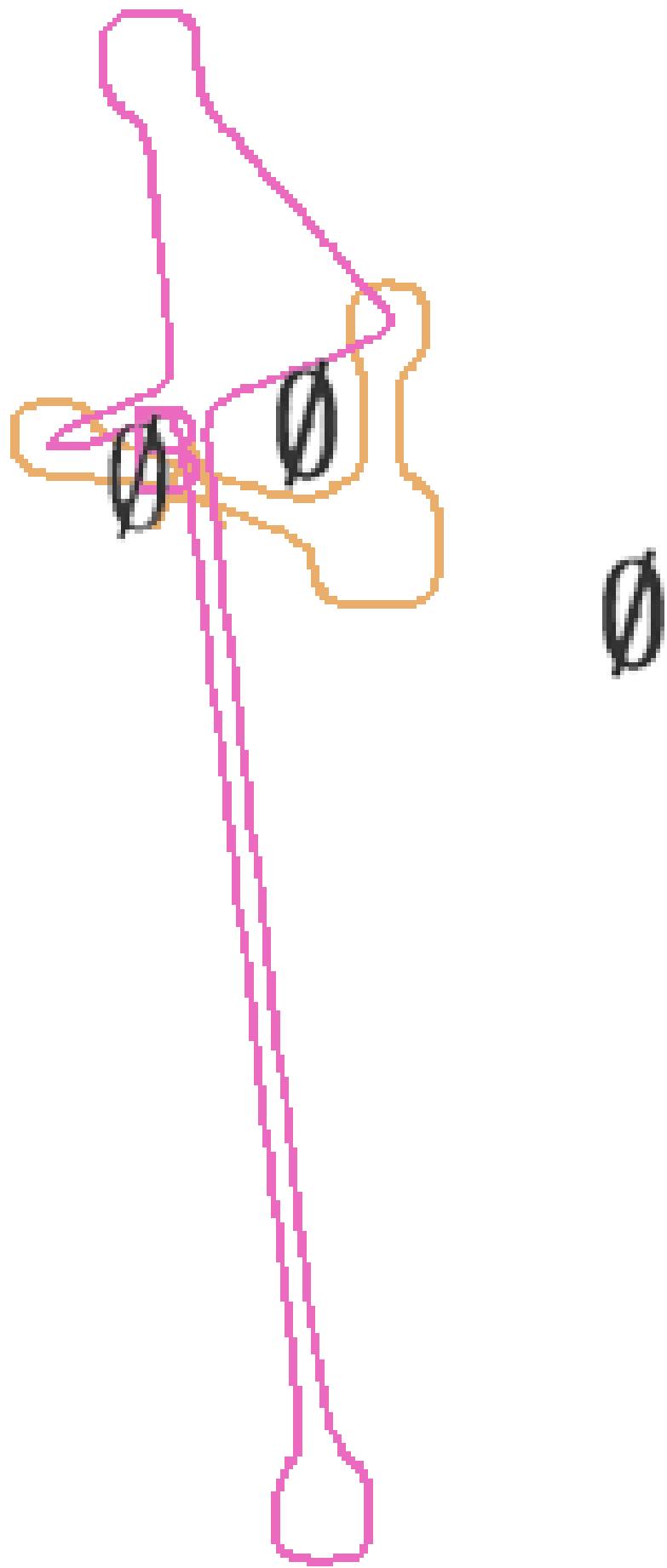
SetNet (without graph)



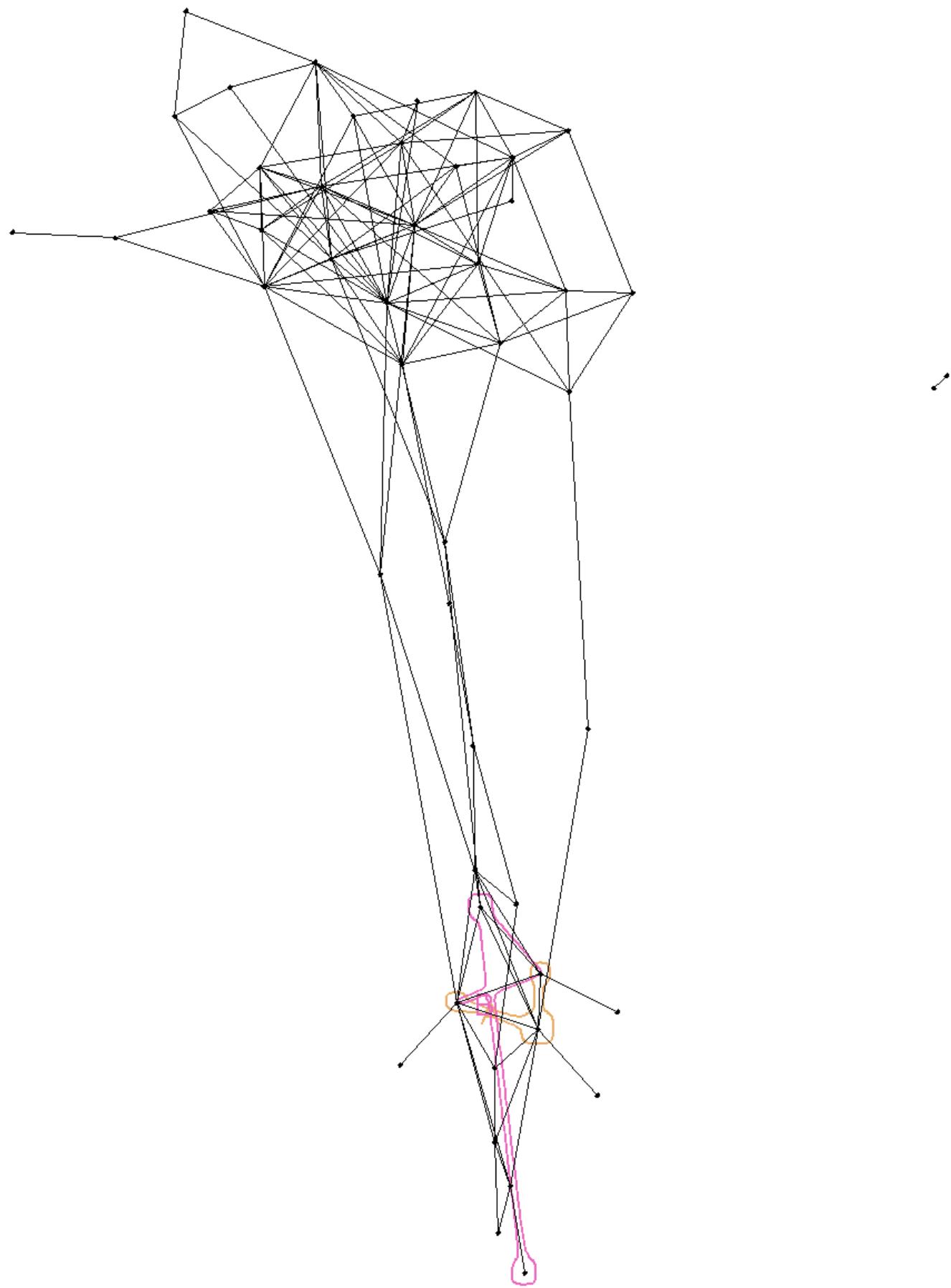
SetNet (with graph)



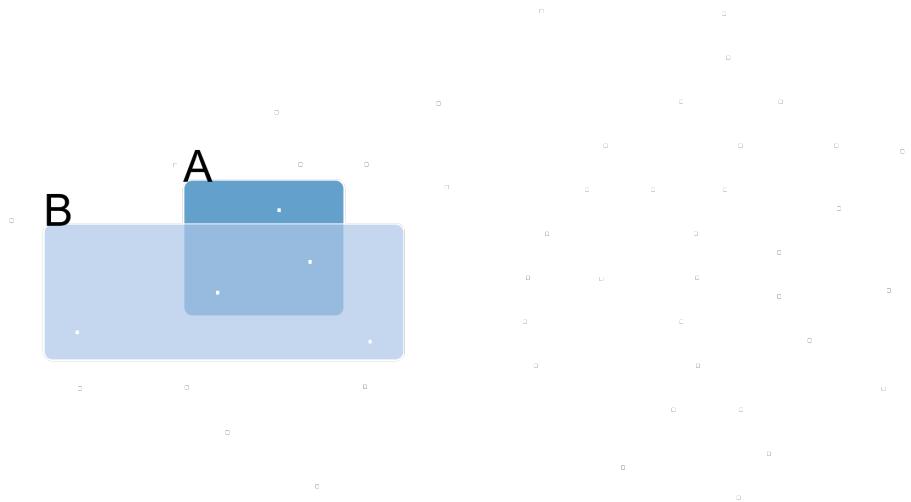
BubbleSets (without graph)



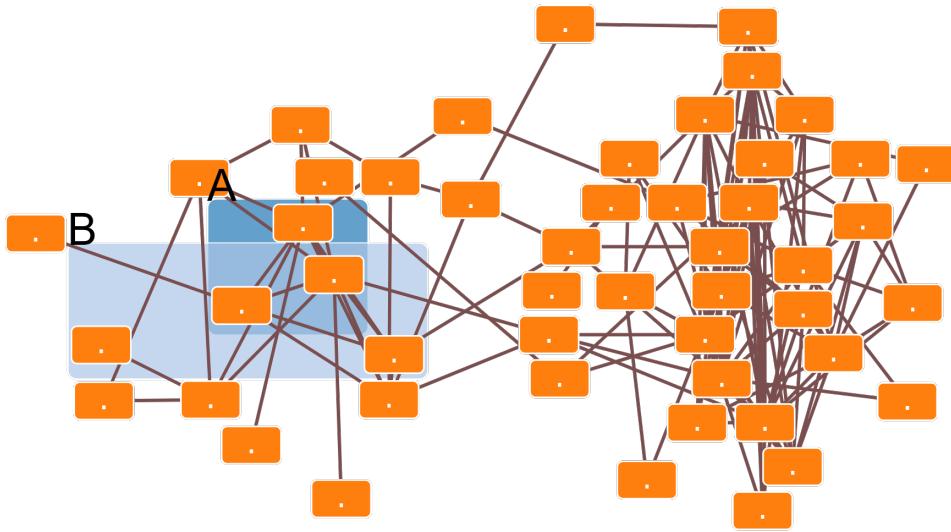
BubbleSets (with graph)



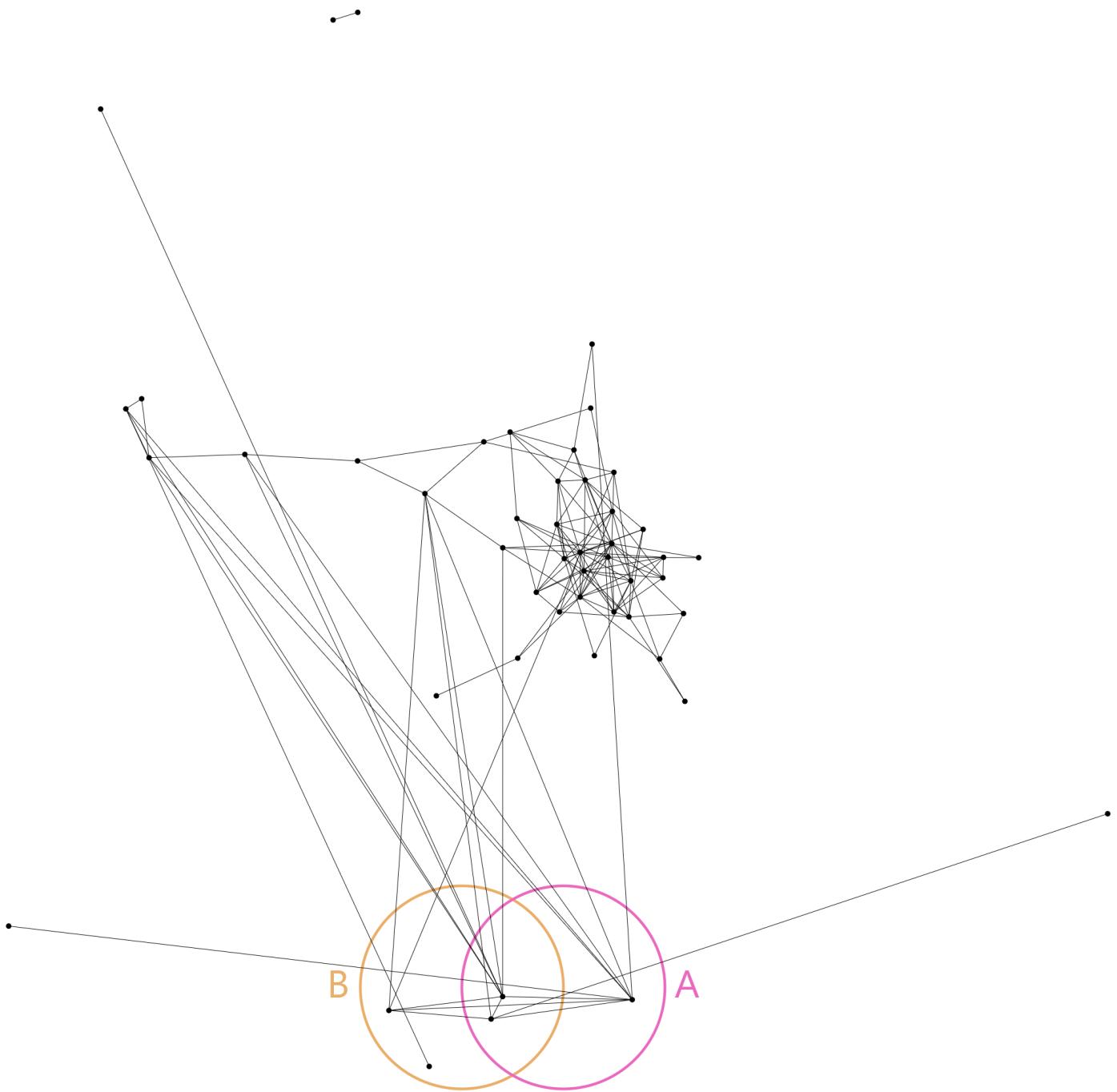
WebCola (without graph)



WebCola (with graph)



GroupNet

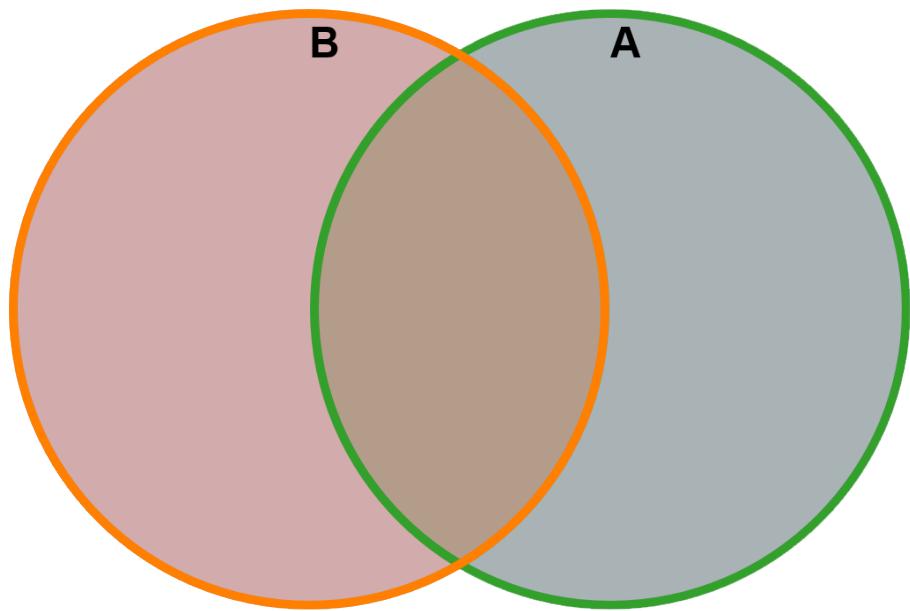


2-set data set 8 : SNAP ID: 20758393

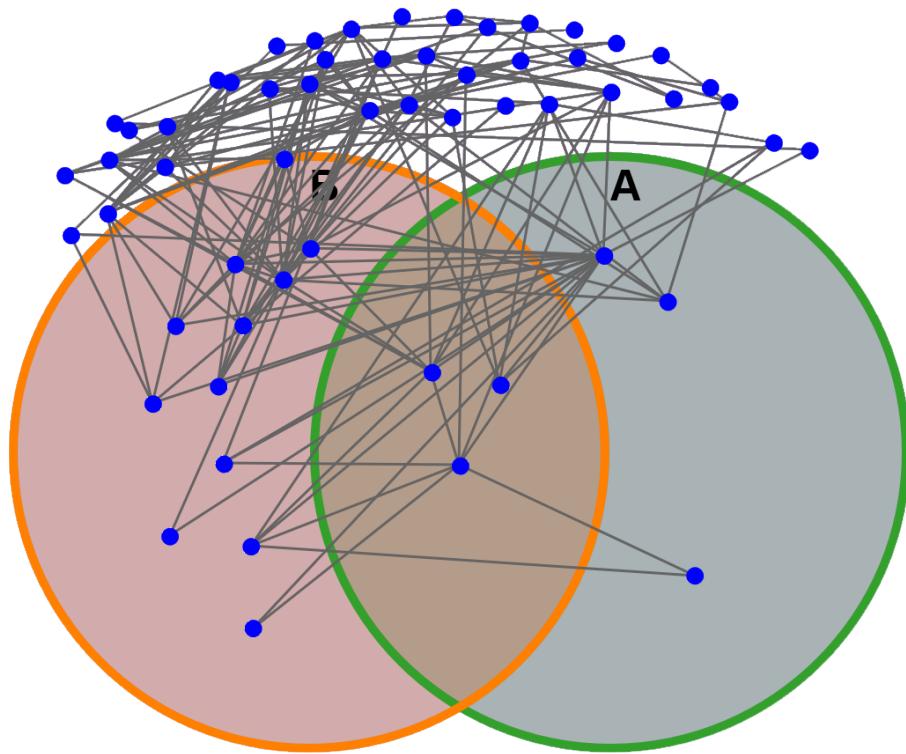
Number of Sets: 2
 Number of Zones: 4
 Number of Nodes: 57
 Number of Edges: 165
 Zones high: yes
 Nodes high: yes
 Edges high: yes

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	112	4	268	26
Vertex-vertex intersections	2	0	0	0
Vertices in incorrect zones	1	0	0	0
Omitted zones	0	0	0	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	7	0	0
Concurrent curves	0	0	0	0
Triple points	0	0	0	0
Non-circles	0	2	2	0
Extra zones	0	0	0	0
Edge crossings	1807	410	1338	1746
Extra edge-curve crossings	7	152	128	6
Runtime (in sec)	3.42	0.561	7.036	17.092

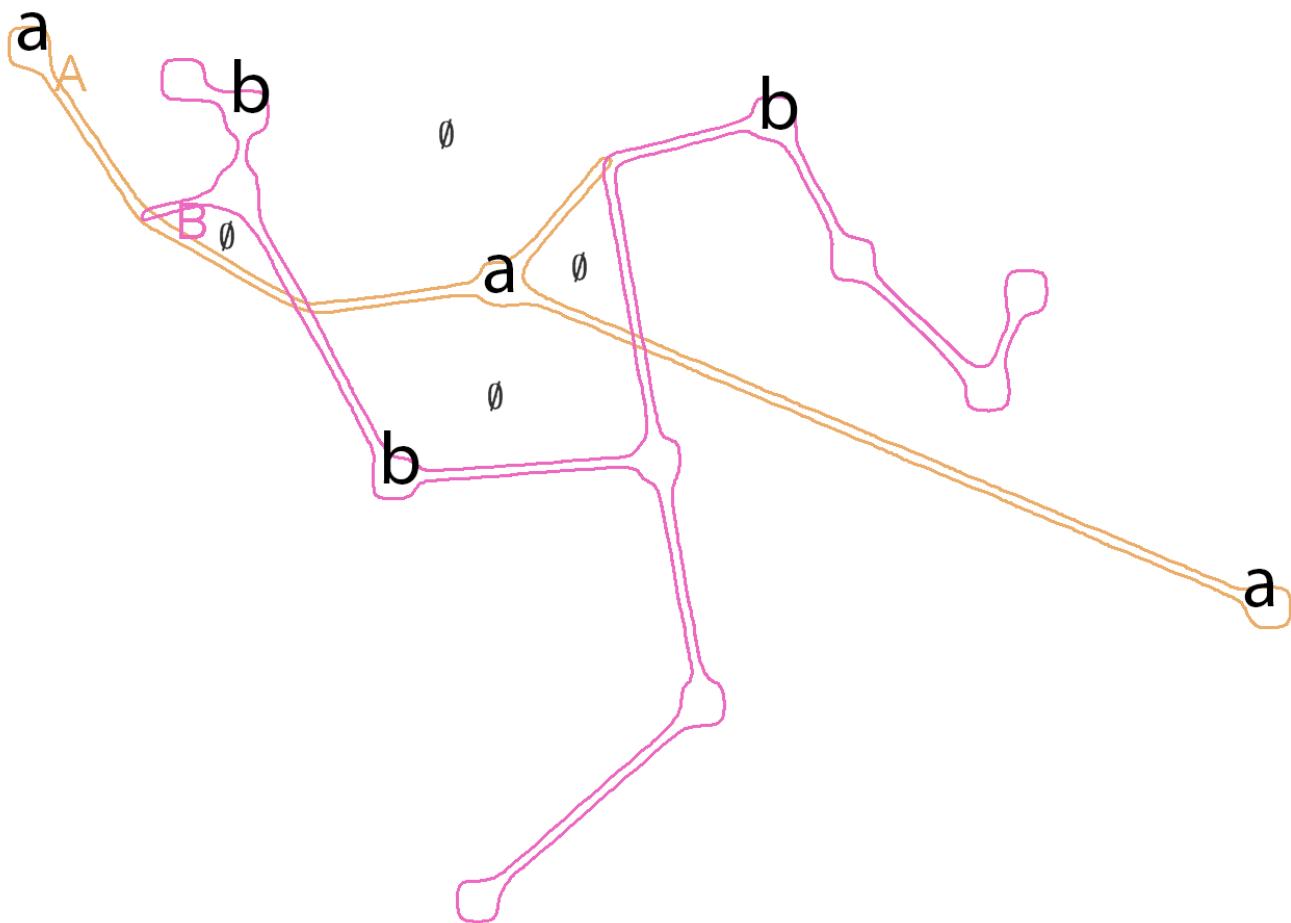
SetNet (without graph)



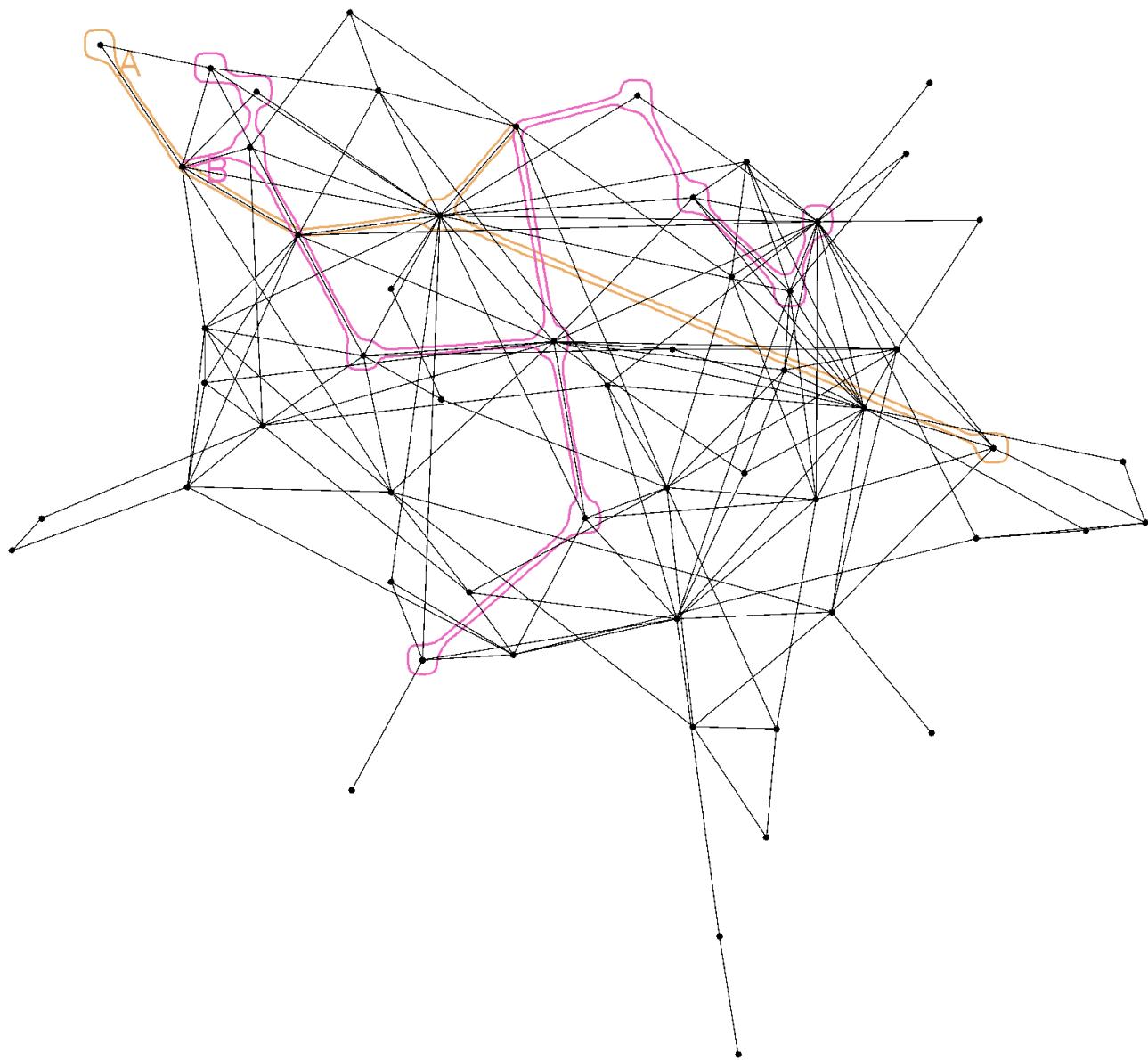
SetNet (with graph)



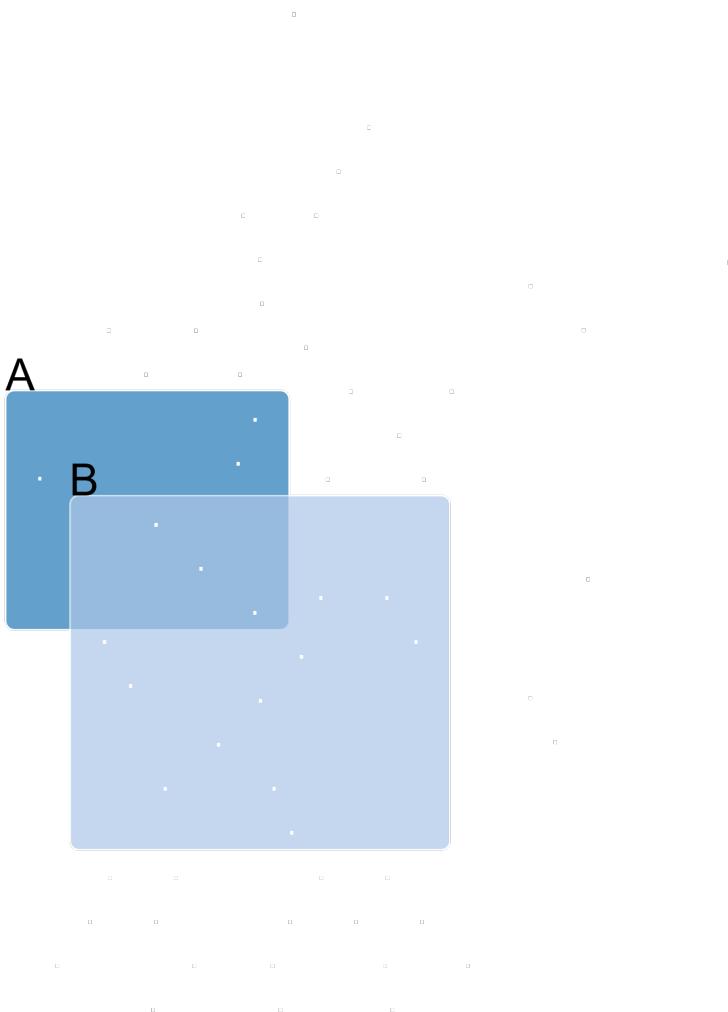
BubbleSets (without graph)



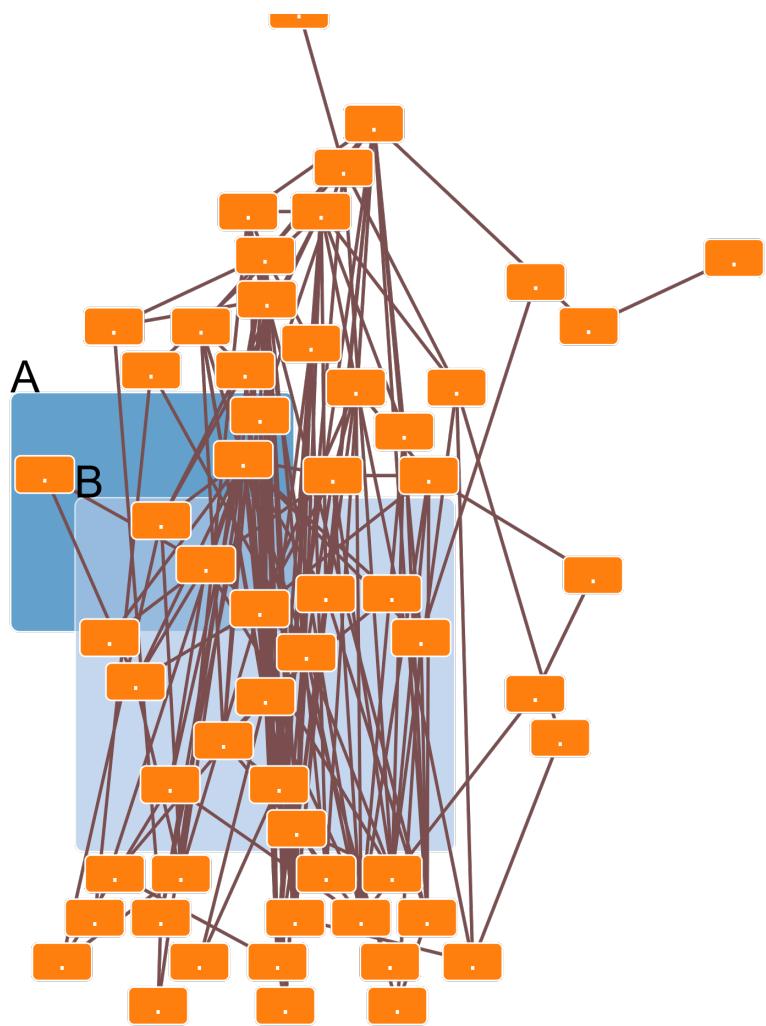
BubbleSets (with graph)



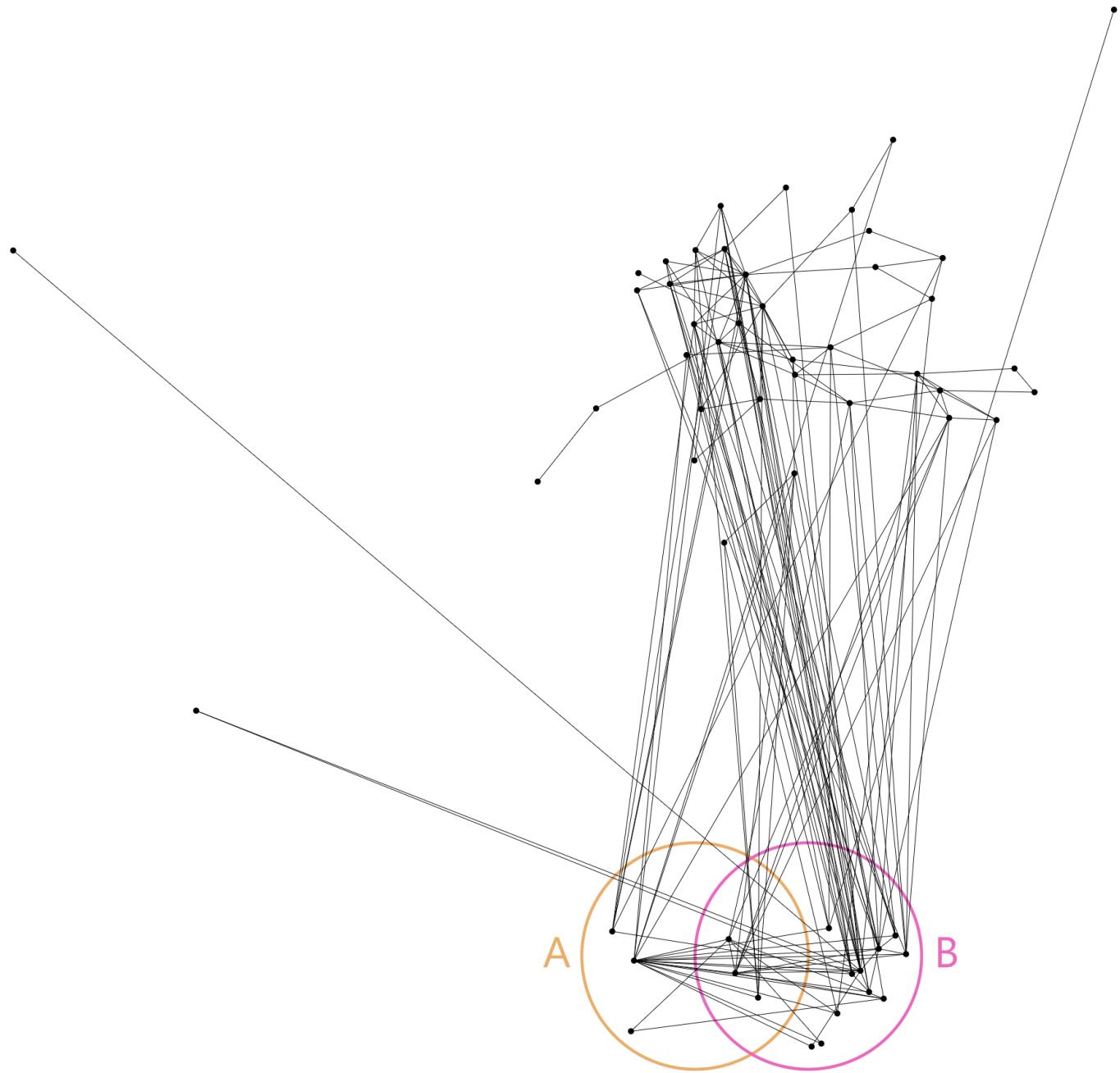
WebCola (without graph)



WebCola (with graph)



GroupNet

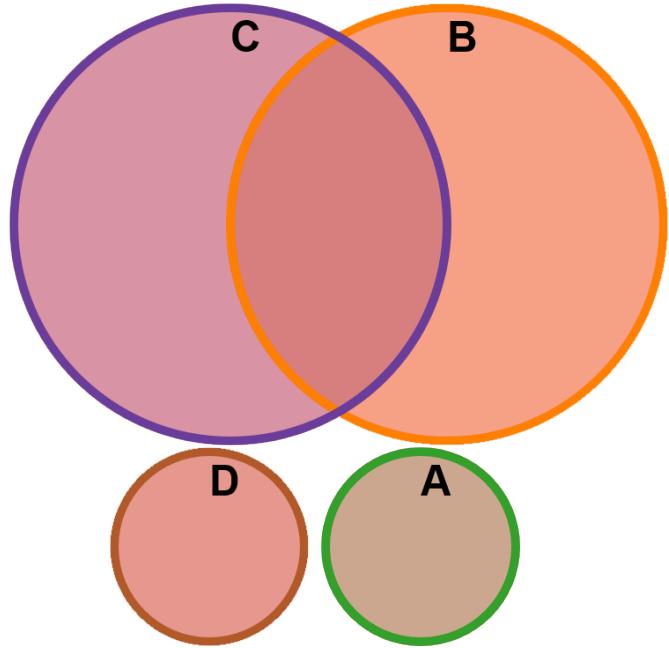


4-set data set 1 : SNAP ID: 198628427

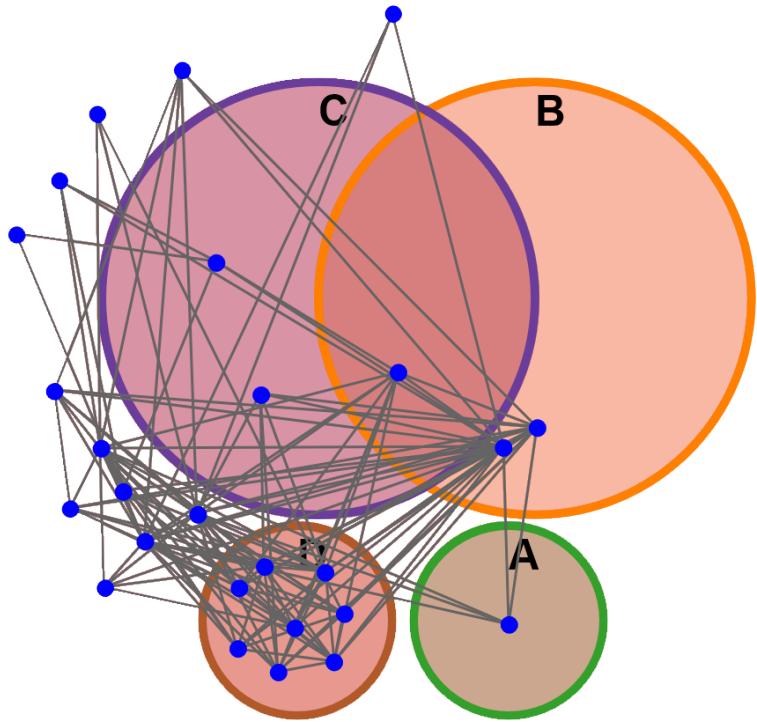
Number of Sets: 4
 Number of Zones: 6
 Number of Nodes: 26
 Number of Edges: 133
 Zones high: no
 Nodes high: no
 Edges high: no

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	39	6	371	0
Vertex-vertex intersections	0	0	0	0
Vertices in incorrect zones	0	0	0	0
Omitted zones	0	0	0	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	11	0	0
Concurrent curves	0	0	0	0
Triple points	0	0	0	0
Non-circles	0	4	4	0
Extra zones	0	4	0	0
Edge crossings	1269	861	1088	1382
Extra edge-curve crossings	29	278	156	6
Runtime (in sec)	1.947	0.772	3.315	5.091

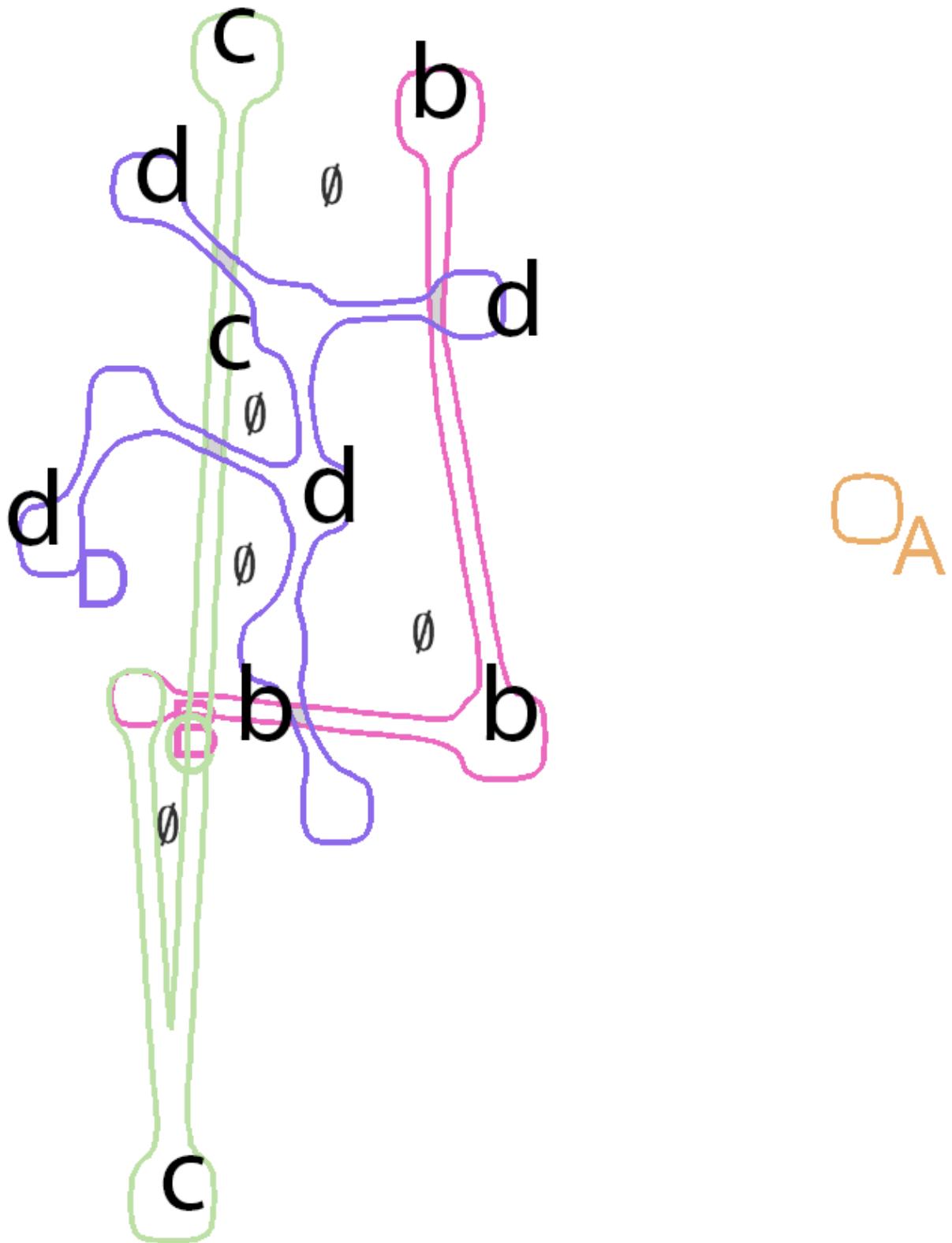
SetNet (without graph)



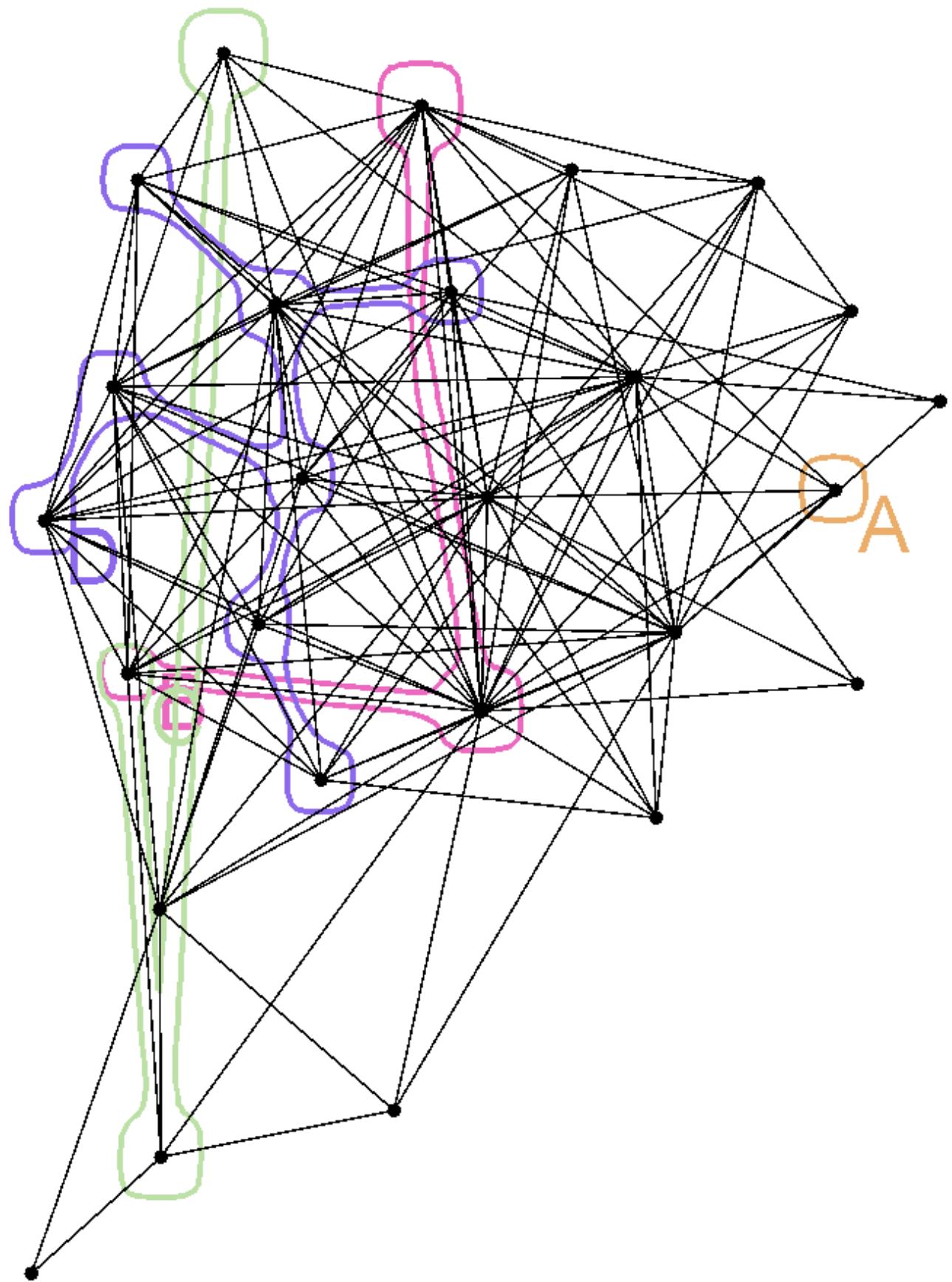
SetNet (with graph)



BubbleSets (without graph)



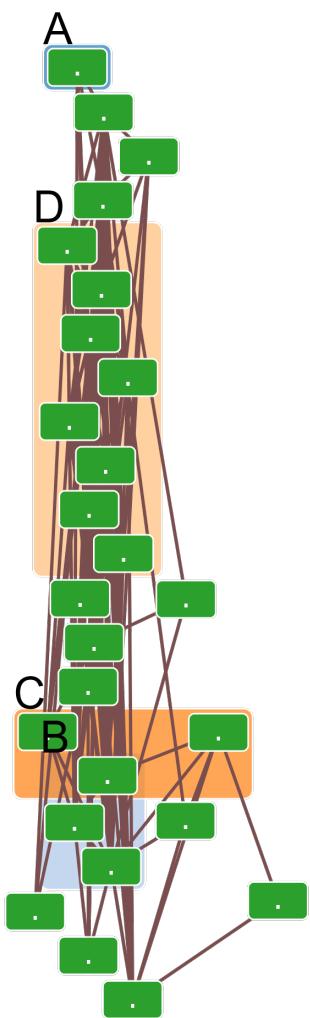
BubbleSets (with graph)



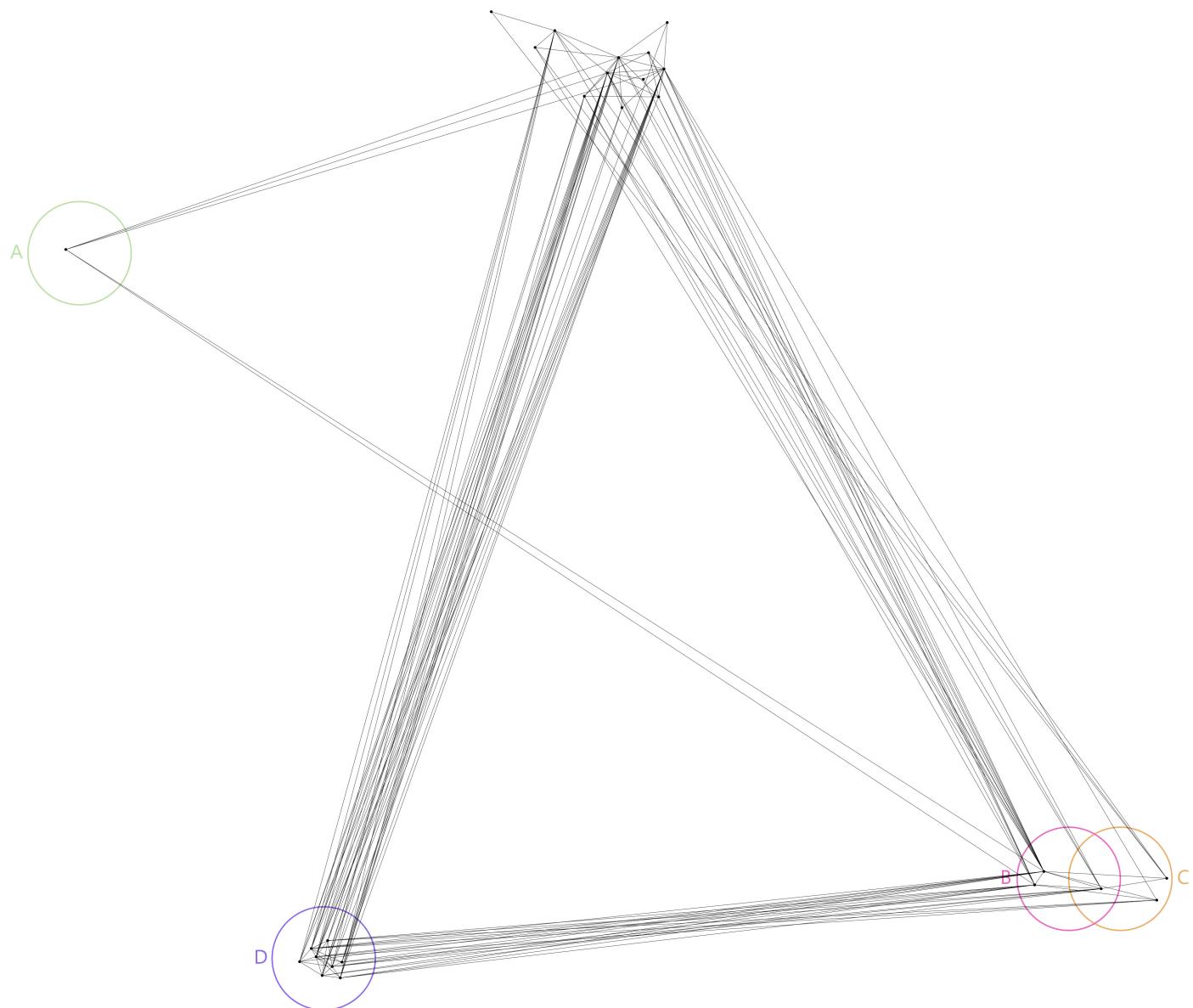
WebCola (without graph)



WebCola (with graph)



GroupNet

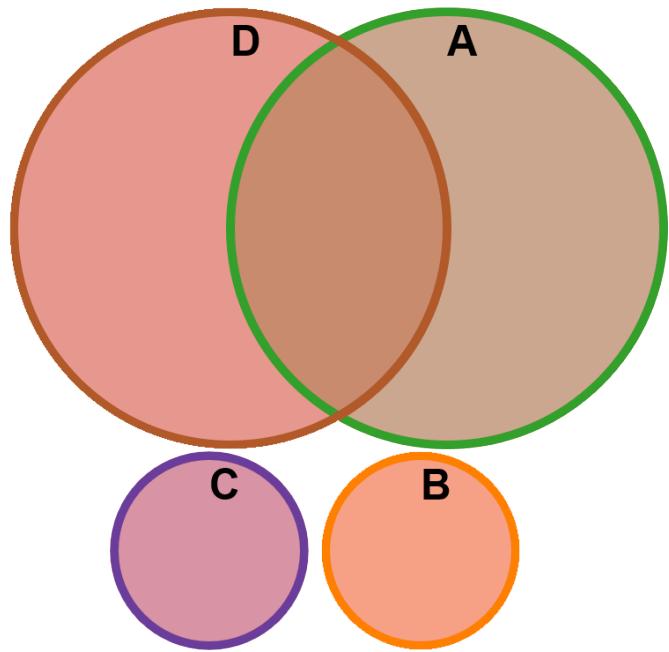


4-set data set 2 : SNAP ID: 351092905

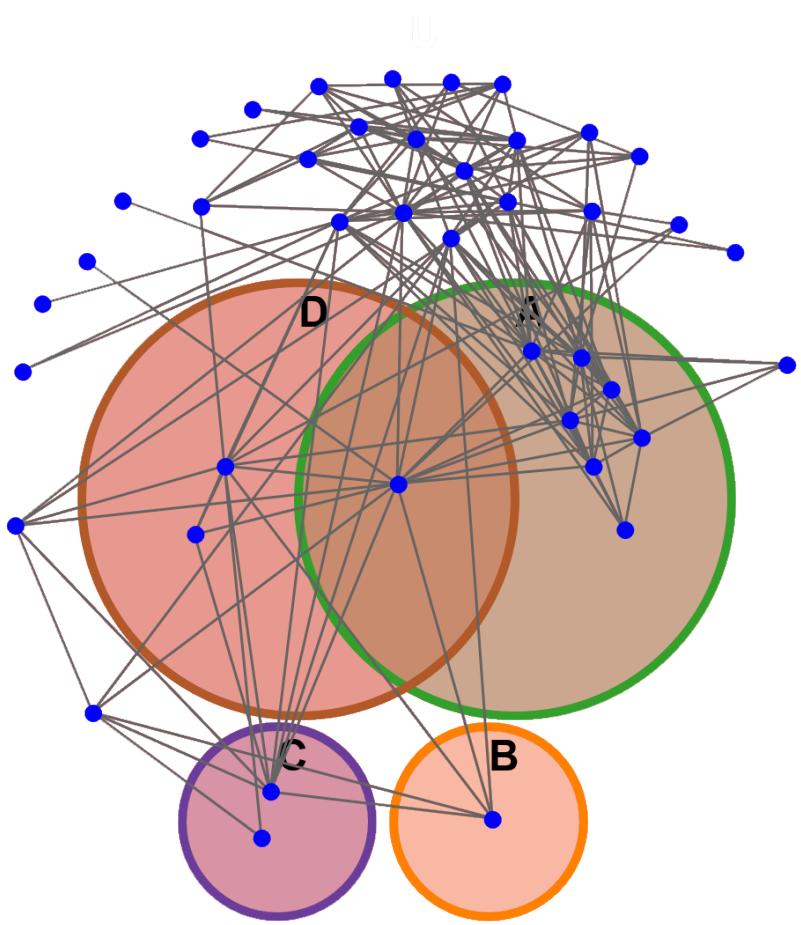
Number of Sets: 4
 Number of Zones: 6
 Number of Nodes: 41
 Number of Edges: 159
 Zones high: no
 Nodes high: no
 Edges high: yes

