

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 and contains evaluation material. In particular, the document 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 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 literature³. 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. 1, 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. 2, 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. 3, 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. 4, 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. 5, 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.

³ Stapleton, G., Howse, J., & Rodgers, P. (2010). A graph theoretic approach to general Euler diagram drawing. *Theoretical Computer Science*, 411(1), 91-112.

- *Non-simple curves*: for each curve, each self-intersection was counted. For example, in Fig 6, the curve R self-intersects twice, so the count is 2.
- *Non-circular curves*: each non-circular curve was counted. In Fig. 7, only S is non-circular, so the count is 1.
- *Extra zones*: each extra zone was counted. In Fig. 7, 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 .

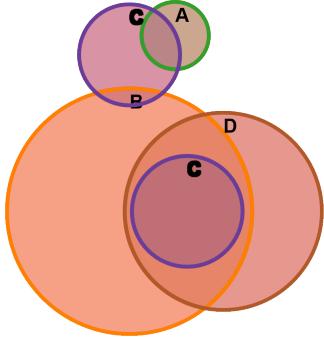


Fig. 1. SetNet: a non-unique label.

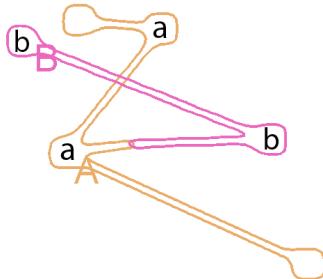


Fig. 2. Bubble Sets: disconnected zones.

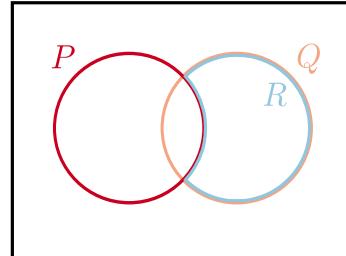


Fig. 3. Concurrency.

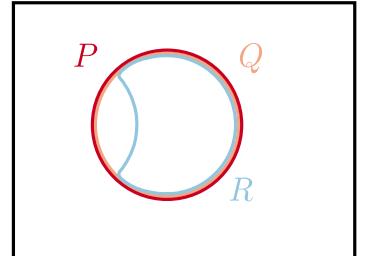


Fig. 4. Concurrency.

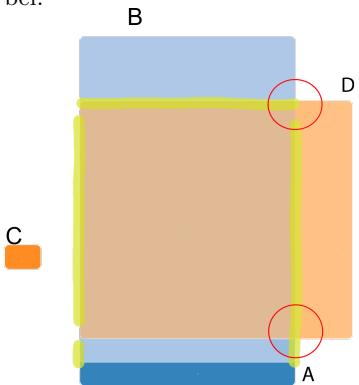


Fig. 5. WebCola: triple points.

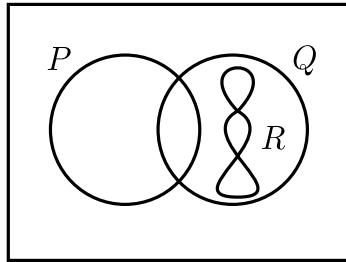


Fig. 6. A non-simple curve R .

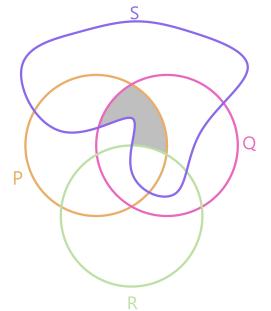


Fig. 7. GroupNet: an extra zone.

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.

3 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.