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	38	6	221	9
Vertex-vertex intersections	0	0	0	0
Vertices in incorrect zones	0	1	0	0
Omitted zones	0	0	0	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	0	0	0
Concurrent curves	0	0	1	0
Triple points	0	0	0	0
Non-circles	0	4	4	0
Extra zones	0	0	0	0
Edge crossings	1050	639	1175	1206
Extra edge-curve crossings	15	98	66	14
Runtime (in sec)	2.782	0.515	6.569	8.696

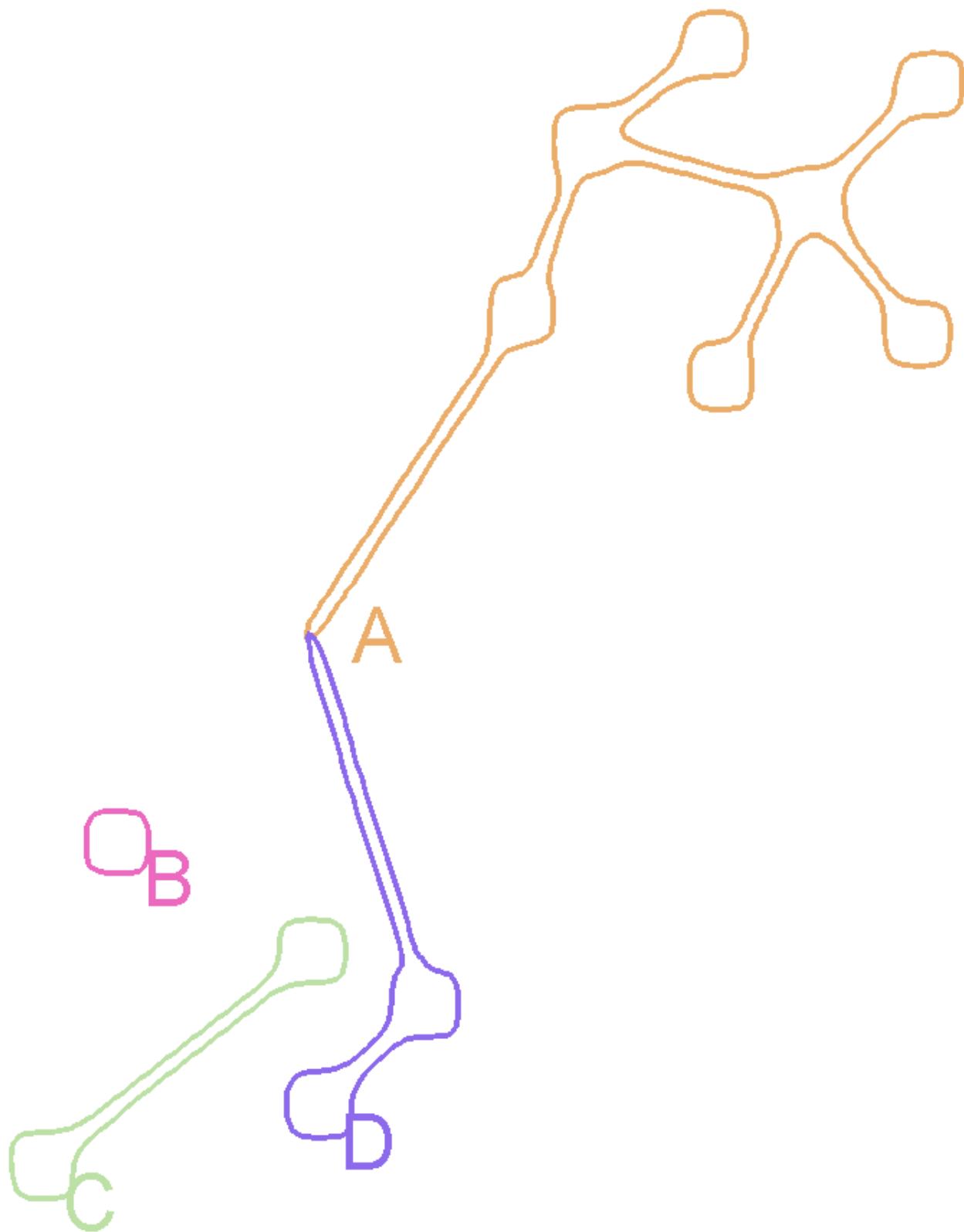
SetNet (without graph)



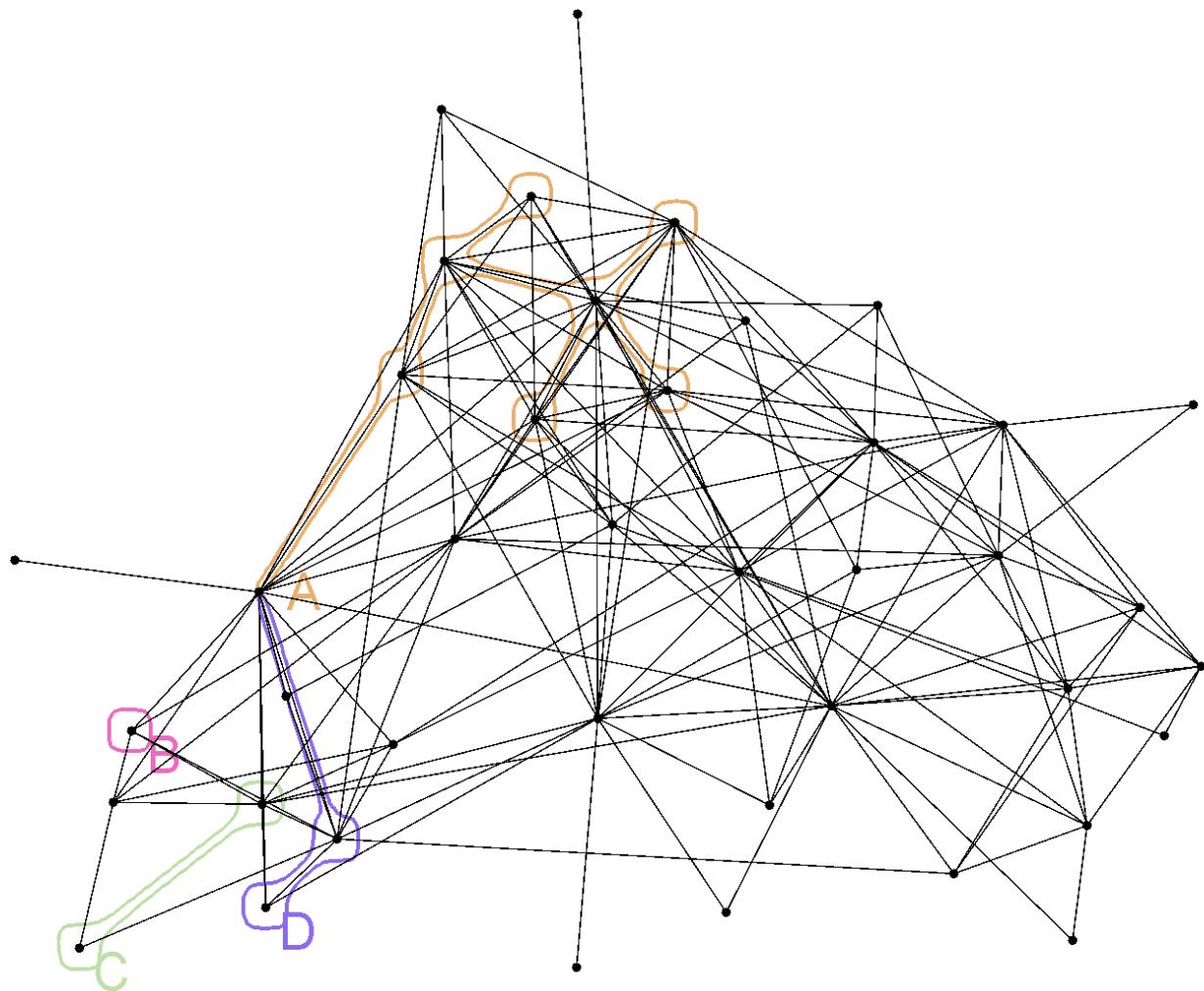
SetNet (with graph)



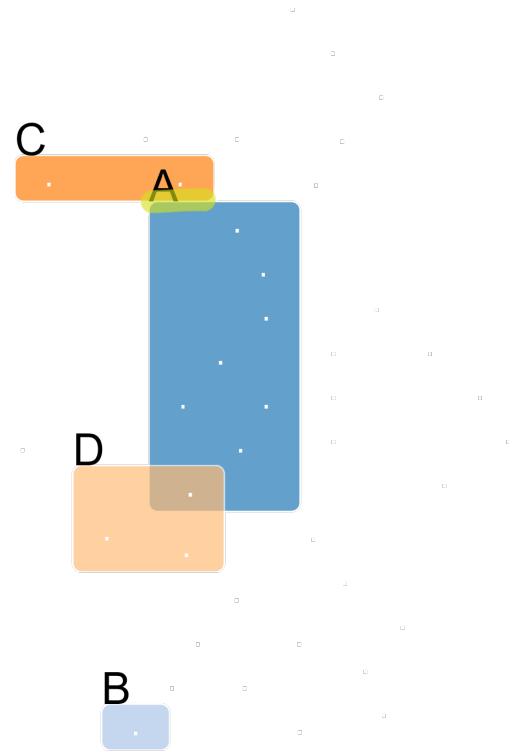
BubbleSets (without graph)



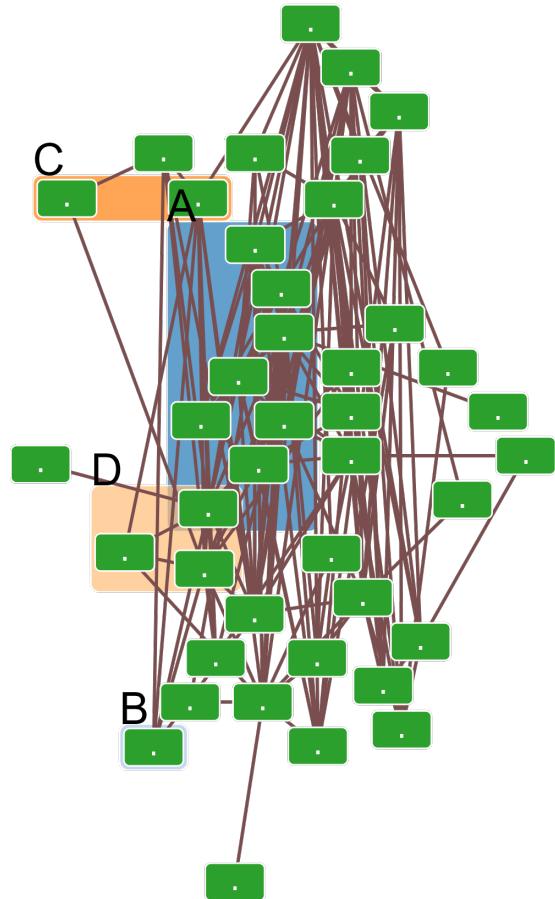
BubbleSets (with graph)



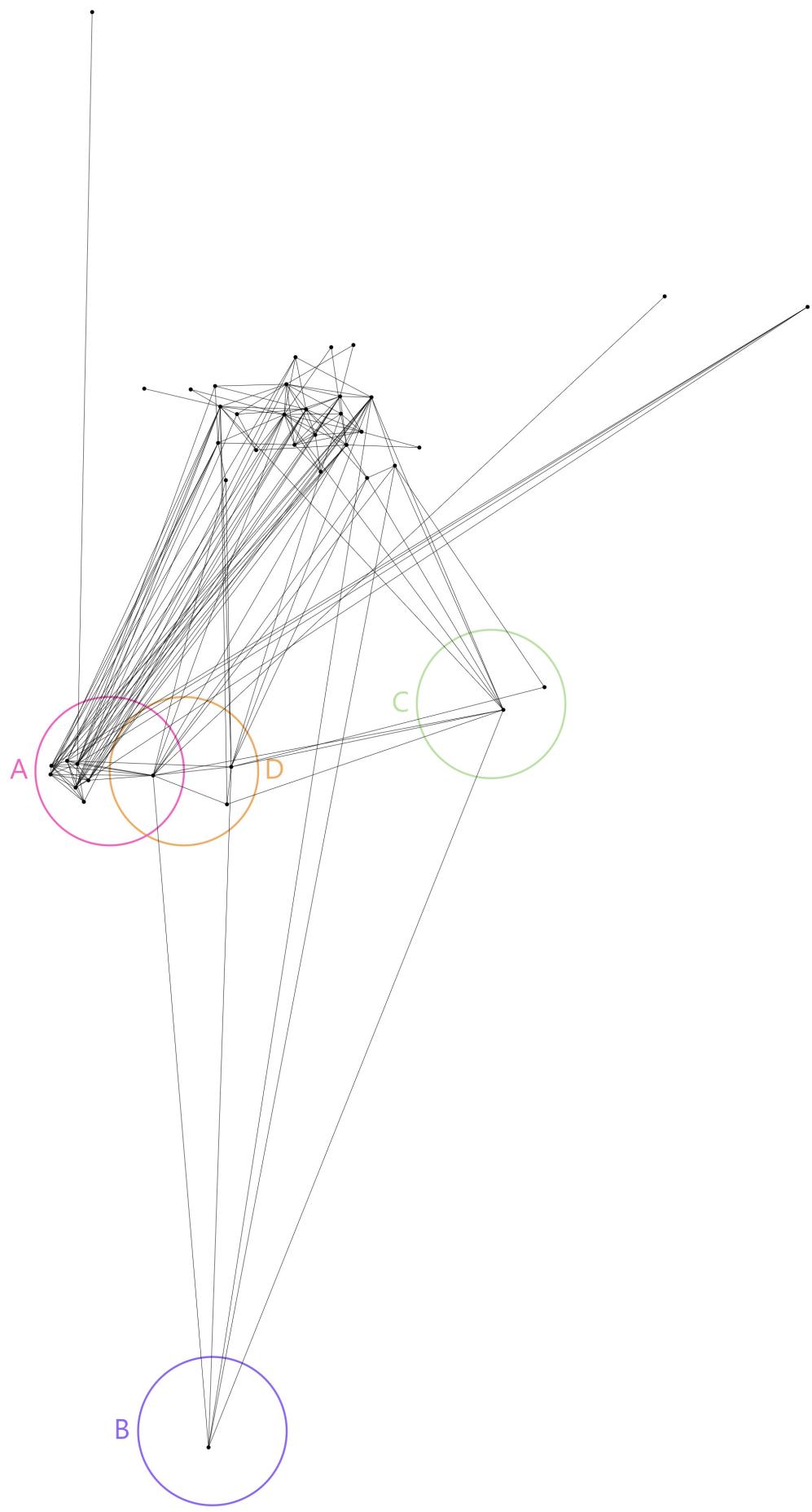
WebCola (without graph)



WebCola (with graph)



GroupNet

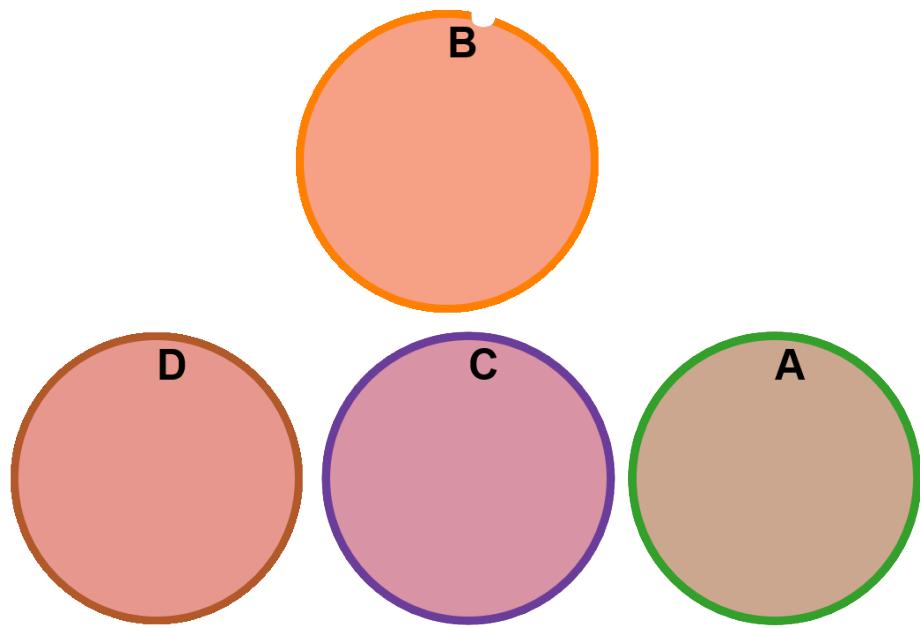


4-set data set 3 : SNAP ID: 31246395

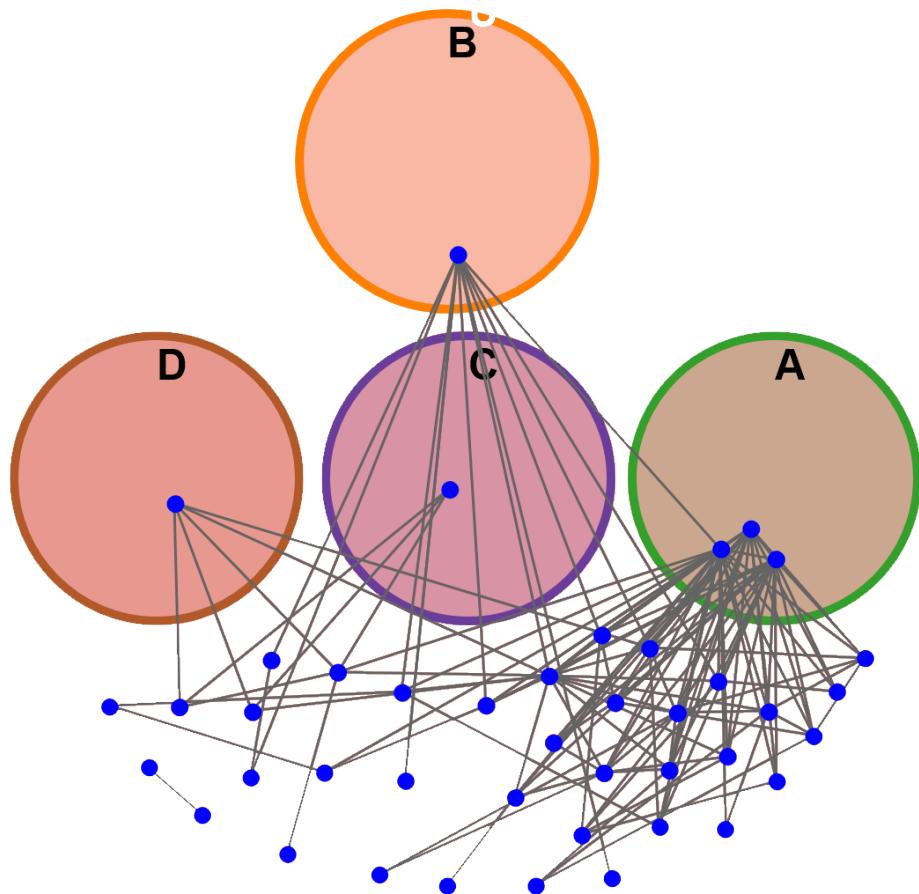
Number of Sets: 4
 Number of Zones: 5
 Number of Nodes: 43
 Number of Edges: 132
 Zones high: no
 Nodes high: yes
 Edges high: no

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	43	7	241	5
Vertex-vertex intersections	1	0	0	0
Vertices in incorrect zones	0	0	0	0
Omitted zones	0	0	0	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	0	0	0
Concurrent curves	0	0	0	0
Triple points	0	0	0	0
Non-circles	0	4	4	0
Extra zones	0	0	0	0
Edge crossings	1018	492	1003	1377
Extra edge-curve crossings	13	28	42	46
Runtime (in sec)	2.32	0.503	7.183	7.476

SetNet (without graph)

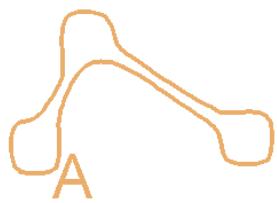


SetNet (with graph)



BubbleSets (without graph)

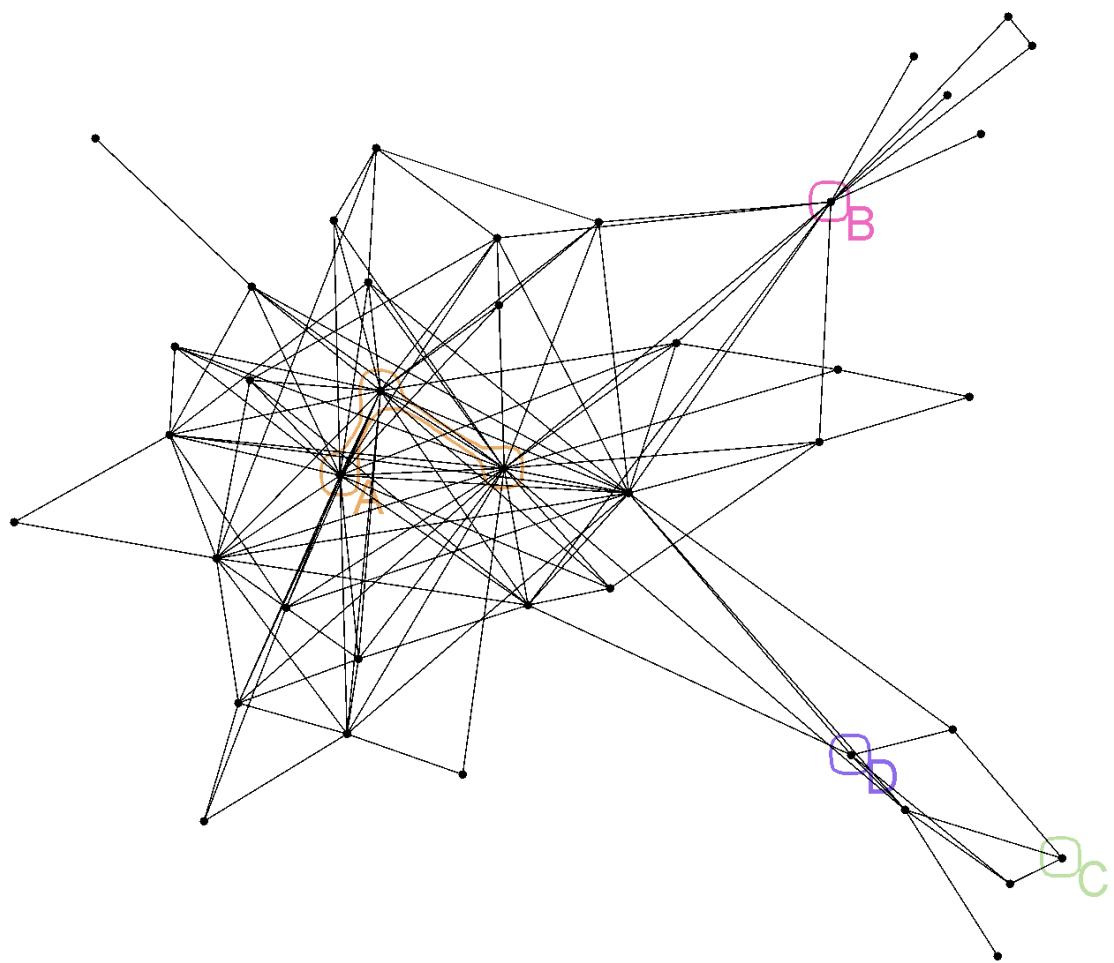
□_B



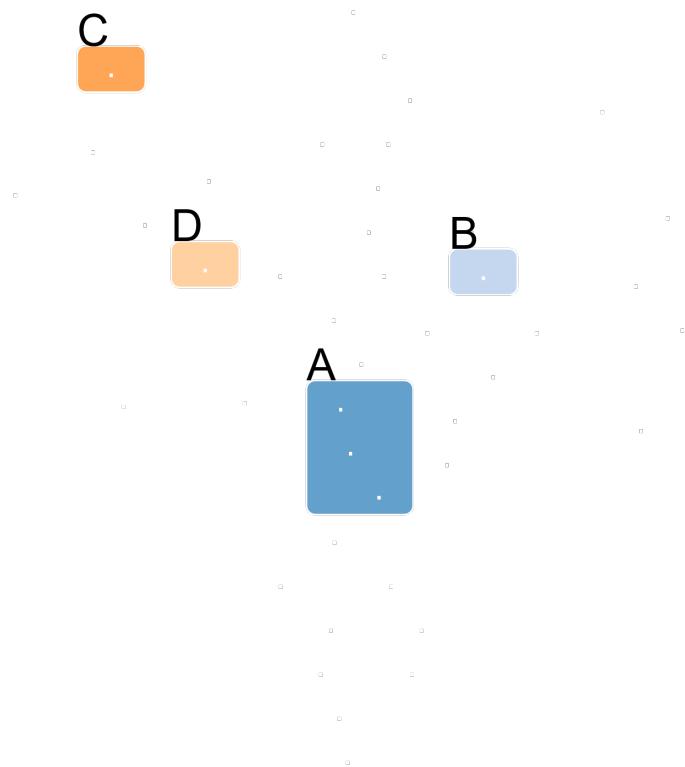
□_D

□_C

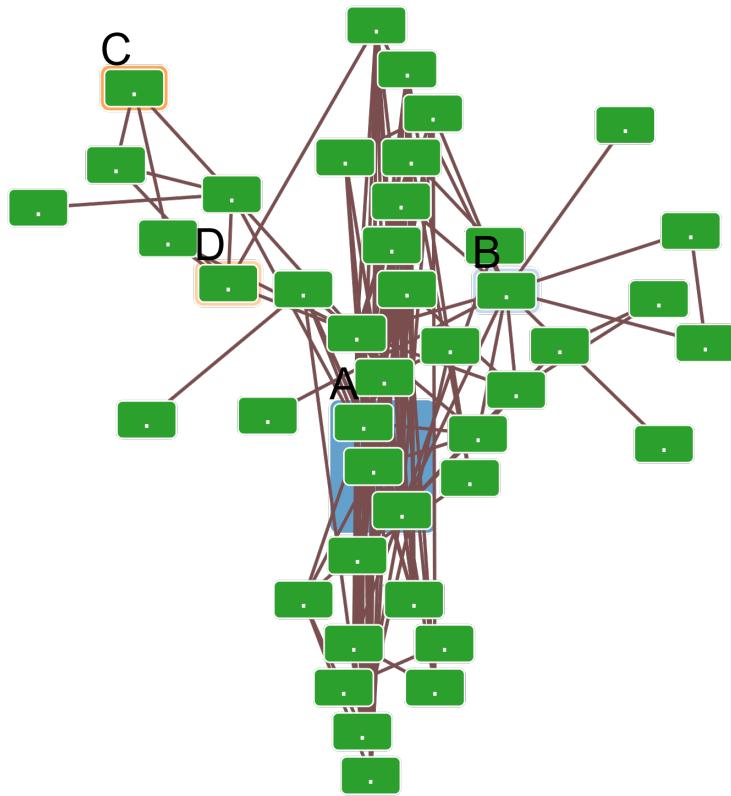
BubbleSets (with graph)



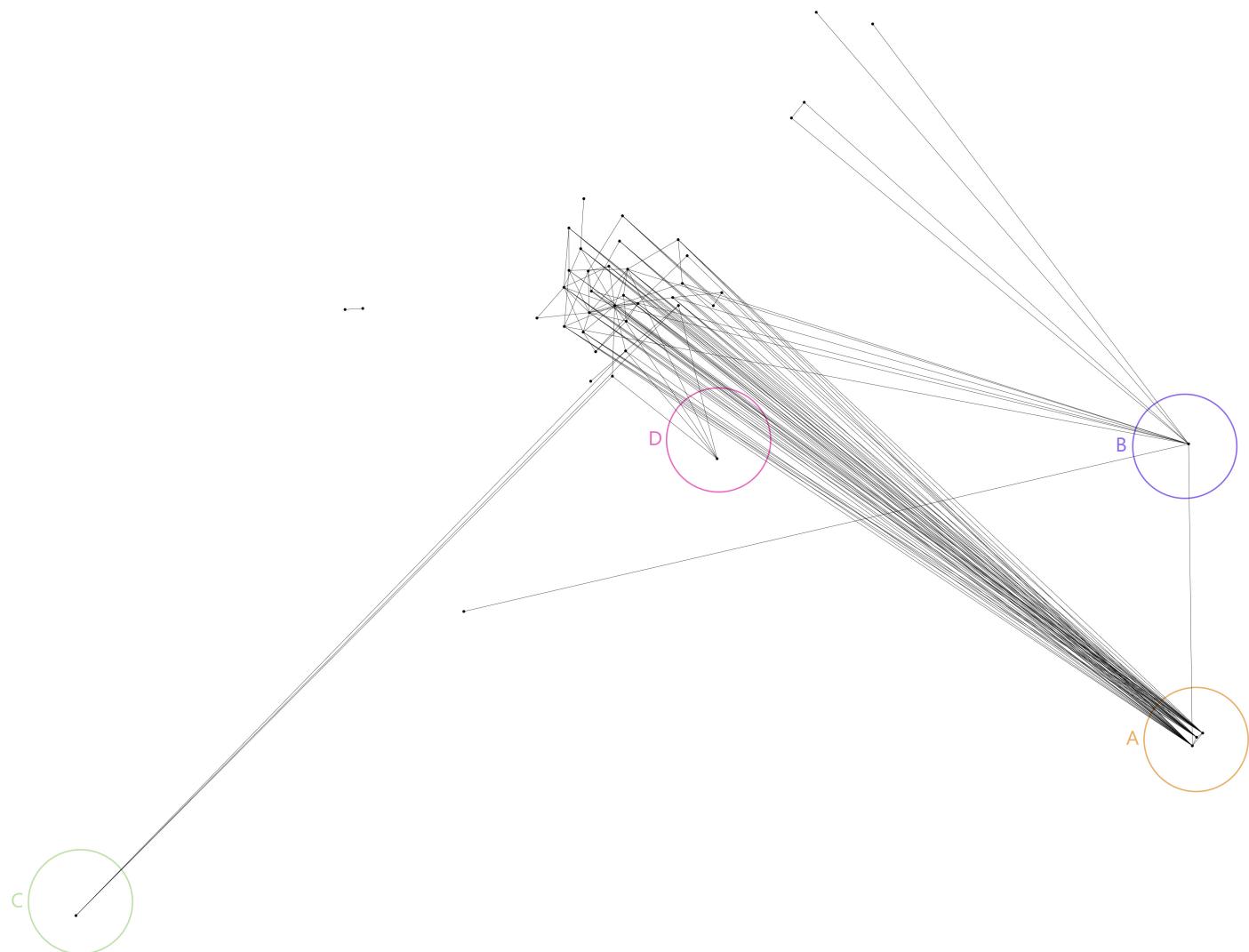
WebCola (without graph)



WebCola (with graph)



GroupNet

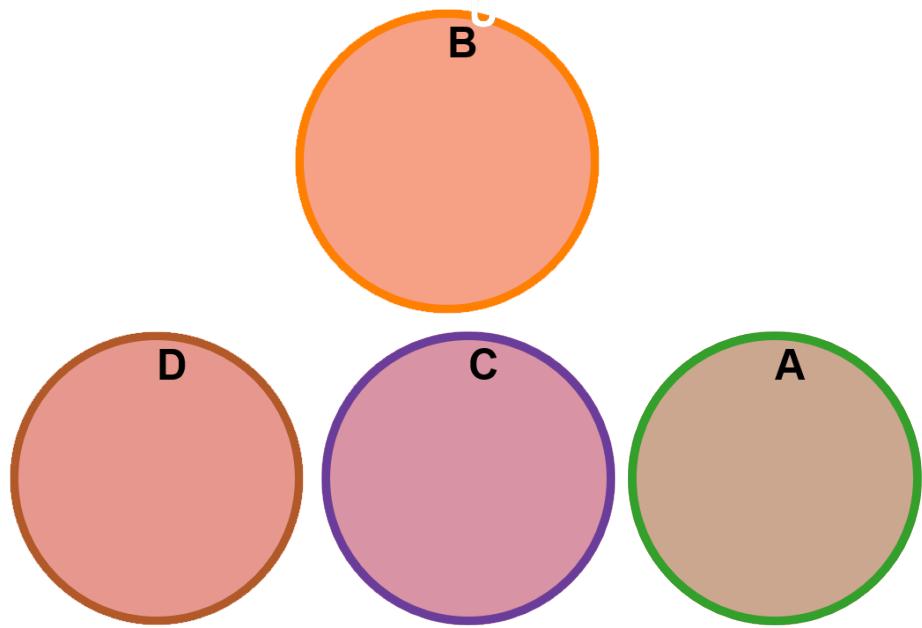


4-set data set 4 : SNAP ID: 15481789

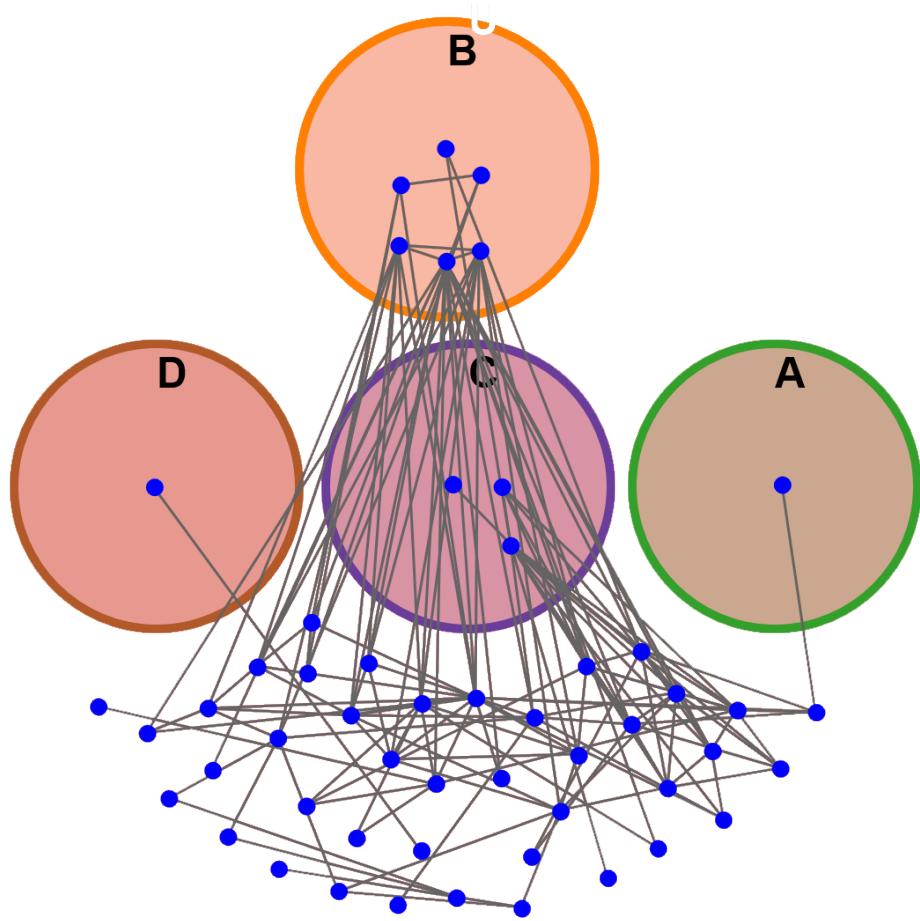
Number of Sets: 4
 Number of Zones: 5
 Number of Nodes: 52
 Number of Edges: 145
 Zones high: no
 Nodes high: yes
 Edges high: yes

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	49	4	140	10
Vertex-vertex intersections	0	0	0	0
Vertices in incorrect zones	0	0	0	0
Omitted zones	0	0	0	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	2	0	0
Concurrent curves	0	0	1	0
Triple points	0	0	0	0
Non-circles	0	4	4	0
Extra zones	0	1	0	0
Edge crossings	821	335	693	1205
Extra edge-curve crossings	39	96	106	96
Runtime (in sec)	3.016	0.718	7.506	9.334

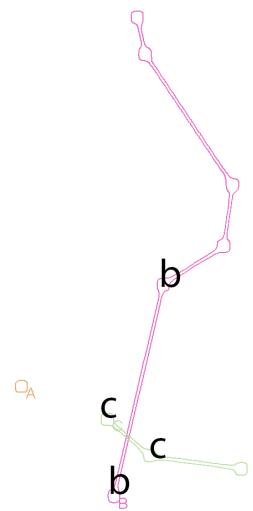
SetNet (without graph)



SetNet (with graph)

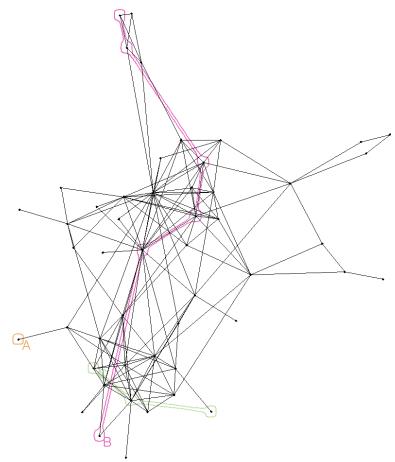


BubbleSets (without graph)



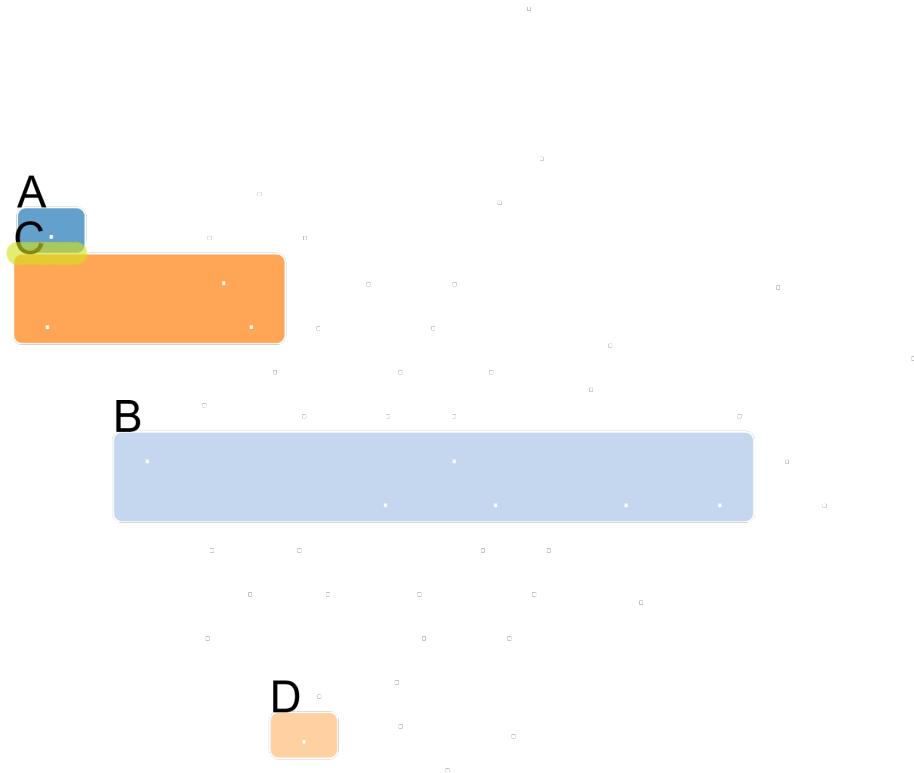
Q_B

BubbleSets (with graph)

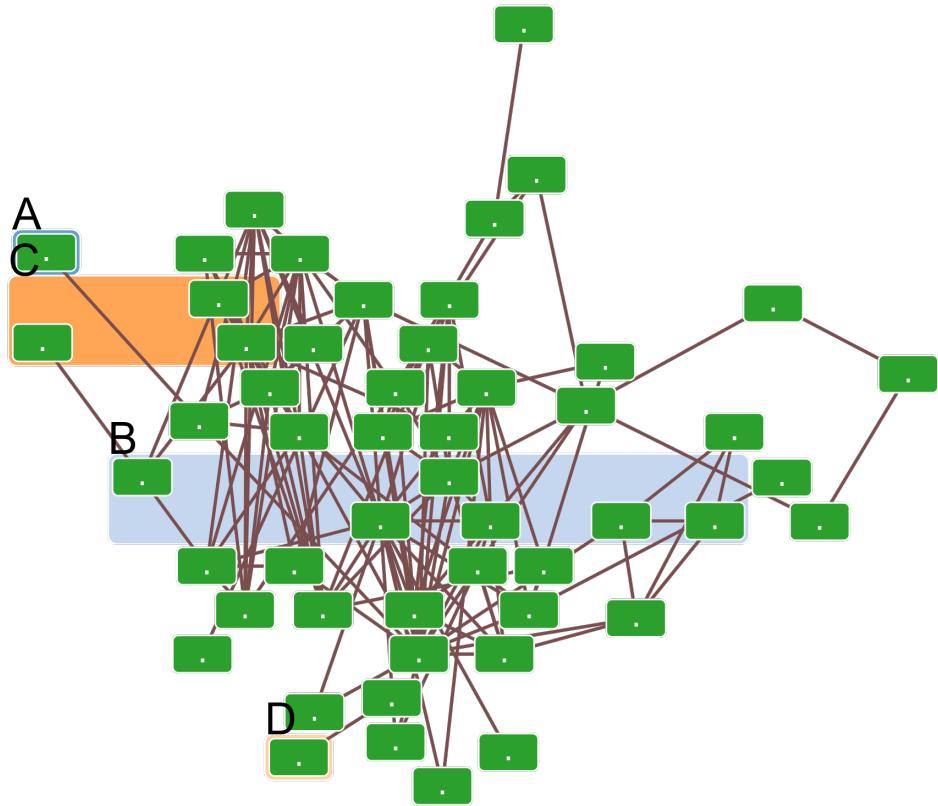


G_b

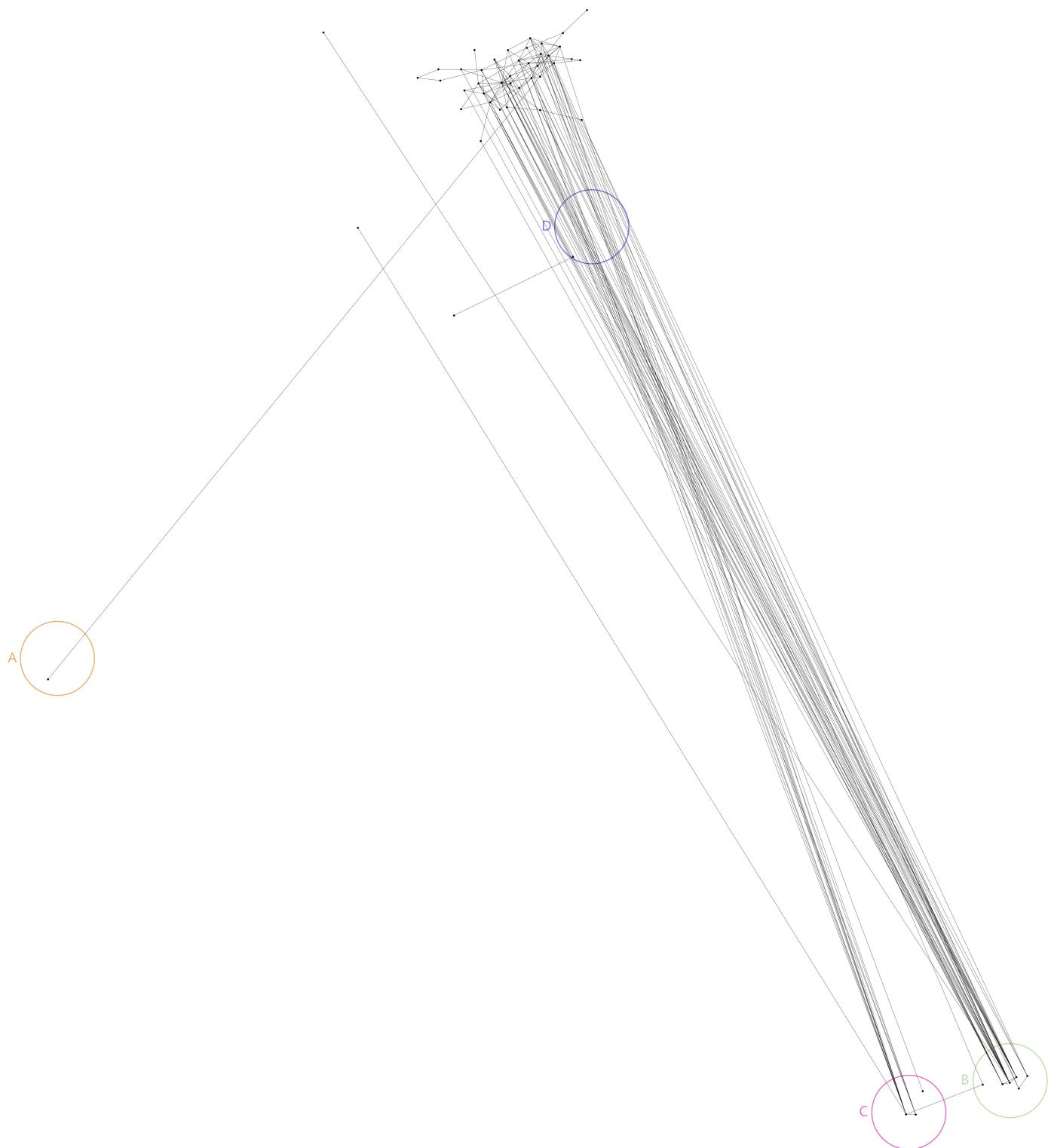
WebCola (without graph)



WebCola (with graph)



GroupNet

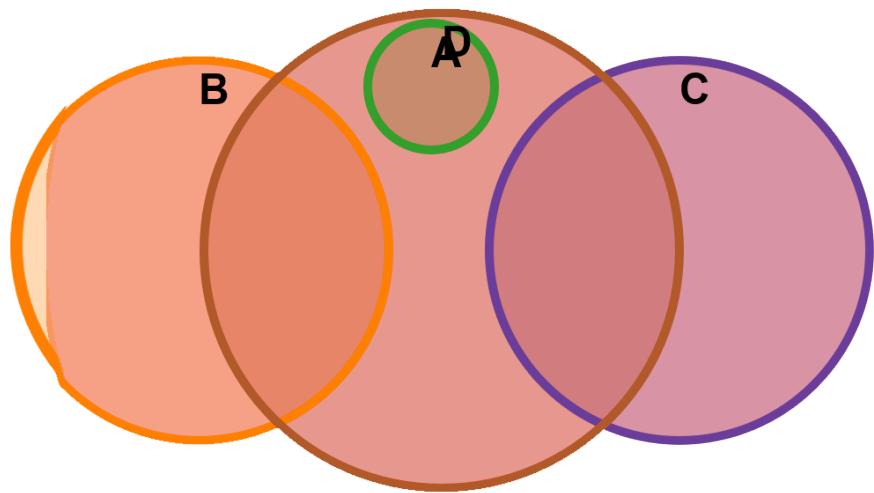


4-set data set 5 : SNAP ID: 428333

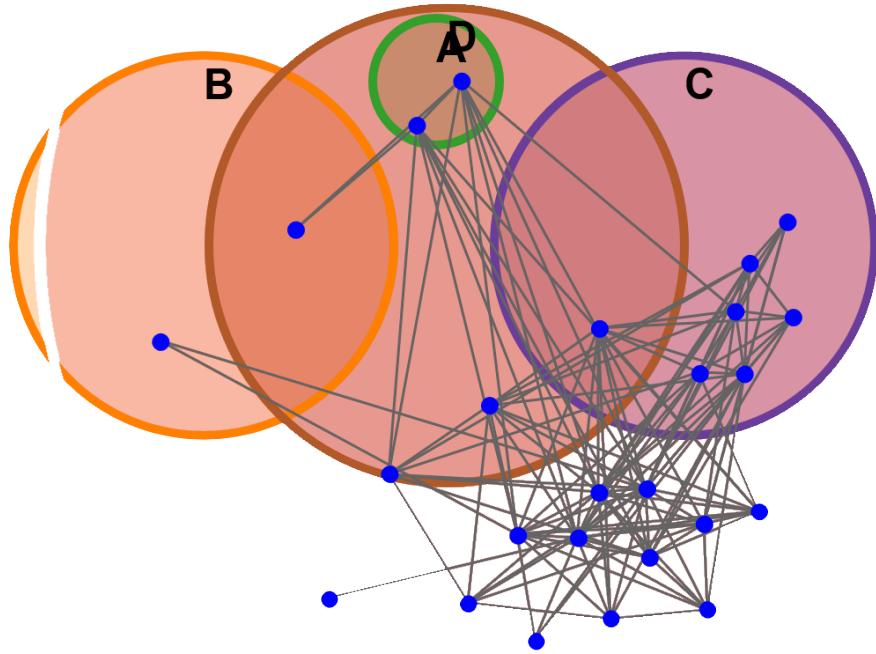
Number of Sets: 4
 Number of Zones: 7
 Number of Nodes: 25
 Number of Edges: 125
 Zones high: yes
 Nodes high: no
 Edges high: no

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	29	4	196	5
Vertex-vertex intersections	0	0	1	0
Vertices in incorrect zones	1	0	1	0
Omitted zones	0	0	0	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	1	1	0
Concurrent curves	0	1	4	0
Triple points	0	0	0	0
Non-circles	0	4	4	0
Extra zones	0	0	0	0
Edge crossings	953	733	1199	1356
Extra edge-curve crossings	13	99	217	0
Runtime (in sec)	1.863	0.513	2.881	7.198

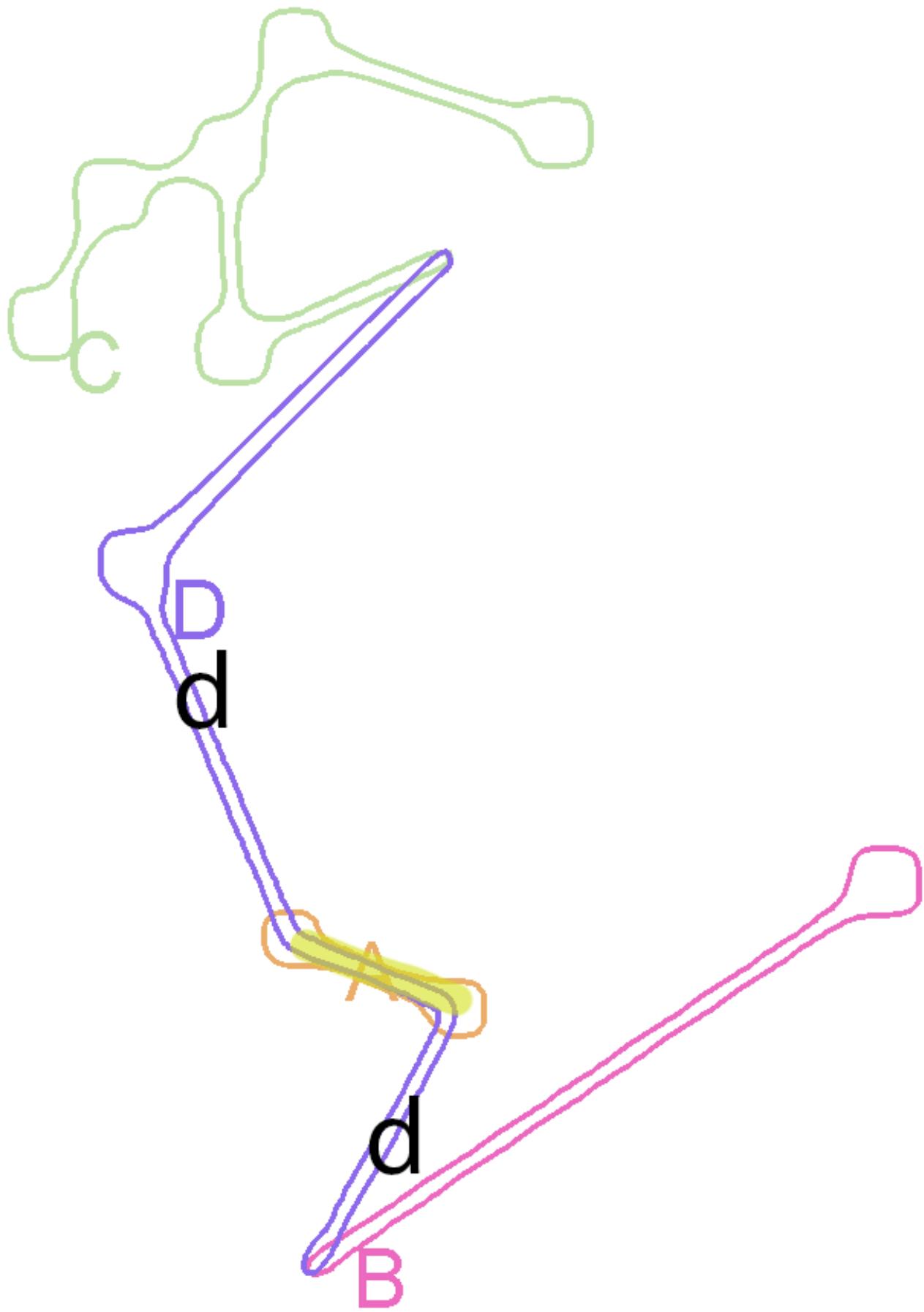
SetNet (without graph)



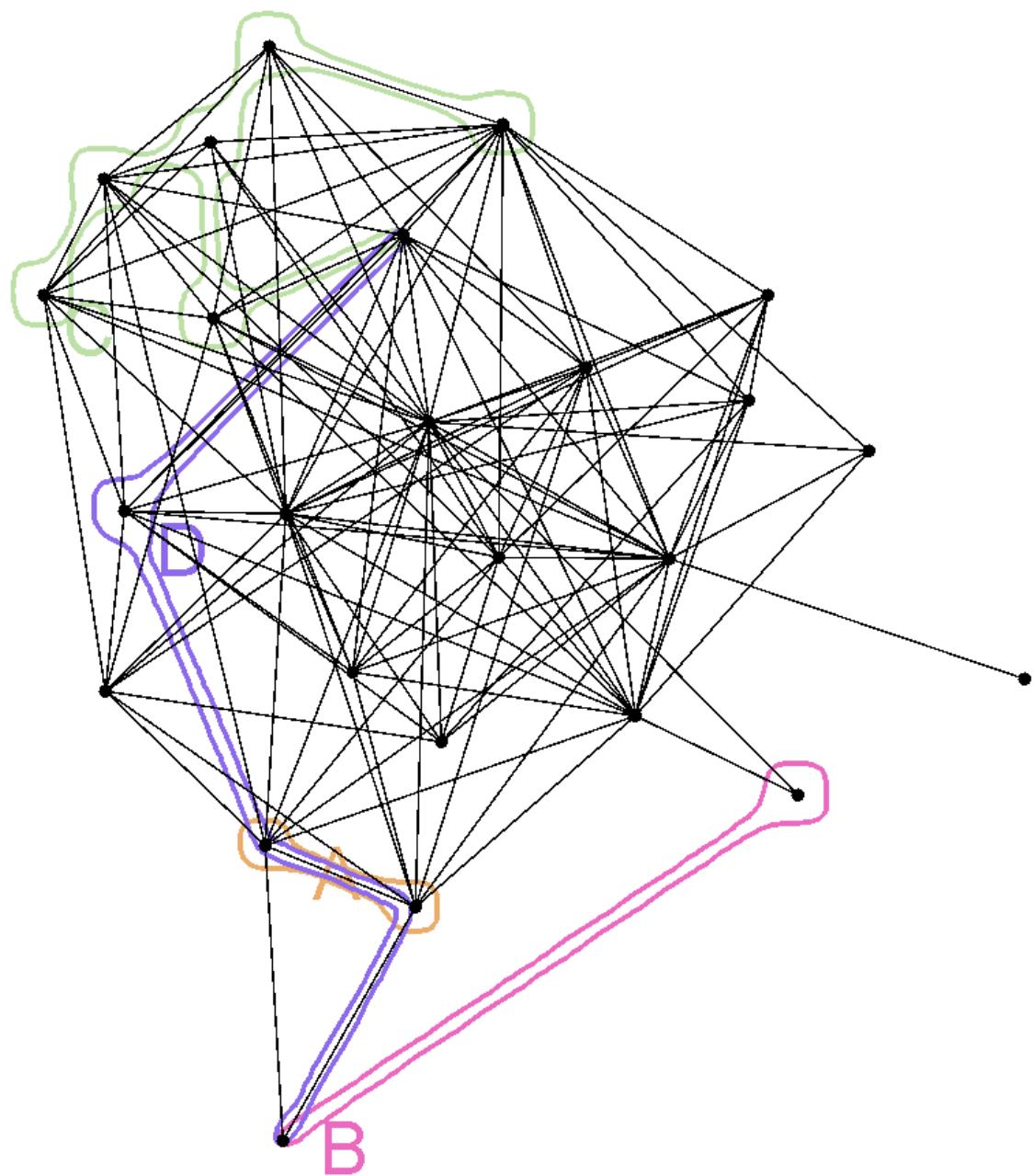
SetNet (with graph)



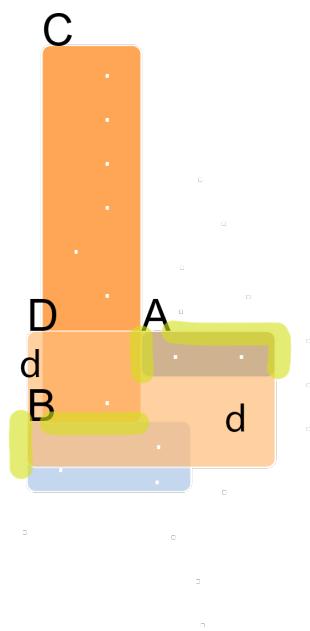
BubbleSets (without graph)



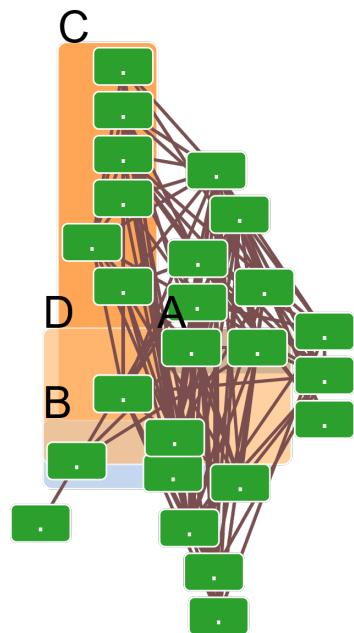
BubbleSets (with graph)



WebCola (without graph)



WebCola (with graph)



GroupNet

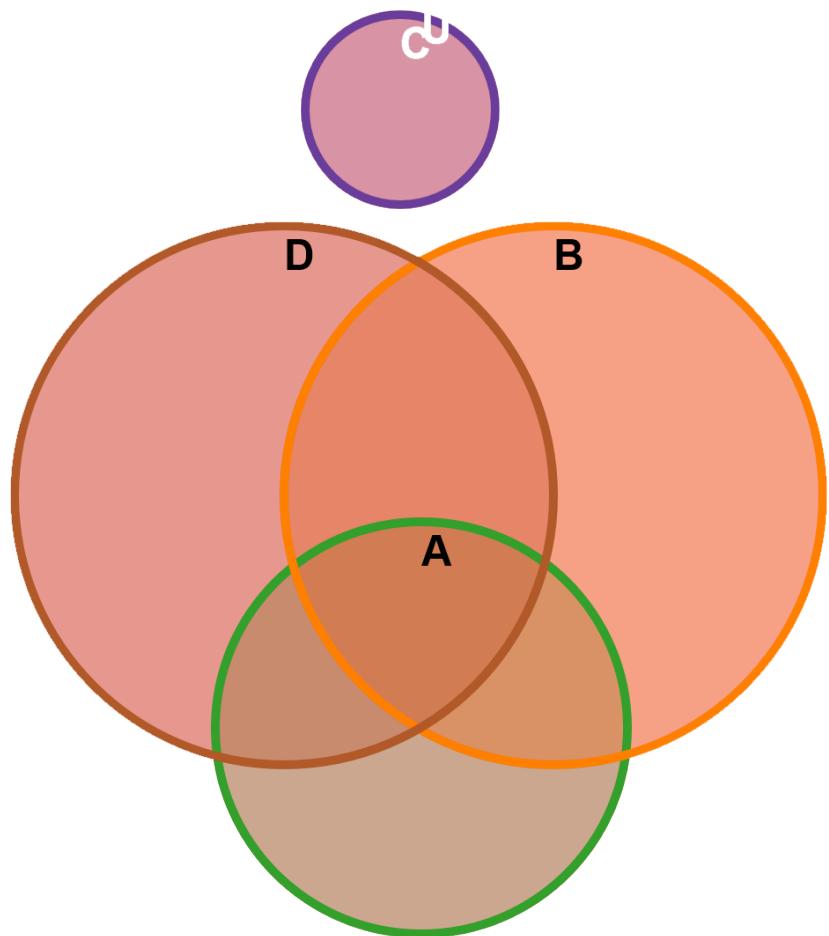


4-set data set 6 : SNAP ID: 259884200

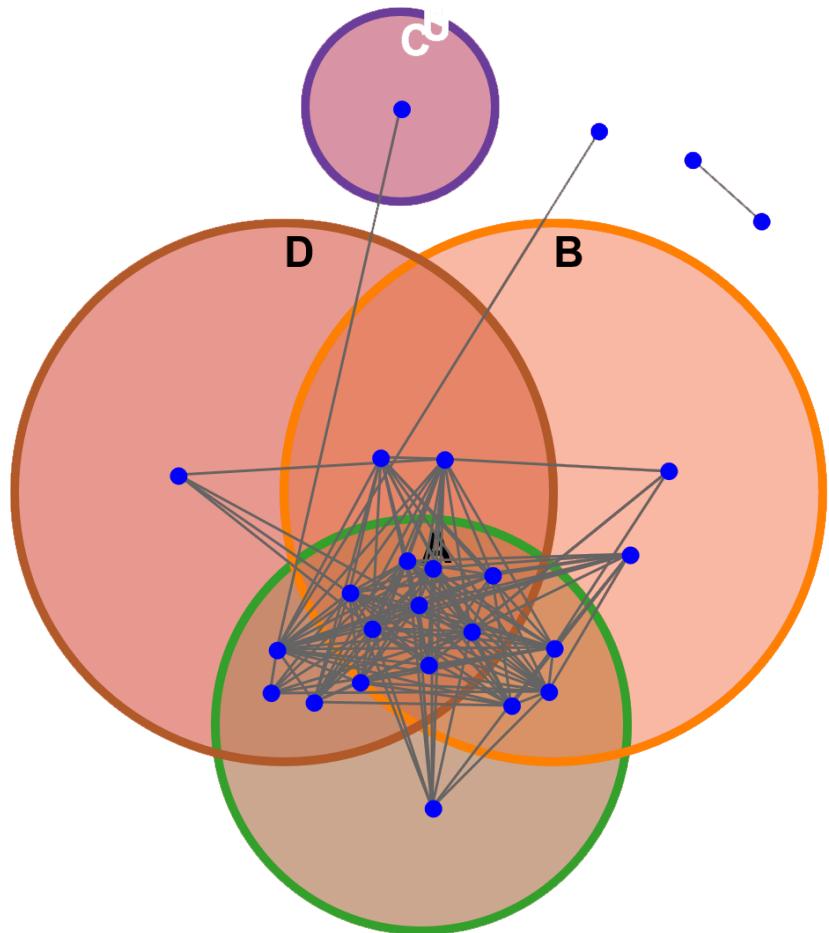
Number of Sets: 4
 Number of Zones: 9
 Number of Nodes: 25
 Number of Edges: 145
 Zones high: yes
 Nodes high: no
 Edges high: yes

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	49	7	229	21
Vertex-vertex intersections	0	0	23	0
Vertices in incorrect zones	1	0	8	0
Omitted zones	0	0	2	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	9	0	0
Concurrent curves	0	3	4	0
Triple points	0	4	2	0
Non-circles	0	4	4	0
Extra zones	0	0	0	0
Edge crossings	1662	1388	1590	1624
Extra edge-curve crossings	11	914	40	6
Runtime (in sec)	2.057	0.874	6.791	4.461

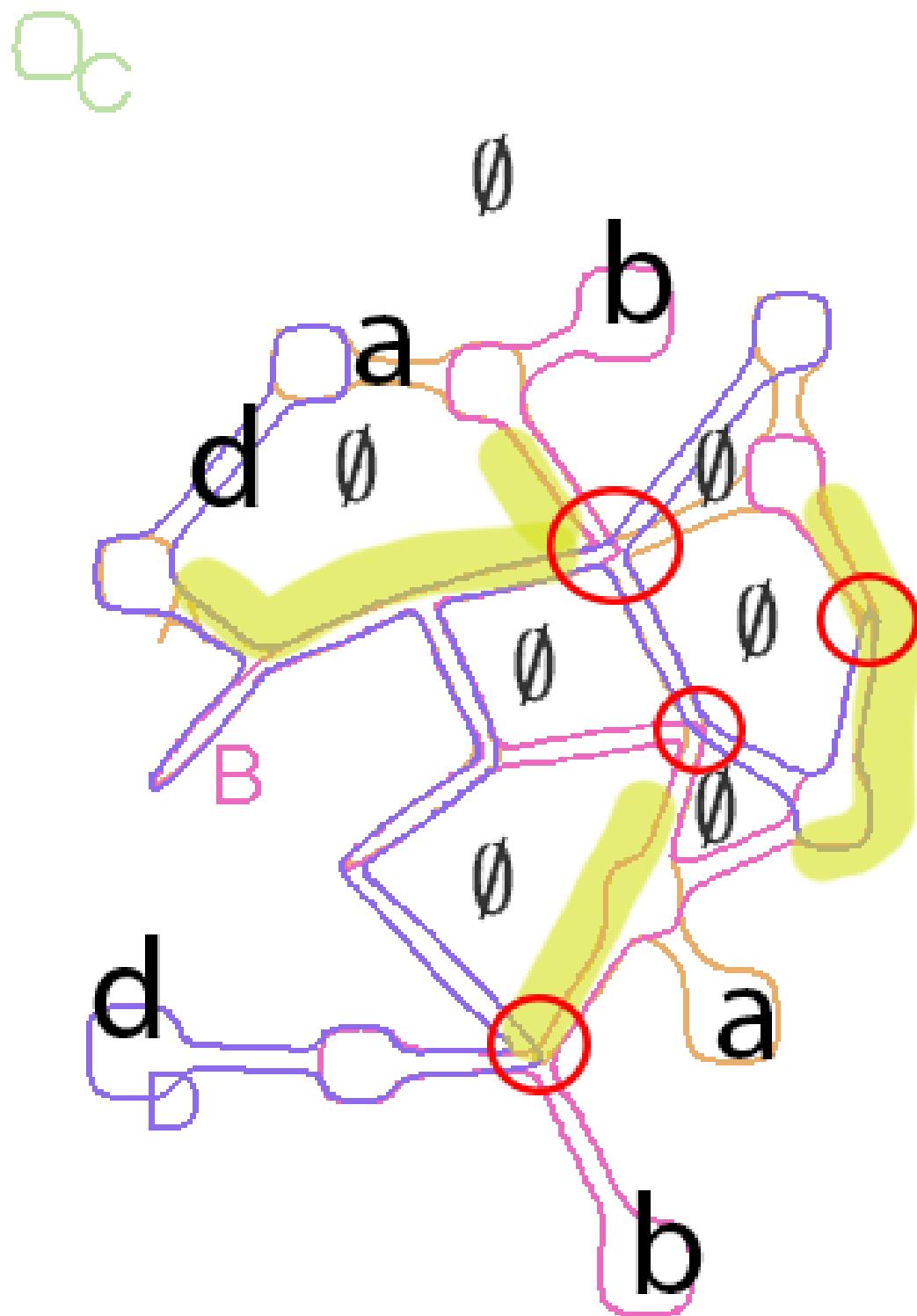
SetNet (without graph)



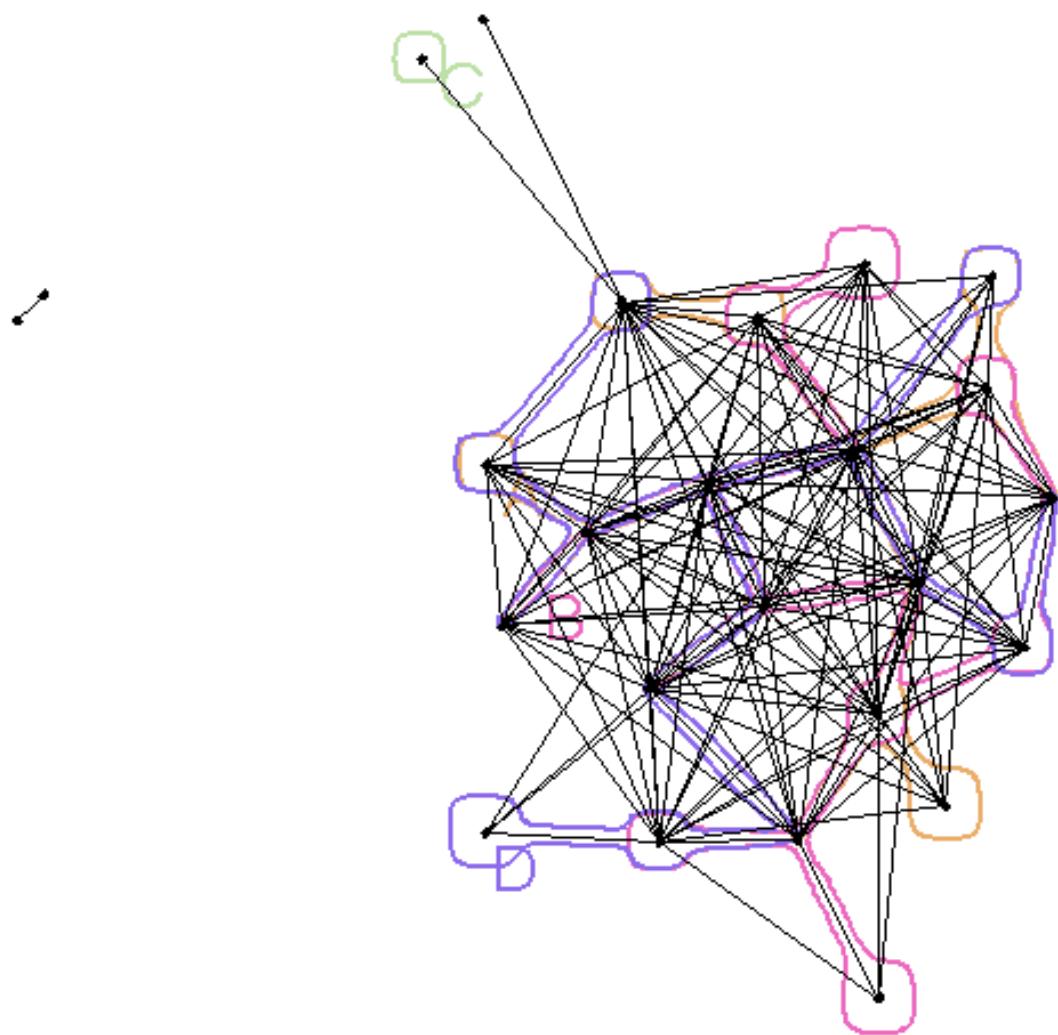
SetNet (with graph)



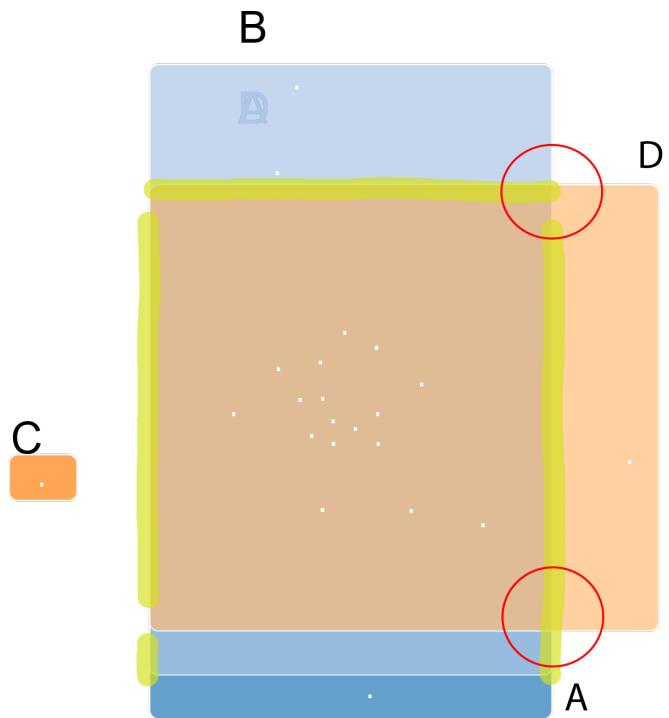
BubbleSets (without graph)



BubbleSets (with graph)

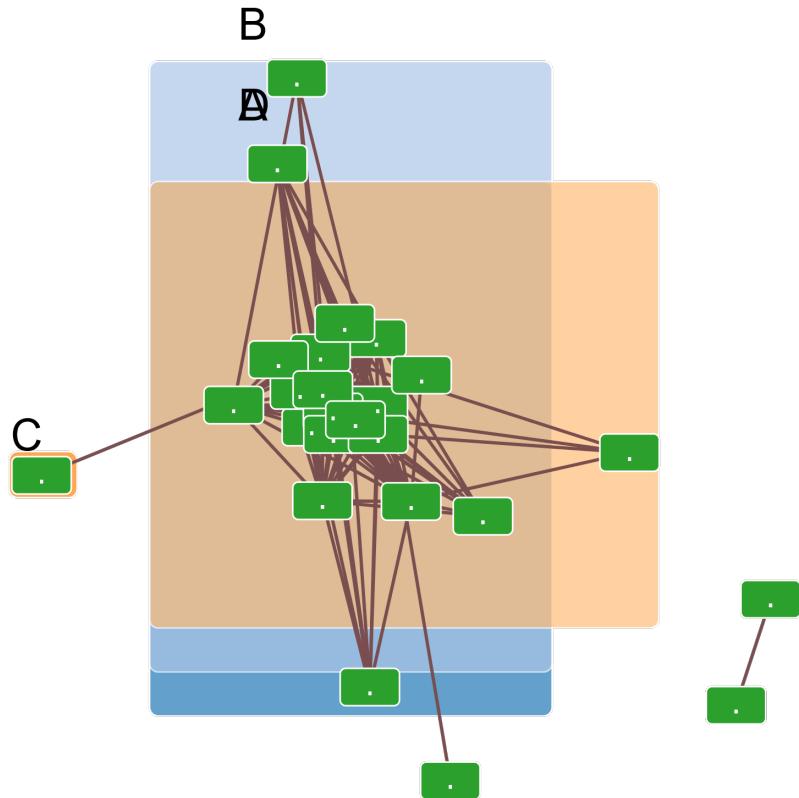


WebCola (without graph)

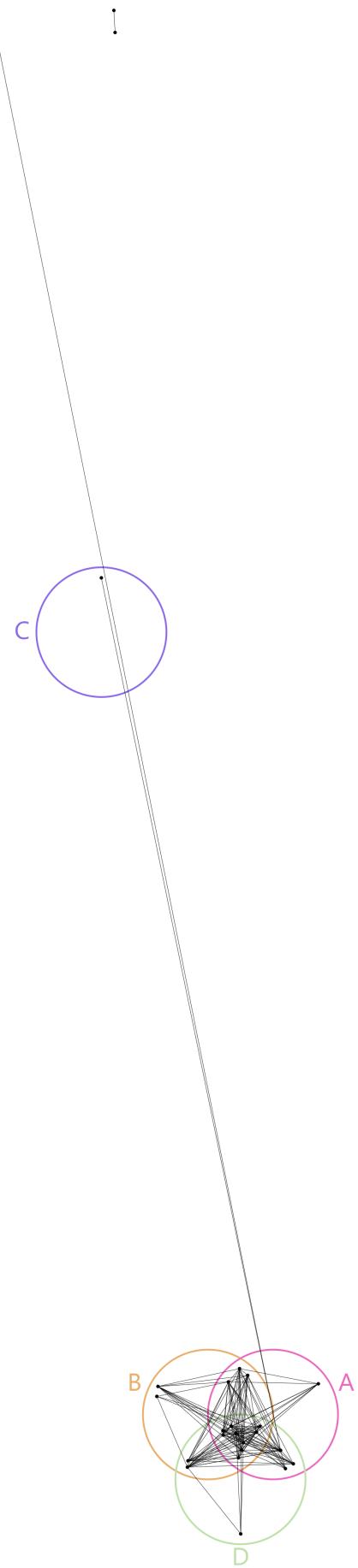


Omitted zones: AD, BD

WebCola (with graph)



GroupNet

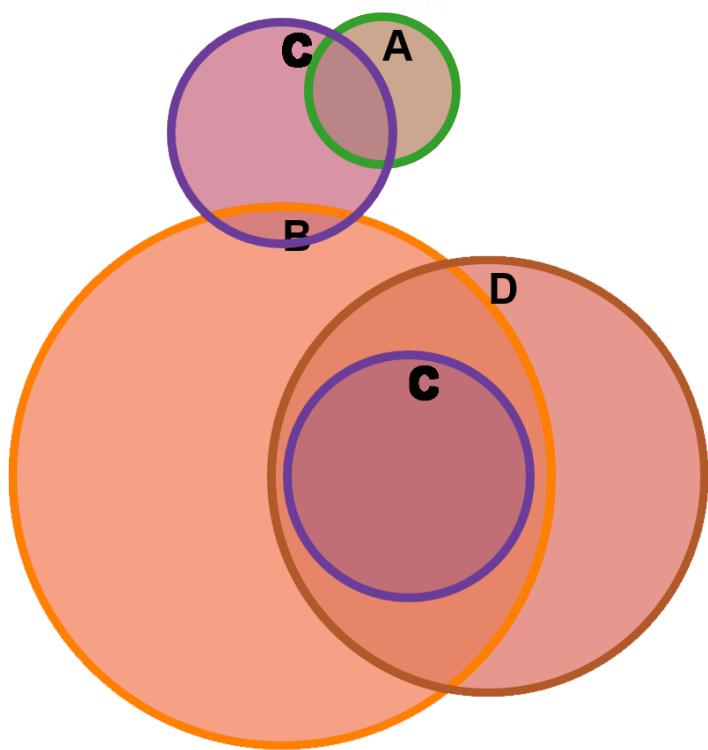


4-set data set 7 : SNAP ID: 1548841

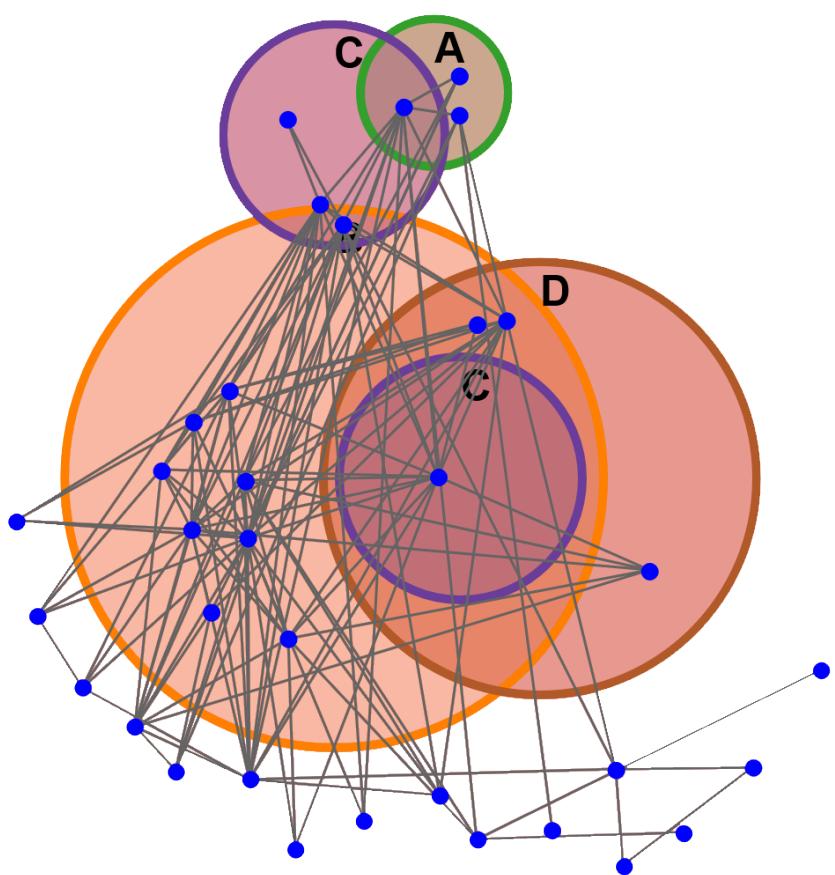
Number of Sets: 4
 Number of Zones: 9
 Number of Nodes: 36
 Number of Edges: 133
 Zones high: yes
 Nodes high: yes
 Edges high: no

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	33	8	168	21
Vertex-vertex intersections	2	0	3	0
Vertices in incorrect zones	0	1	2	0
Omitted zones	0	0	1	0
Ineffective properties				
Non-unique labels	1	0	0	0
Disconnected zones	0	12	0	0
Concurrent curves	0	1	1	0
Triple points	0	1	2	0
Non-circles	0	4	4	0
Extra zones	0	0	0	1
Edge crossings	1009	625	1003	1467
Extra edge-curve crossings	48	301	62	134
Runtime (in sec)	2.263	0.537	6.689	12.583

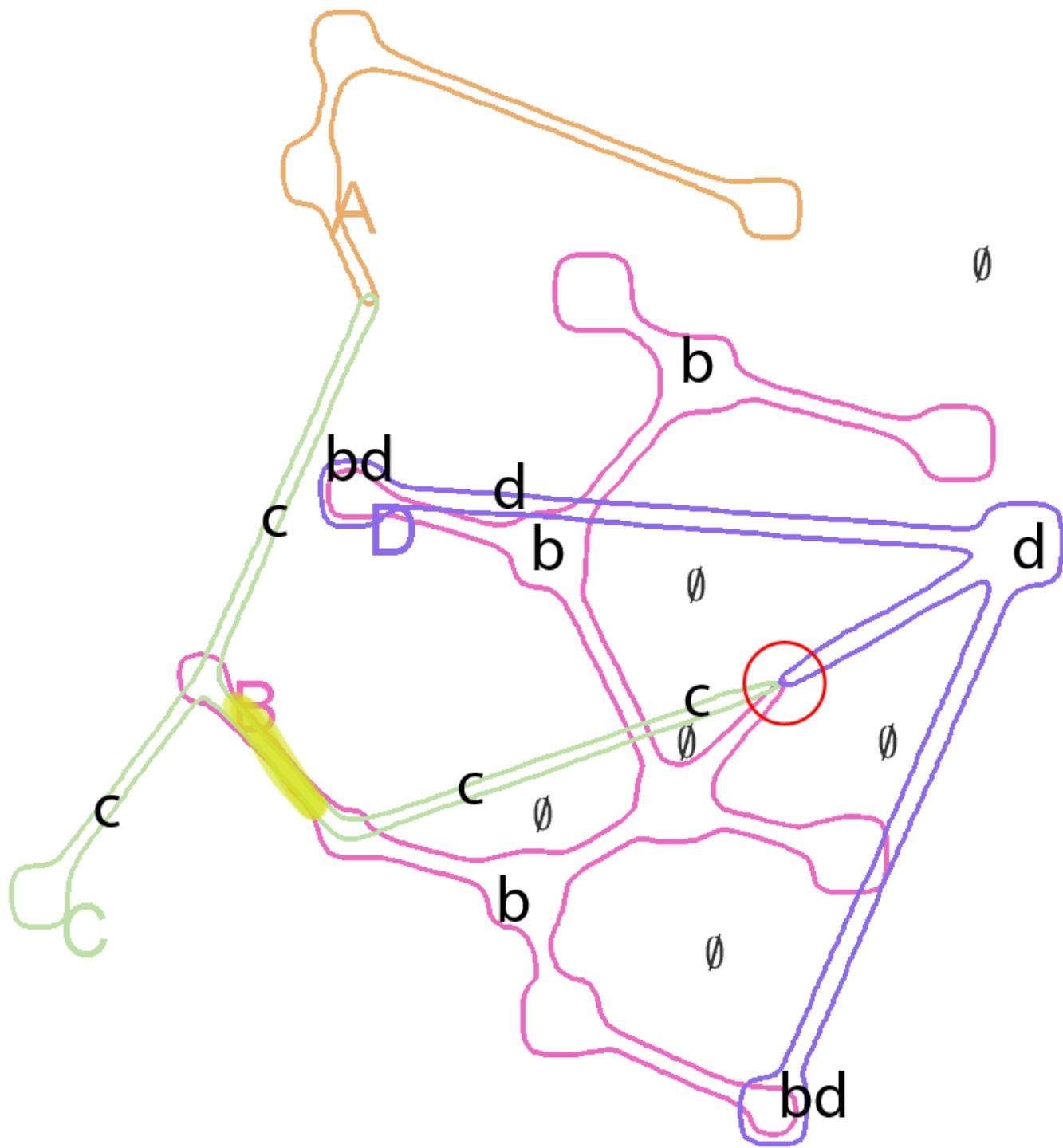
SetNet (without graph)



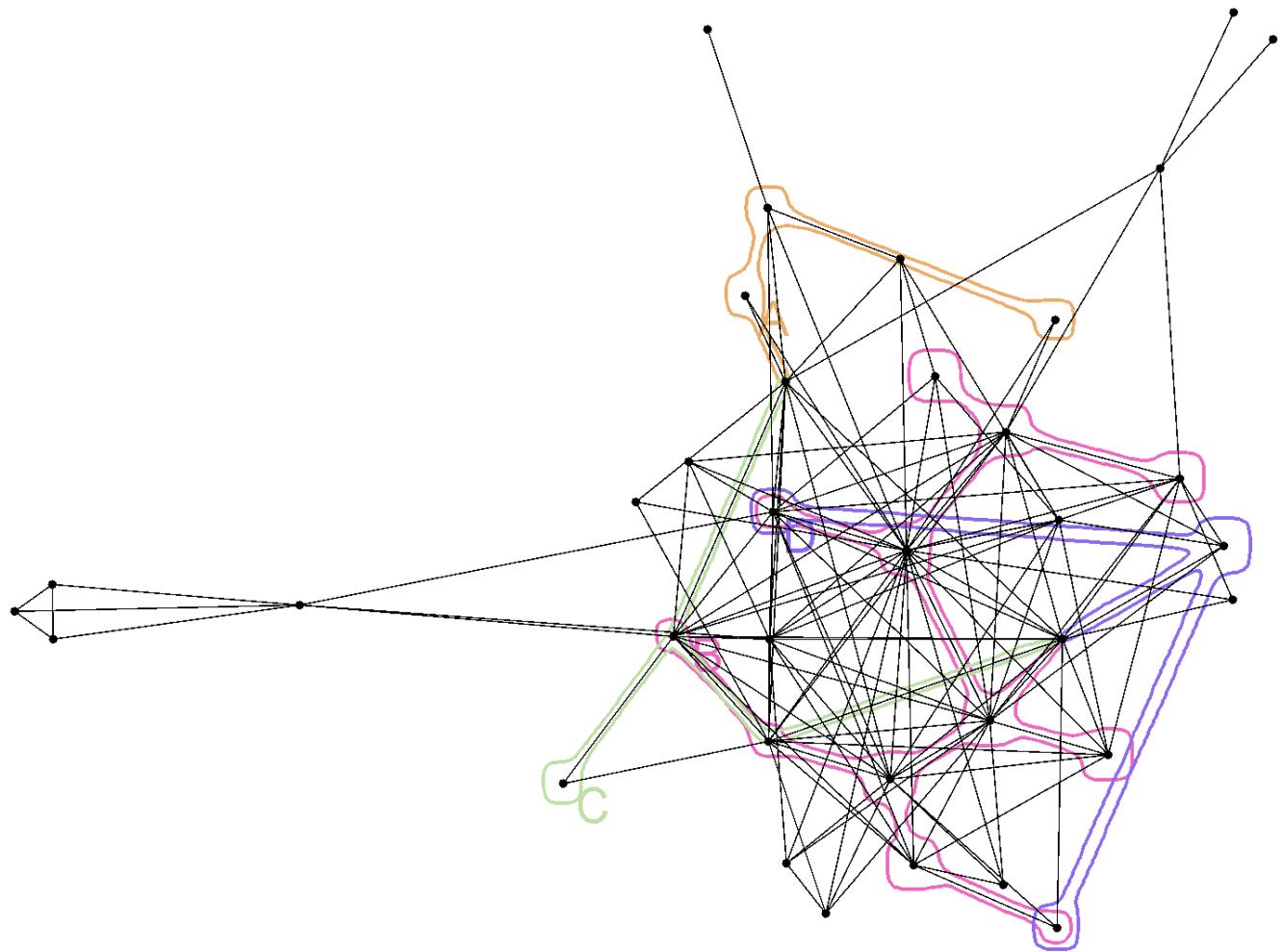
SetNet (with graph)



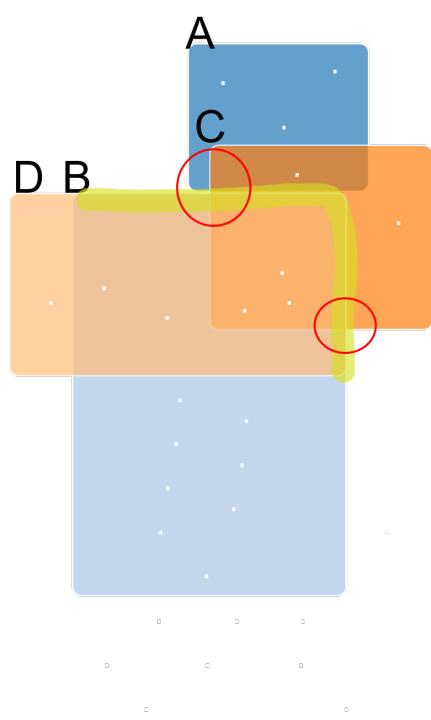
BubbleSets (without graph)



BubbleSets (with graph)

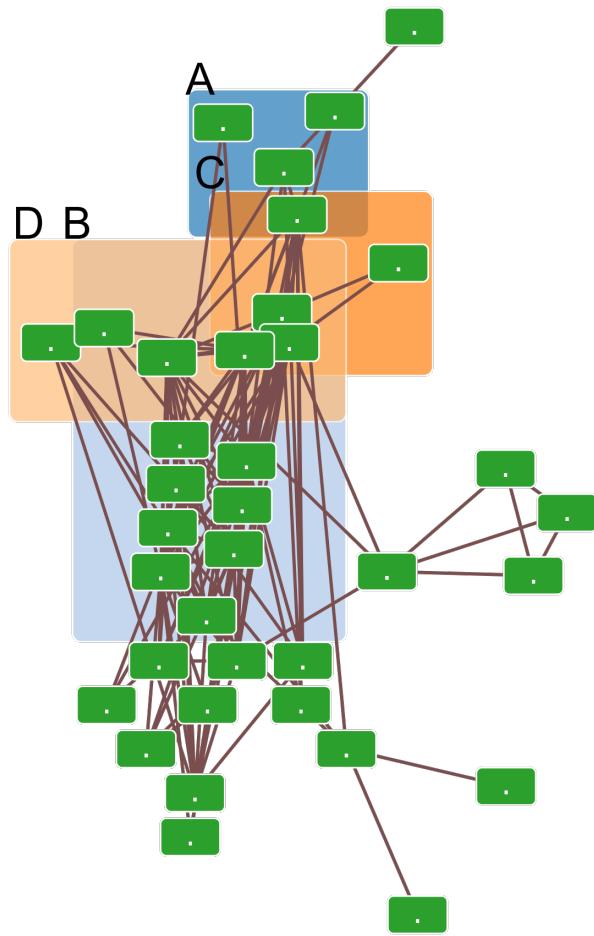


WebCola (without graph)

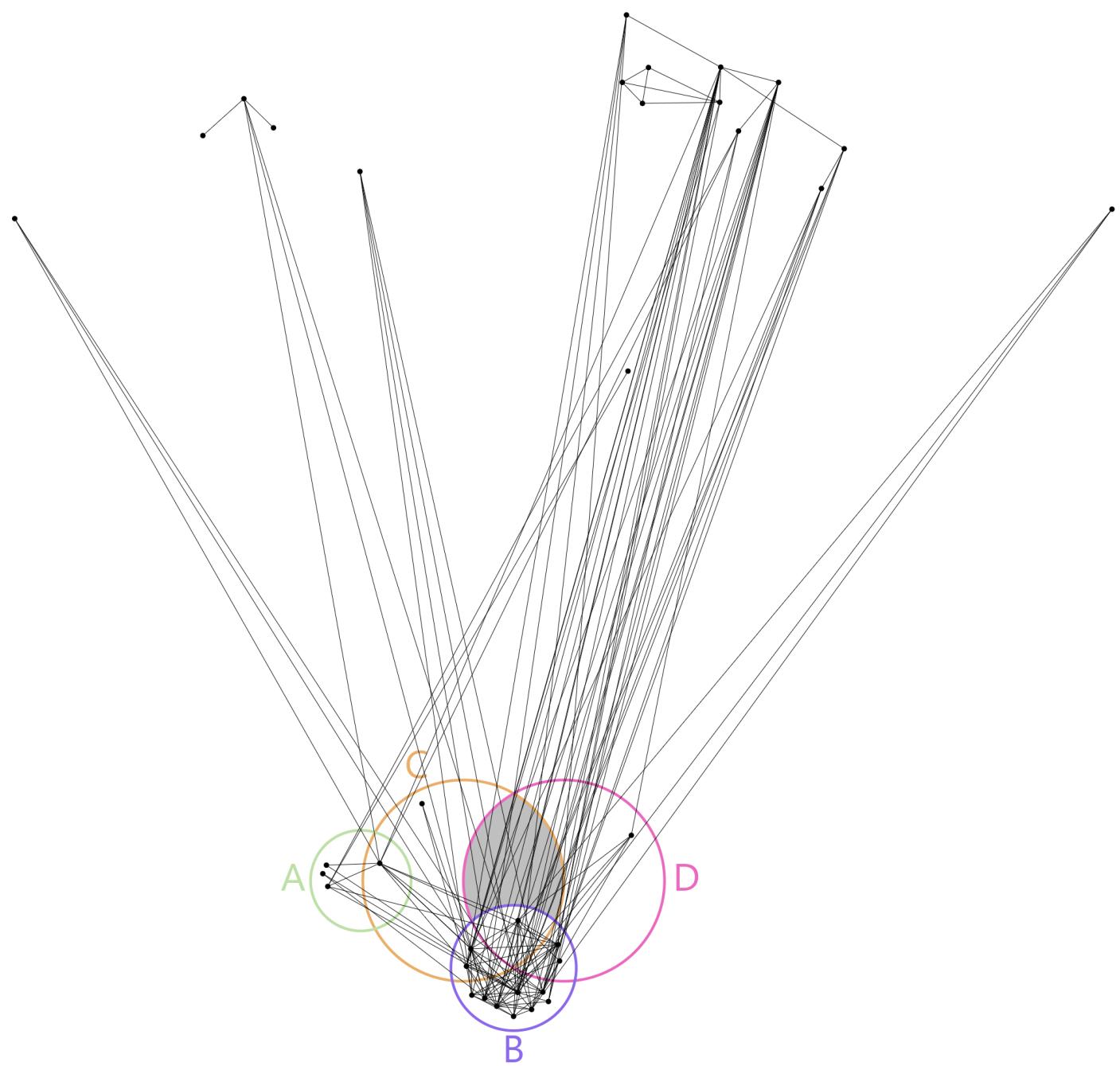


Omitted zones: BC

WebCola (with graph)



GroupNet

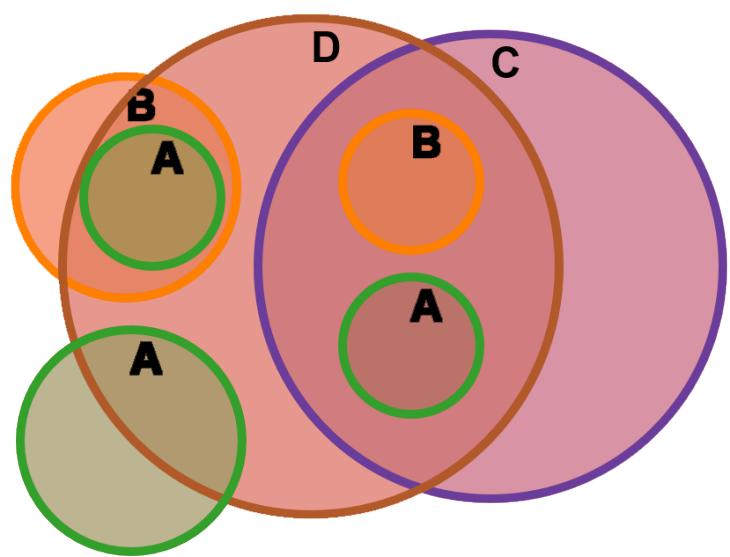


4-set data set 8 : SNAP ID: 232006900

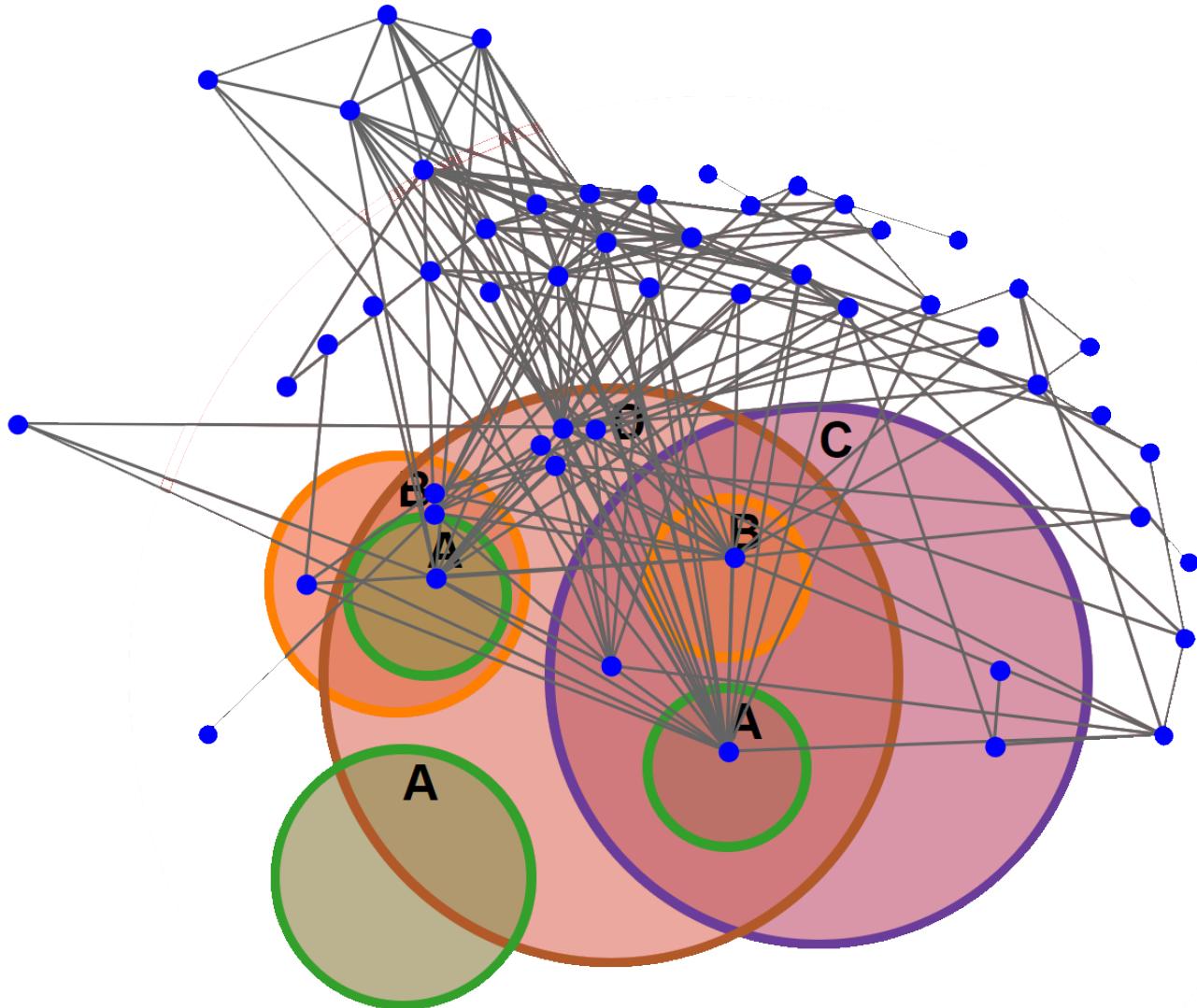
Number of Sets: 4
 Number of Zones: 11
 Number of Nodes: 53
 Number of Edges: 168
 Zones high: yes
 Nodes high: yes
 Edges high: yes

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	83	10	230	13
Vertex-vertex intersections	0	0	4	0
Vertices in incorrect zones	6	1	7	0
Omitted zones	0	0	2	0
Ineffective properties				
Non-unique labels	3	0	0	0
Disconnected zones	0	20	1	0
Concurrent curves	0	2	3	0
Triple points	0	3	4	0
Non-circles	0	4	4	1
Extra zones	0	0	1	5
Edge crossings	1623	661	1744	1737
Extra edge-curve crossings	64	232	275	178
Runtime (in sec)	3.813	0.543	7.33	78.305

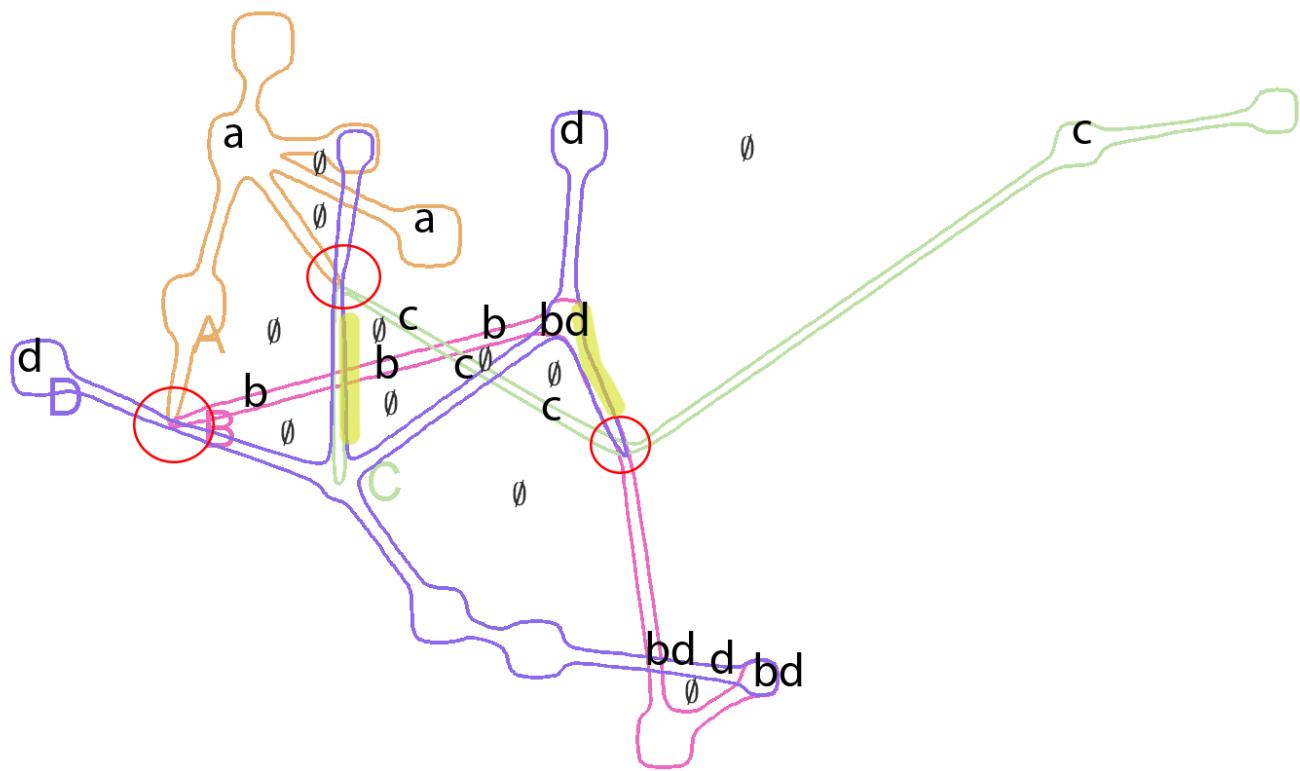
SetNet (without graph)



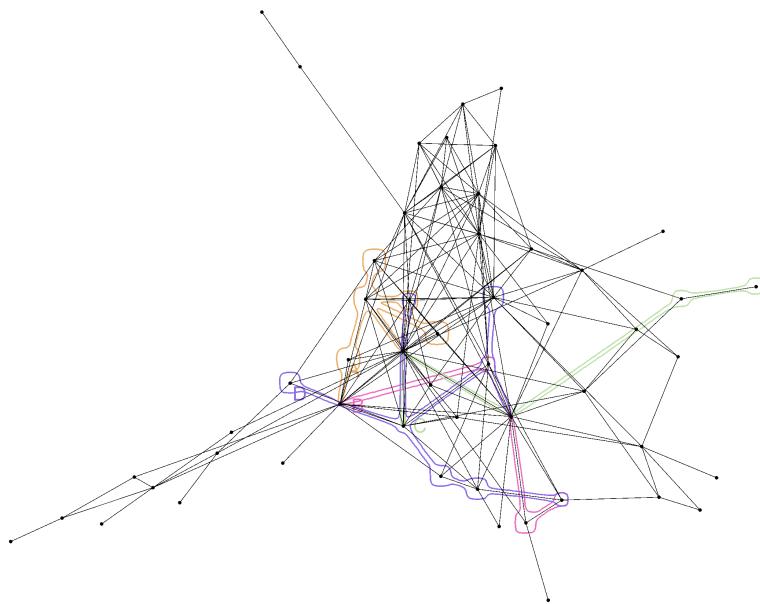
SetNet (with graph)



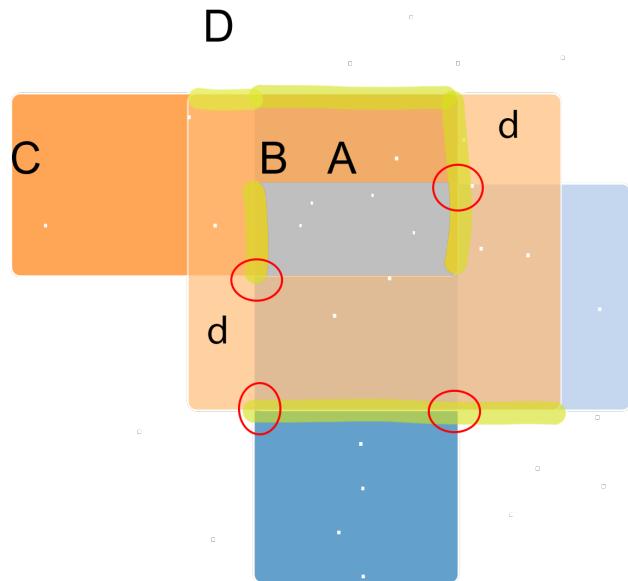
BubbleSets (without graph)



BubbleSets (with graph)

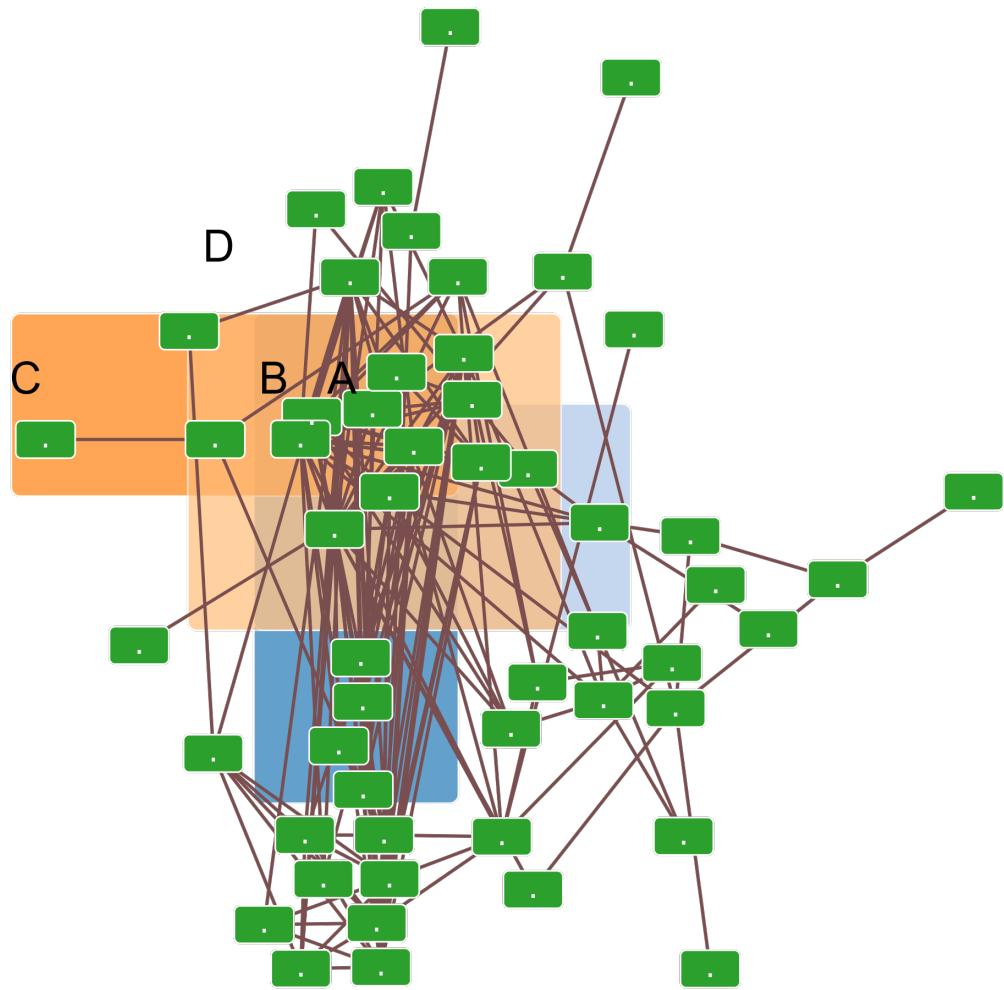


WebCola (without graph)