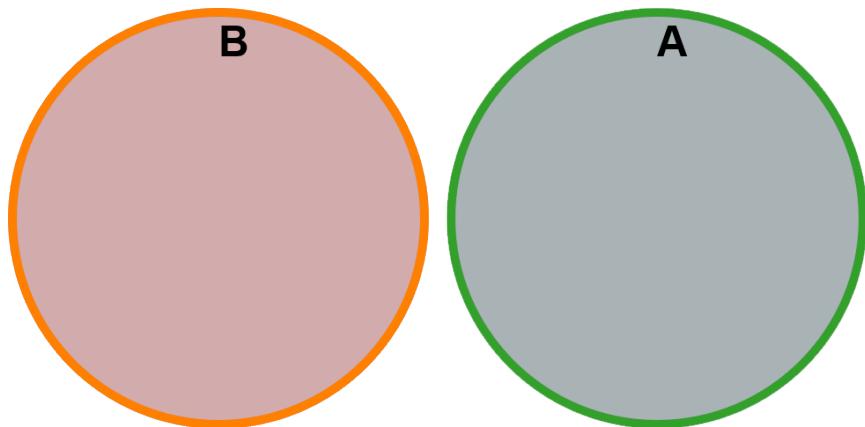
There was no occurrence of non-simple curves in any of the produced diagrams. Therefore, to avoid clutter, the entry for non-simple curves is omitted from the following tables.

2-set data set 1 : SNAP ID: 64619842

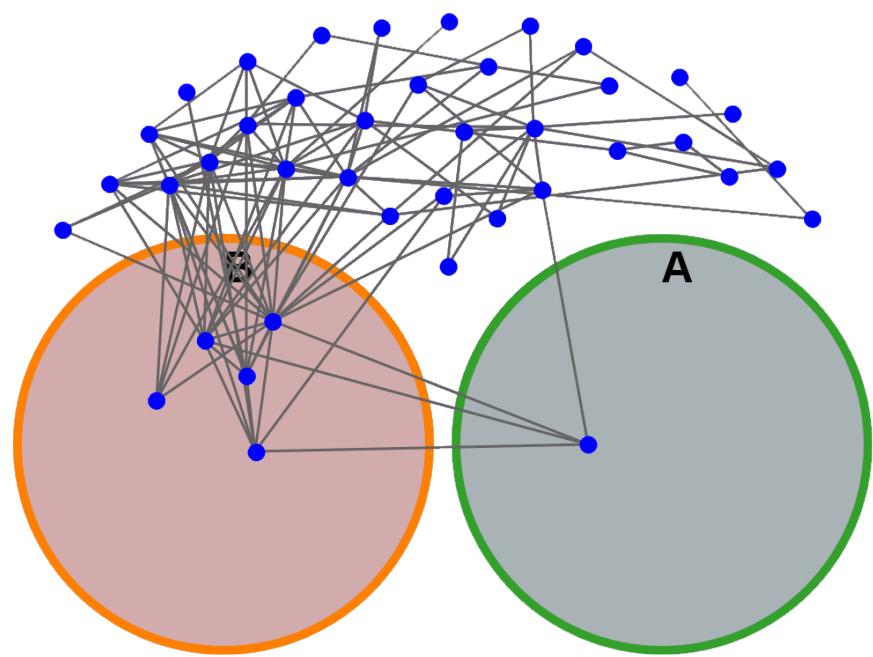
Number of Sets: 2
Number of Zones: 3
Number of Nodes: 40
Number of Edges: 110
Zones high: no
Nodes high: no
Edges high: no

	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

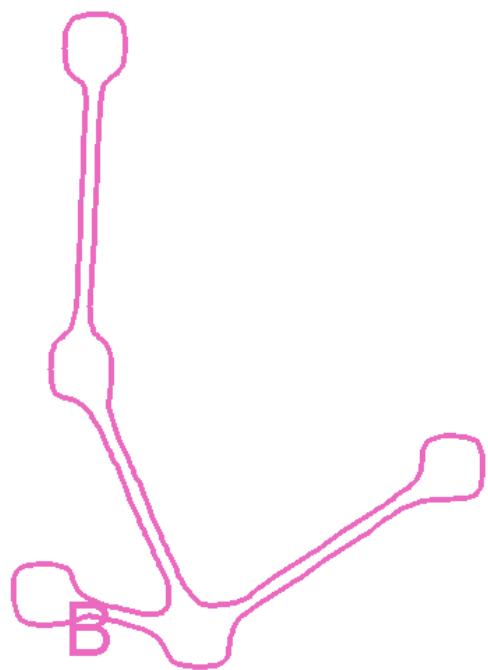
SetNet (without graph)