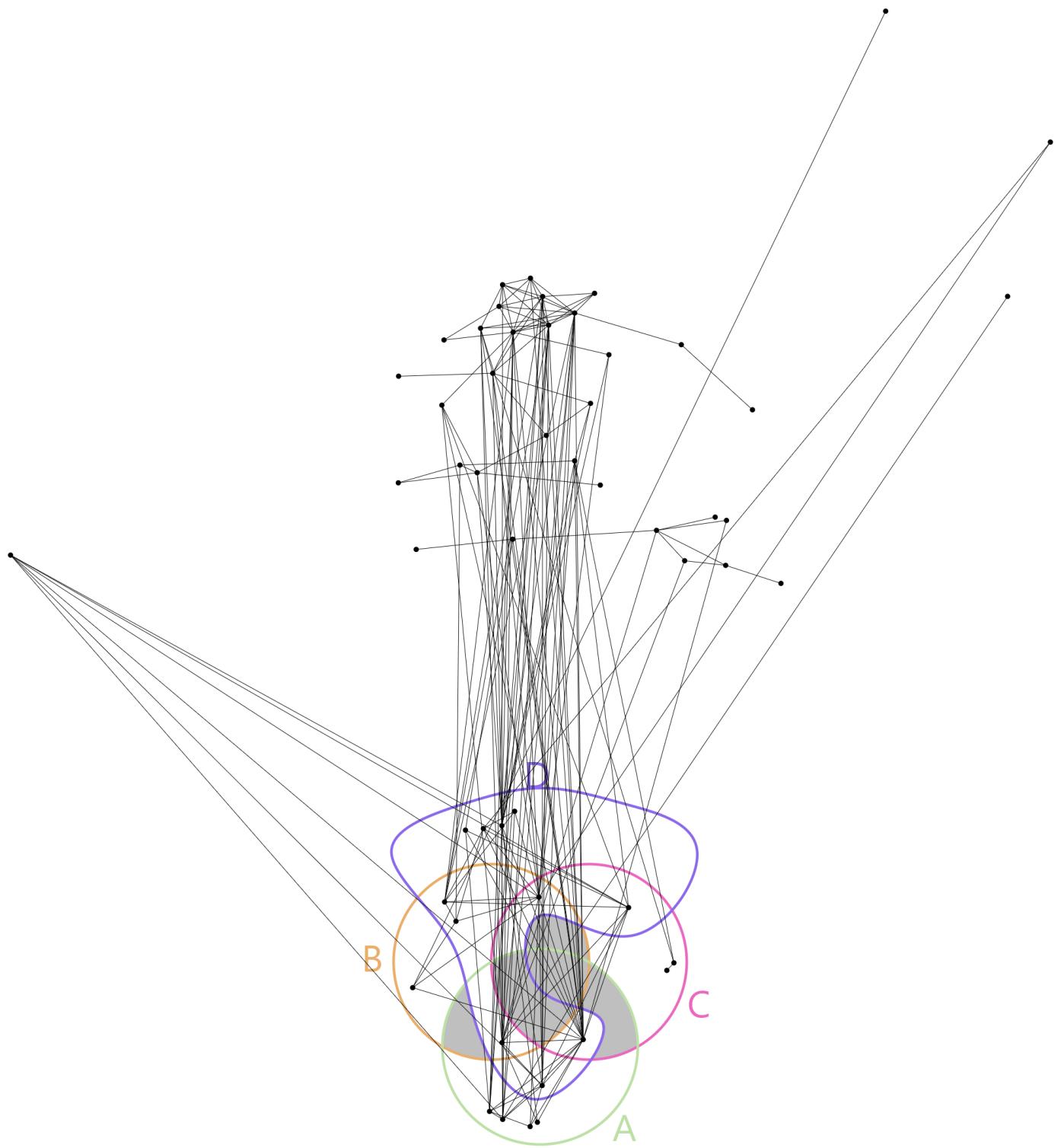


Omitted zones: AD, BCD

WebCola (with graph)



GroupNet

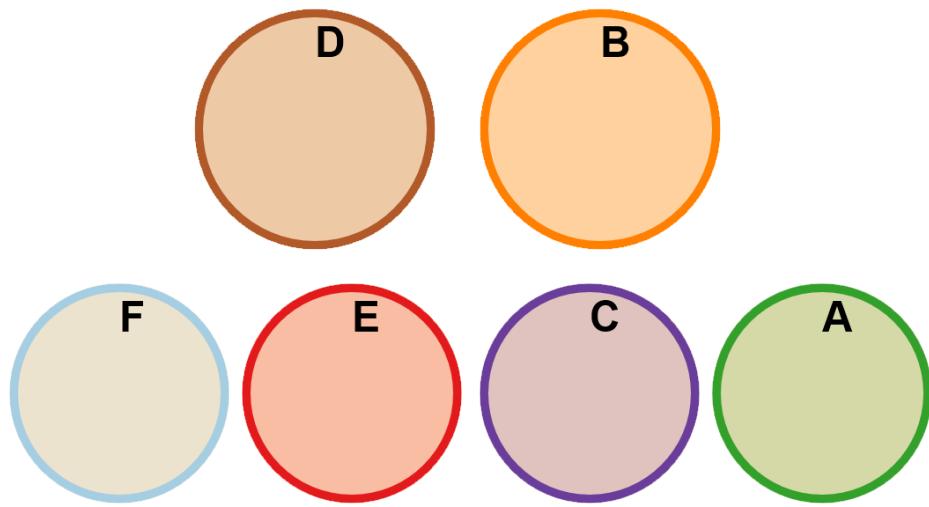


6-set data set 1 : SNAP ID: 80297299

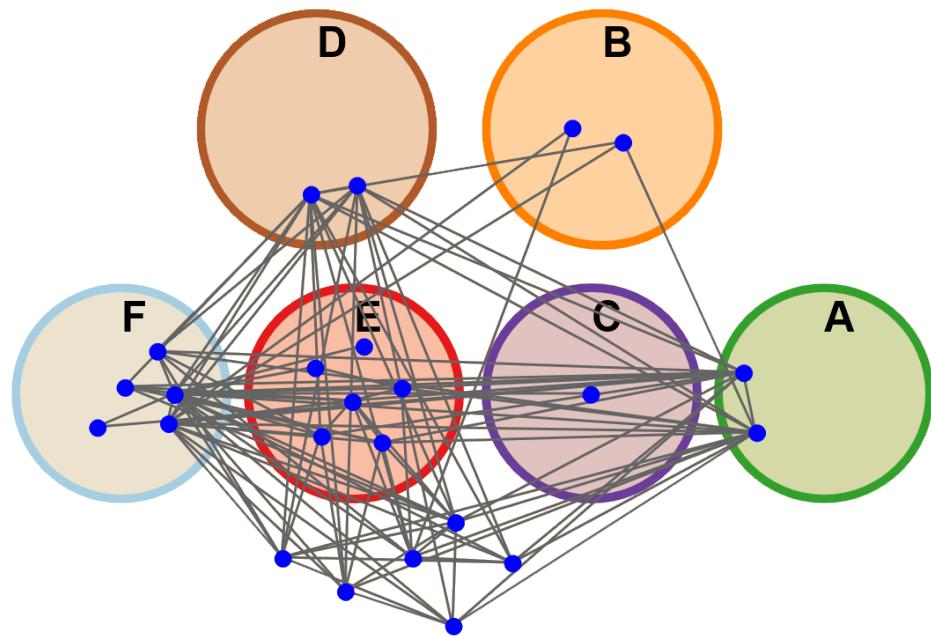
Number of Sets: 6
Number of Zones: 7
Number of Nodes: 24
Number of Edges: 103
Zones high: no
Nodes high: no
Edges high: no

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	36	4	238	0
Vertex-vertex intersections	0	0	0	0
Vertices in incorrect zones	0	1	0	0
Omitted zones	0	0	0	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	12	0	0
Concurrent curves	0	0	3	0
Triple points	0	0	0	0
Non-circles	0	6	6	0
Extra zones	0	5	0	0
Edge crossings	938	489	803	1054
Extra edge-curve crossings	53	200	168	18
Runtime (in sec)	1.616	0.753	6.999	4.825

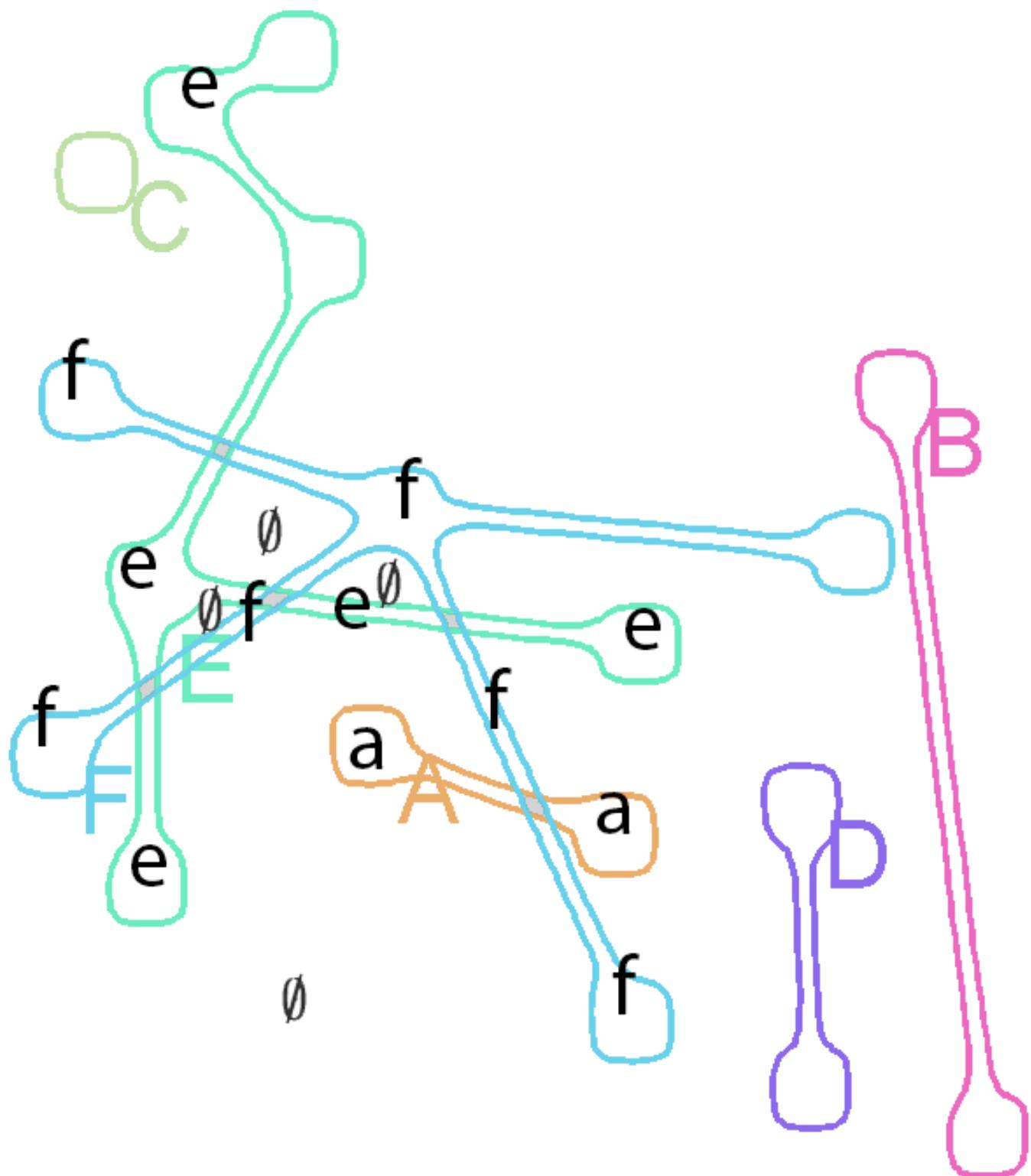
SetNet (without graph)



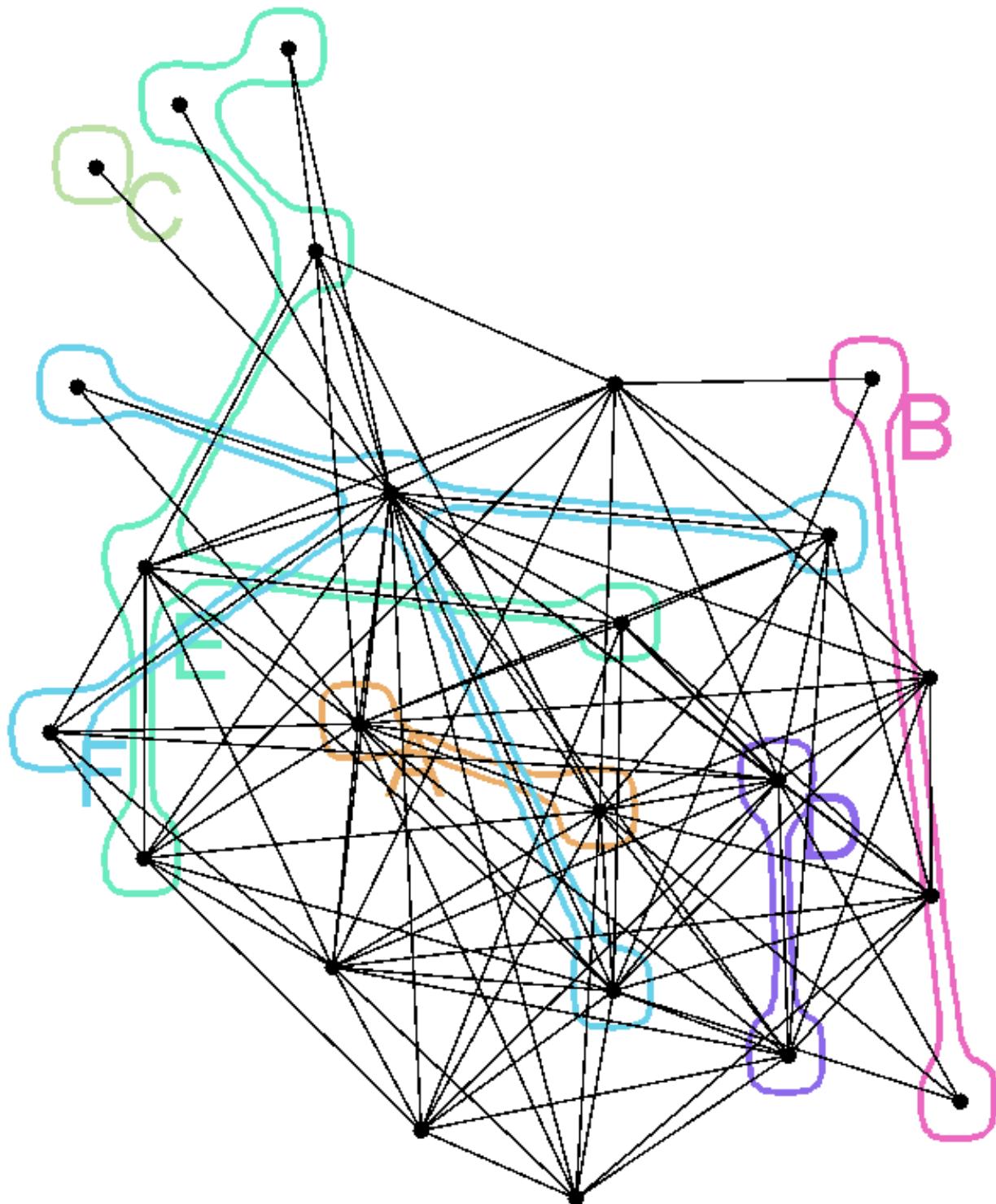
SetNet (with graph)



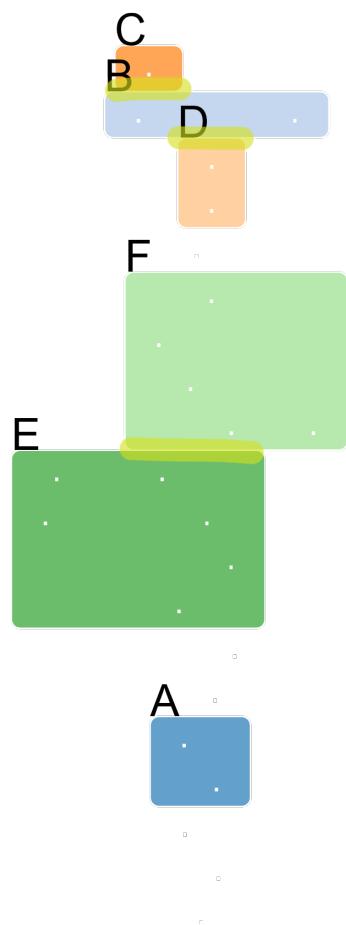
BubbleSets (without graph)



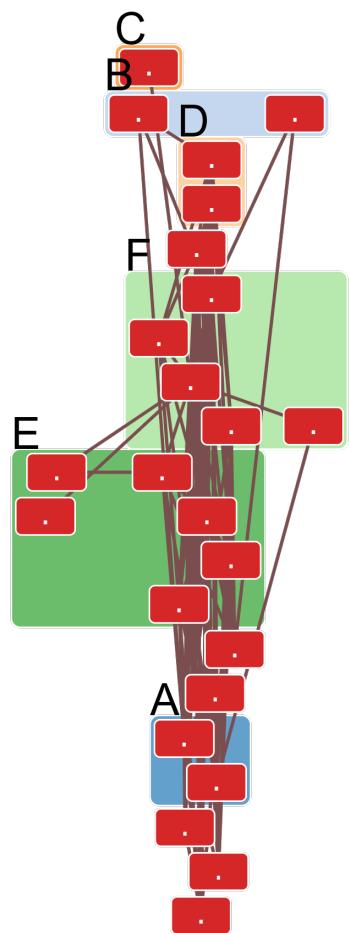
BubbleSets (with graph)



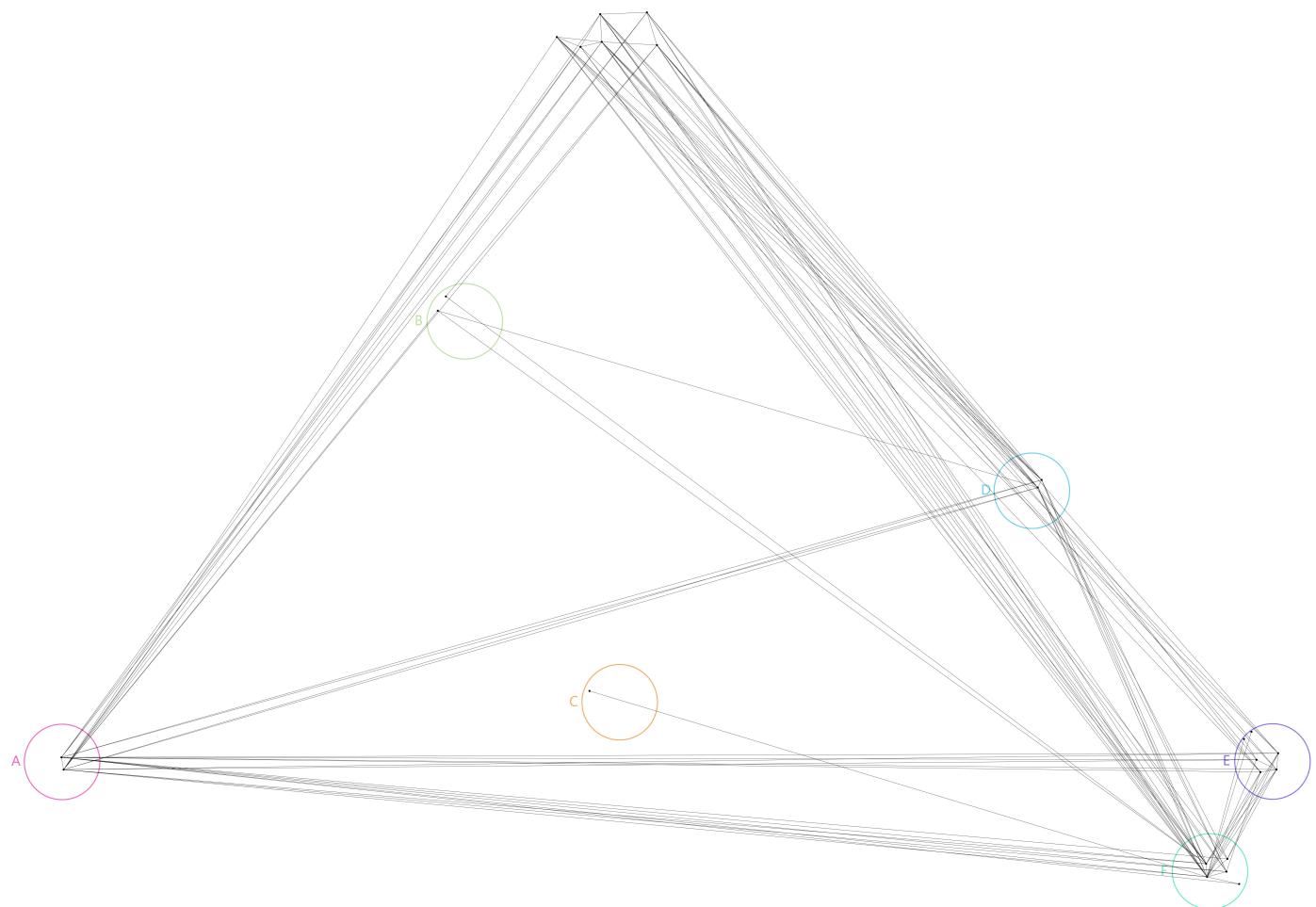
WebCola (without graph)



WebCola (with graph)



GroupNet

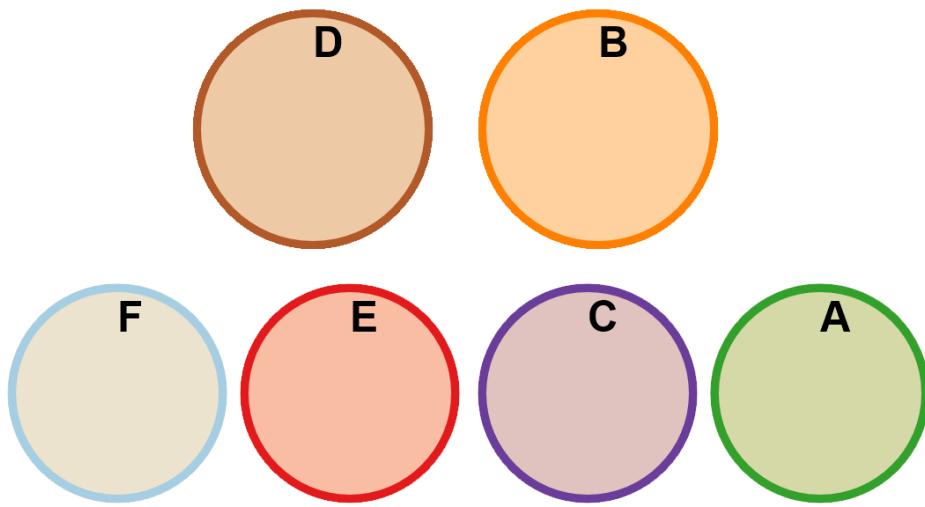


6-set data set 2 : SNAP ID: 18734310

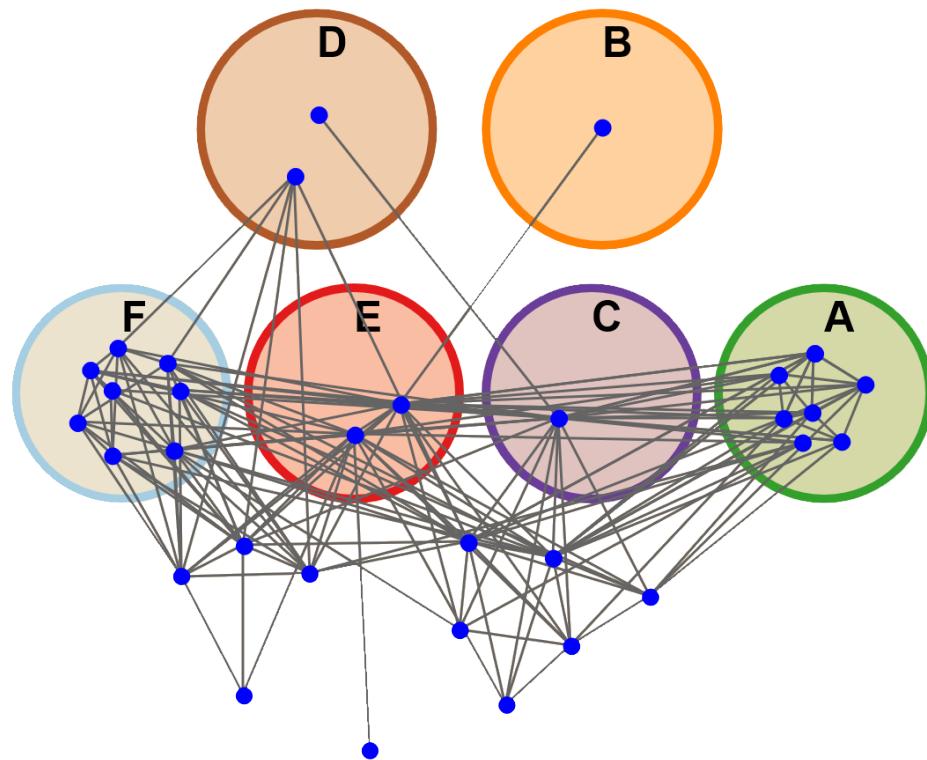
Number of Sets: 6
 Number of Zones: 7
 Number of Nodes: 33
 Number of Edges: 160
 Zones high: no
 Nodes high: no
 Edges high: yes

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	56	6	419	0
Vertex-vertex intersections	1	0	0	0
Vertices in incorrect zones	0	1	0	0
Omitted zones	0	0	0	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	4	0	0
Concurrent curves	0	1	3	0
Triple points	0	0	0	0
Non-circles	0	6	6	0
Extra zones	0	2	0	0
Edge crossings	1149	801	1510	1790
Extra edge-curve crossings	30	301	298	10
Runtime (in sec)	2.702	0.533	6.789	6.012

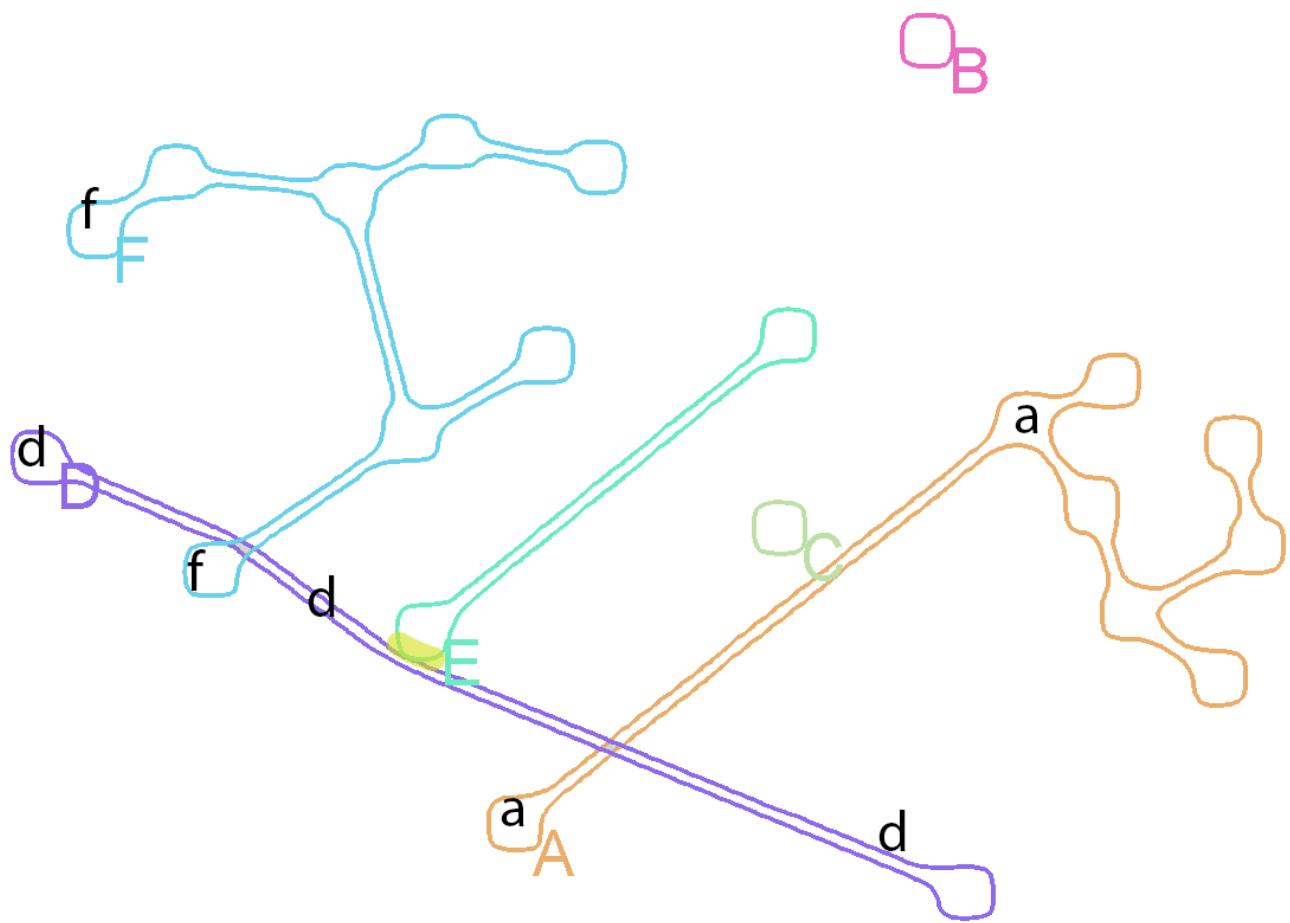
SetNet (without graph)



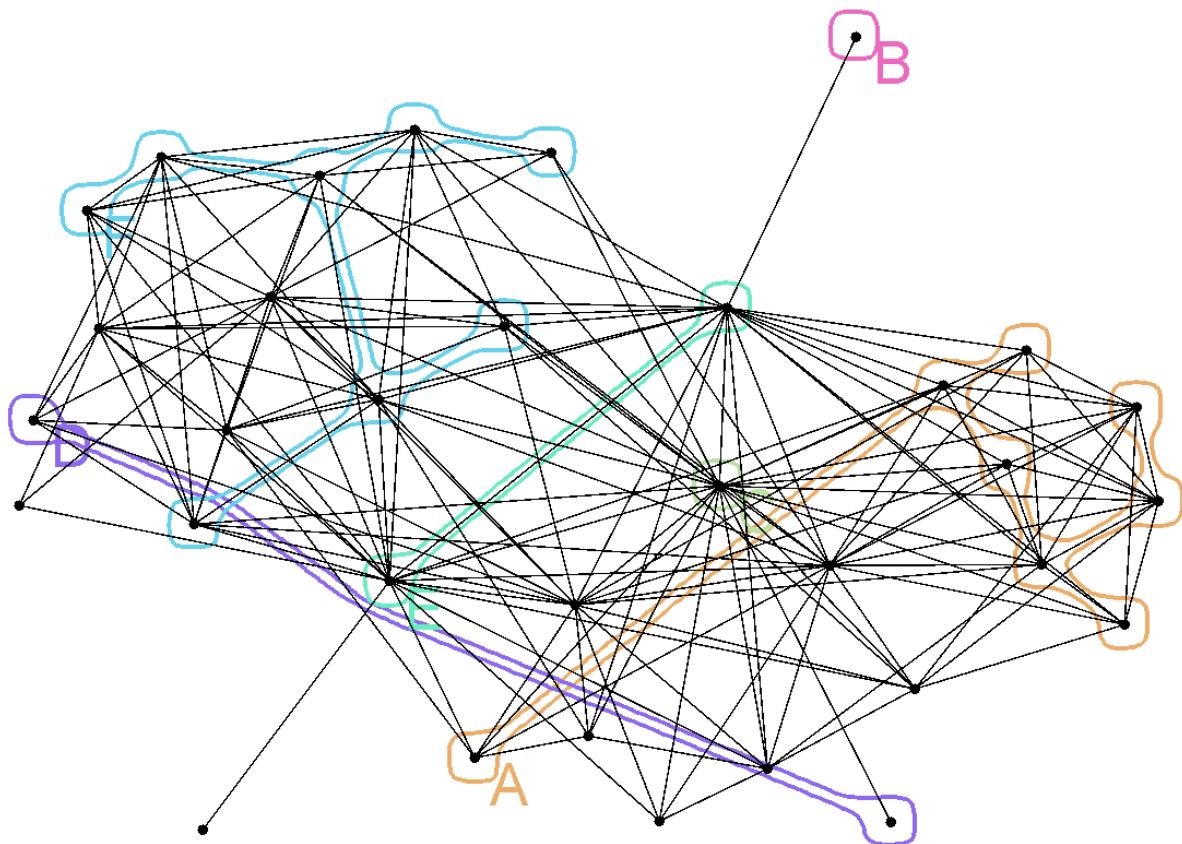
SetNet (with graph)



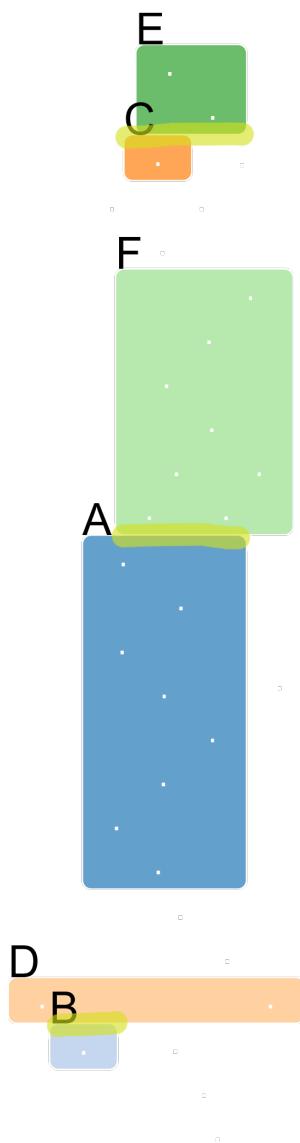
BubbleSets (without graph)



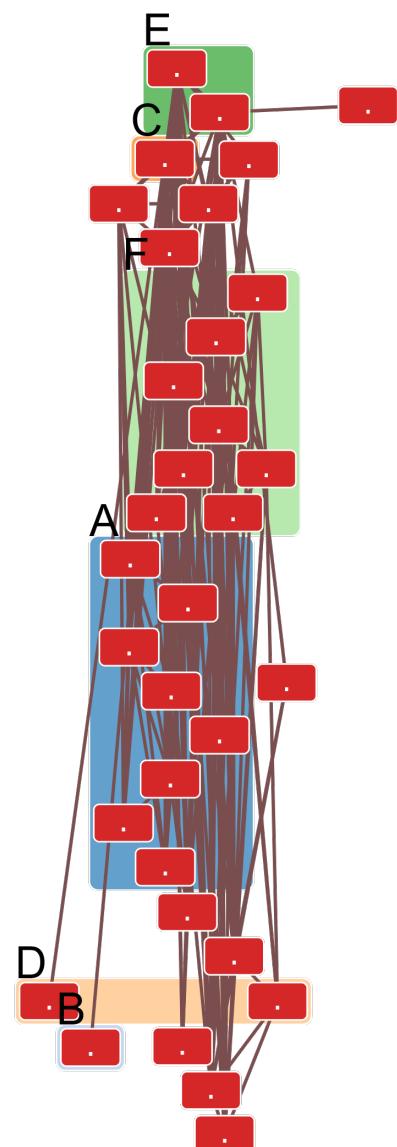
BubbleSets (with graph)



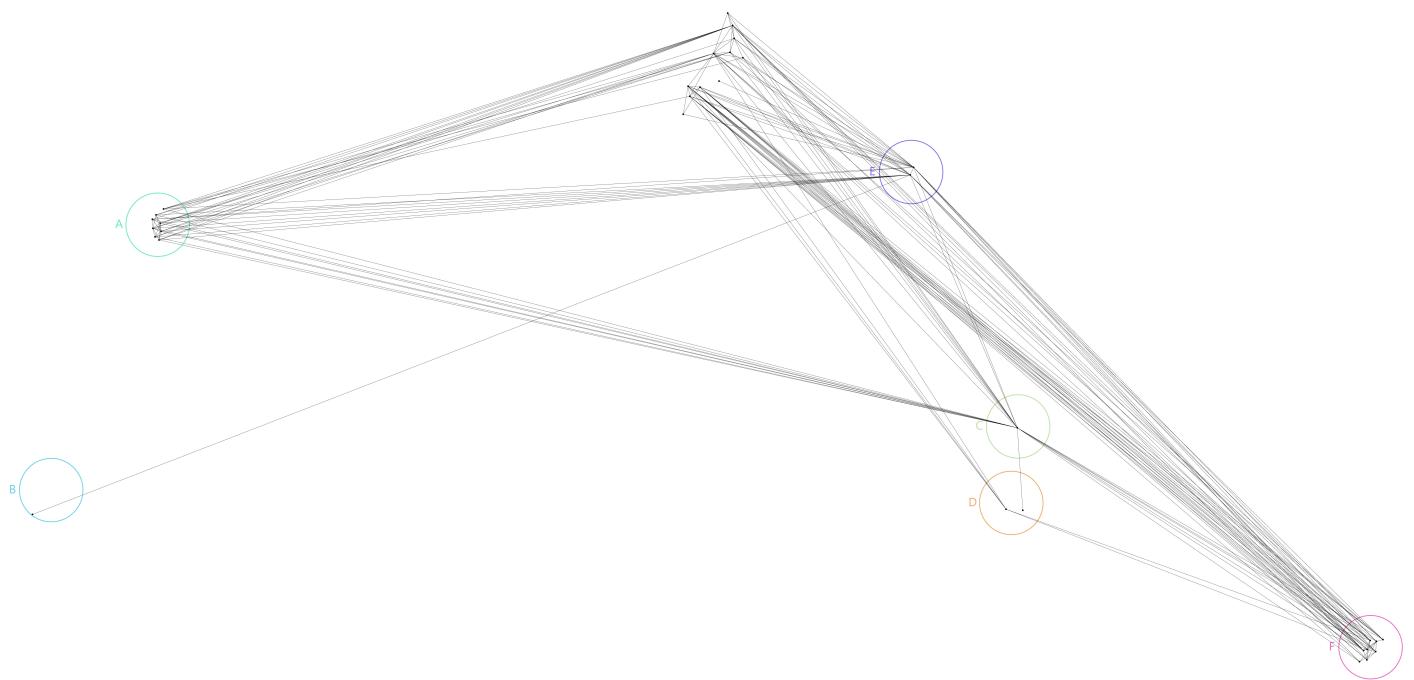
WebCola (without graph)



WebCola (with graph)



GroupNet

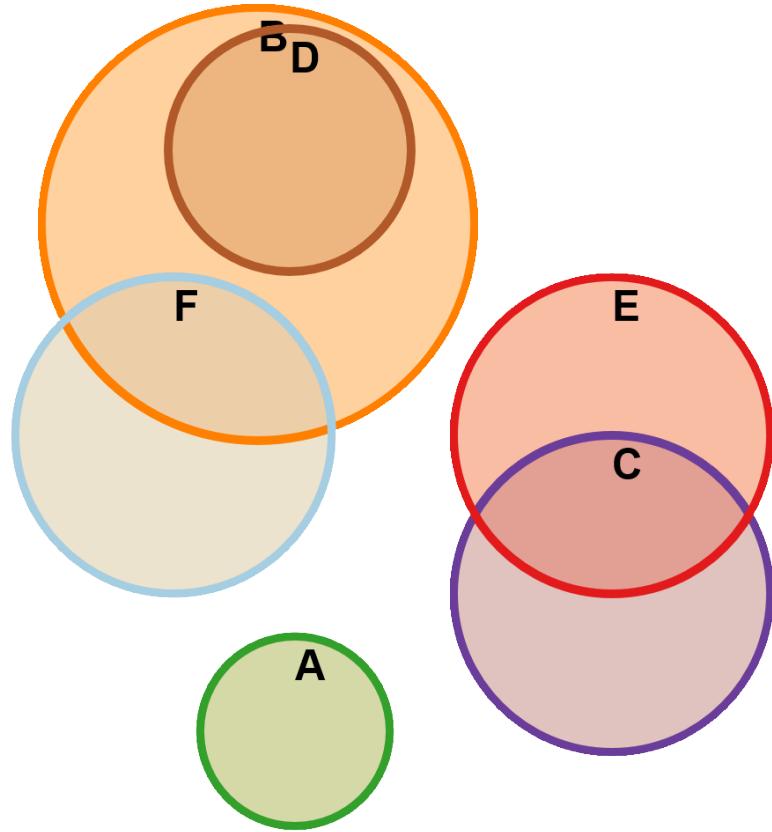


6-set data set 3 : SNAP ID: 30970675

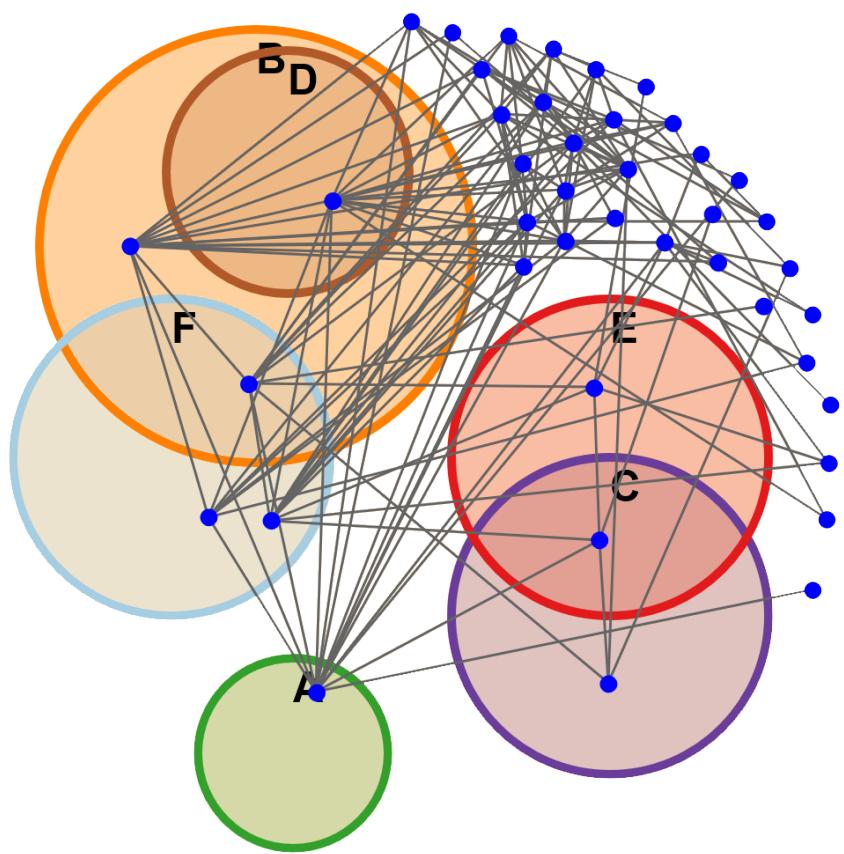
Number of Sets: 6
 Number of Zones: 9
 Number of Nodes: 42
 Number of Edges: 139
 Zones high: no
 Nodes high: yes
 Edges high: no

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	42	7	237	6
Vertex-vertex intersections	0	0	0	0
Vertices in incorrect zones	0	1	0	0
Omitted zones	0	0	0	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	4	0	0
Concurrent curves	0	0	2	0
Triple points	0	0	0	0
Non-circles	0	6	6	0
Extra zones	0	0	0	0
Edge crossings	1330	531	1233	1393
Extra edge-curve crossings	44	121	250	48
Runtime (in sec)	2.787	0.512	8.466	10.953

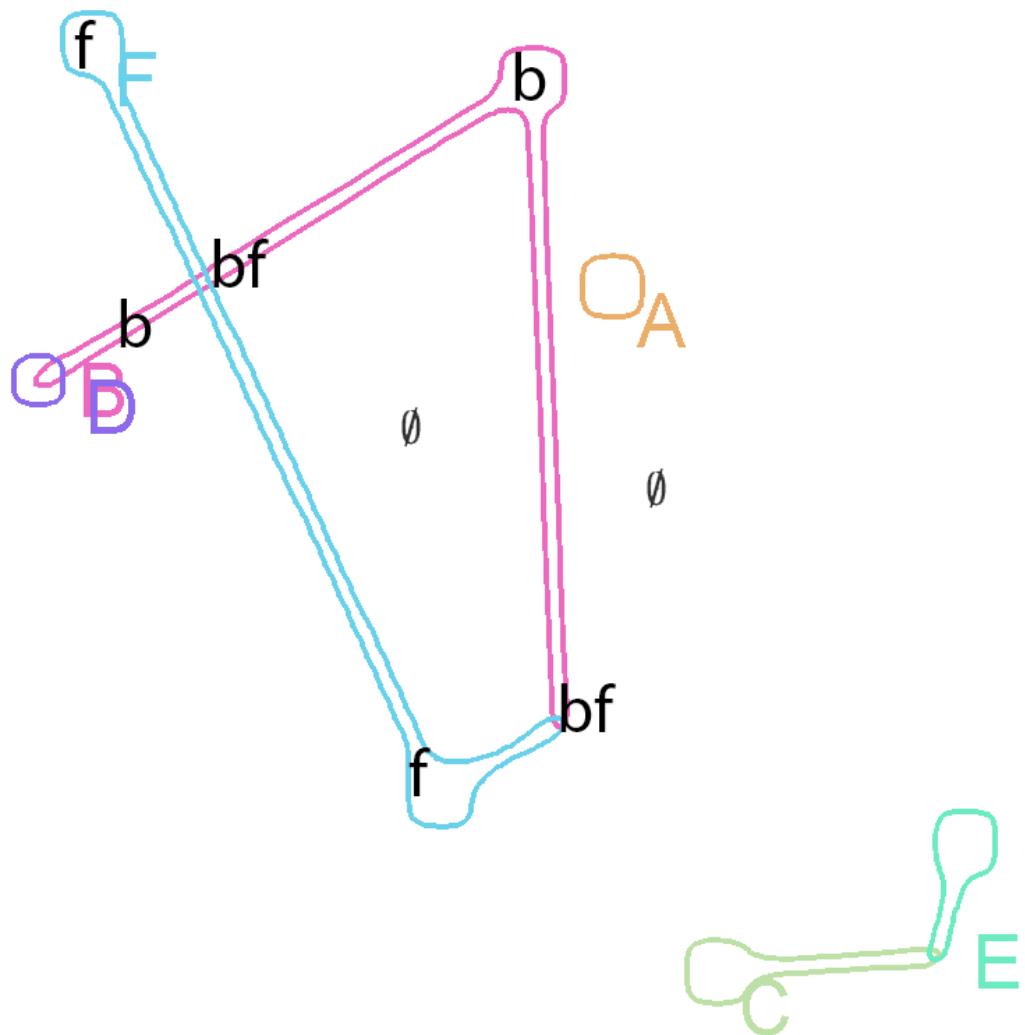
SetNet (without graph)



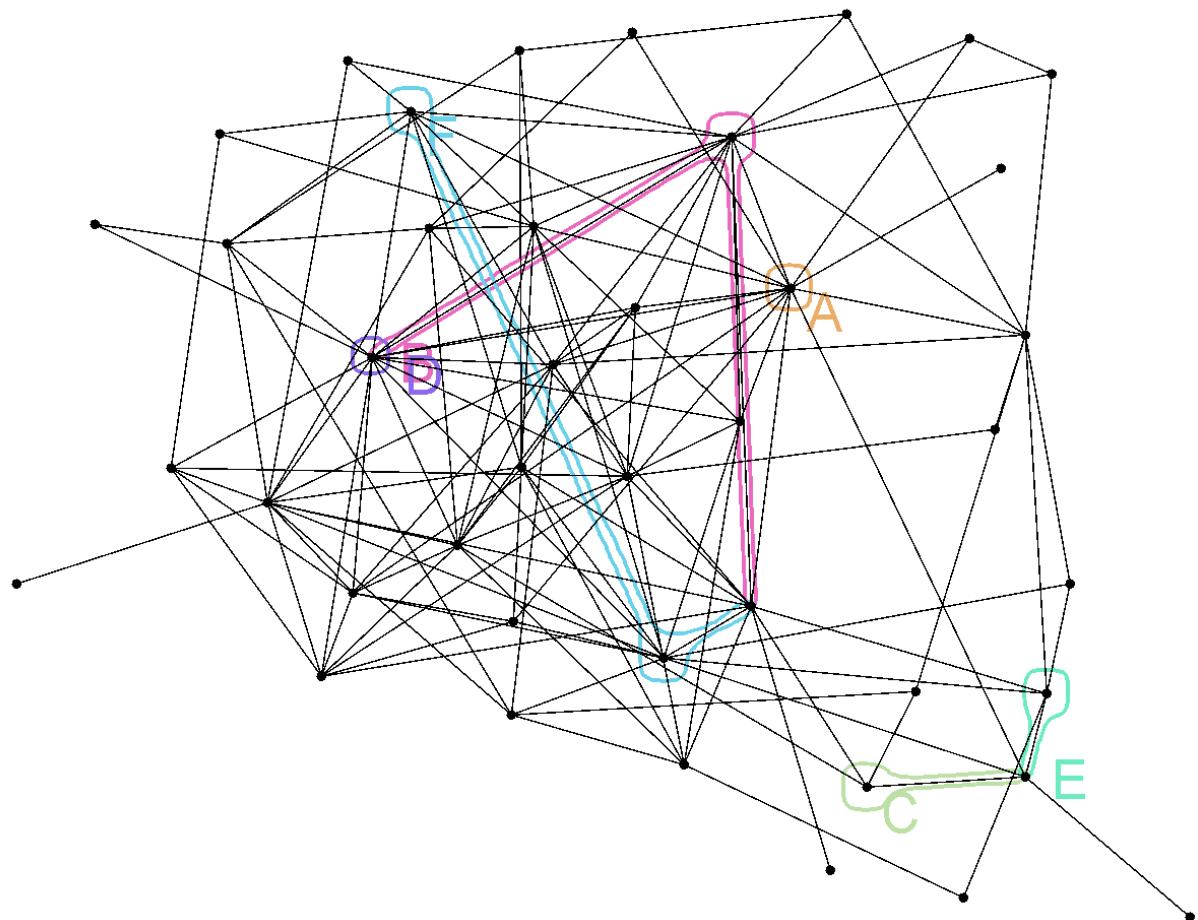
SetNet (with graph)



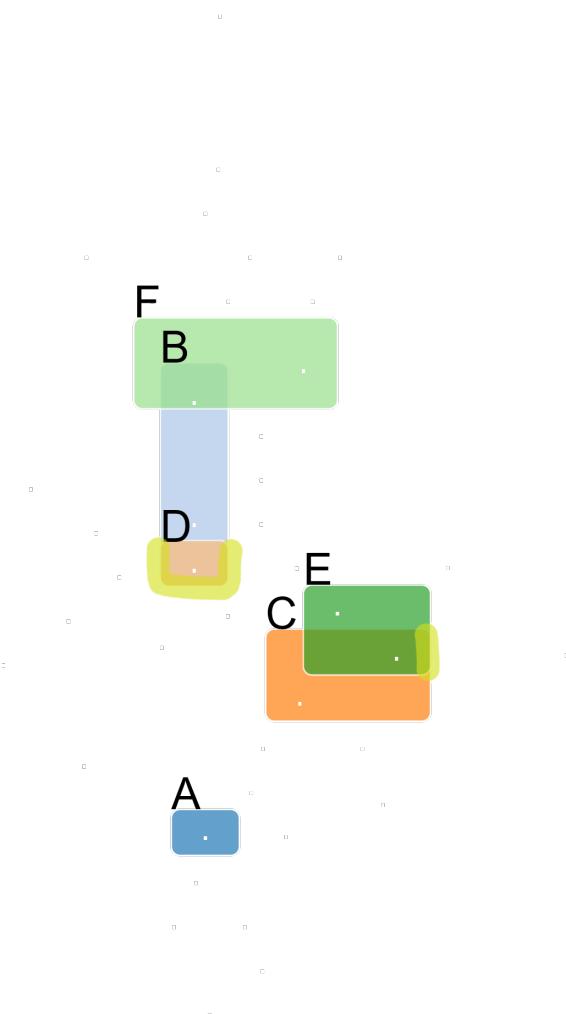
BubbleSets (without graph)



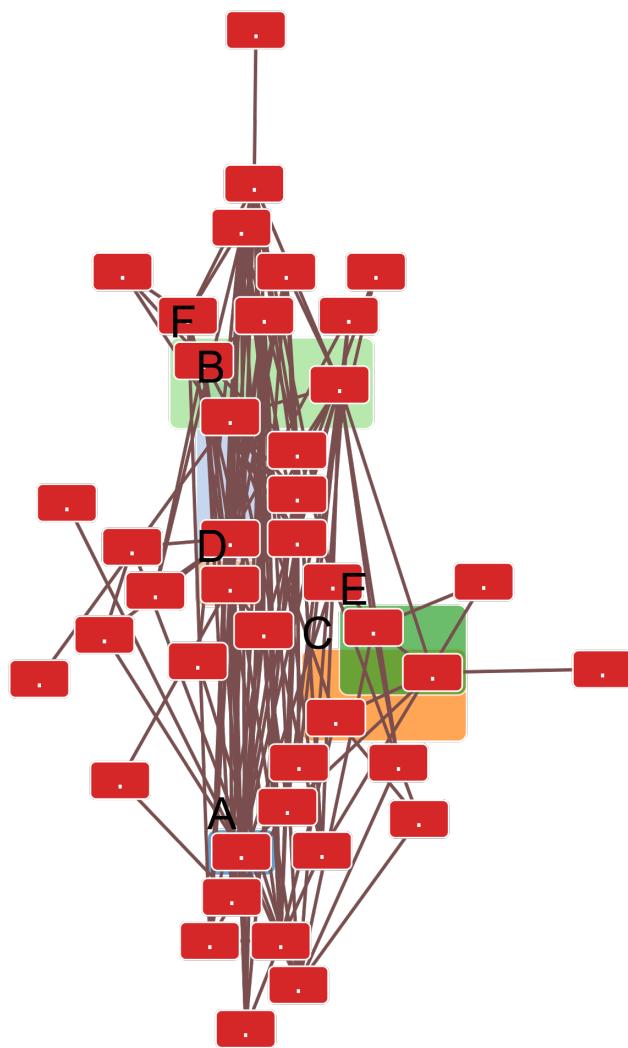
BubbleSets (with graph)



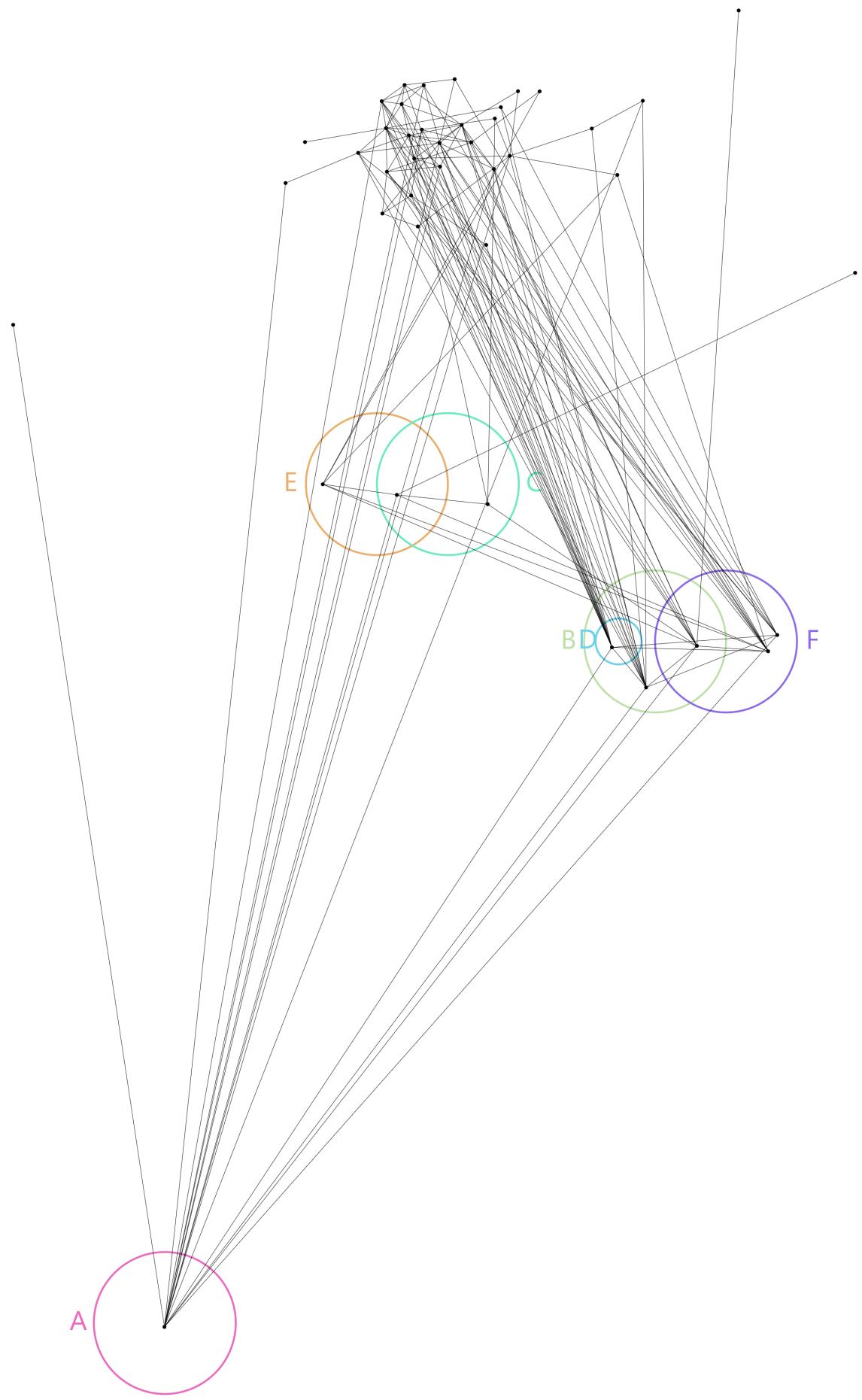
WebCola (without graph)



WebCola (with graph)



GroupNet

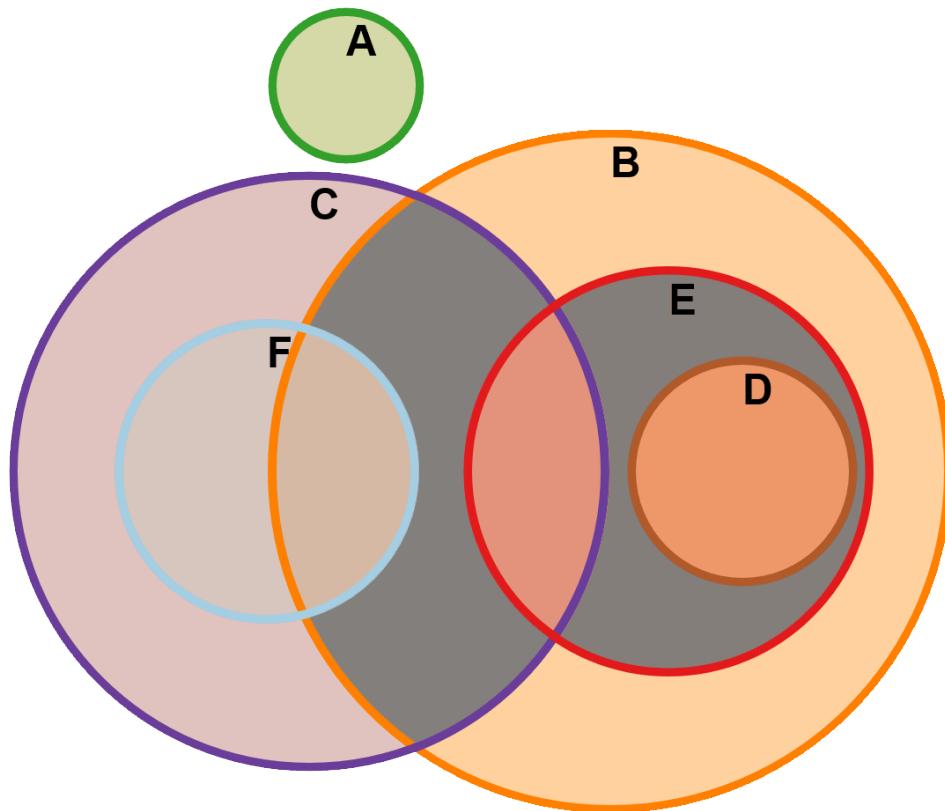


6-set data set 4 : SNAP ID: 253751053

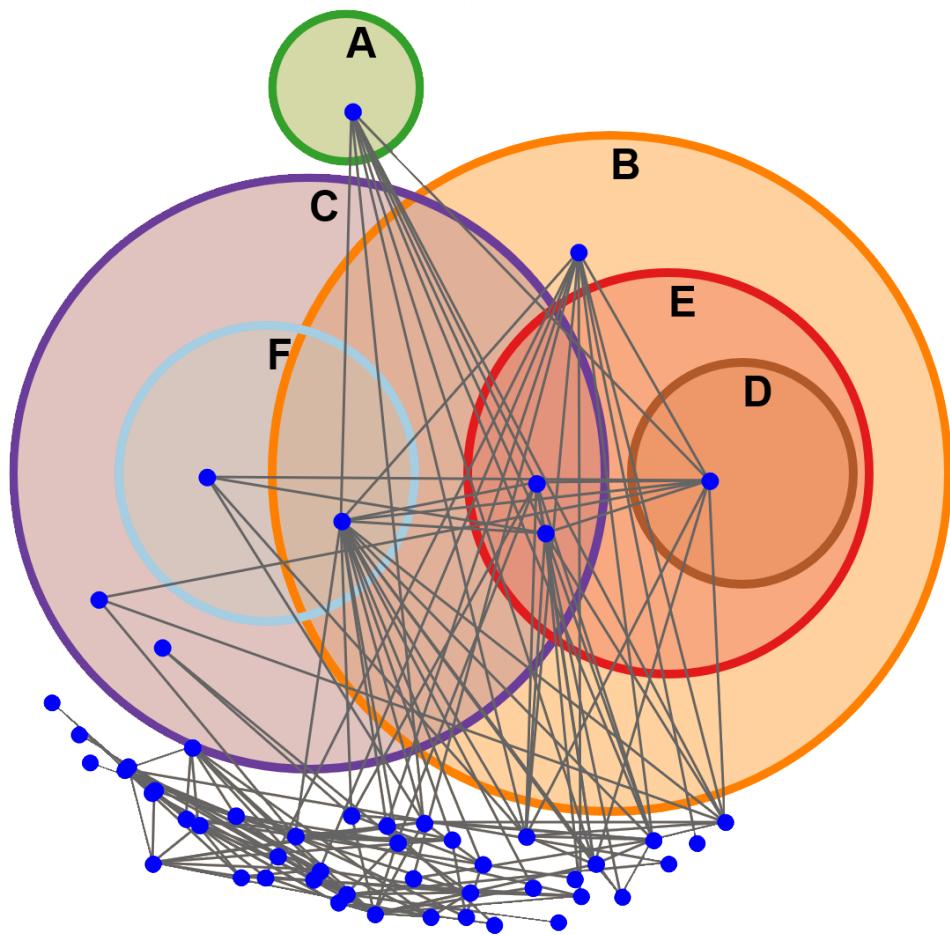
Number of Sets: 6
 Number of Zones: 8
 Number of Nodes: 52
 Number of Edges: 156
 Zones high: no
 Nodes high: yes
 Edges high: yes

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	147	9	180	15
Vertex-vertex intersections	5	0	1	0
Vertices in incorrect zones	1	2	6	0
Omitted zones	0	0	1	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	6	0	0
Concurrent curves	0	2	3	0
Triple points	0	2	0	0
Non-circles	0	6	6	0
Extra zones	2	6	0	3
Edge crossings	1228	408	825	1043
Extra edge-curve crossings	44	213	32	34
Runtime (in sec)	3.428	0.793	7.345	9.557

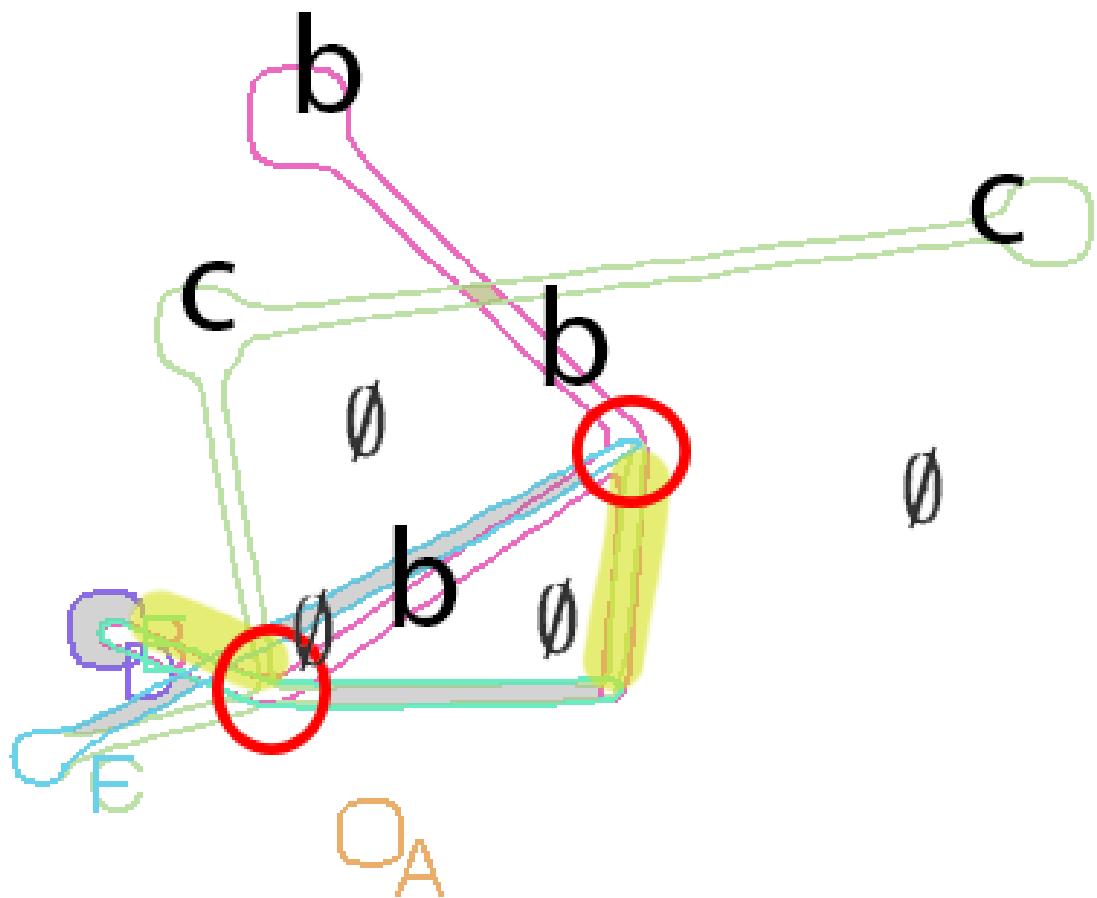
SetNet (without graph)



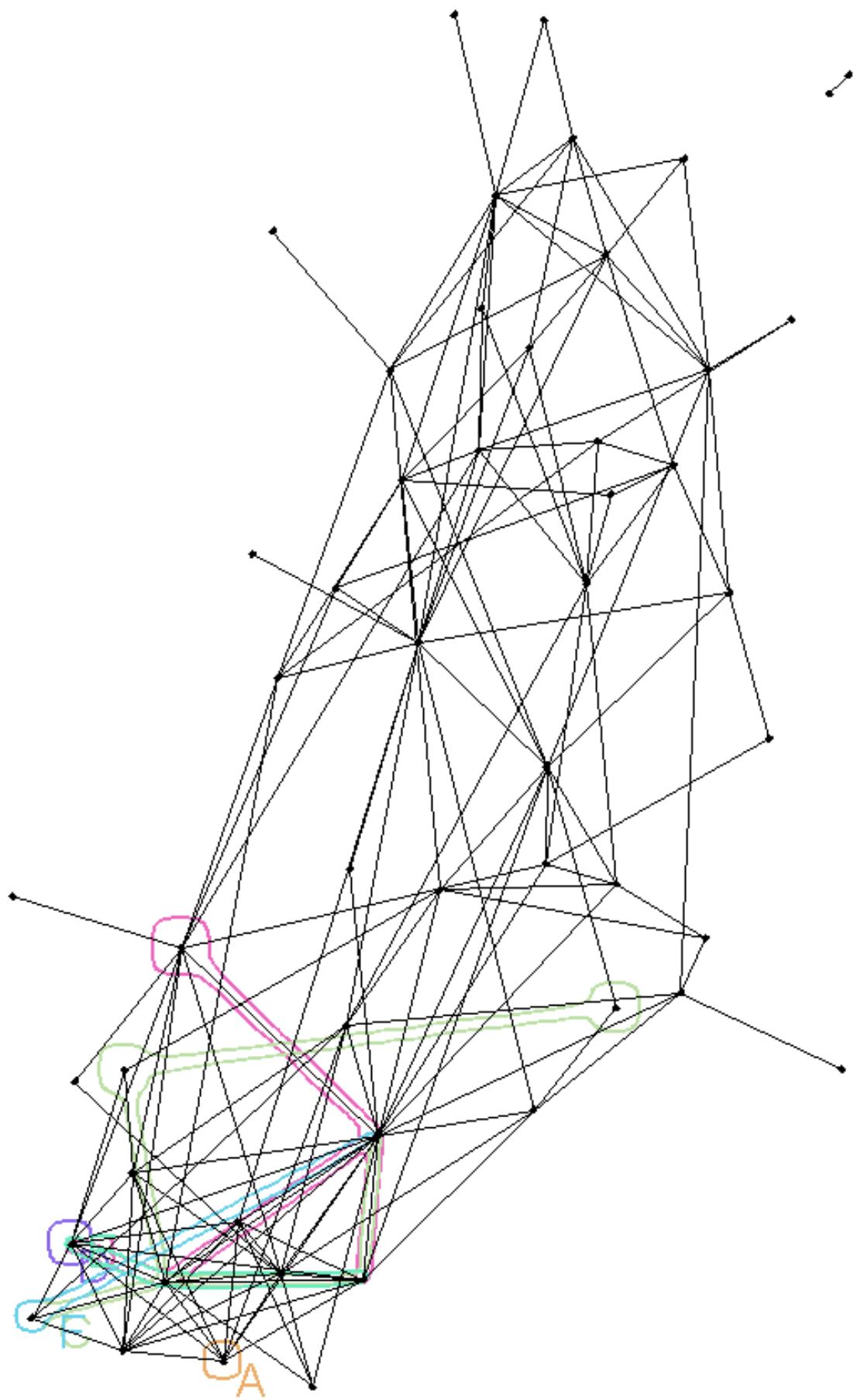
SetNet (with graph)



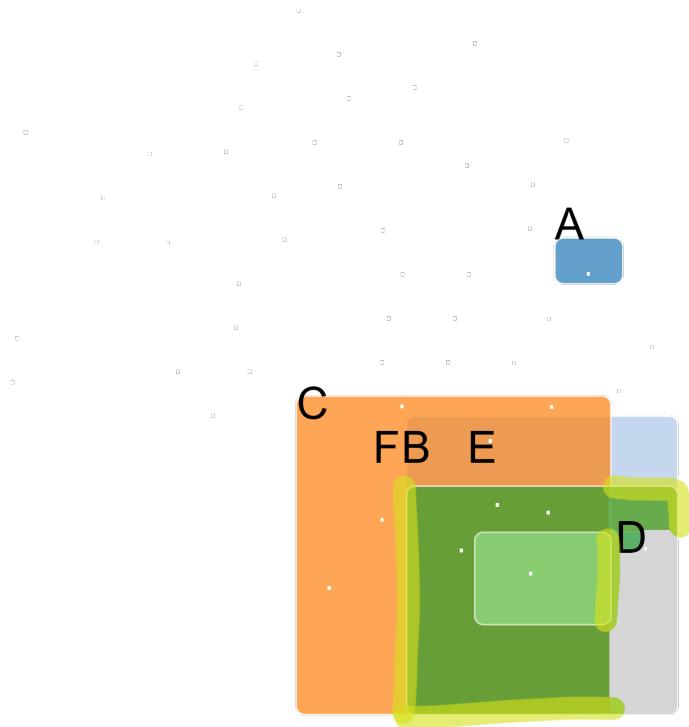
BubbleSets (without graph)



BubbleSets (with graph)

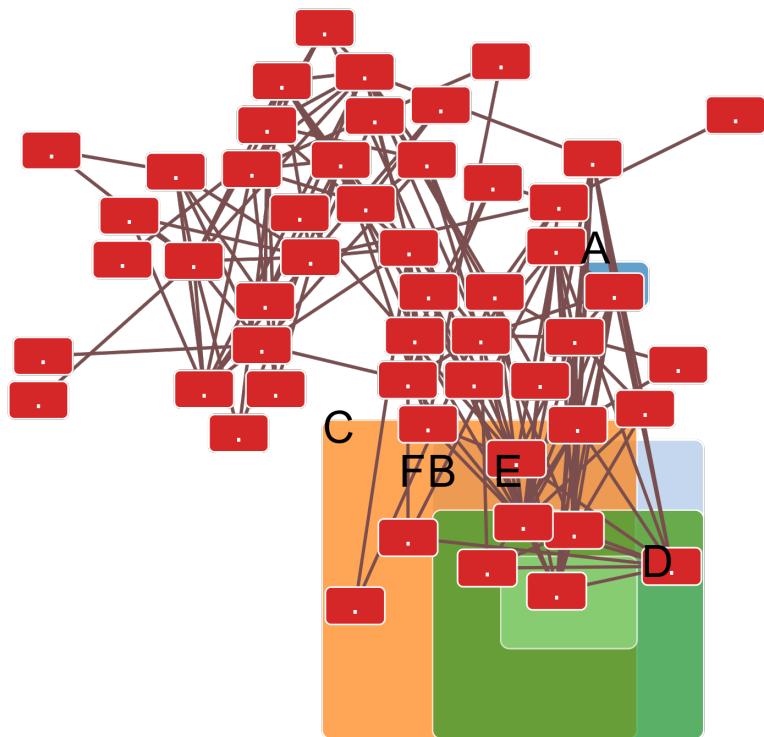


WebCola (without graph)

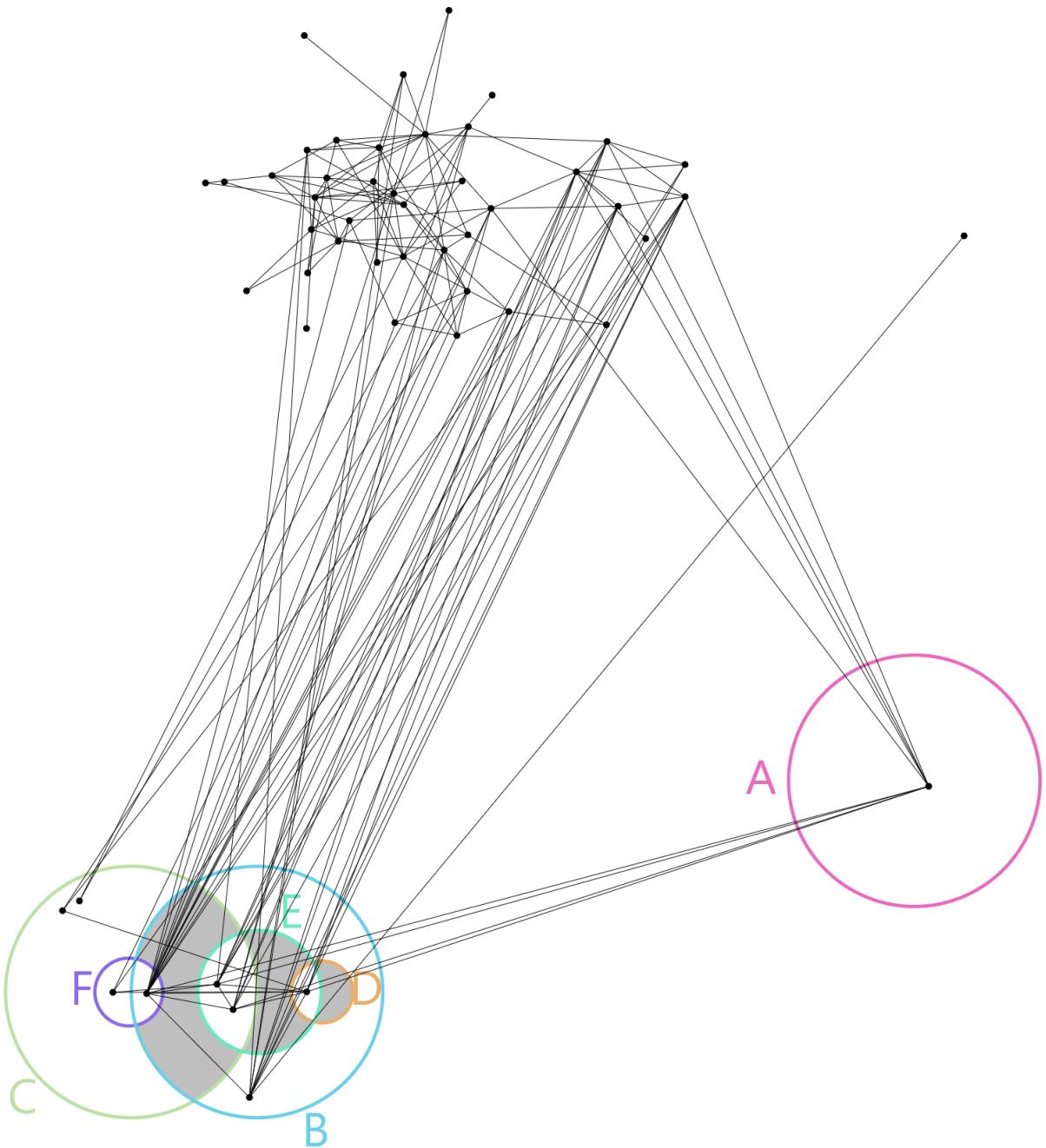


Omitted zones: BCF

WebCola (with graph)



GroupNet

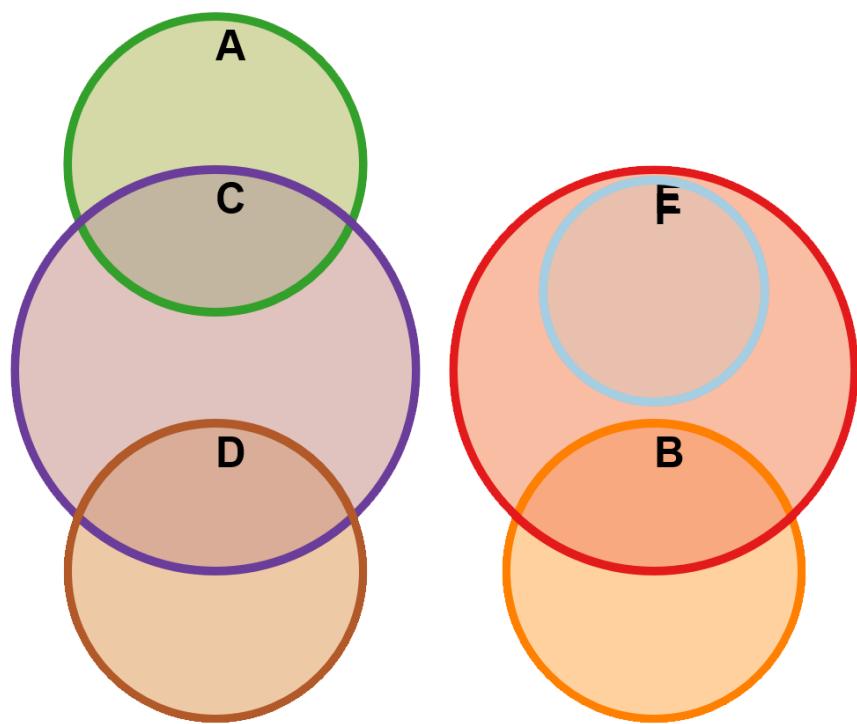


6-set data set 5 : SNAP ID: 204145356

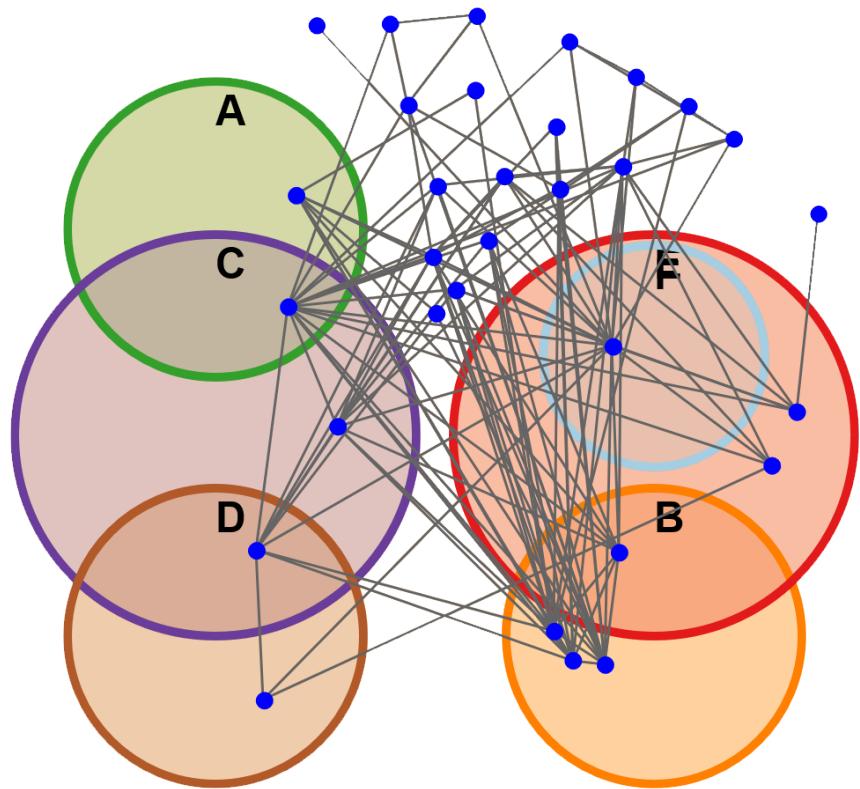
Number of Sets: 6
 Number of Zones: 10
 Number of Nodes: 31
 Number of Edges: 114
 Zones high: yes
 Nodes high: no
 Edges high: no

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	32	8	165	0
Vertex-vertex intersections	0	0	0	0
Vertices in incorrect zones	0	0	2	0
Omitted zones	0	0	0	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	6	0	0
Concurrent curves	0	0	3	0
Triple points	0	0	1	0
Non-circles	0	6	6	0
Extra zones	0	4	1	0
Edge crossings	1118	366	926	947
Extra edge-curve crossings	46	98	170	28
Runtime (in sec)	1.807	0.508	6.84	11.051

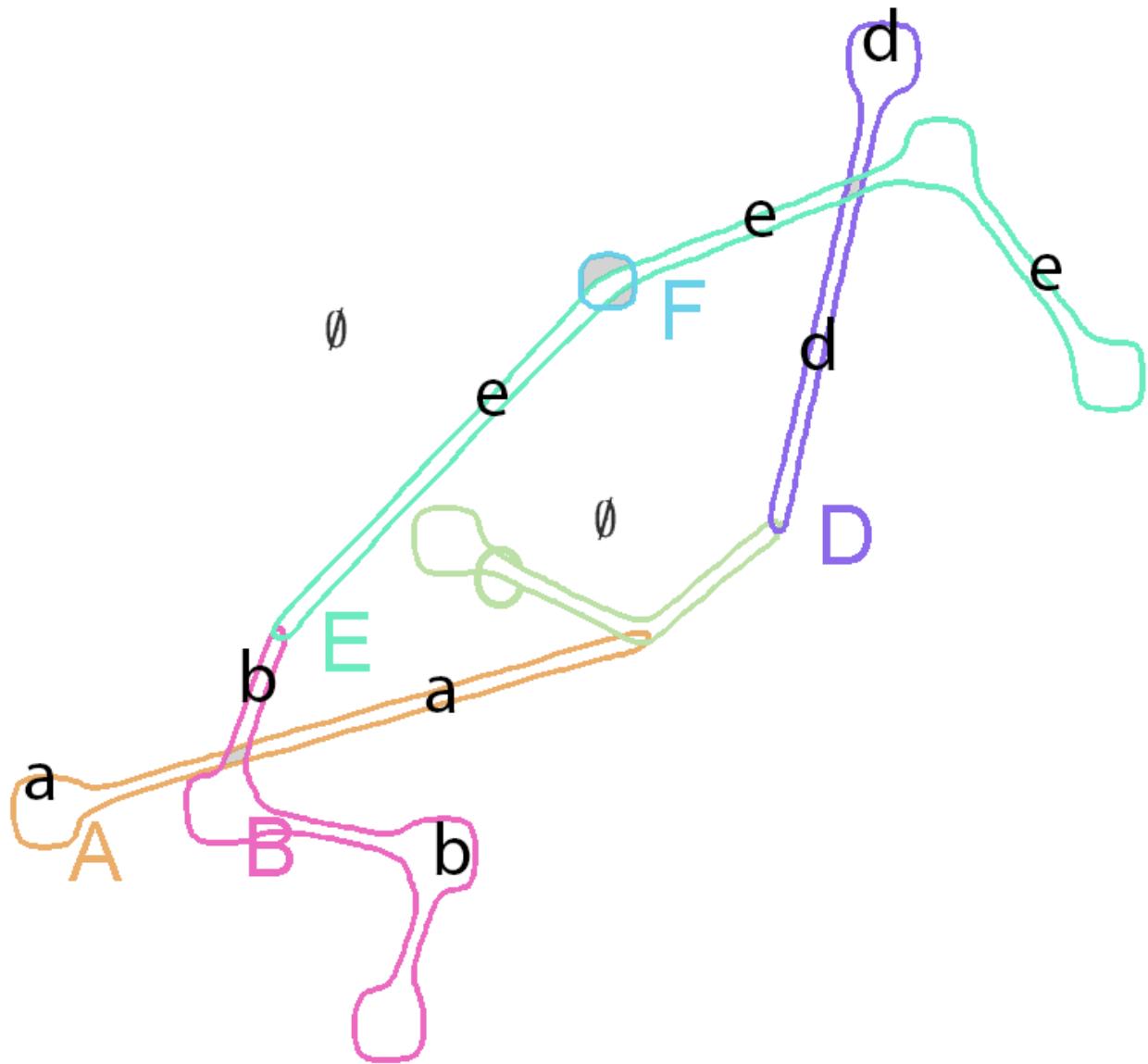
SetNet (without graph)



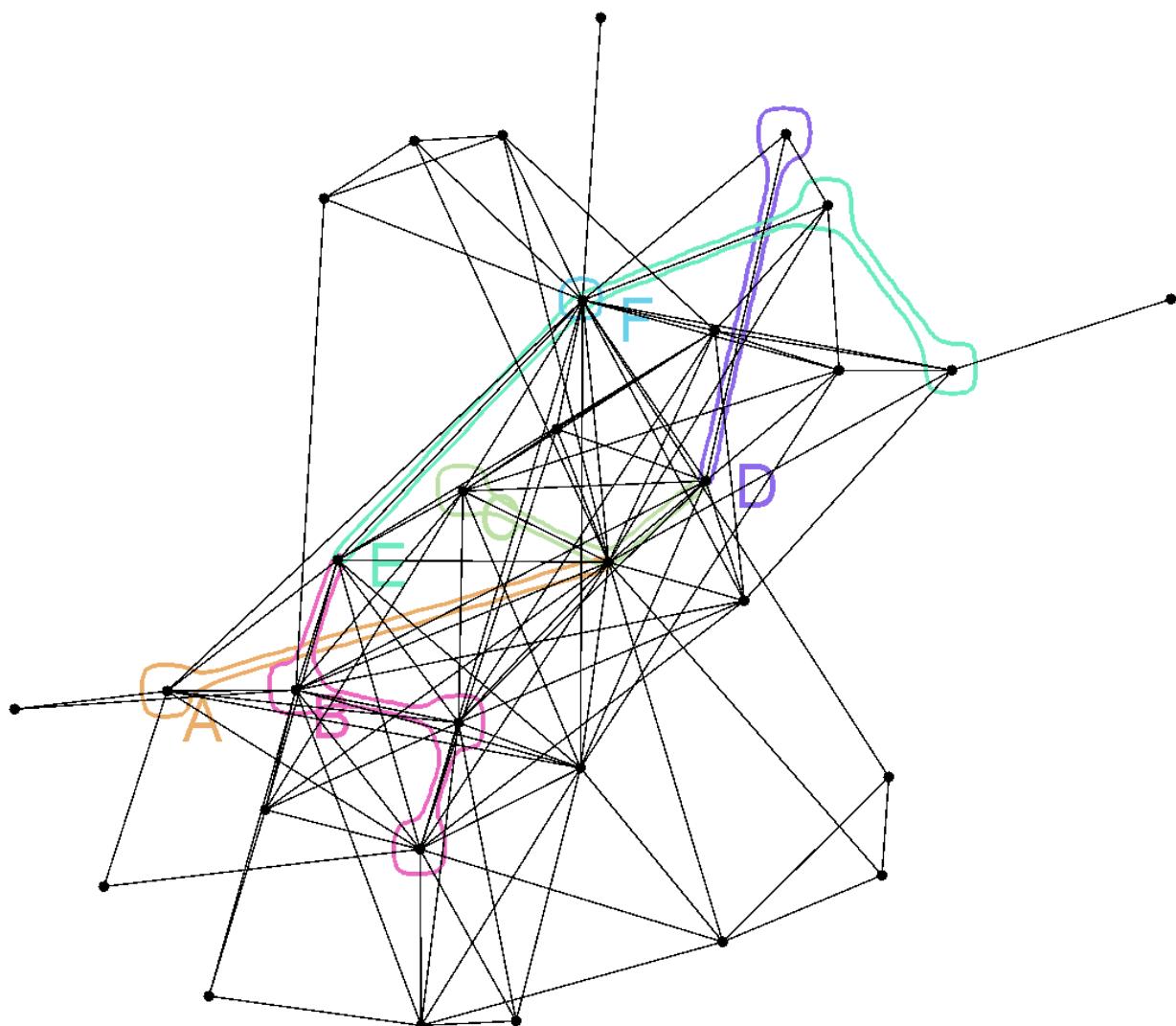
SetNet (with graph)



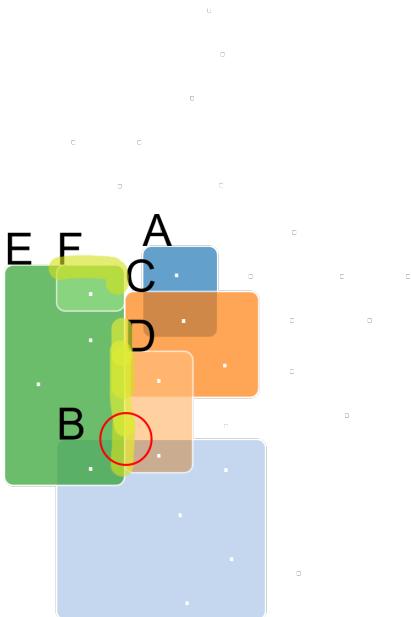
BubbleSets (without graph)



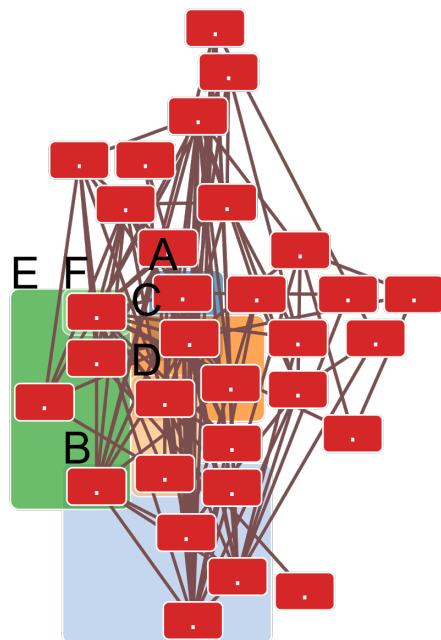
BubbleSets (with graph)



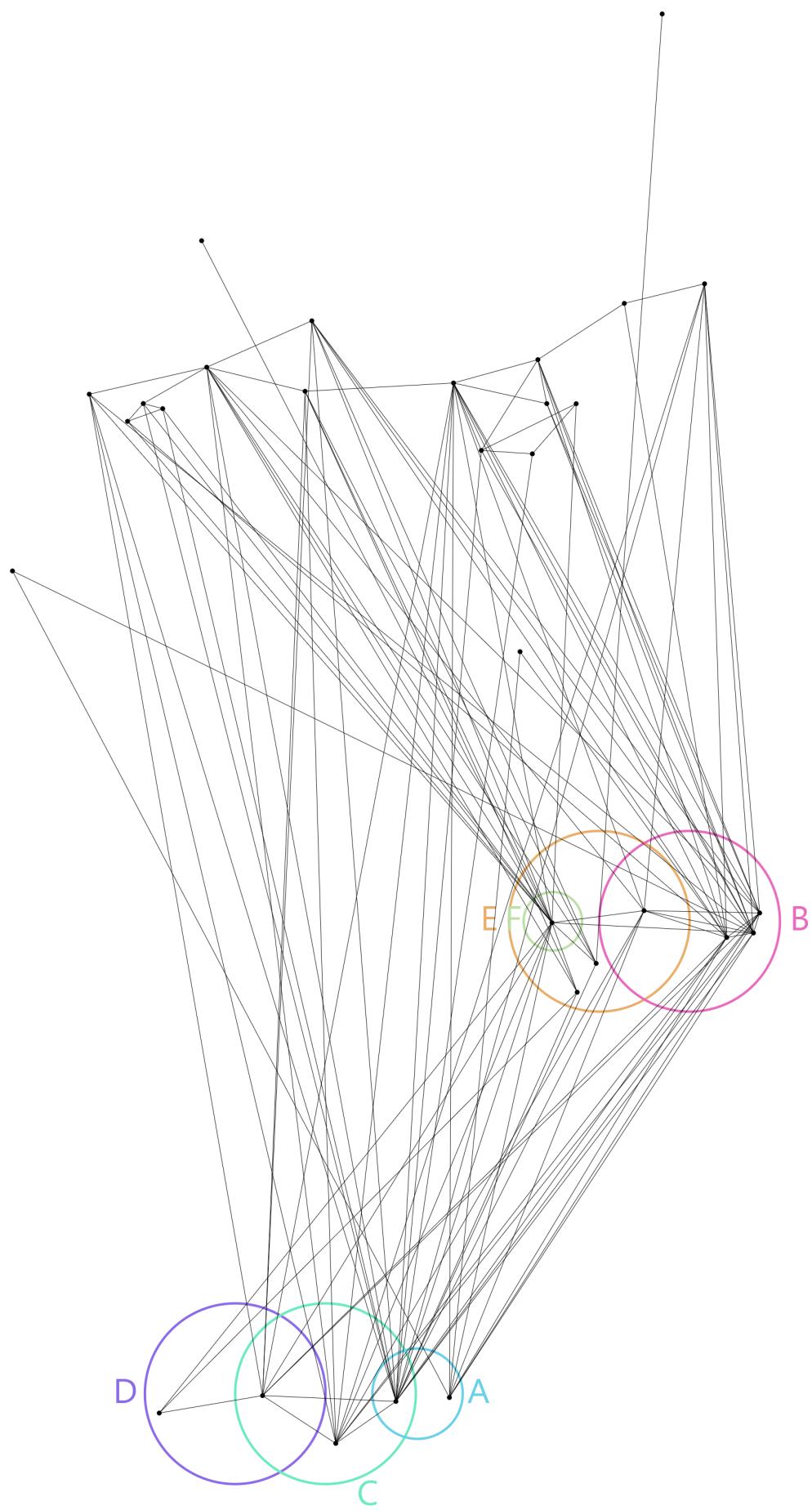
WebCola (without graph)



WebCola (with graph)



GroupNet

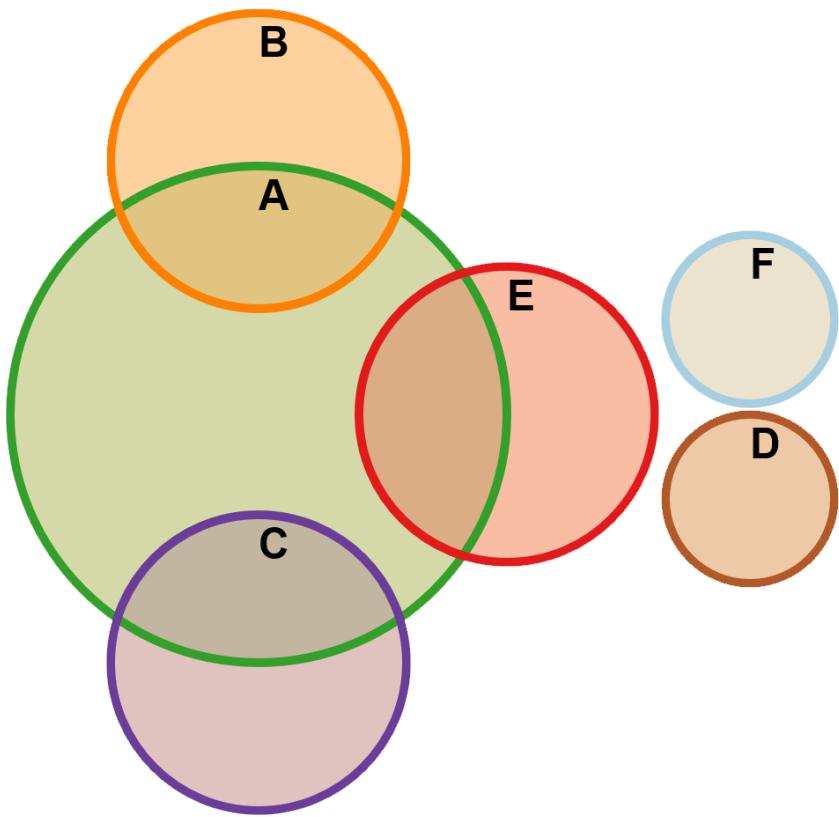


6-set data set 6 : SNAP ID: 255790981

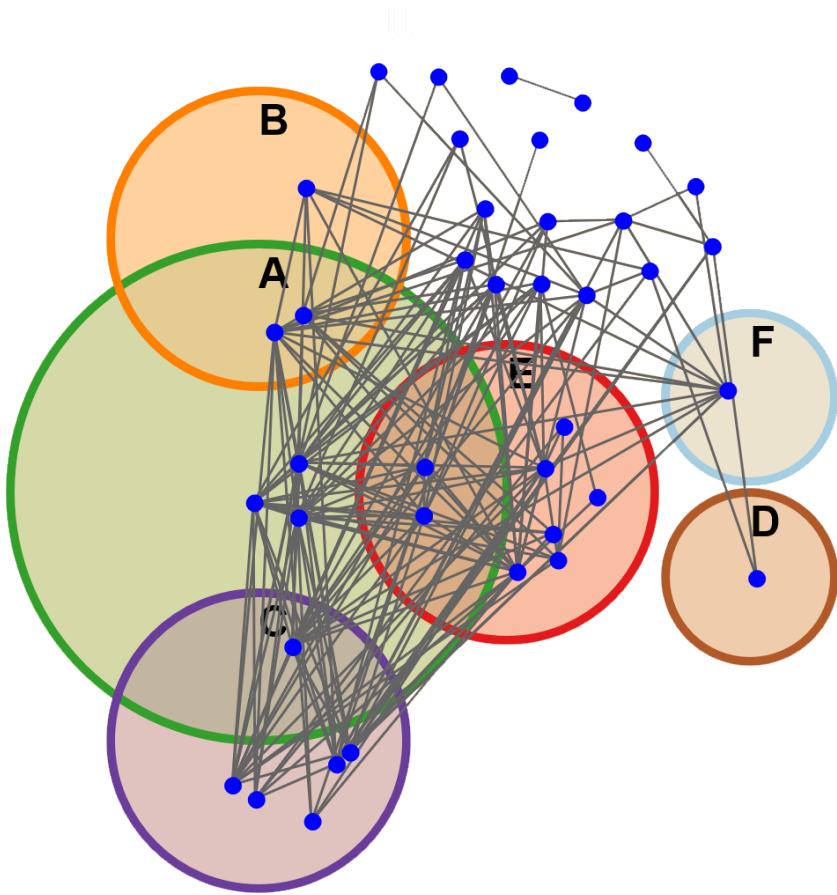
Number of Sets: 6
 Number of Zones: 10
 Number of Nodes: 39
 Number of Edges: 167
 Zones high: yes
 Nodes high: no
 Edges high: yes

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	68	7	262	19
Vertex-vertex intersections	0	0	2	0
Vertices in incorrect zones	0	2	5	0
Omitted zones	0	0	0	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	26	0	0
Concurrent curves	0	2	1	0
Triple points	0	0	0	0
Non-circles	0	6	6	0
Extra zones	0	2	0	0
Edge crossings	2588	1105	2233	2564
Extra edge-curve crossings	58	460	137	108
Runtime (in sec)	3.119	0.533	8.35	12.207

SetNet (without graph)

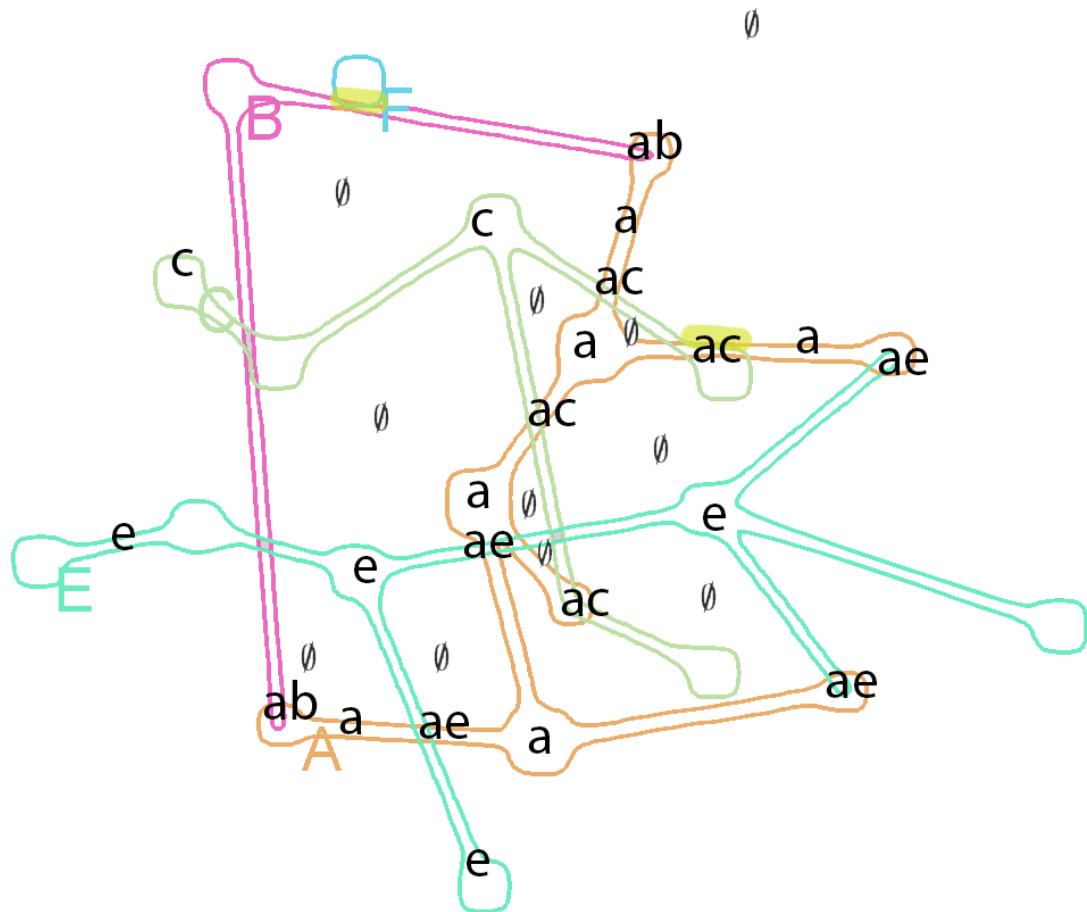


SetNet (with graph)

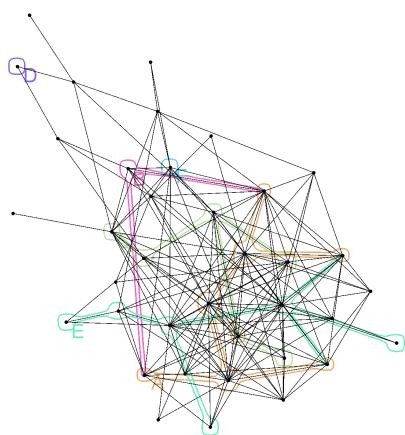


BubbleSets (without graph)

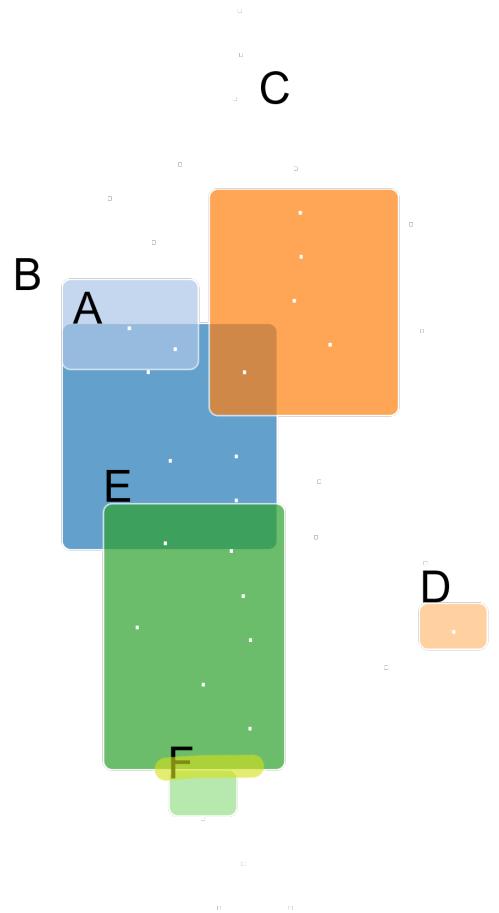
O
D



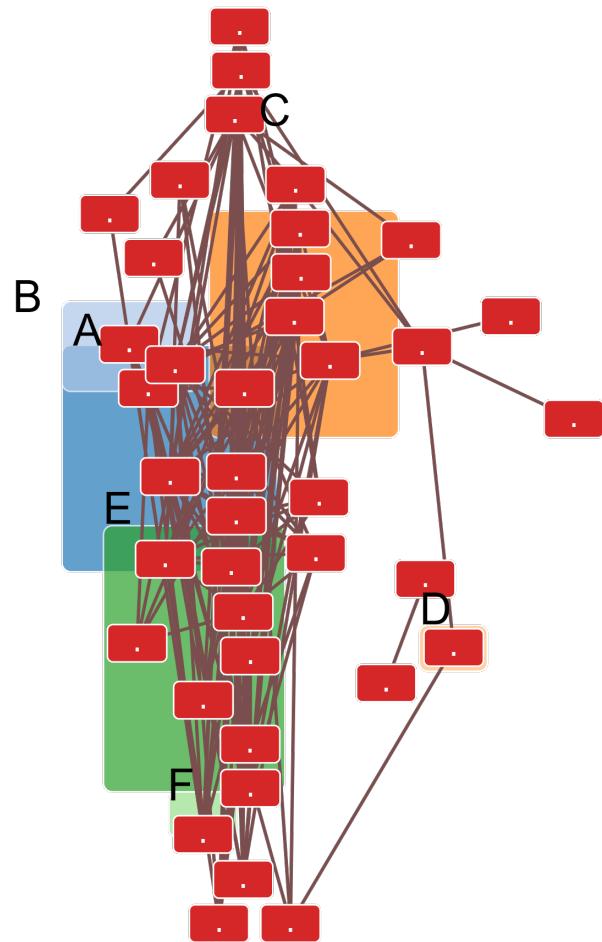
BubbleSets (with graph)