SetNet (with graph)

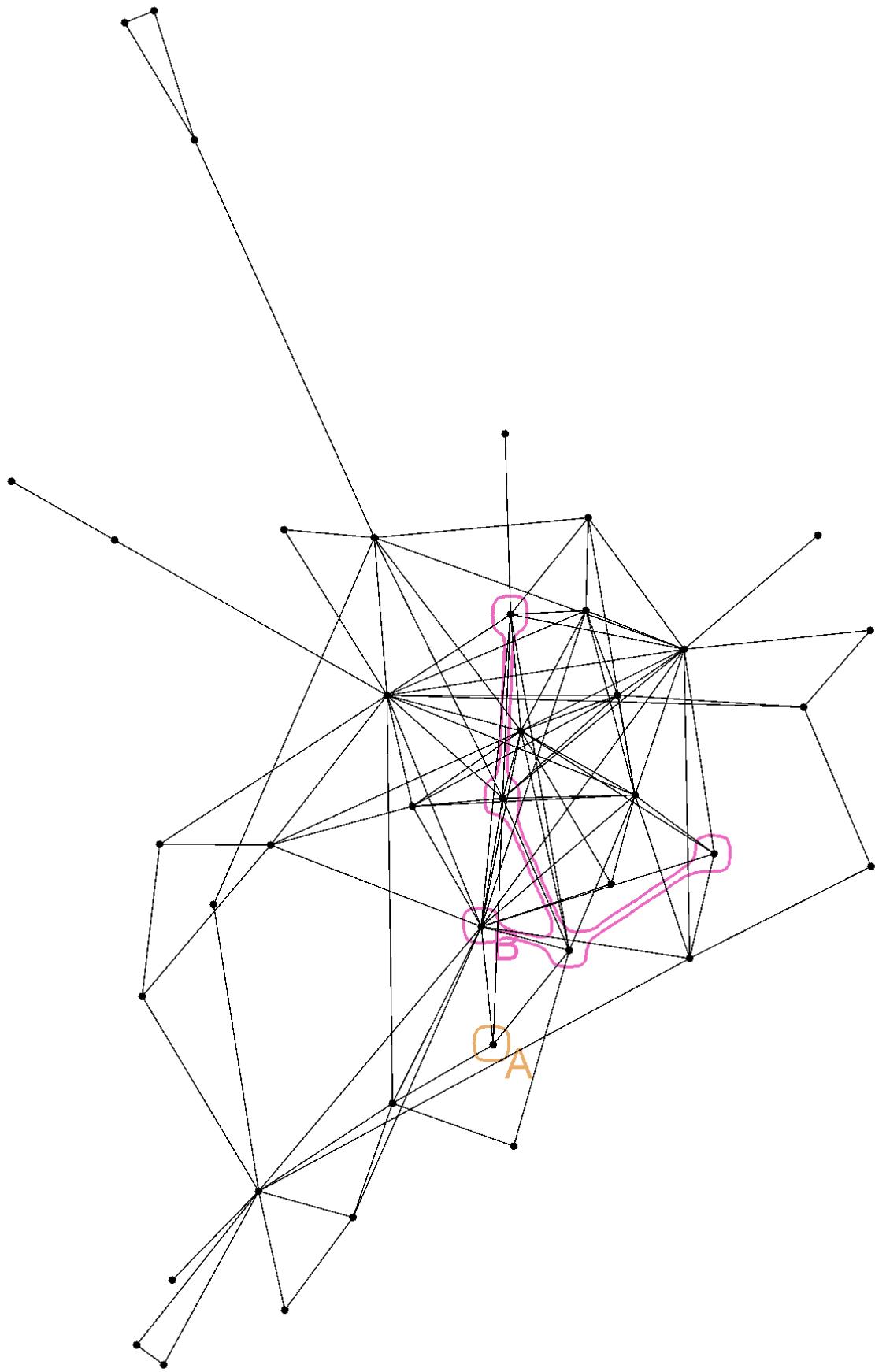


BubbleSets (without graph)