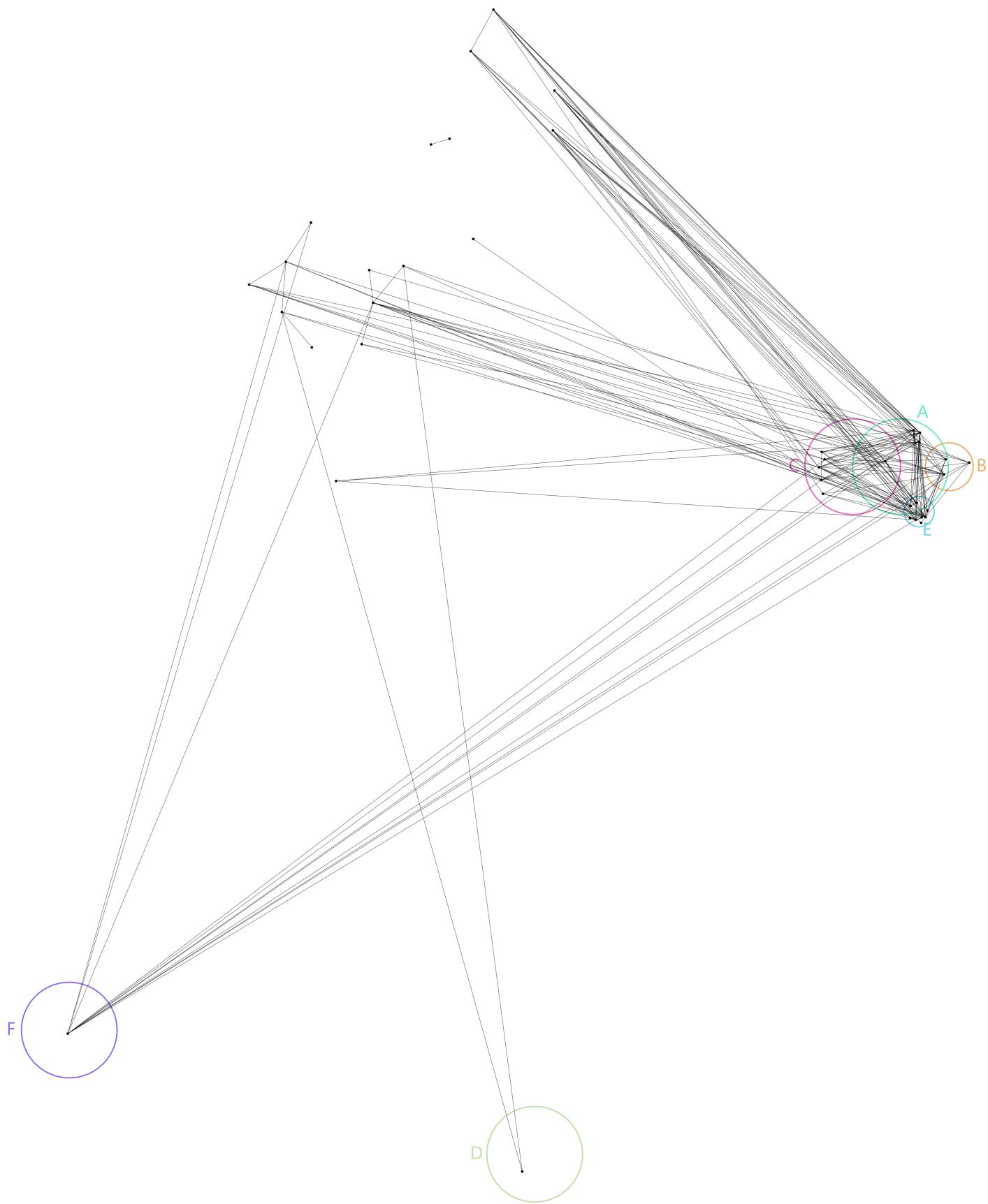
WebCola (without graph)



WebCola (with graph)



GroupNet

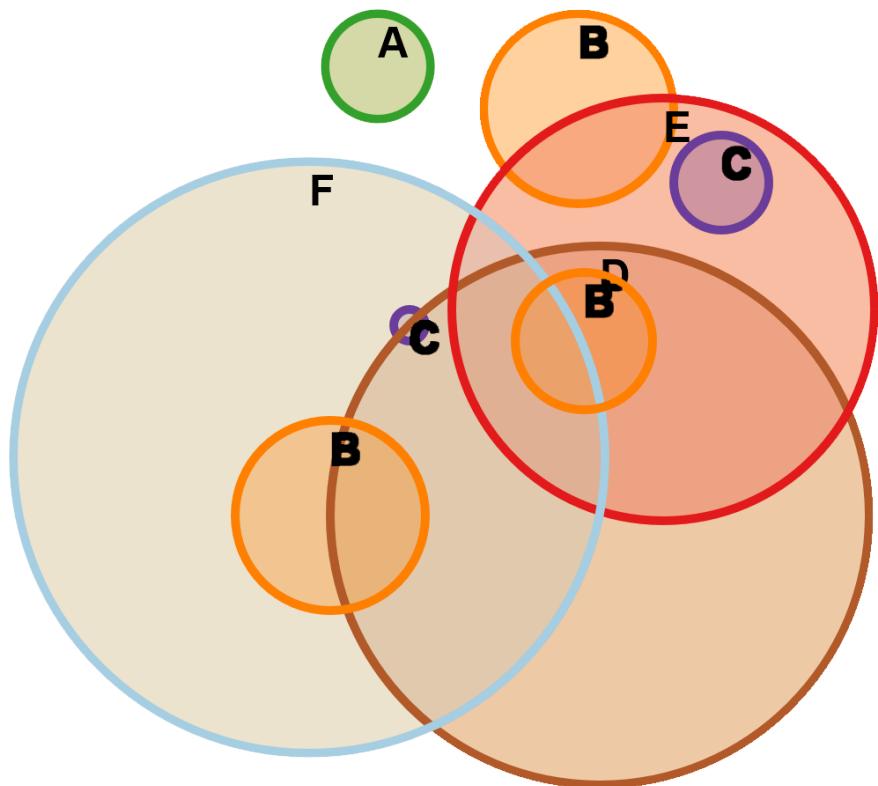


6-set data set 7 : SNAP ID: 326259198

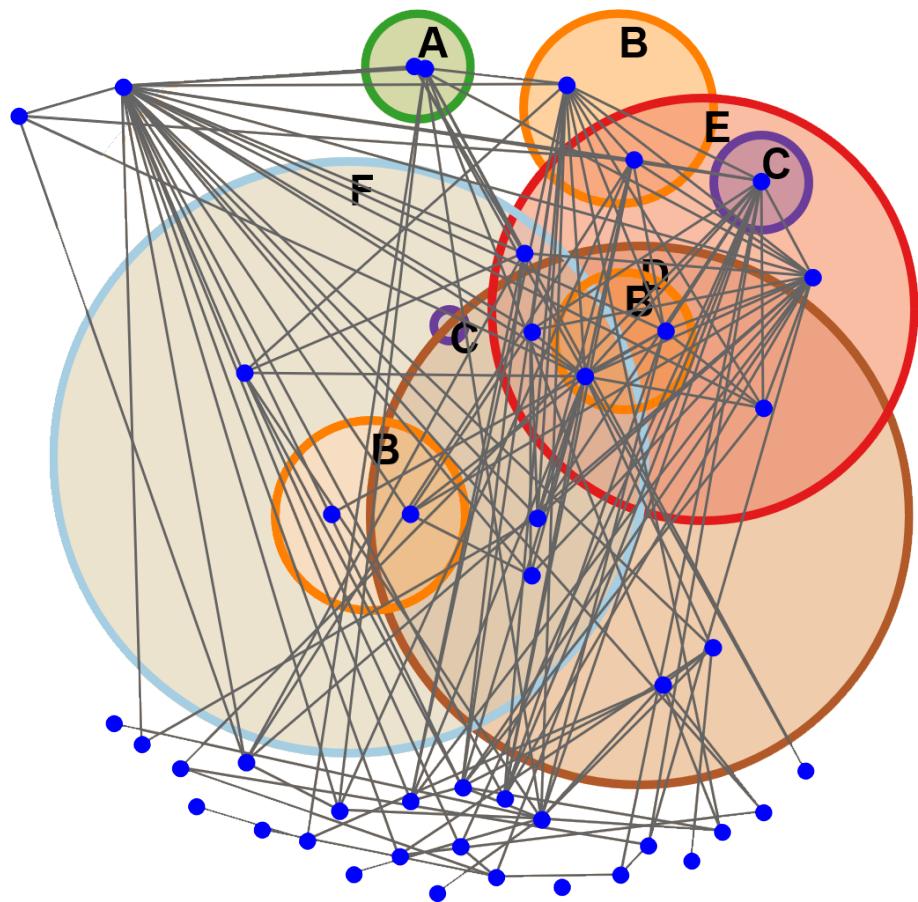
Number of Sets: 6
 Number of Zones: 18
 Number of Nodes: 45
 Number of Edges: 142
 Zones high: yes
 Nodes high: yes
 Edges high: no

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	40	3	215	10
Vertex-vertex intersections	2	0	8	0
Vertices in incorrect zones	2	0	14	0
Omitted zones	0	0	6	0
Ineffective properties				
Non-unique labels	3	0	0	0
Disconnected zones	0	17	3	0
Concurrent curves	0	2	5	0
Triple points	0	5	2	0
Non-circles	0	6	6	2
Extra zones	0	4	3	5
Edge crossings	1474	425	1532	1330
Extra edge-curve crossings	106	411	272	262
Runtime (in sec)	2.942	0.633	7.167	29.078

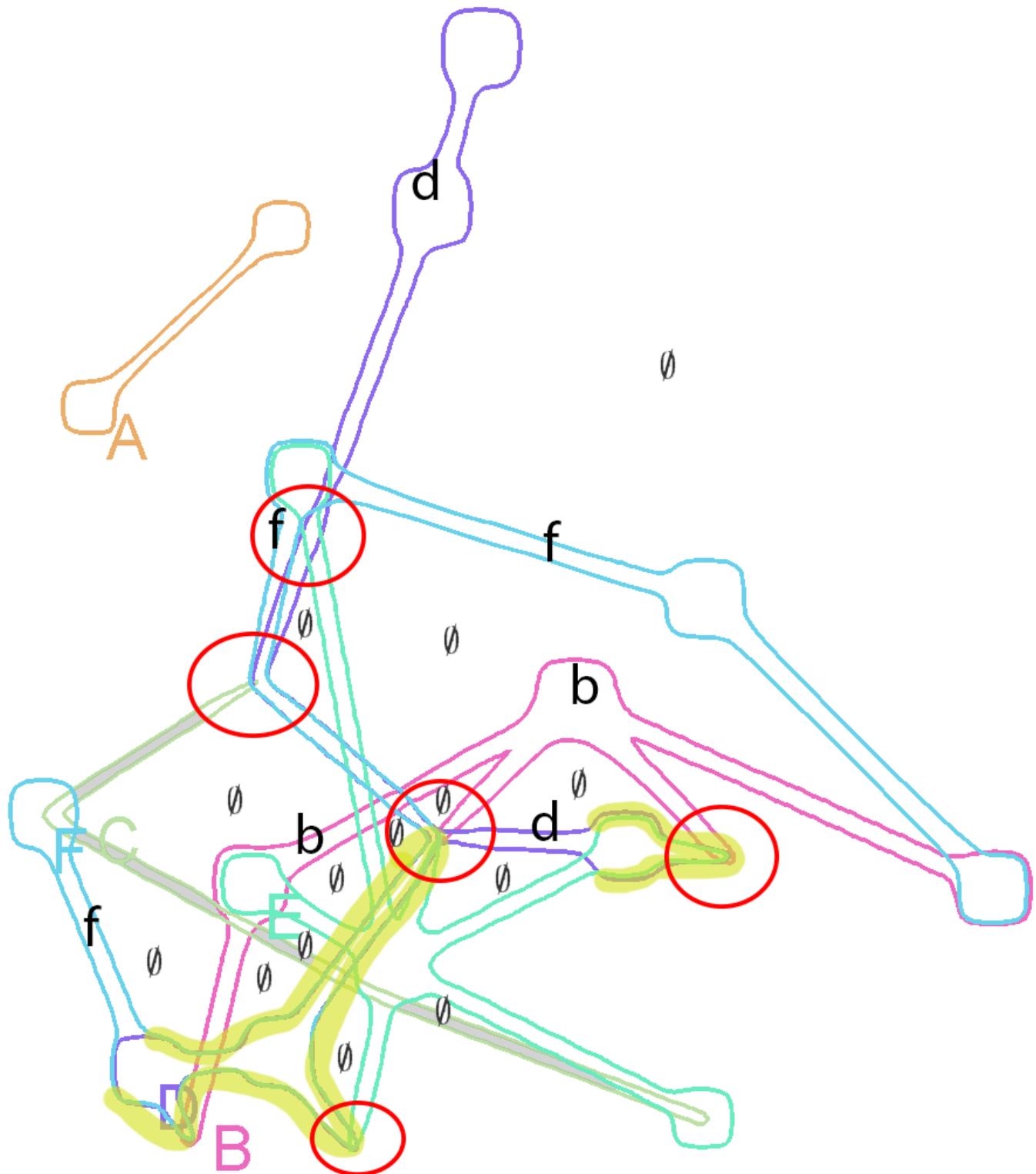
SetNet (without graph)



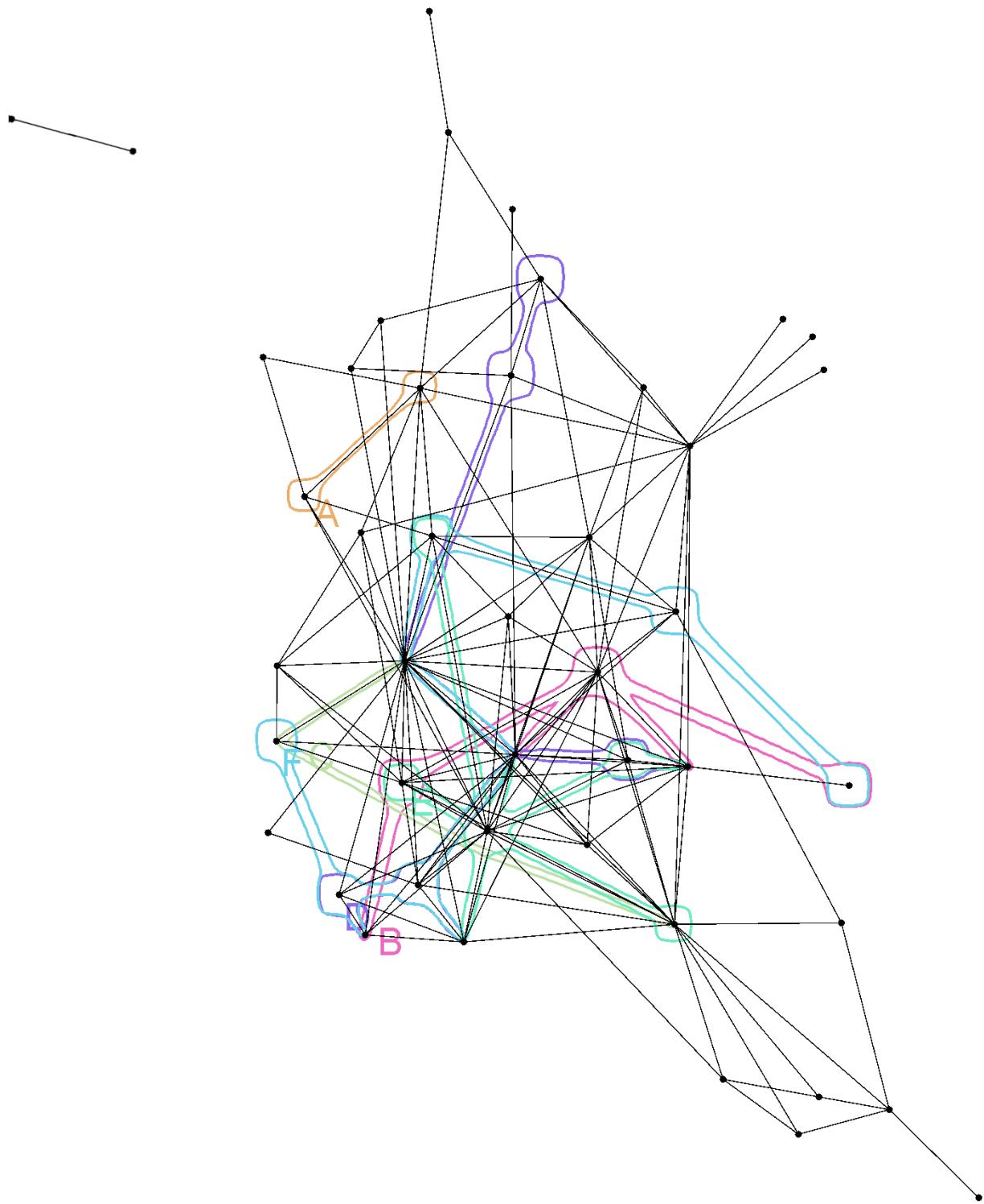
SetNet (with graph)



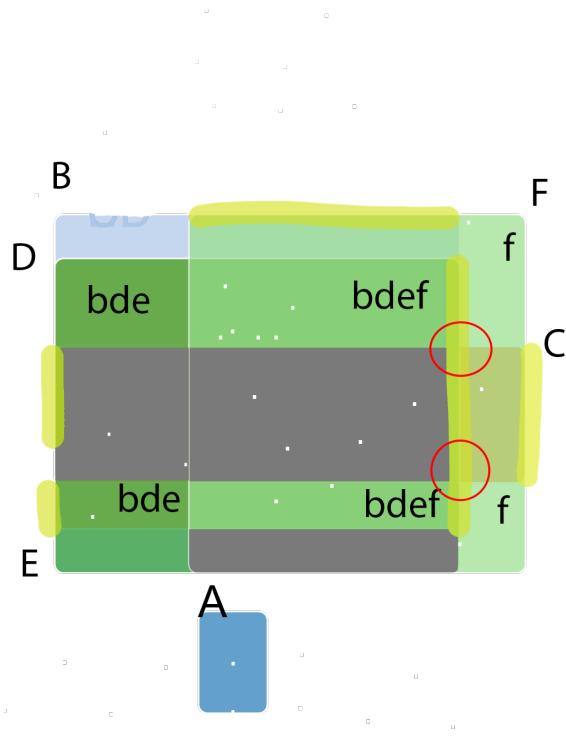
BubbleSets (without graph)



BubbleSets (with graph)

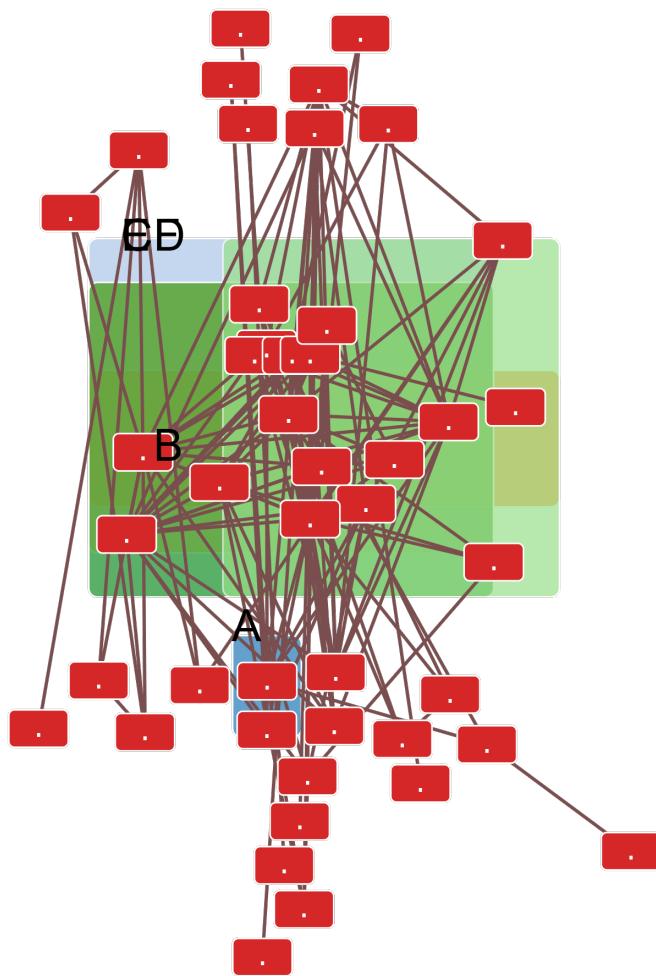


WebCola (without graph)



Omitted zones: D, E, CE, DE, CDF, DEF

WebCola (with graph)



GroupNet

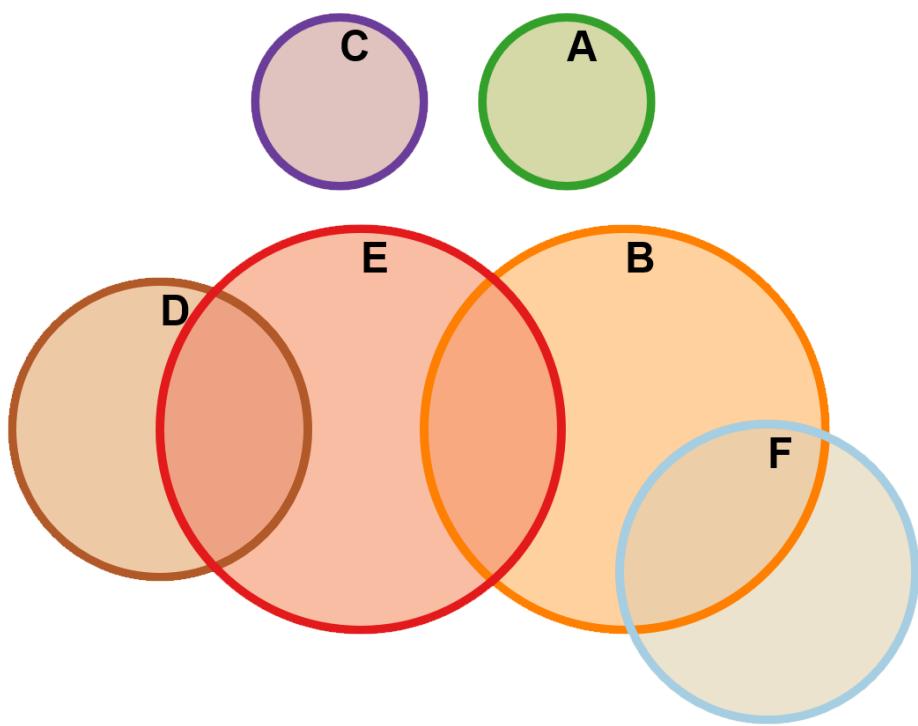


6-set data set 8 : SNAP ID: 170729553

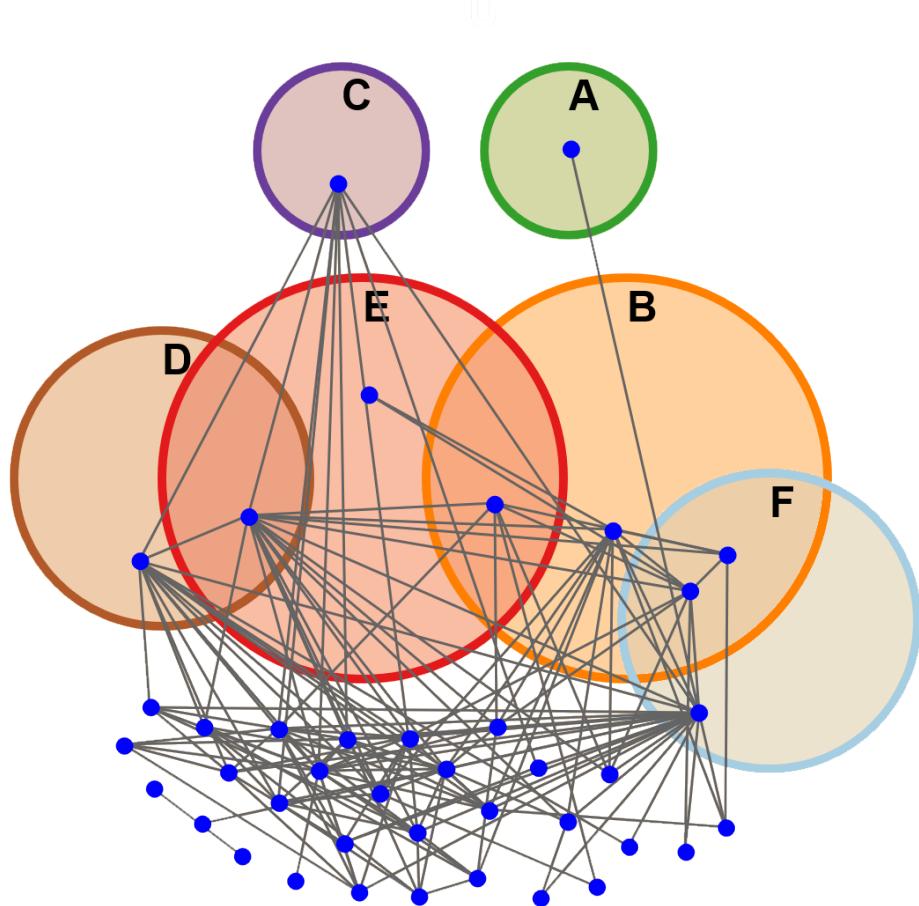
Number of Sets: 6
 Number of Zones: 10
 Number of Nodes: 40
 Number of Edges: 152
 Zones high: yes
 Nodes high: yes
 Edges high: yes

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	33	5	247	22
Vertex-vertex intersections	0	0	0	0
Vertices in incorrect zones	0	0	1	0
Omitted zones	0	0	0	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	2	1	0
Concurrent curves	0	1	2	0
Triple points	0	0	0	0
Non-circles	0	6	6	0
Extra zones	0	0	0	0
Edge crossings	1247	587	1615	1527
Extra edge-curve crossings	20	80	232	176
Runtime (in sec)	3.027	0.715	7.873	9.609

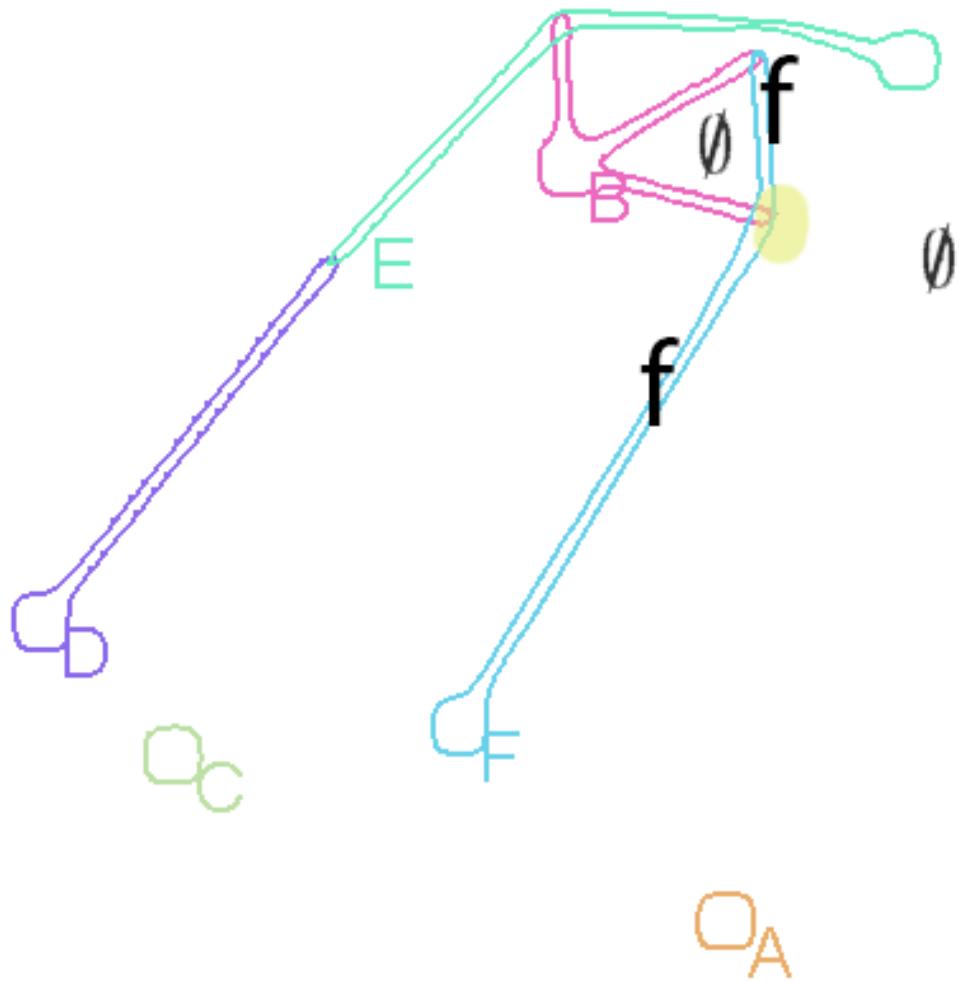
SetNet (without graph)



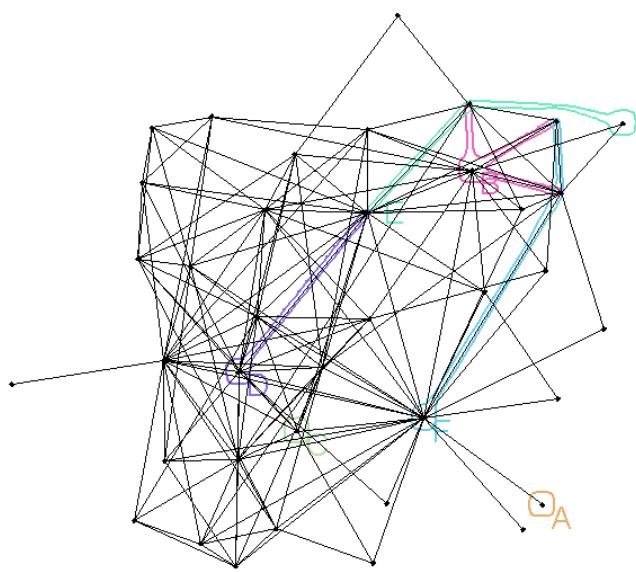
SetNet (with graph)



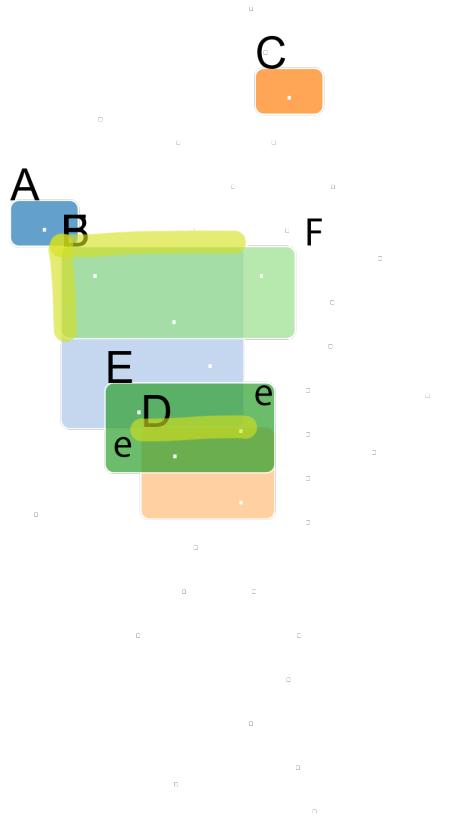
BubbleSets (without graph)



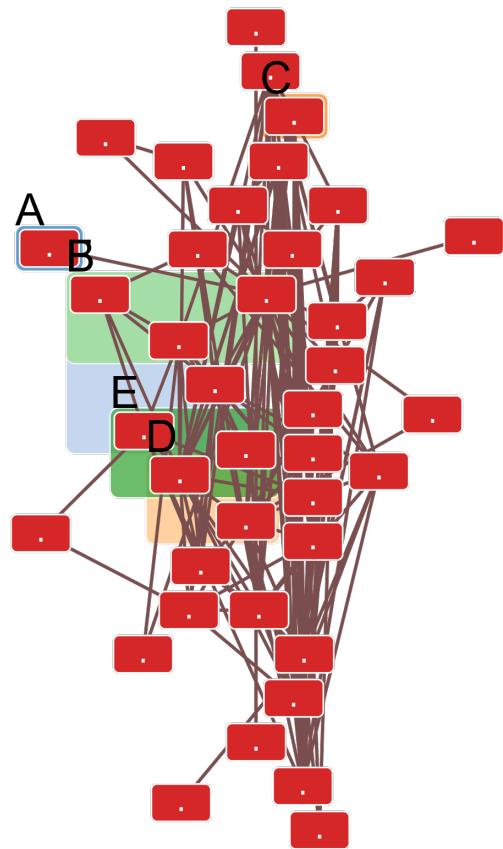
BubbleSets (with graph)



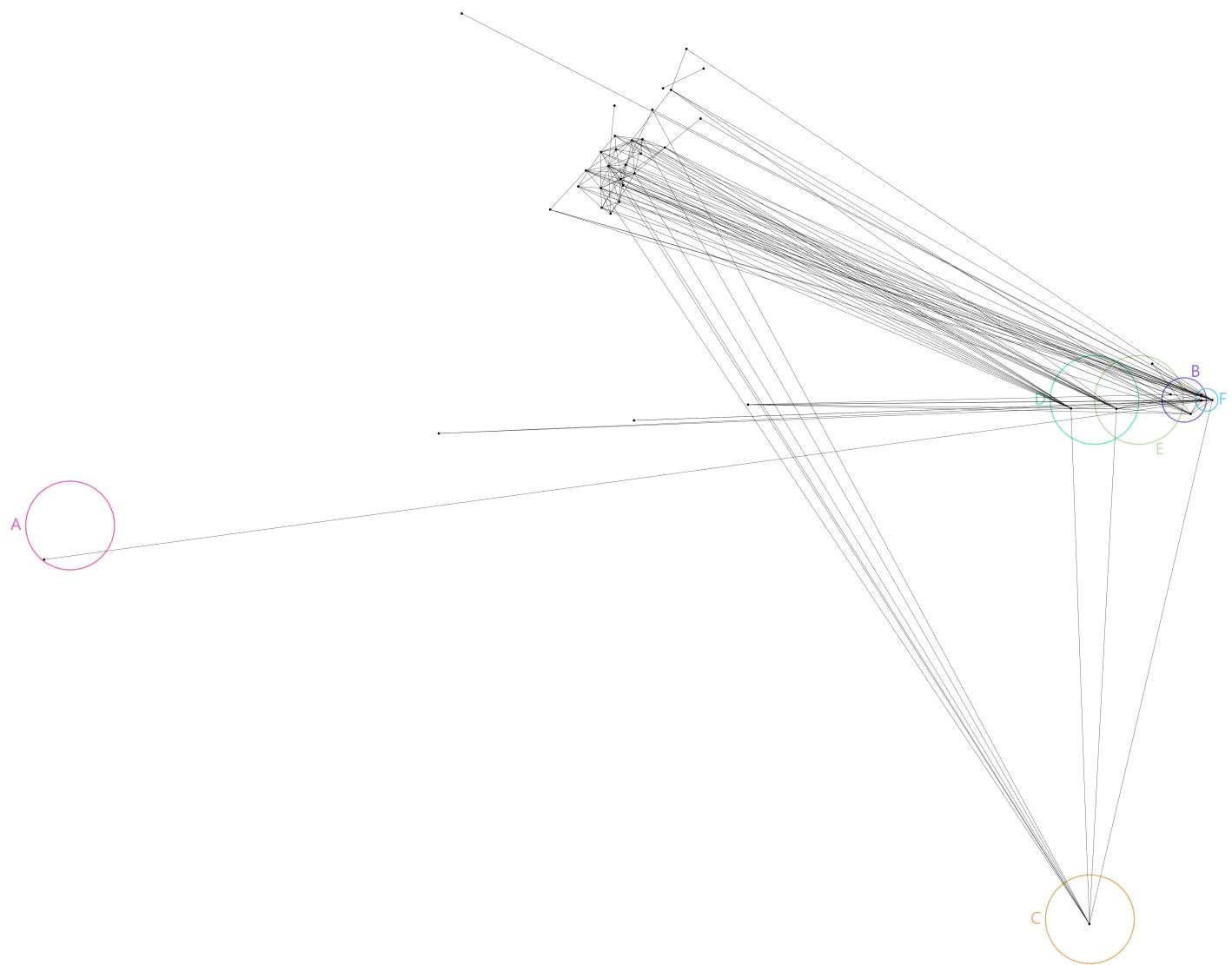
WebCola (without graph)



WebCola (with graph)



GroupNet

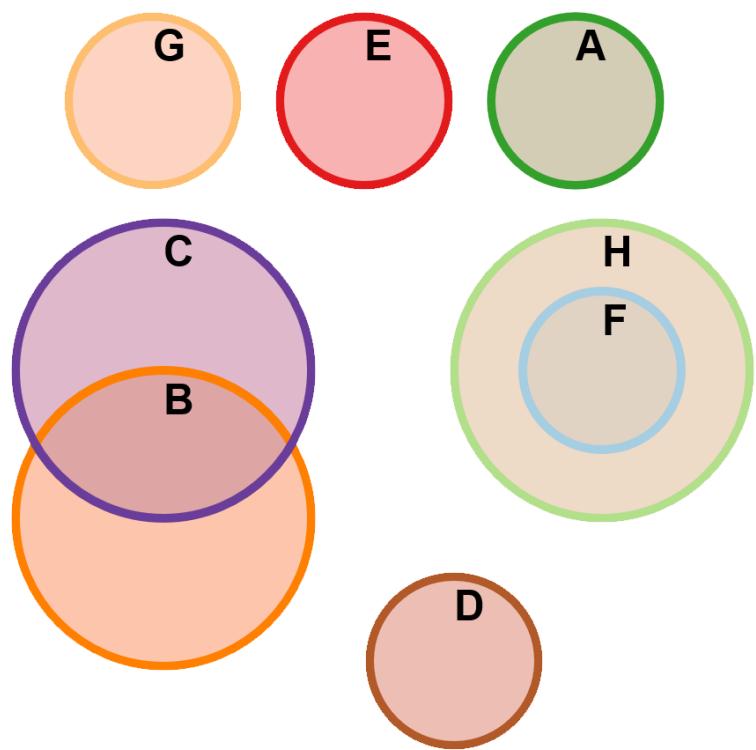


8-set data set 1 : SNAP ID: 11348282

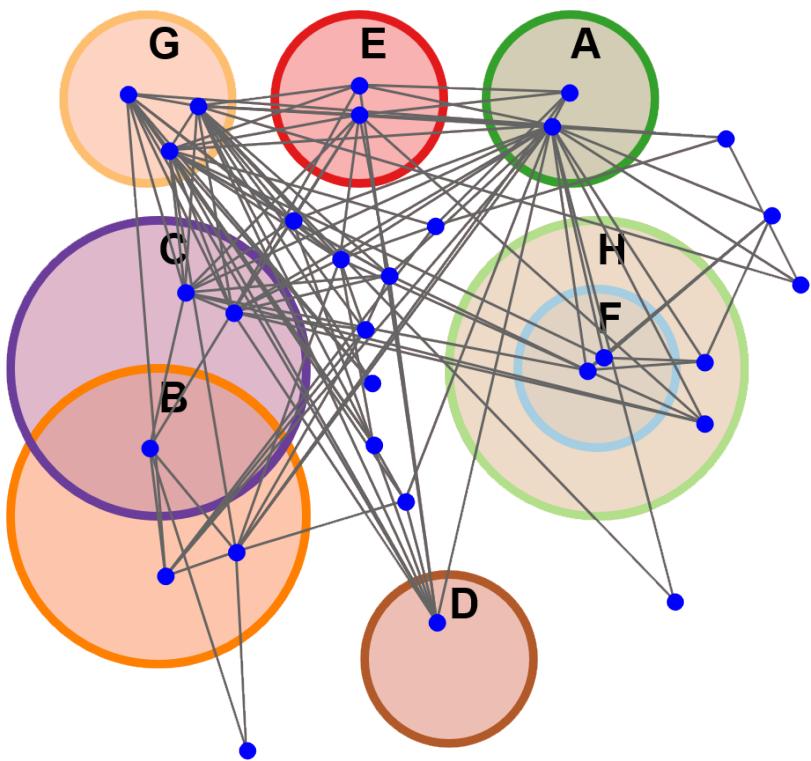
Number of Sets: 8
Number of Zones: 10
Number of Nodes: 30
Number of Edges: 118
Zones high: no
Nodes high: no
Edges high: no

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	35	4	157	0
Vertex-vertex intersections	0	0	0	0
Vertices in incorrect zones	0	0	1	0
Omitted zones	0	0	0	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	4	0	0
Concurrent curves	0	1	4	0
Triple points	0	0	0	0
Non-circles	0	8	8	0
Extra zones	0	5	0	0
Edge crossings	854	512	845	1277
Extra edge-curve crossings	29	153	194	30
Runtime (in sec)	2.011	0.703	7.014	11.768

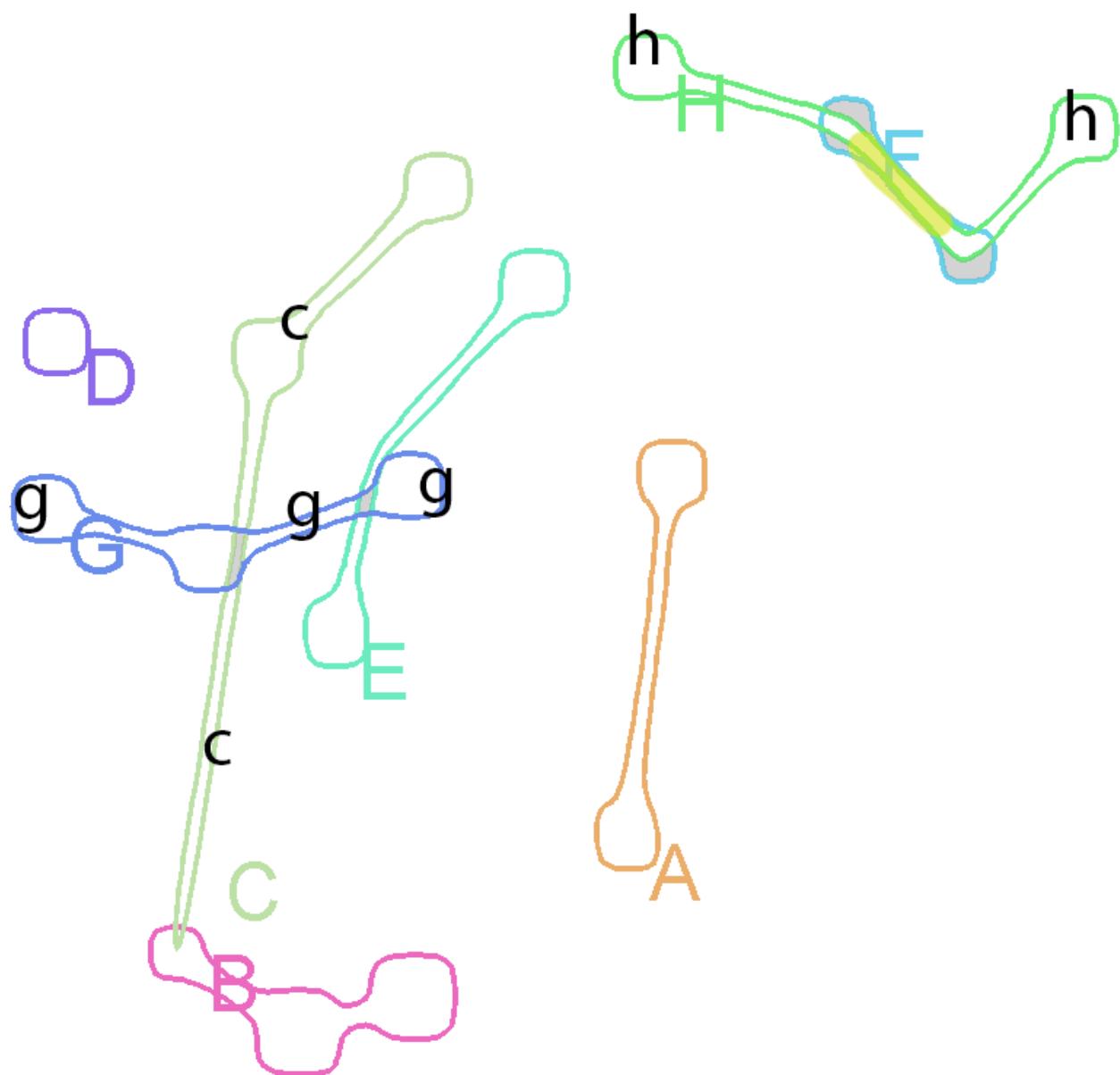
SetNet (without graph)



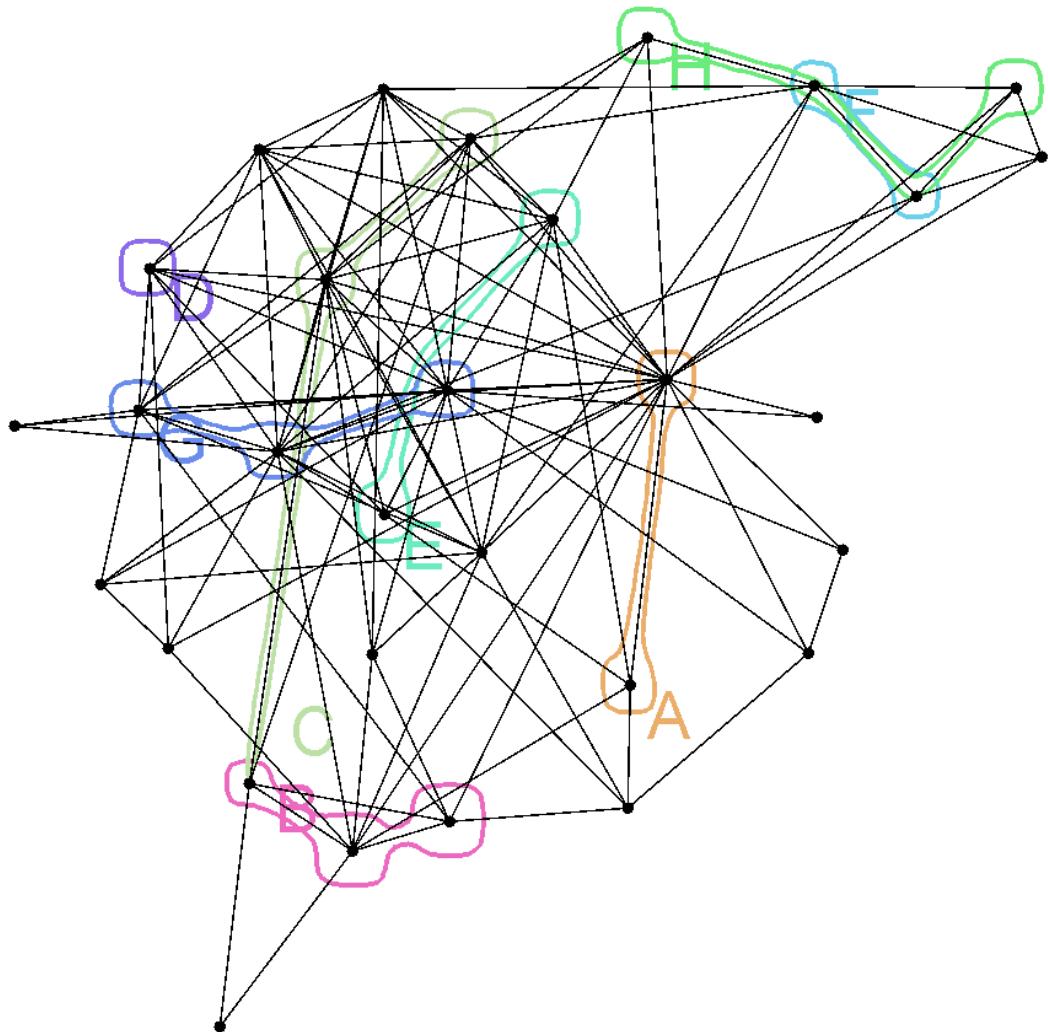
SetNet (with graph)



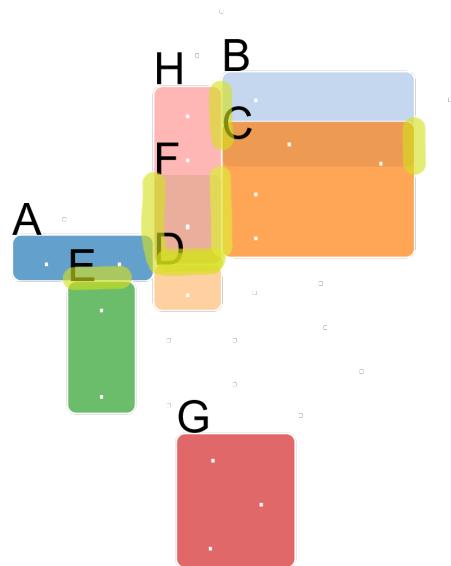
BubbleSets (without graph)



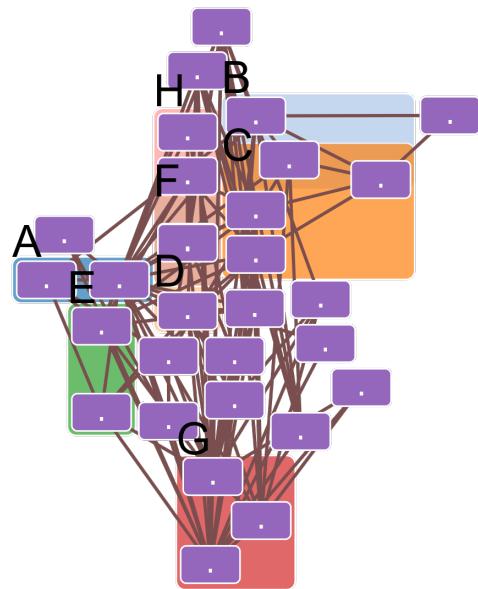
BubbleSets (with graph)



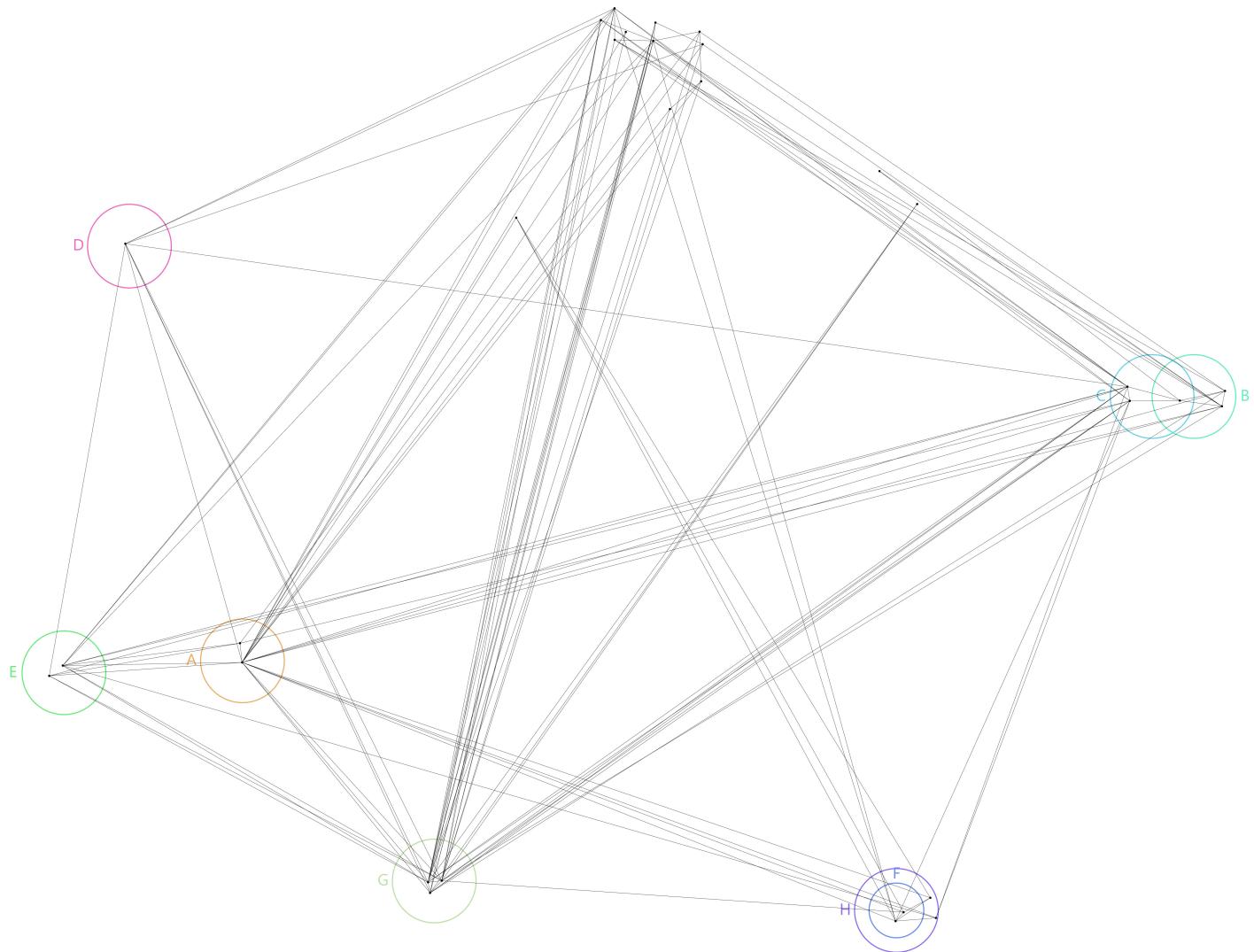
WebCola (without graph)



WebCola (with graph)



GroupNet

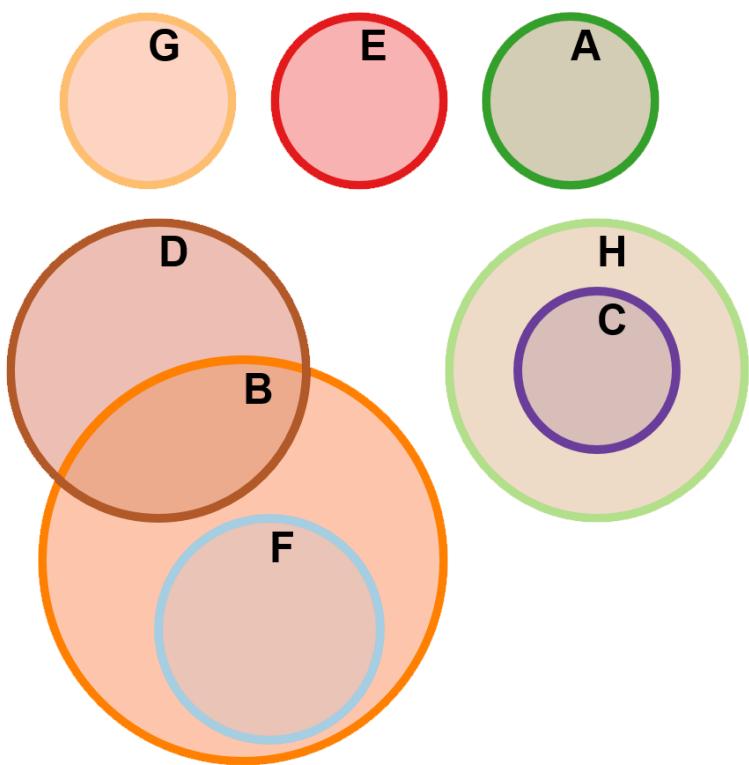


8-set data set 2 : SNAP ID: 21028234

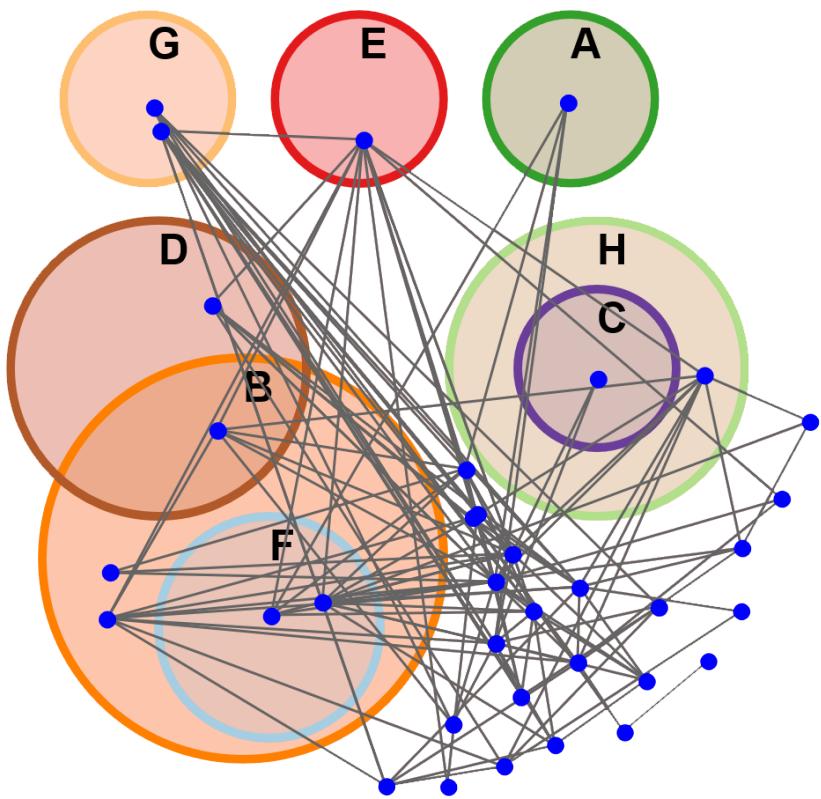
Number of Sets: 8
 Number of Zones: 10
 Number of Nodes: 35
 Number of Edges: 128
 Zones high: no
 Nodes high: no
 Edges high: yes

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	69	9	196	1
Vertex-vertex intersections	1	0	0	0
Vertices in incorrect zones	0	1	3	0
Omitted zones	0	0	1	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	9	0	0
Concurrent curves	0	1	2	0
Triple points	0	0	0	0
Non-circles	0	8	8	0
Extra zones	0	3	1	0
Edge crossings	1372	416	984	1621
Extra edge-curve crossings	54	196	387	58
Runtime (in sec)	2.389	0.734	6.552	14.392

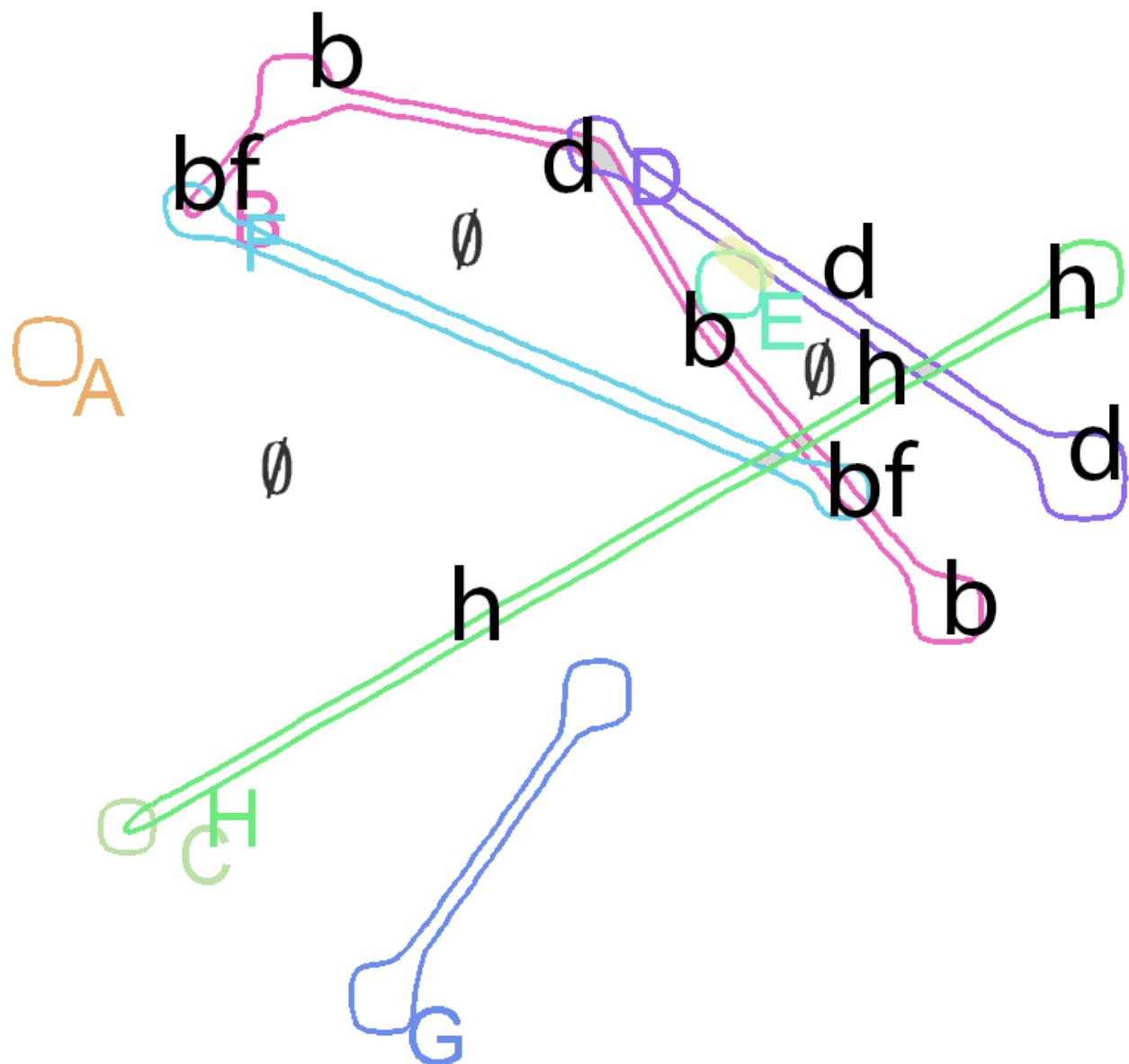
SetNet (without graph)



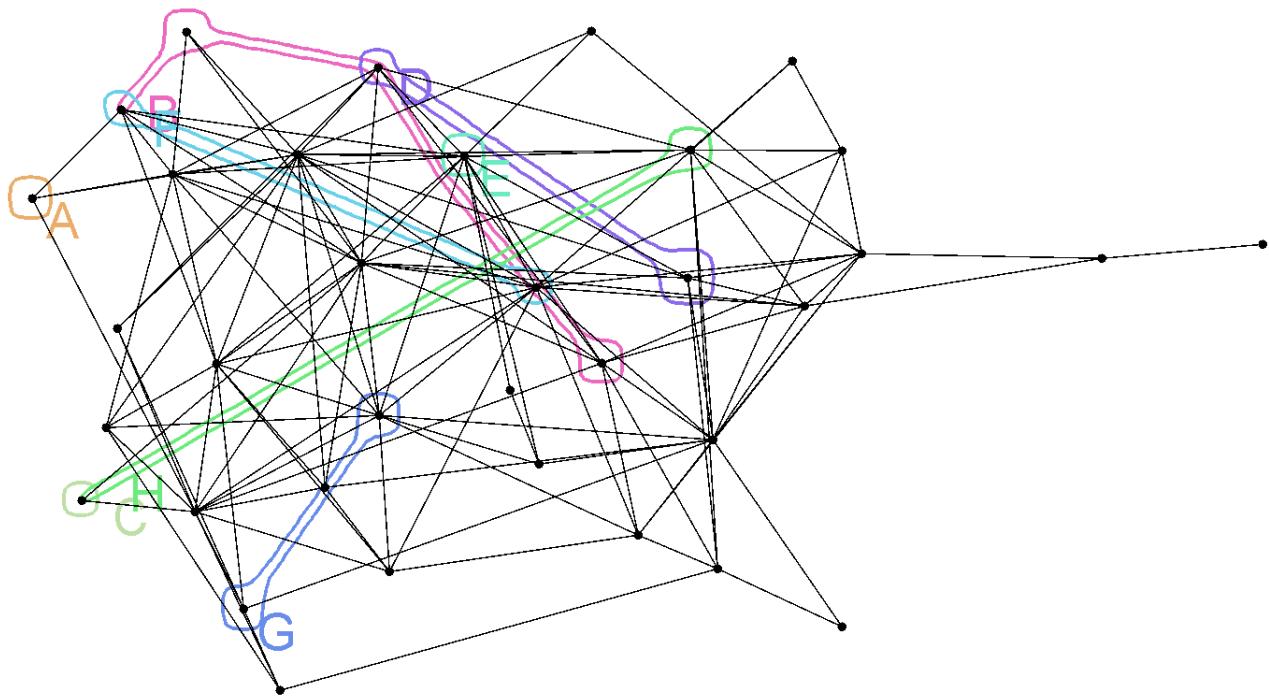
SetNet (with graph)



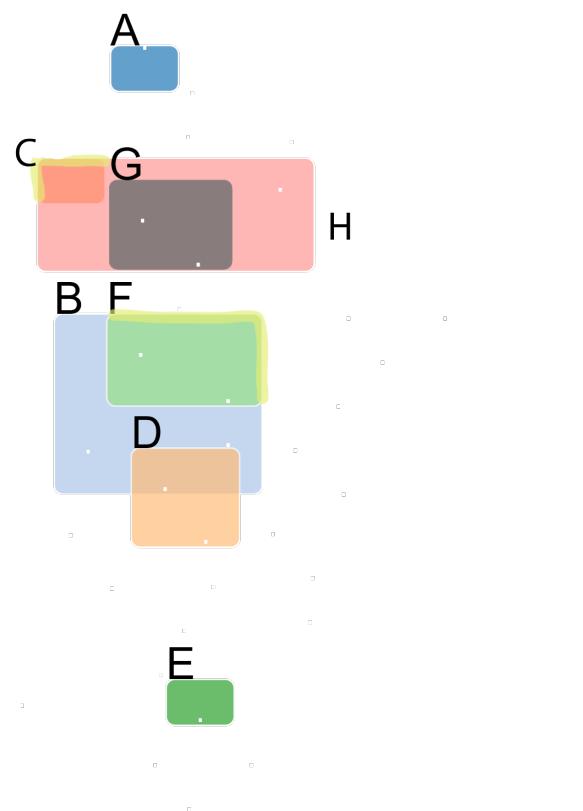
BubbleSets (without graph)



BubbleSets (with graph)

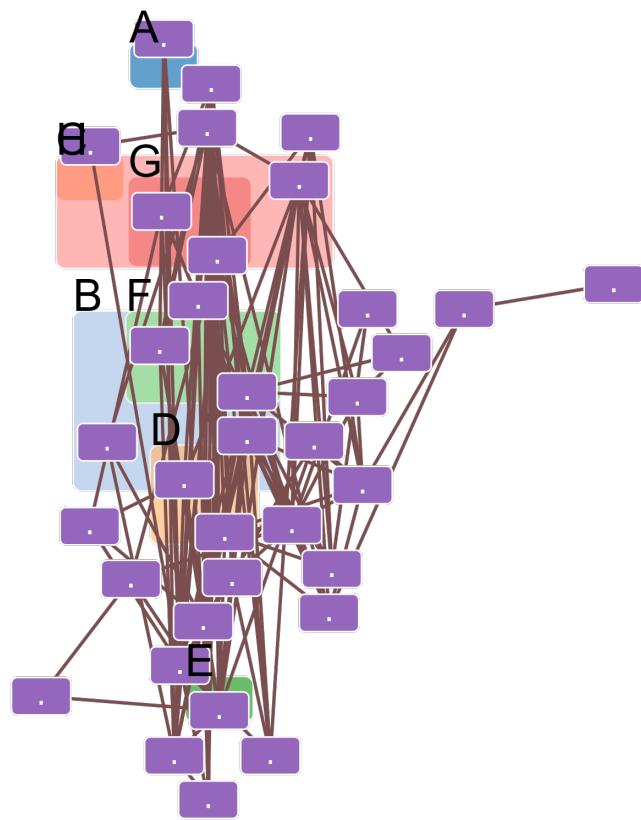


WebCola (without graph)

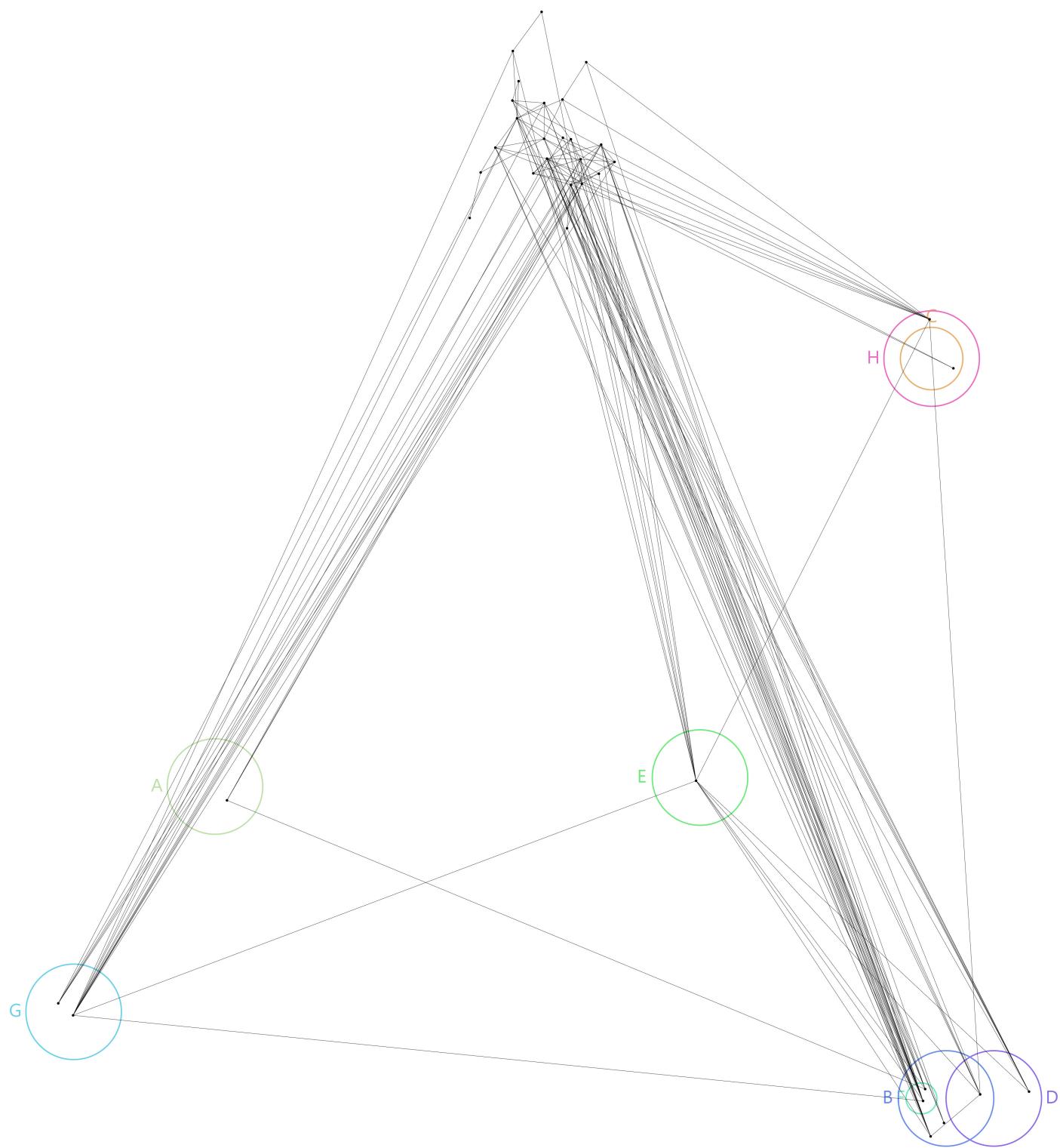


Omitted zones: G

WebCola (with graph)



GroupNet

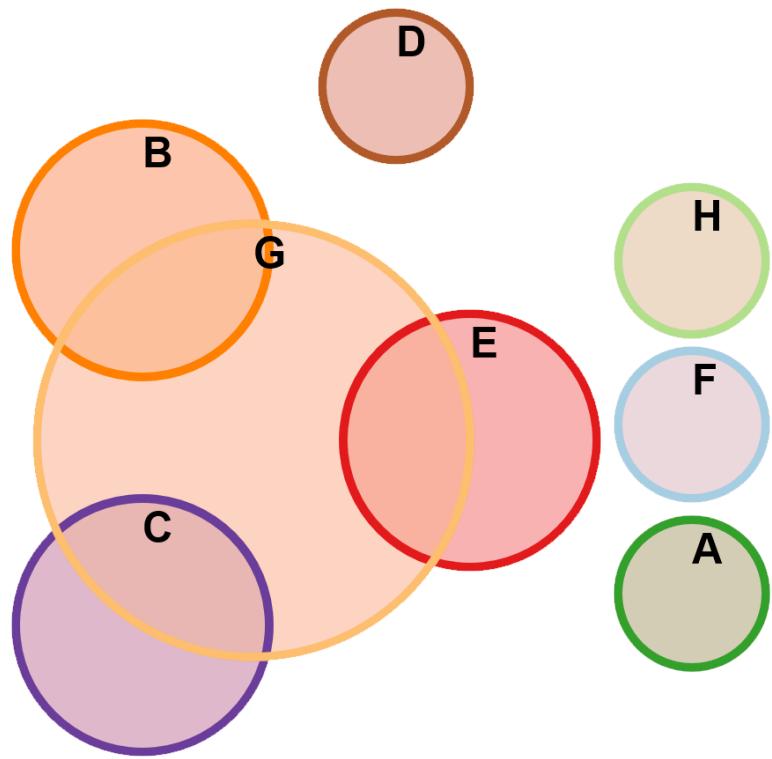


8-set data set 3 : SNAP ID: 61311054

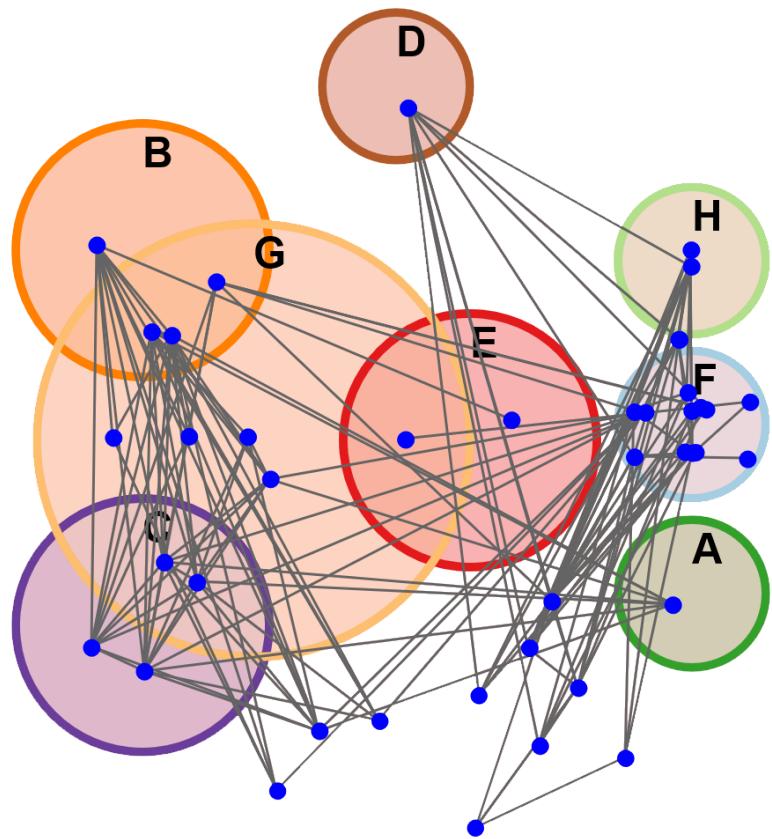
Number of Sets: 8
 Number of Zones: 12
 Number of Nodes: 43
 Number of Edges: 144
 Zones high: no
 Nodes high: yes
 Edges high: no

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	139	7	332	12
Vertex-vertex intersections	11	0	0	0
Vertices in incorrect zones	1	1	1	0
Omitted zones	0	0	0	0
Ineffective properties				
Non-unique labels	0	0	0	0
Disconnected zones	0	17	0	0
Concurrent curves	0	0	3	0
Triple points	0	0	1	0
Non-circles	0	8	8	0
Extra zones	0	5	0	0
Edge crossings	1344	359	1042	1284
Extra edge-curve crossings	48	218	107	98
Runtime (in sec)	3.057	0.922	8.481	13.275

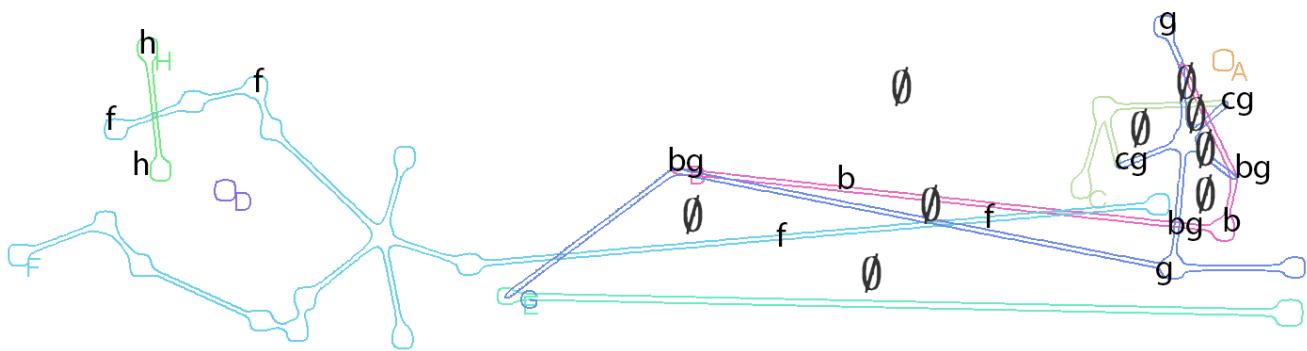
SetNet (without graph)



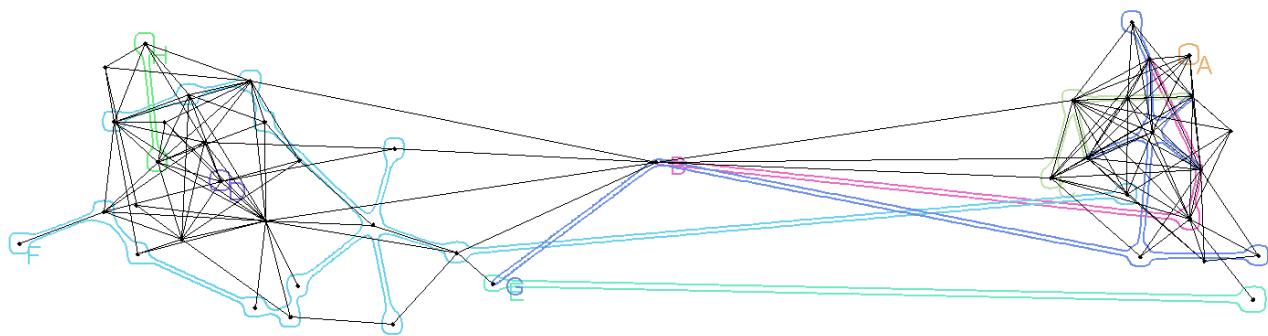
SetNet (with graph)



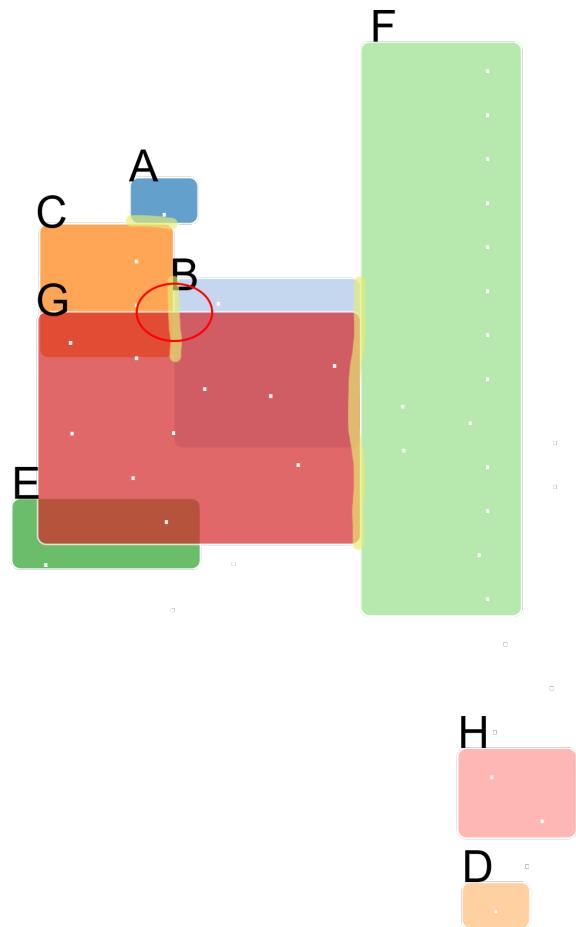
BubbleSets (without graph)



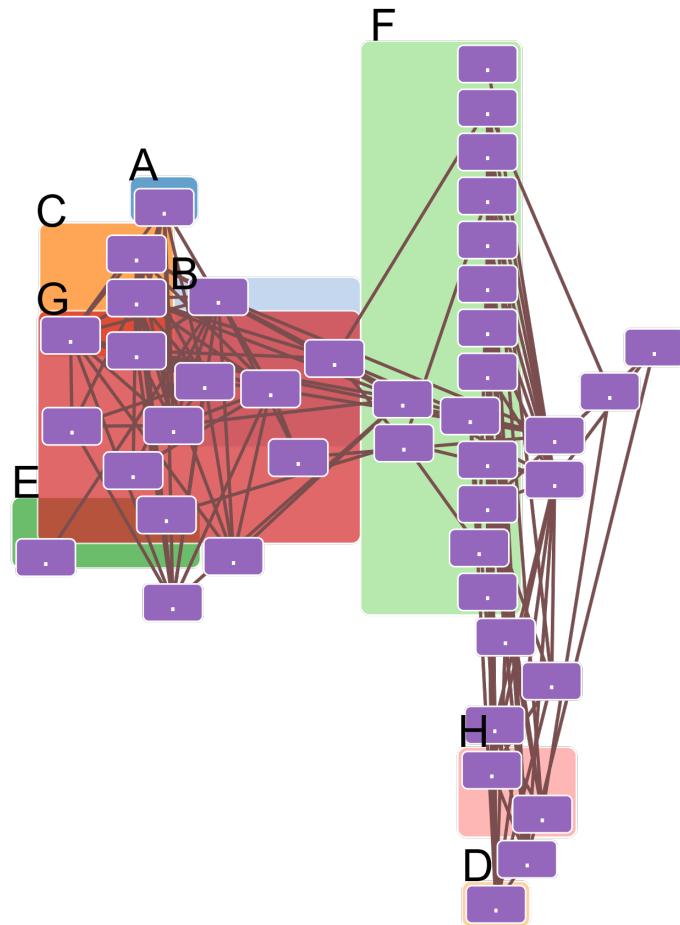
BubbleSets (with graph)



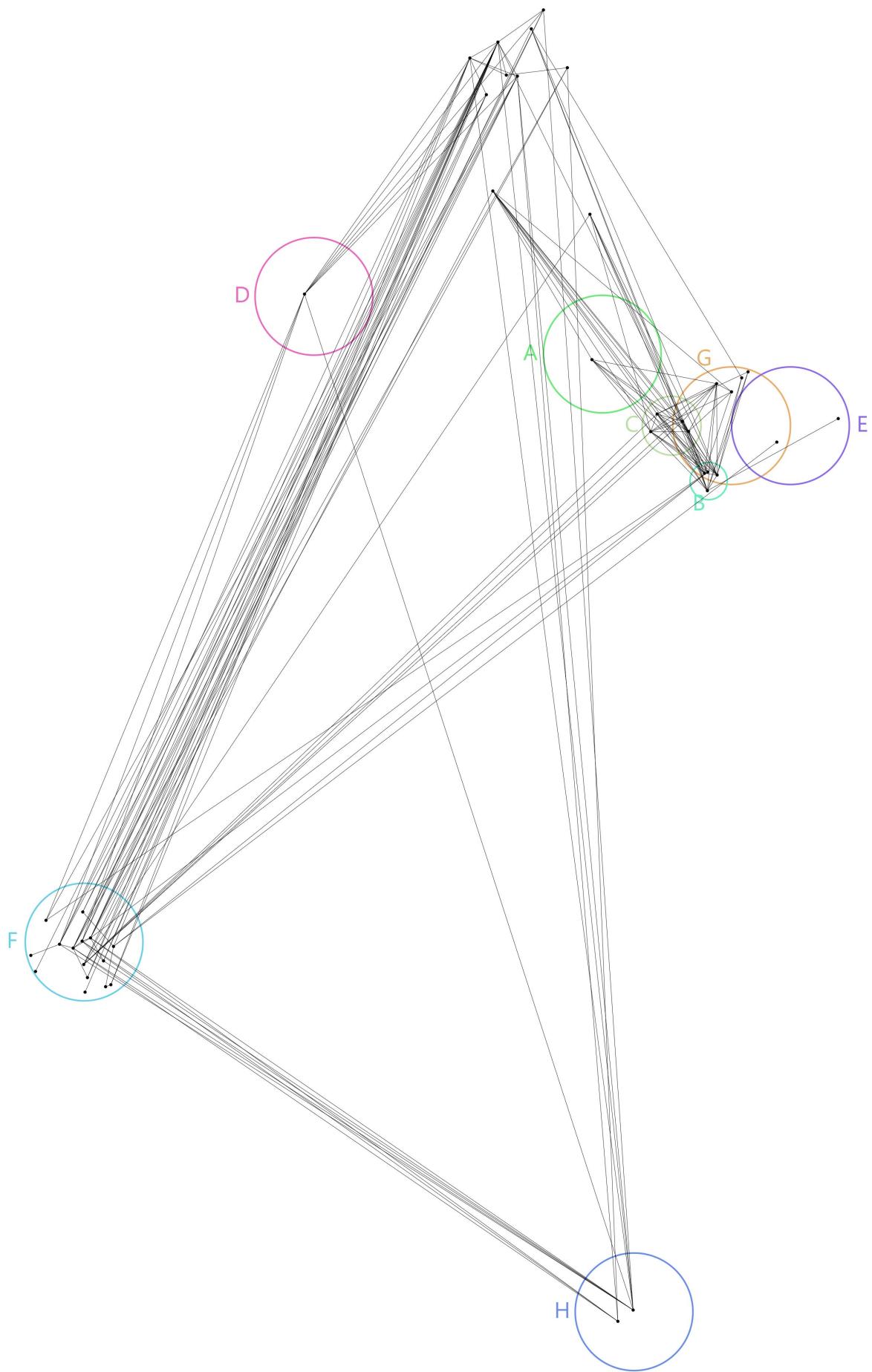
WebCola (without graph)



WebCola (with graph)



GroupNet

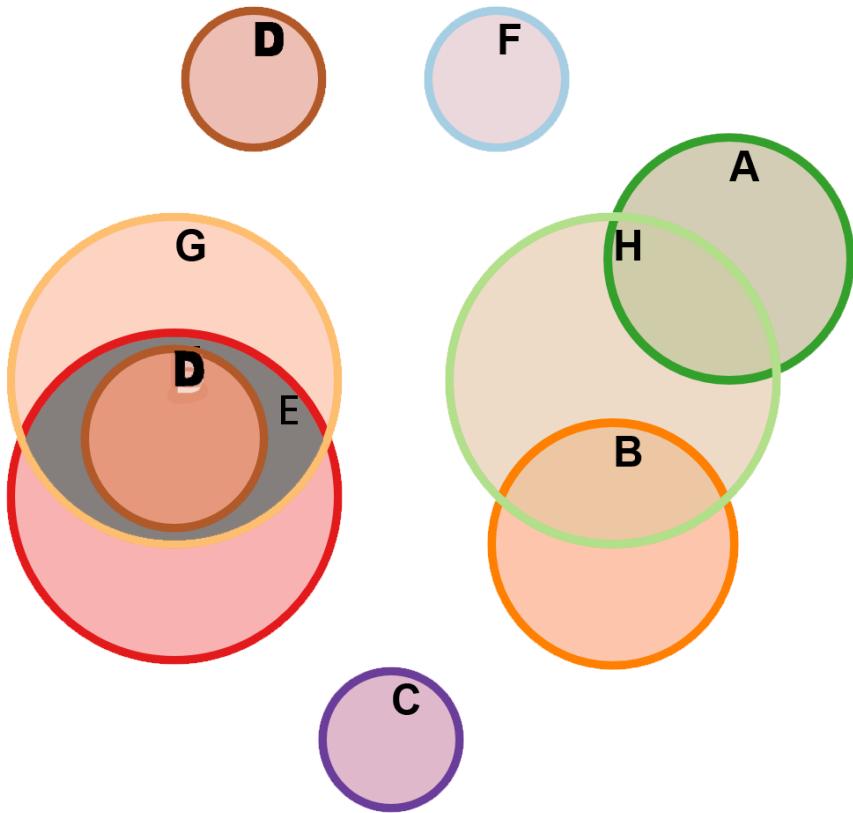


8-set data set 4 : SNAP ID: 13274152

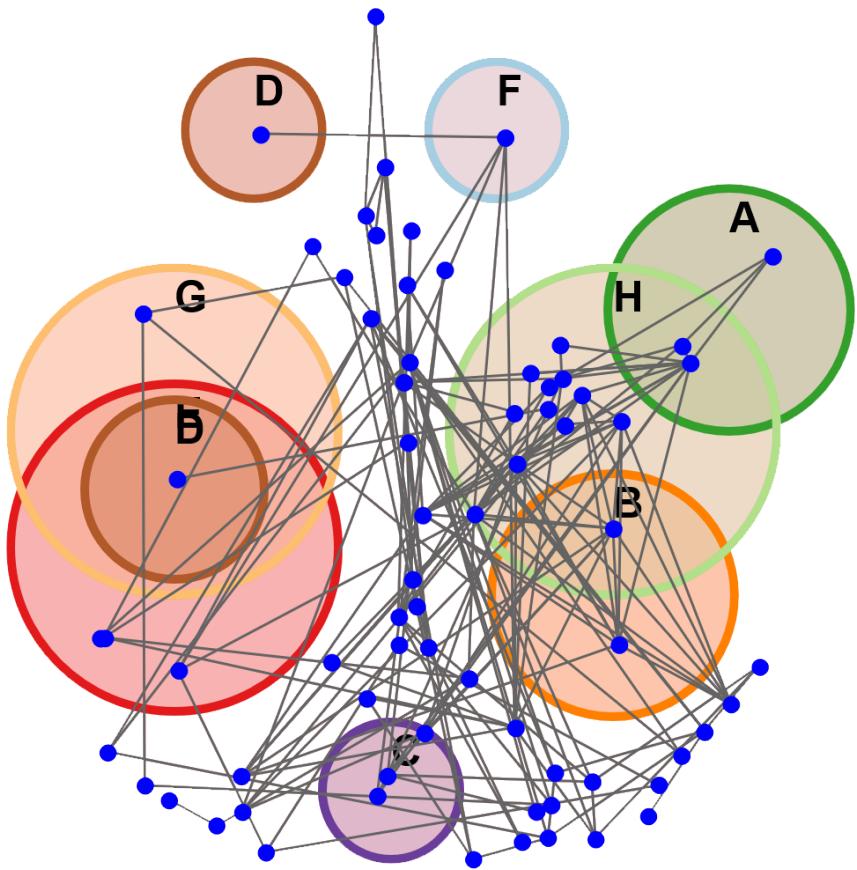
Number of Sets: 8
 Number of Zones: 12
 Number of Nodes: 70
 Number of Edges: 157
 Zones high: no
 Nodes high: yes
 Edges high: yes

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	133	7	207	20
Vertex-vertex intersections	3	0	0	0
Vertices in incorrect zones	2	2	3	0
Omitted zones	0	0	1	0
Ineffective properties				
Non-unique labels	1	0	0	0
Disconnected zones	0	12	0	0
Concurrent curves	0	0	5	0
Triple points	0	0	2	0
Non-circles	0	8	8	0
Extra zones	1	2	2	3
Edge crossings	1678	200	881	1025
Extra edge-curve crossings	61	148	223	66
Runtime (in sec)	5.141	0.594	9.028	22.053

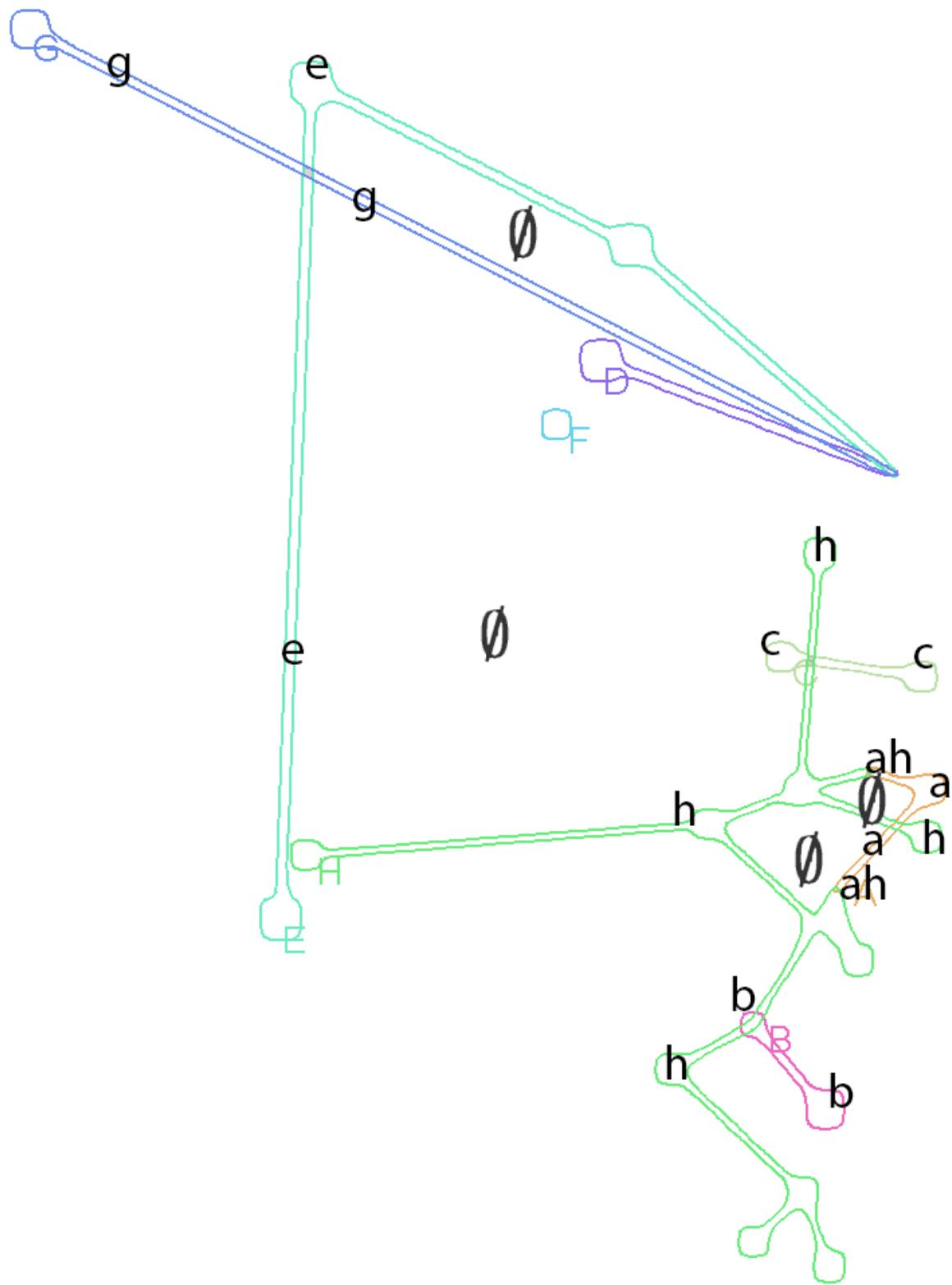
SetNet (without graph)



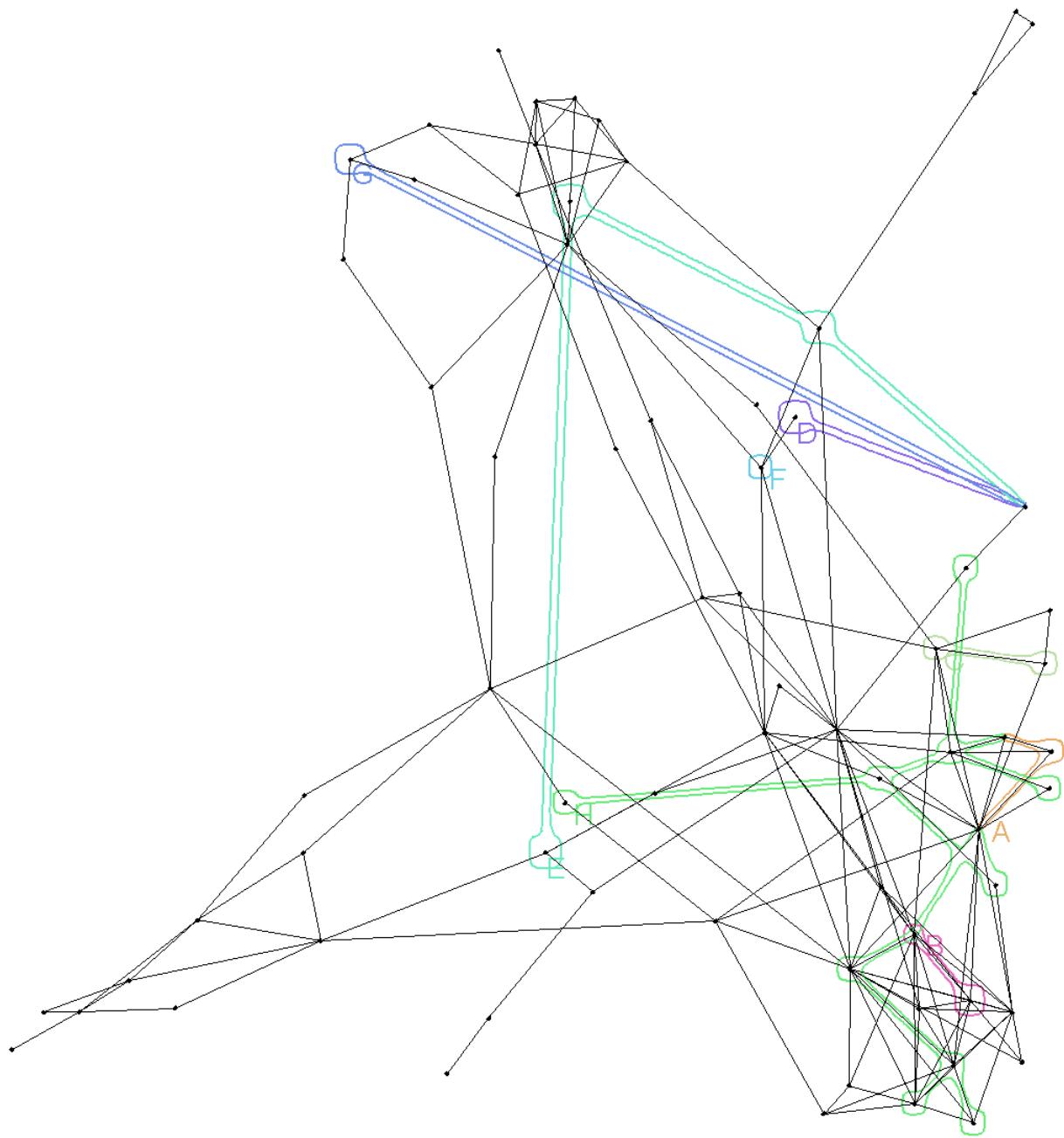
SetNet (with graph)



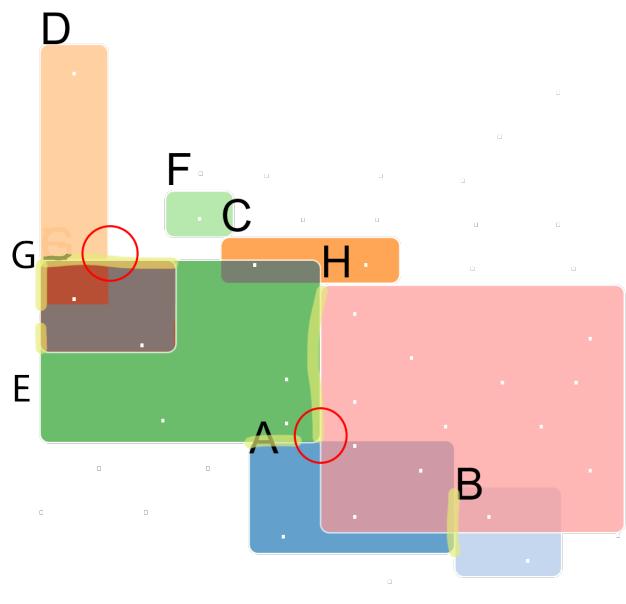
BubbleSets (without graph)



BubbleSets (with graph)

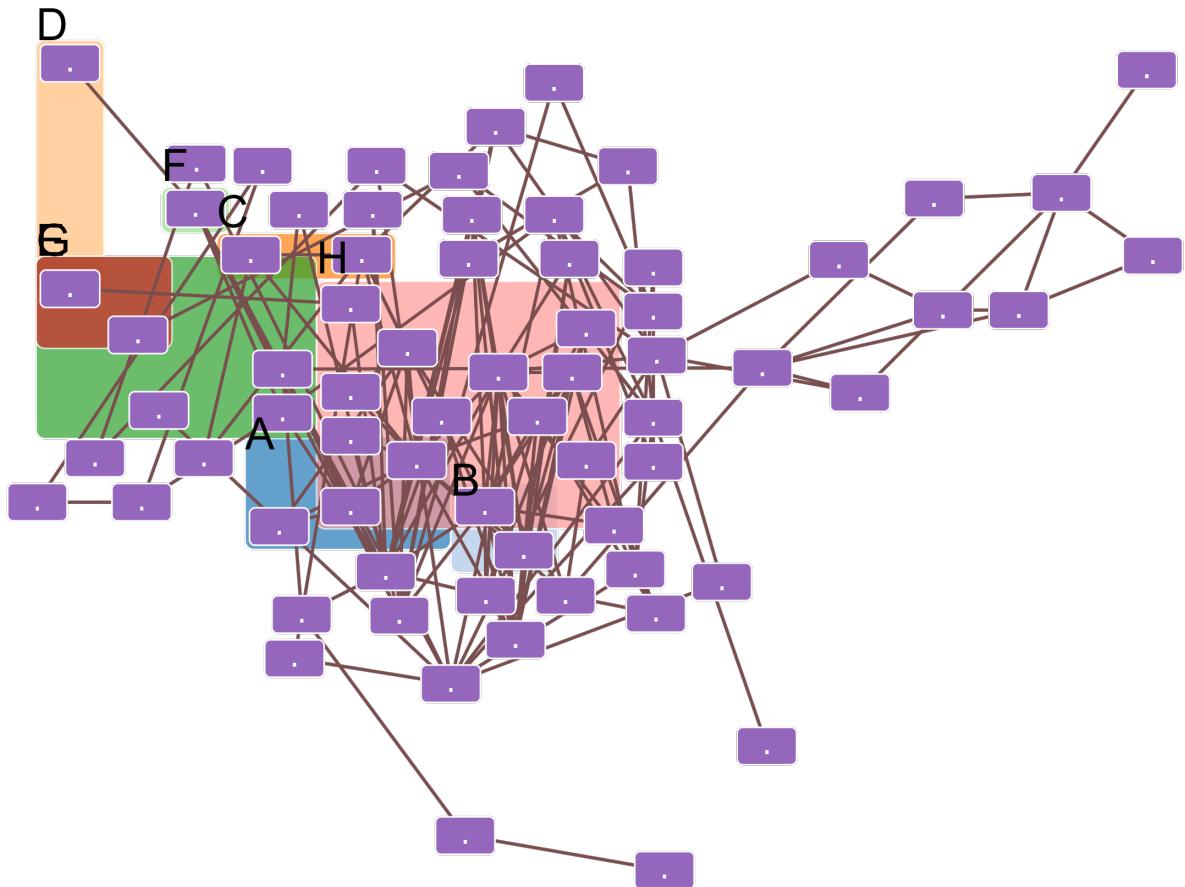


WebCola (without graph)

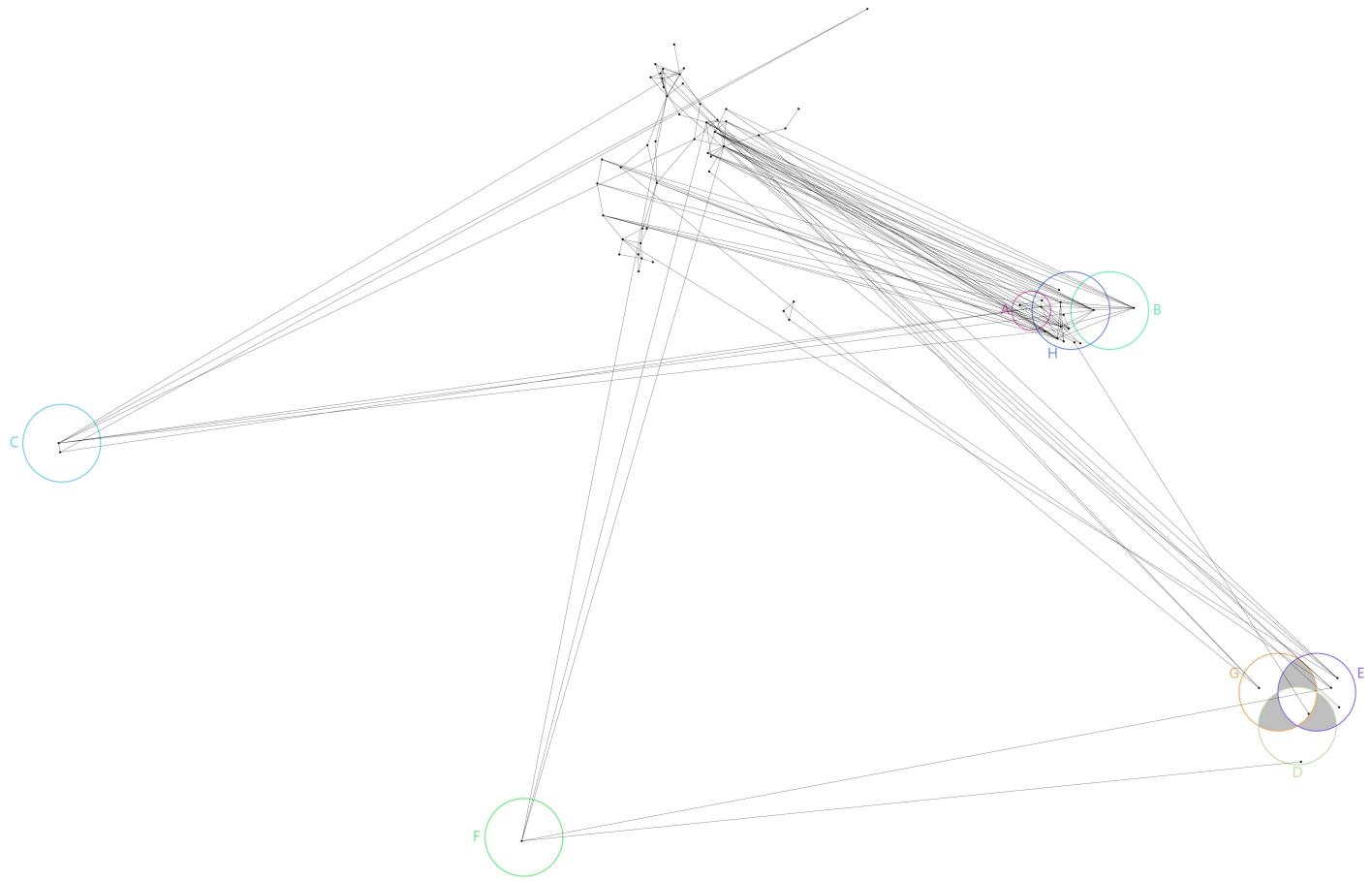


Omitted zones: G

WebCola (with graph)



GroupNet

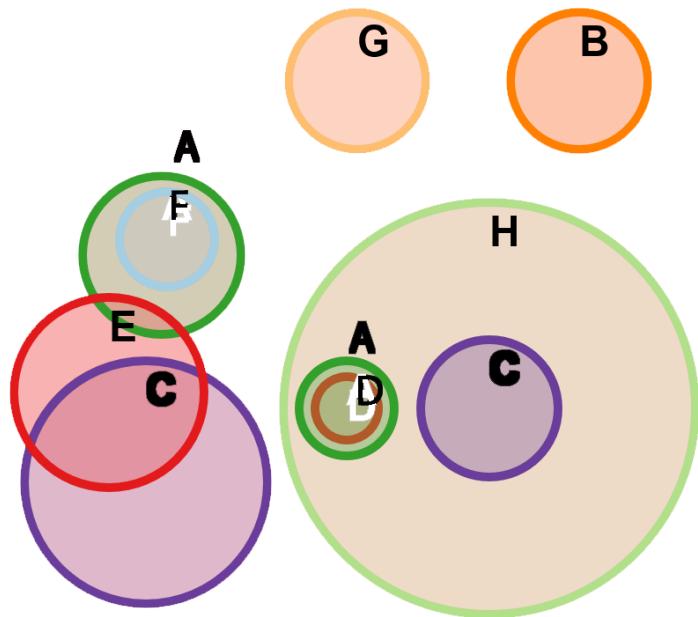


8-set data set 5 : SNAP ID: 77843323

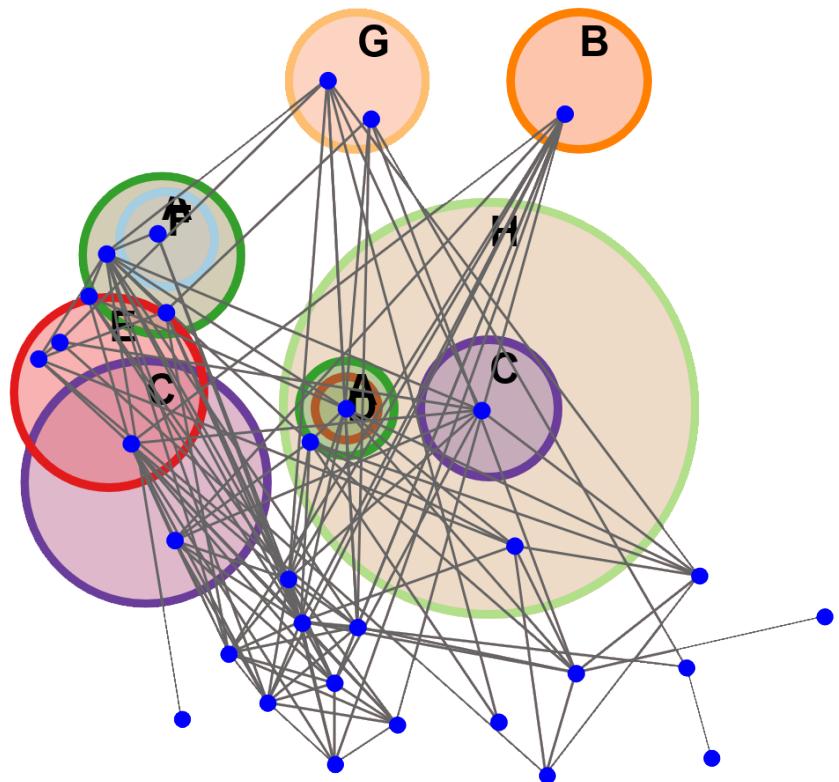
Number of Sets: 8
 Number of Zones: 13
 Number of Nodes: 31
 Number of Edges: 122
 Zones high: yes
 Nodes high: no
 Edges high: no

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	26	7	144	13
Vertex-vertex intersections	0	0	1	0
Vertices in incorrect zones	3	1	3	0
Omitted zones	0	0	0	0
Ineffective properties				
Non-unique labels	2	0	0	0
Disconnected zones	0	19	0	0
Concurrent curves	0	2	3	0
Triple points	0	1	3	0
Non-circles	0	8	8	1
Extra zones	0	3	2	3
Edge crossings	934	411	847	1378
Extra edge-curve crossings	73	208	188	130
Runtime (in sec)	2.445	0.515	8.399	37.447

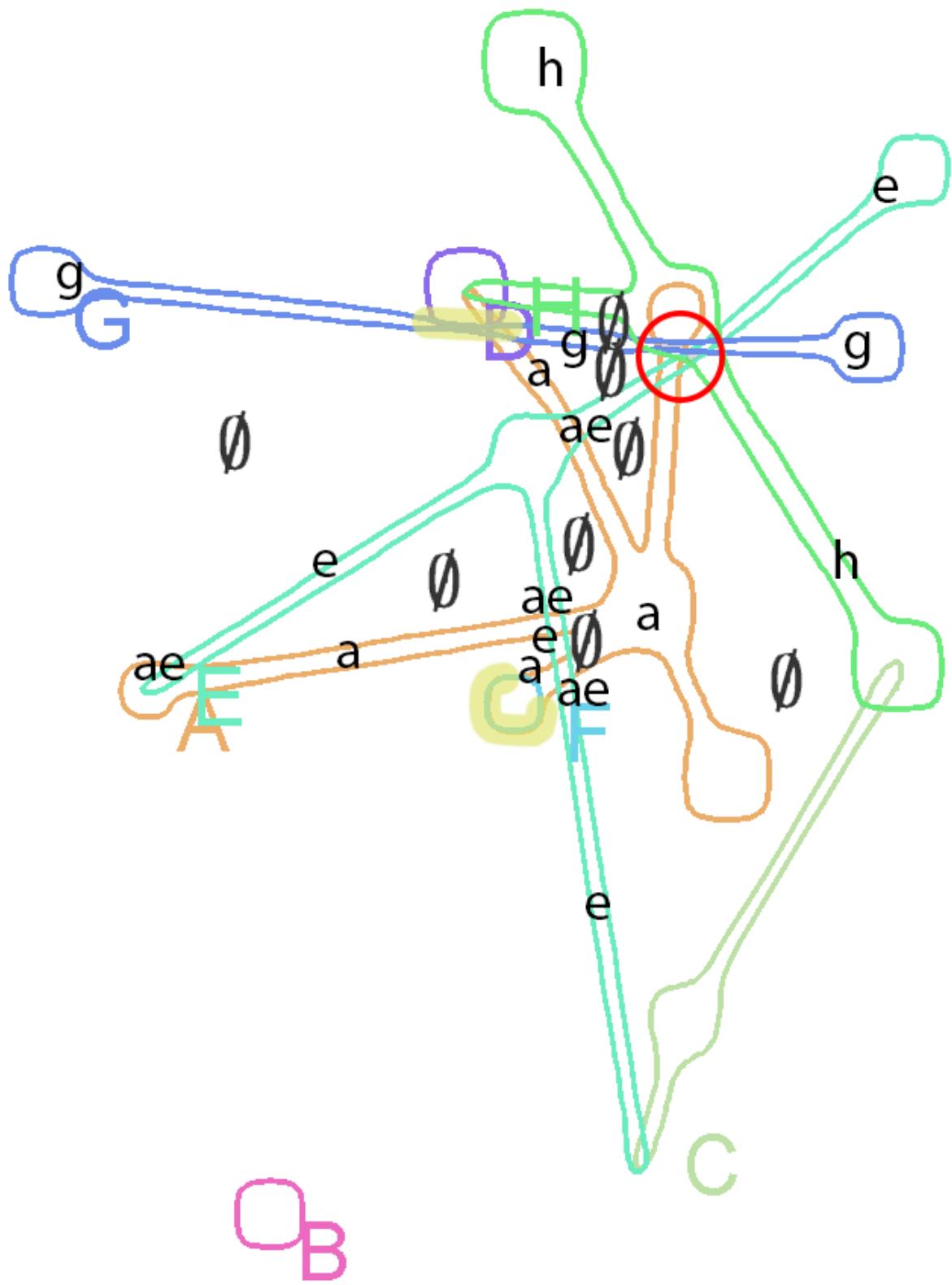
SetNet (without graph)



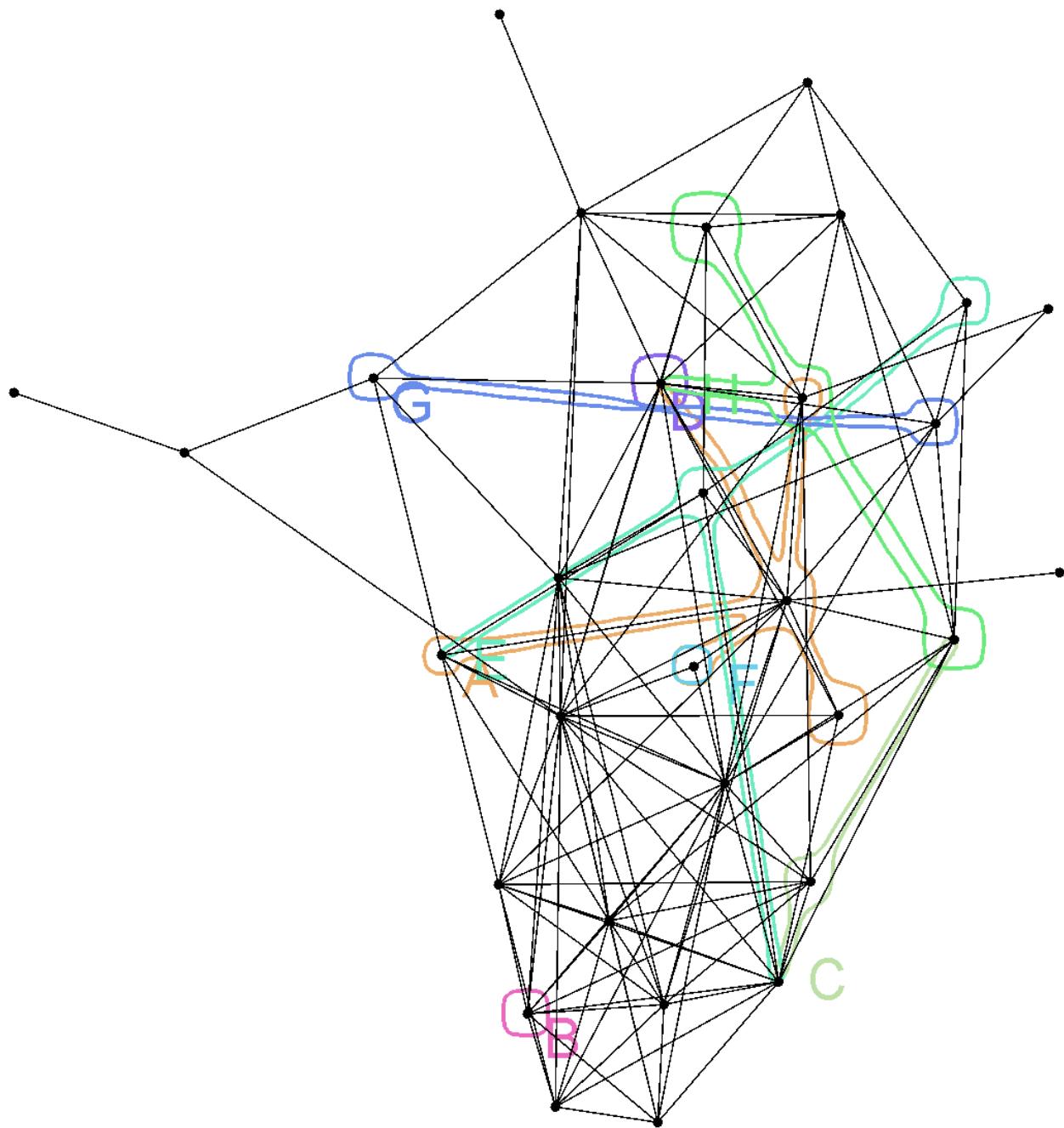
SetNet (with graph)



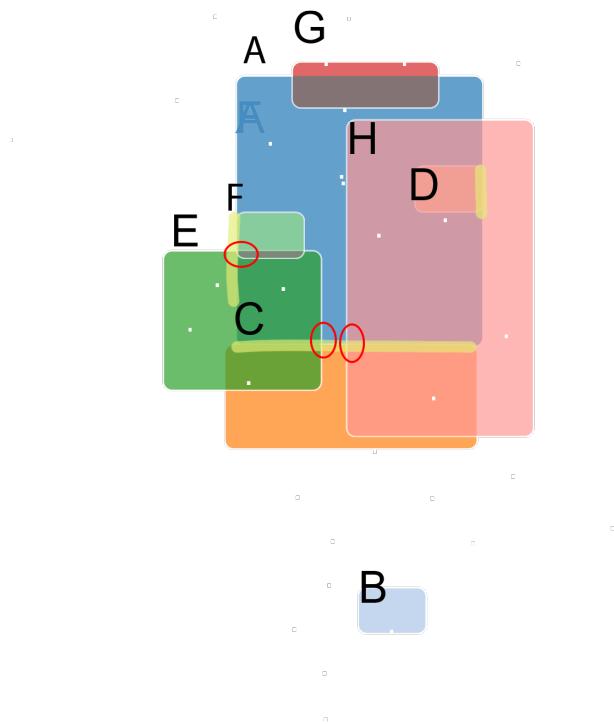
BubbleSets (without graph)



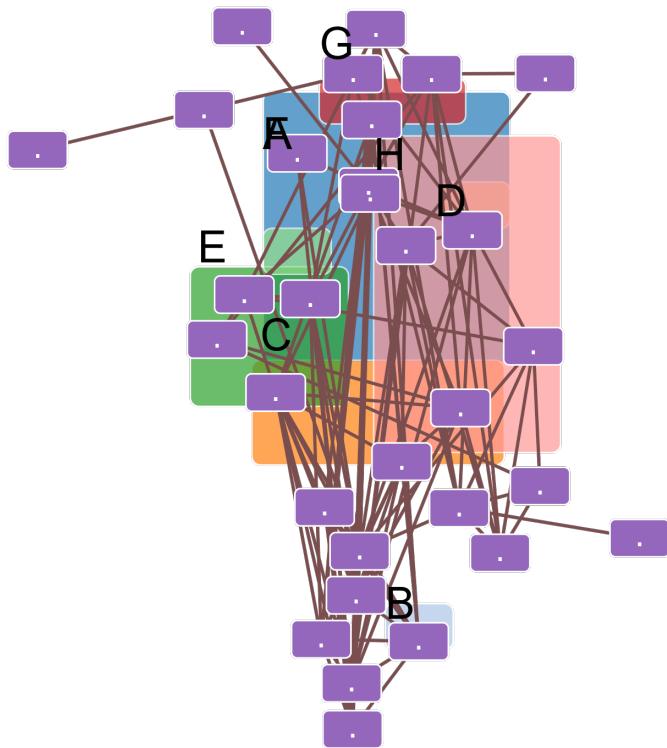
BubbleSets (with graph)



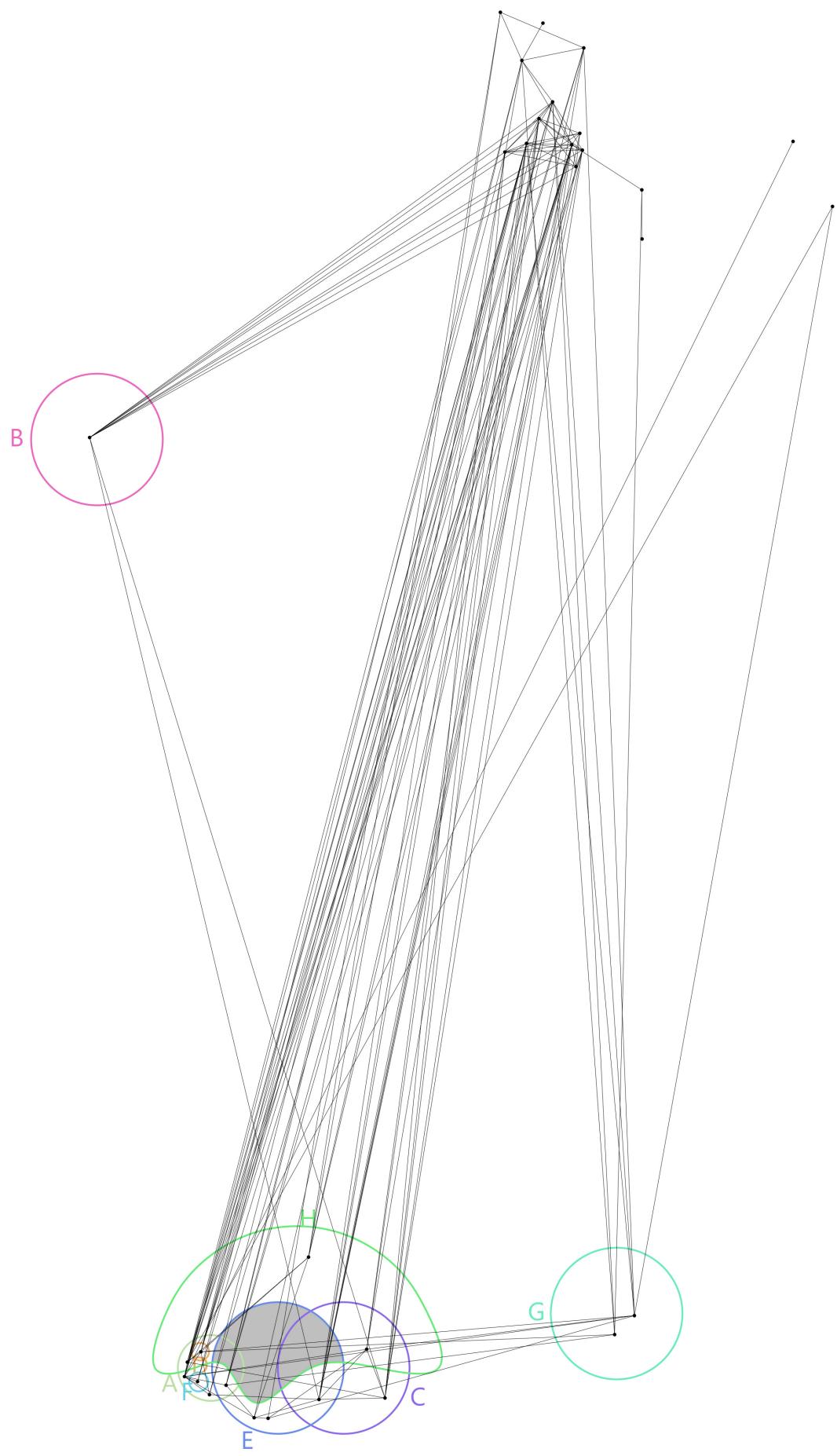
WebCola (without graph)



WebCola (with graph)



GroupNet

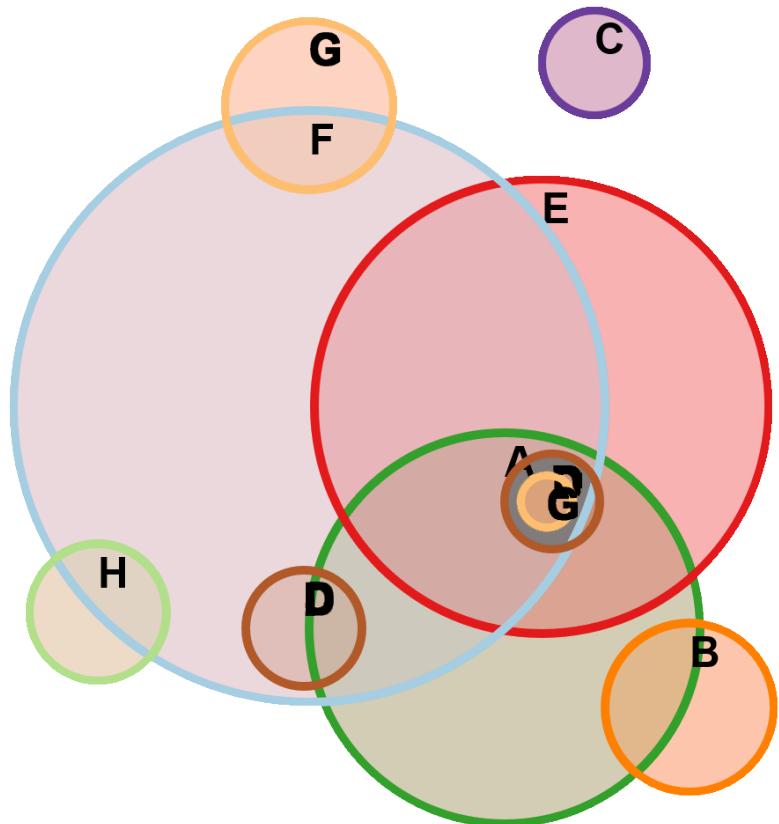


8-set data set 6 : SNAP ID: 45310286

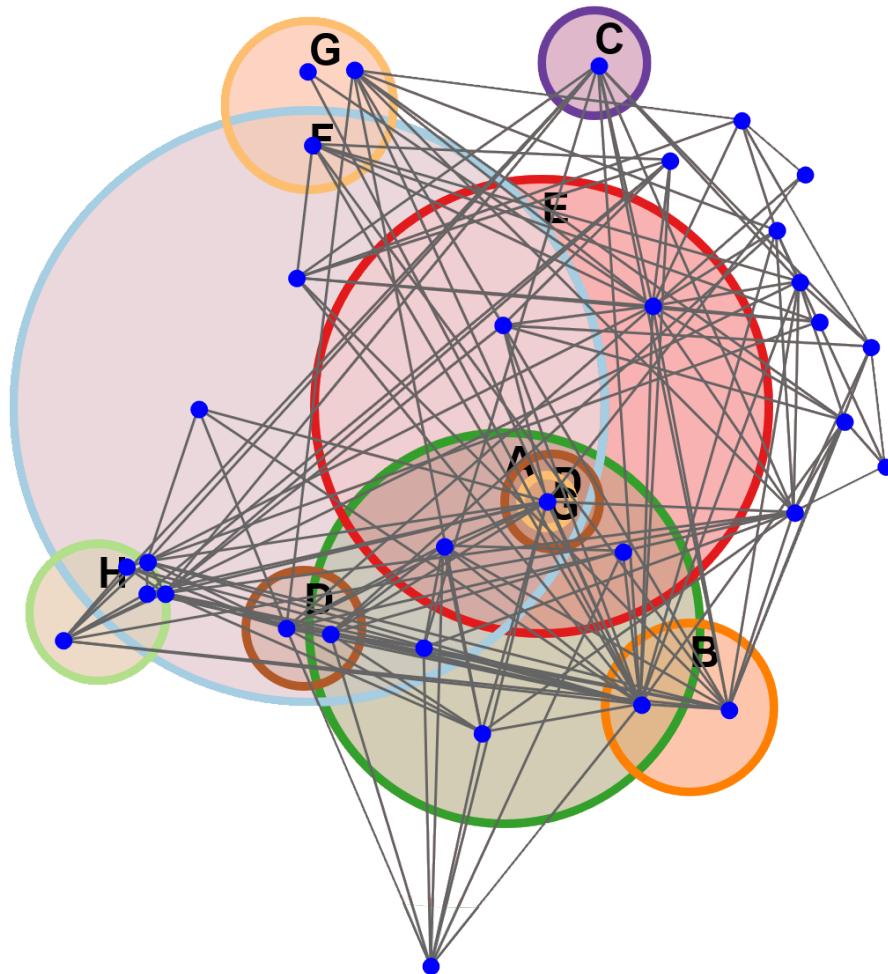
Number of Sets: 8
 Number of Zones: 19
 Number of Nodes: 33
 Number of Edges: 148
 Zones high: yes
 Nodes high: yes
 Edges high: no

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	37	4	203	25
Vertex-vertex intersections	0	0	10	0
Vertices in incorrect zones	3	0	13	0
Omitted zones	0	0	8	0
Ineffective properties				
Non-unique labels	2	0	0	0
Disconnected zones	0	25	0	0
Concurrent curves	0	7	7	0
Triple points	0	4	0	0
Non-circles	0	8	8	2
Extra zones	0	3	3	8
Edge crossings	1420	595	1477	1355
Extra edge-curve crossings	90	437	267	252
Runtime (in sec)	2.844	0.643	7.989	26.098

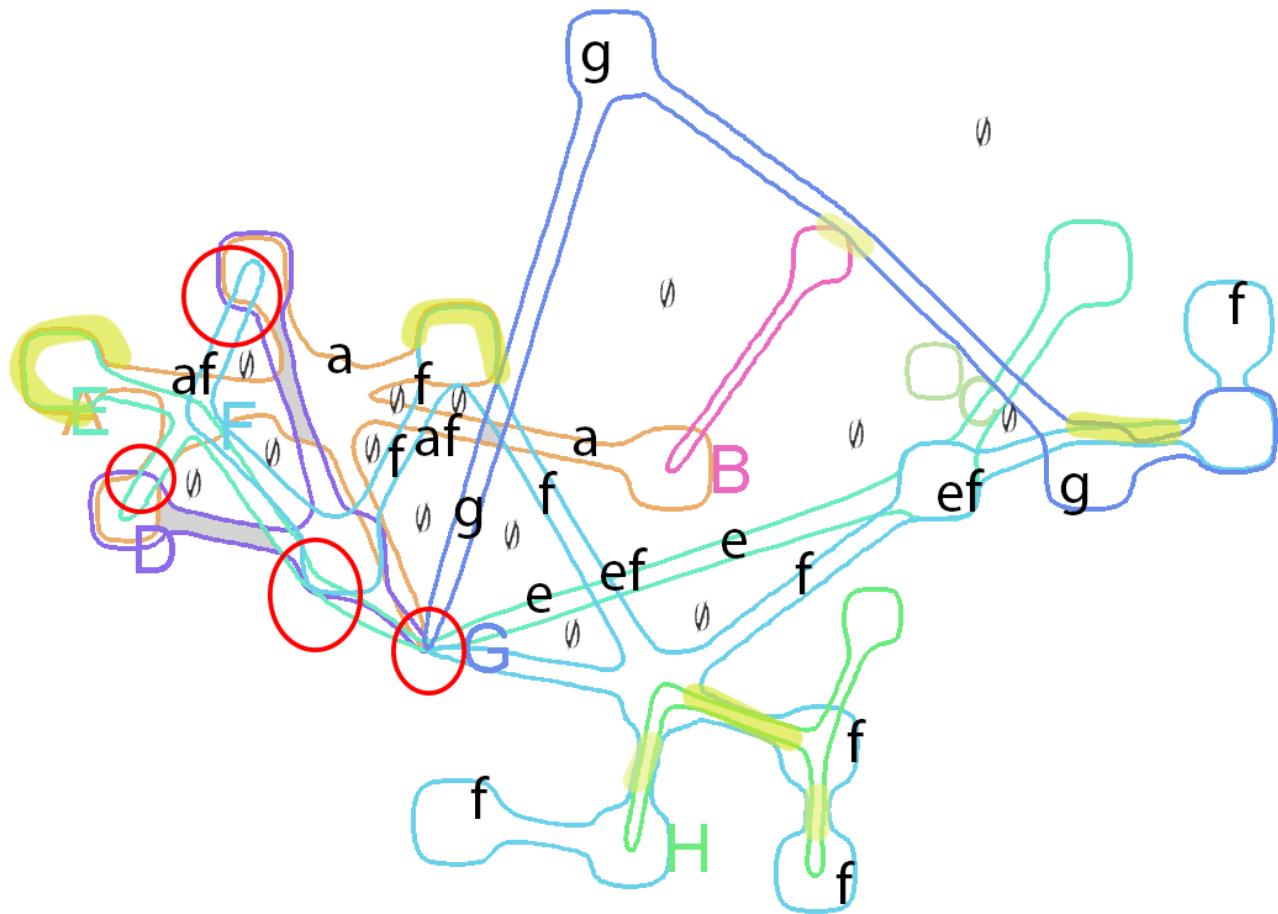
SetNet (without graph)



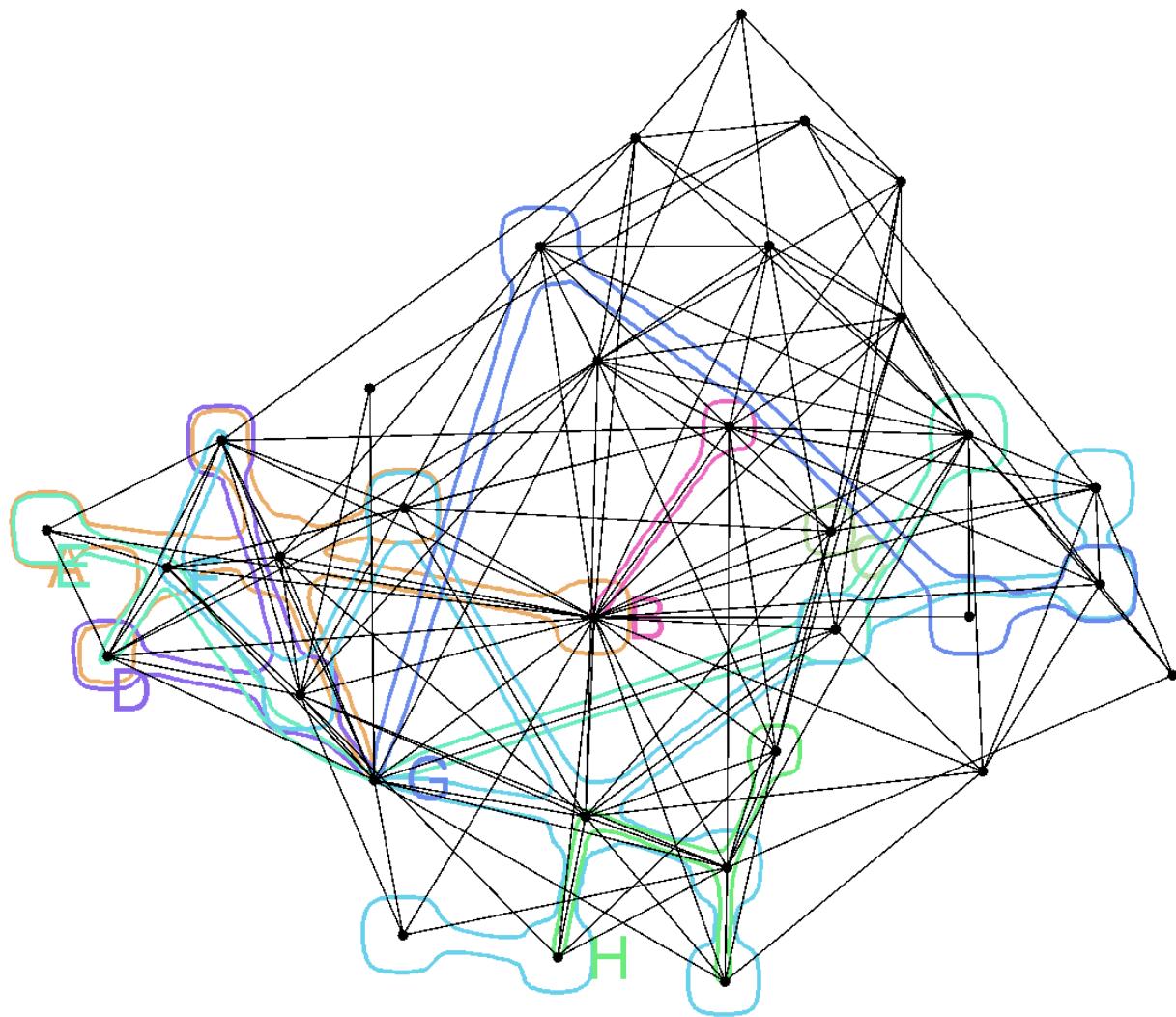
SetNet (with graph)



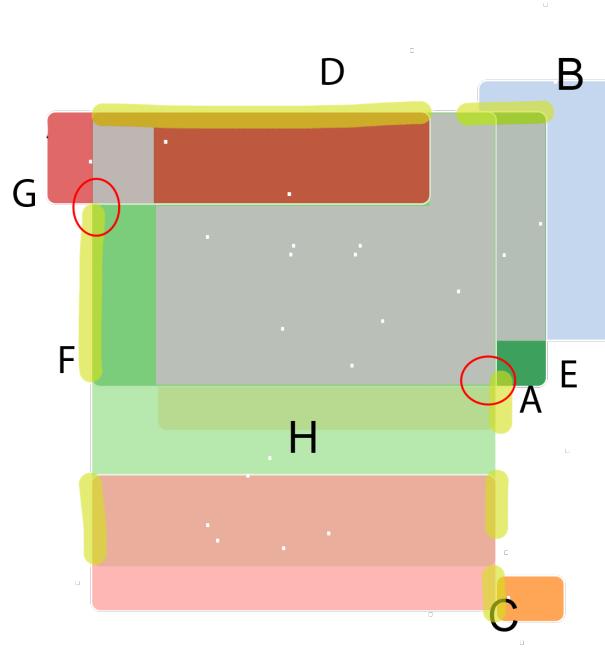
BubbleSets (without graph)



BubbleSets (with graph)

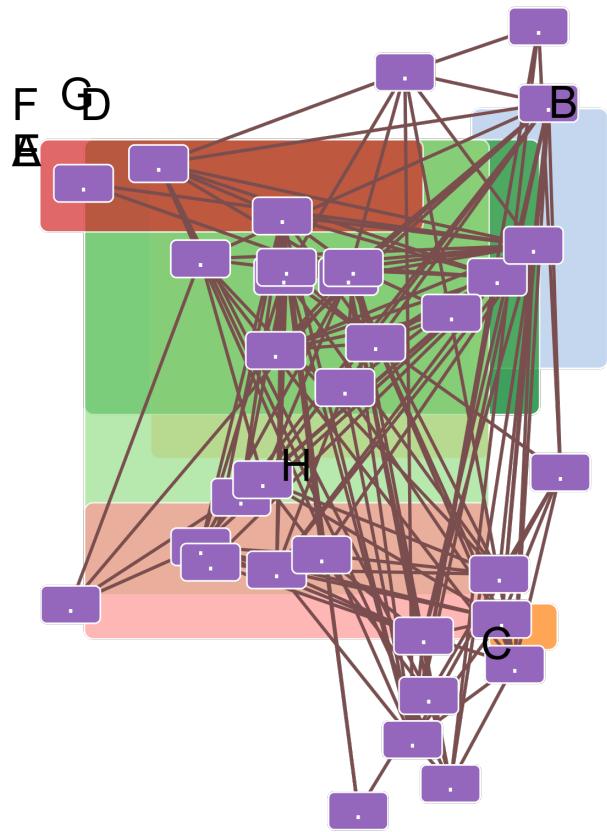


WebCola (without graph)

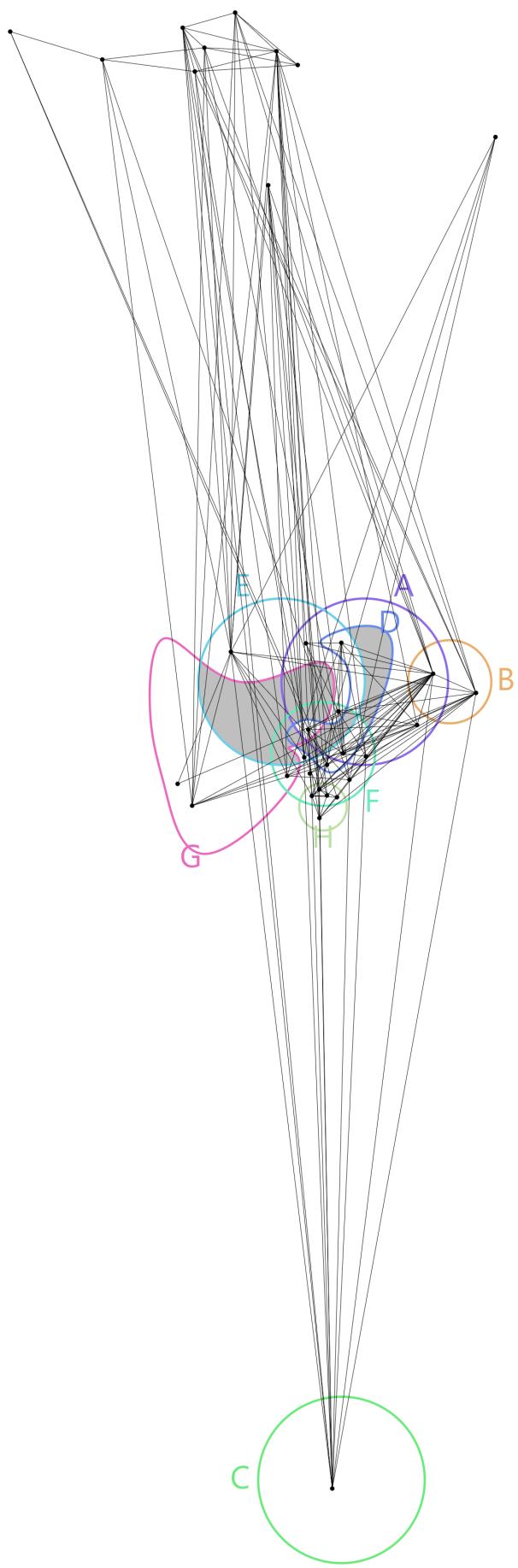


Omitted zones: A, E, AB, AF, EF, FG, ADE,
ADF

WebCola (with graph)



GroupNet

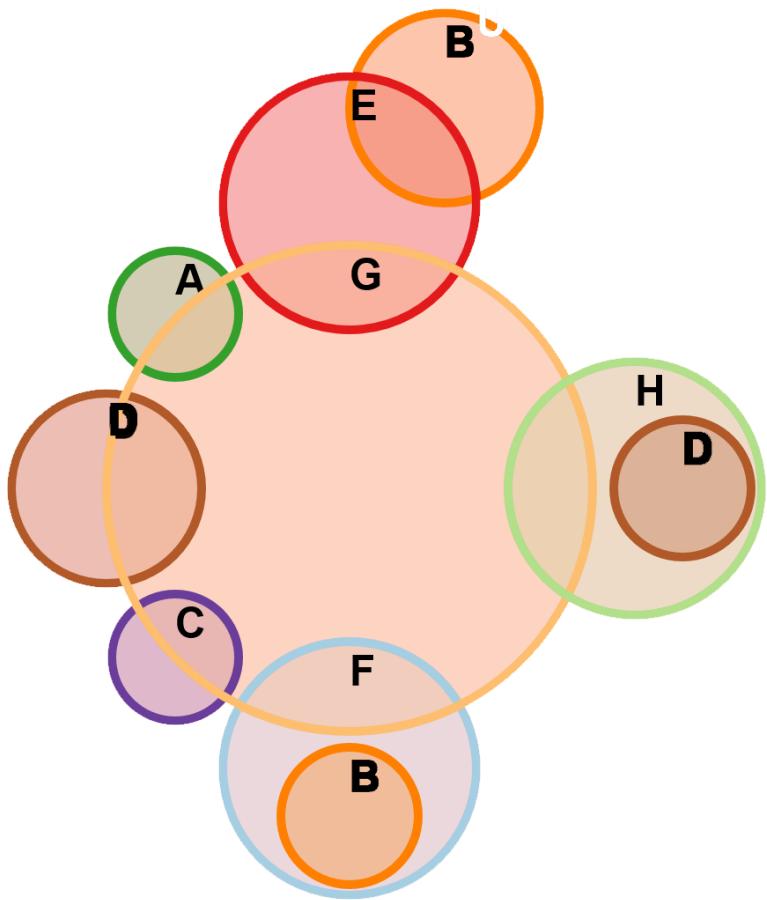


8-set data set 7 : SNAP ID: 16809036

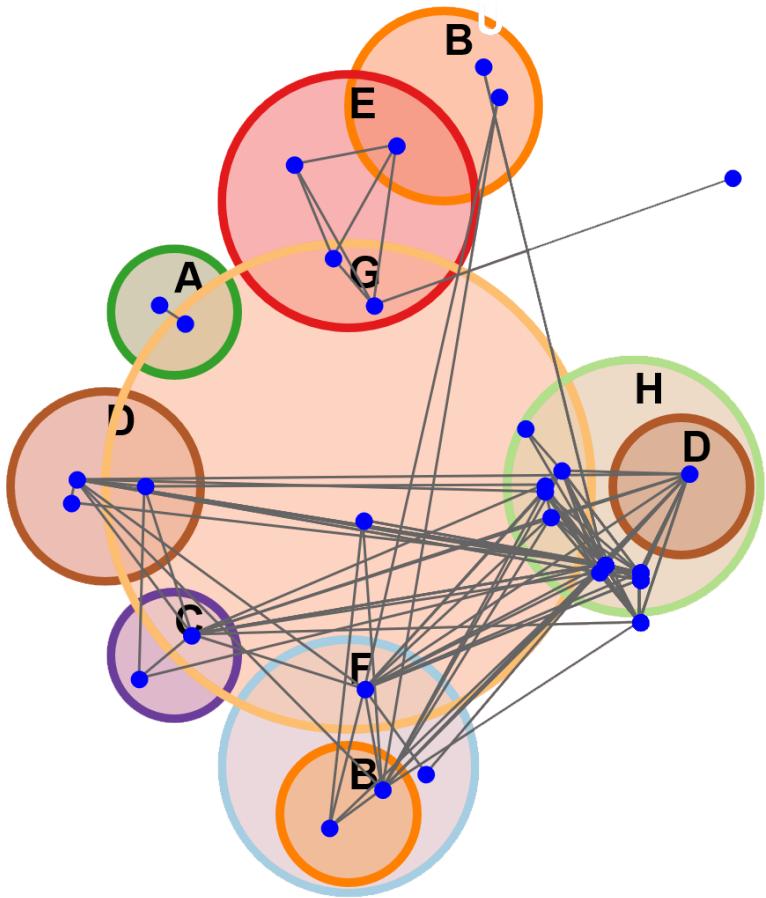
Number of Sets: 8
 Number of Zones: 18
 Number of Nodes: 41
 Number of Edges: 161
 Zones high: yes
 Nodes high: yes
 Edges high: yes

	SetNet	Bubble Sets	WebCola	GroupNet
Inaccuracy properties				
Edge-vertex intersections	648	10	247	31
Vertex-vertex intersections	38	0	19	0
Vertices in incorrect zones	1	1	7	0
Omitted zones	0	0	1	0
Ineffective properties				
Non-unique labels	2	0	0	0
Disconnected zones	0	16	1	0
Concurrent curves	0	3	4	0
Triple points	0	2	0	0
Non-circles	0	8	8	1
Extra zones	0	3	1	6
Edge crossings	1307	1019	1588	1695
Extra edge-curve crossings	51	549	67	82
Runtime (in sec)	3.488	4.354	8.198	39.397

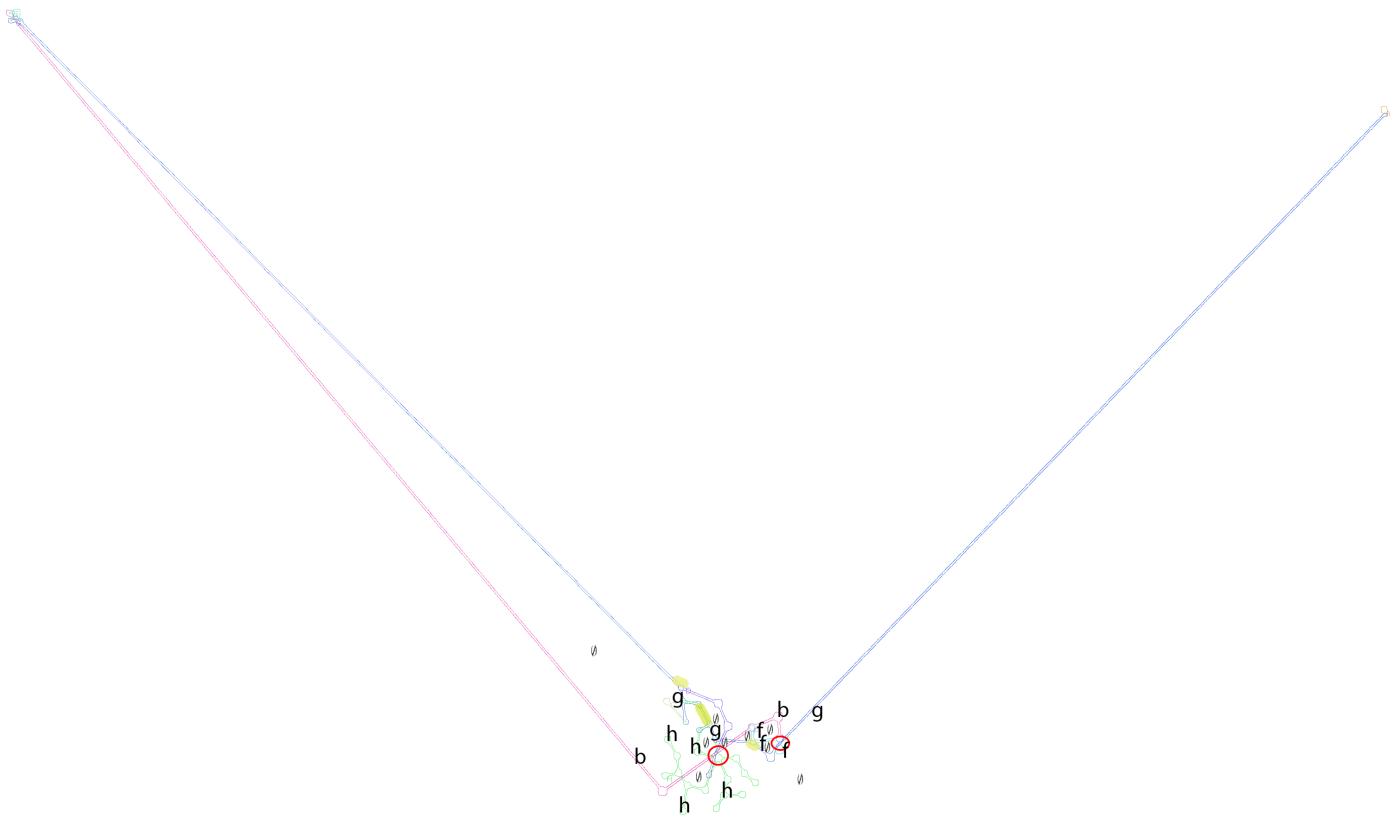
SetNet (without graph)



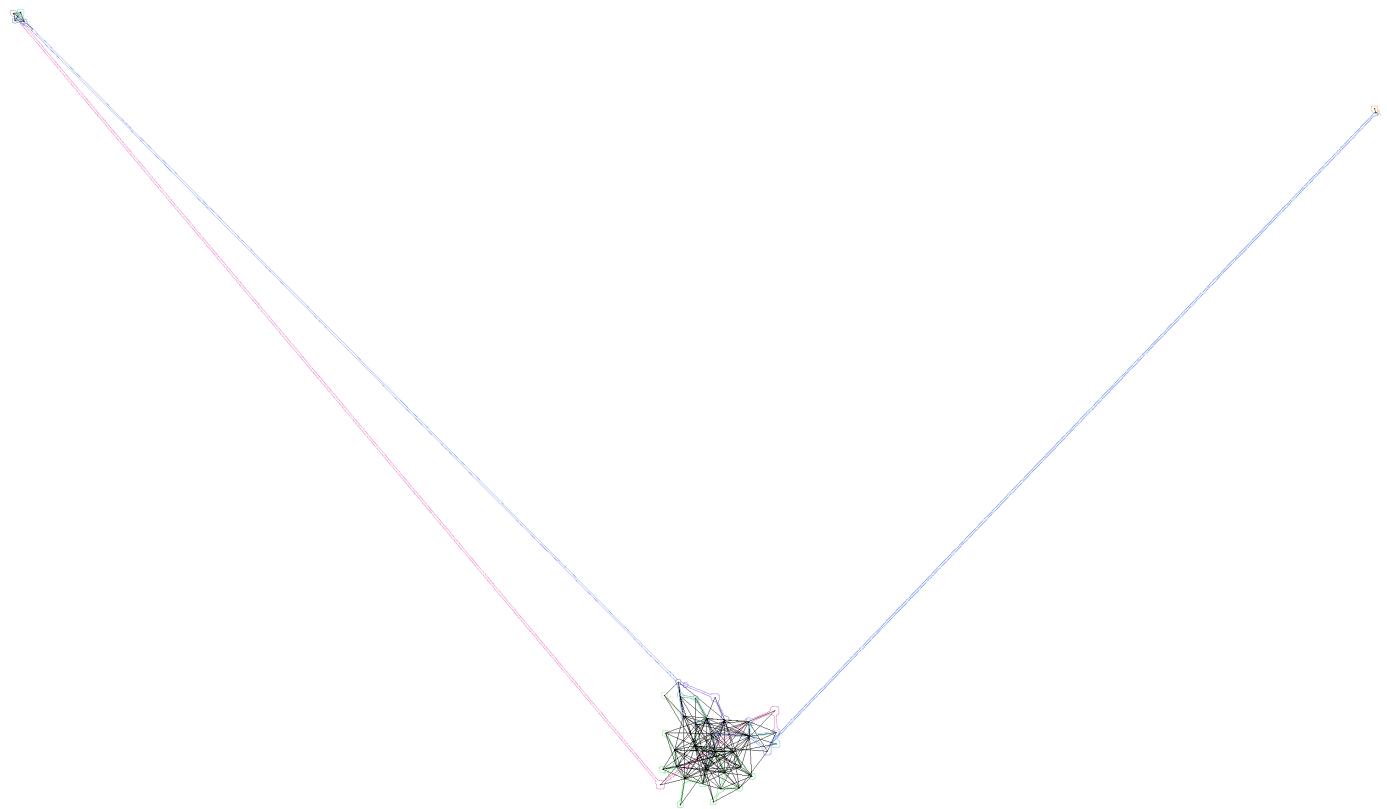
SetNet (with graph)



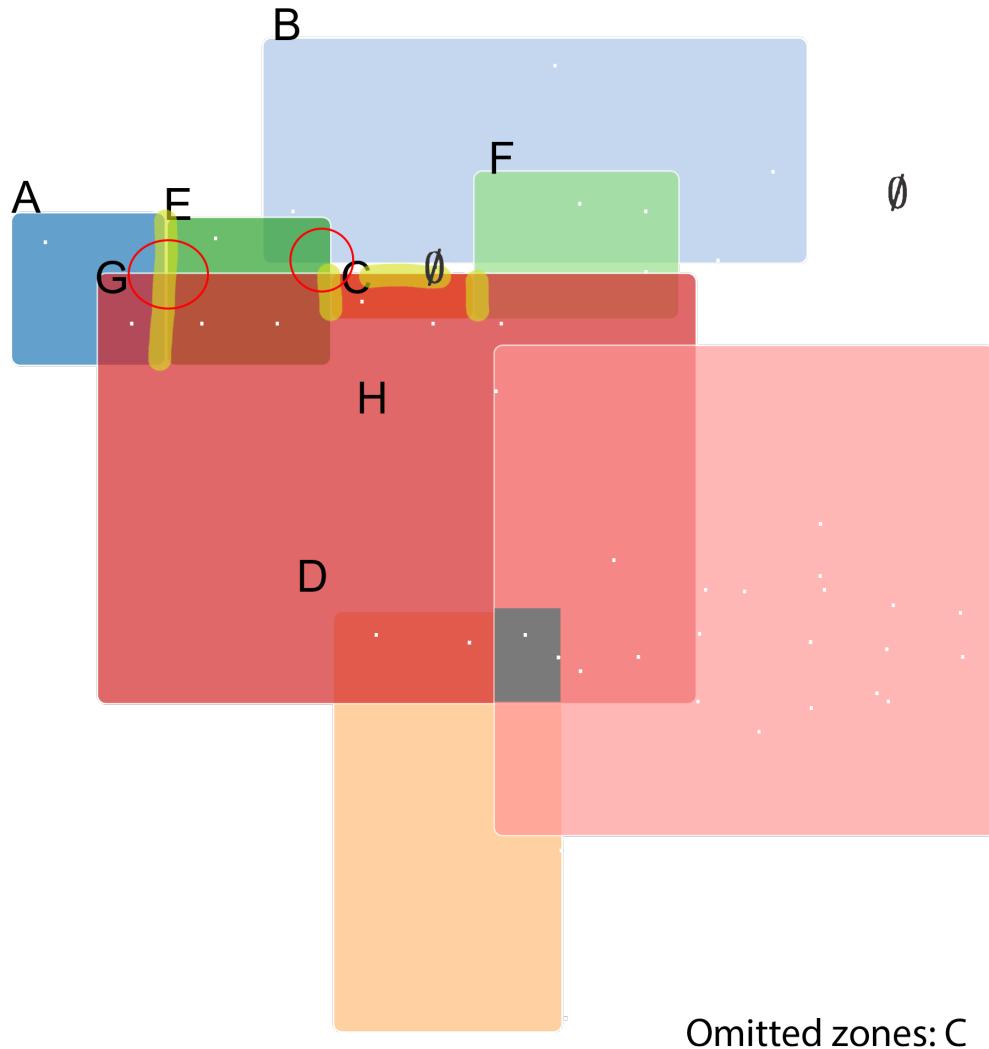
BubbleSets (without graph)



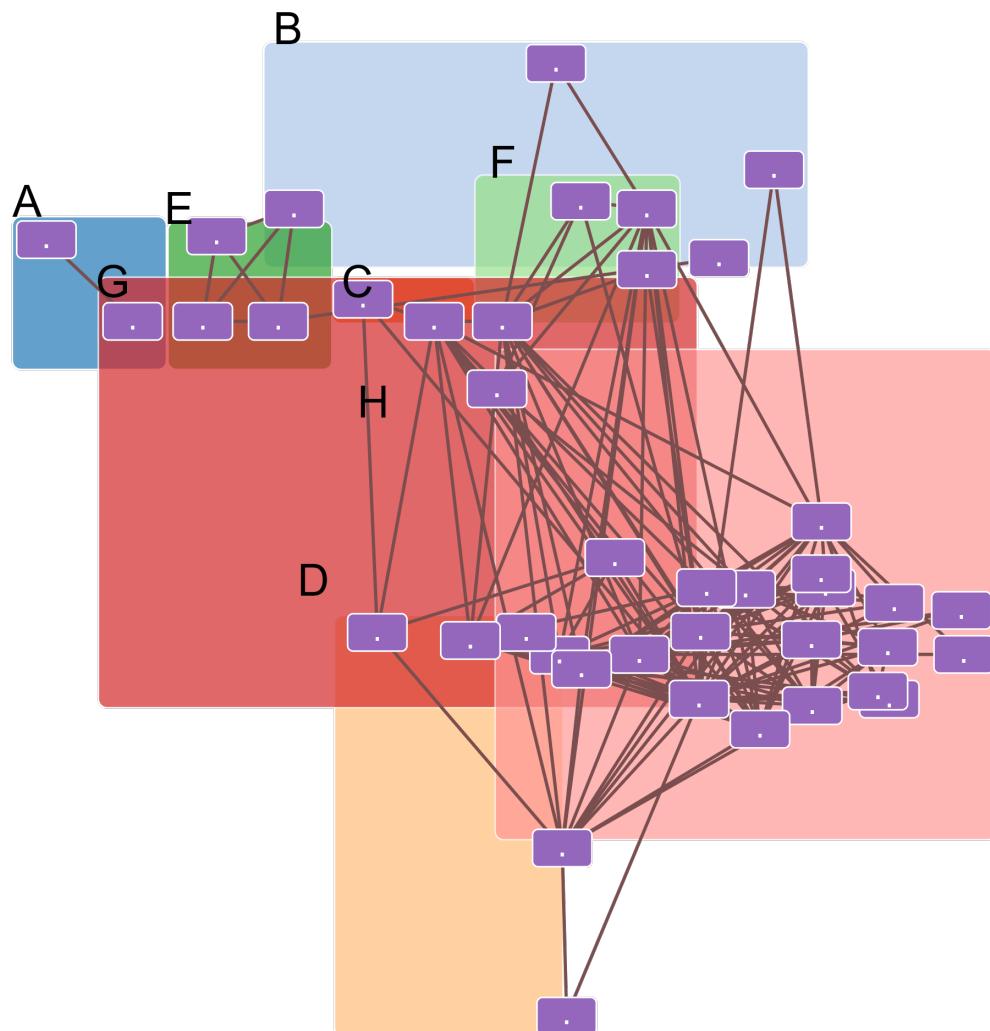
BubbleSets (with graph)



WebCola (without graph)



WebCola (with graph)



GroupNet