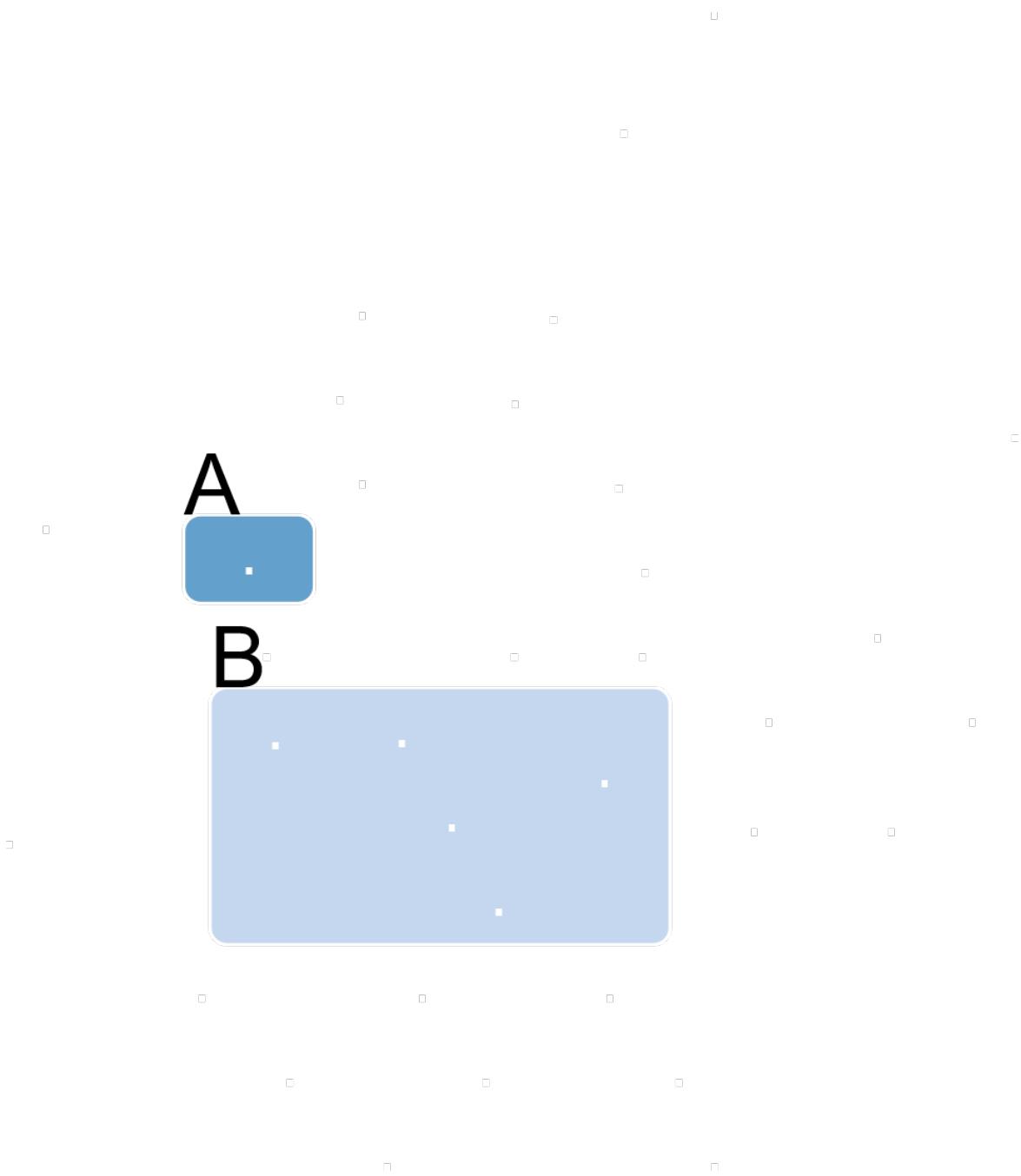


O_A

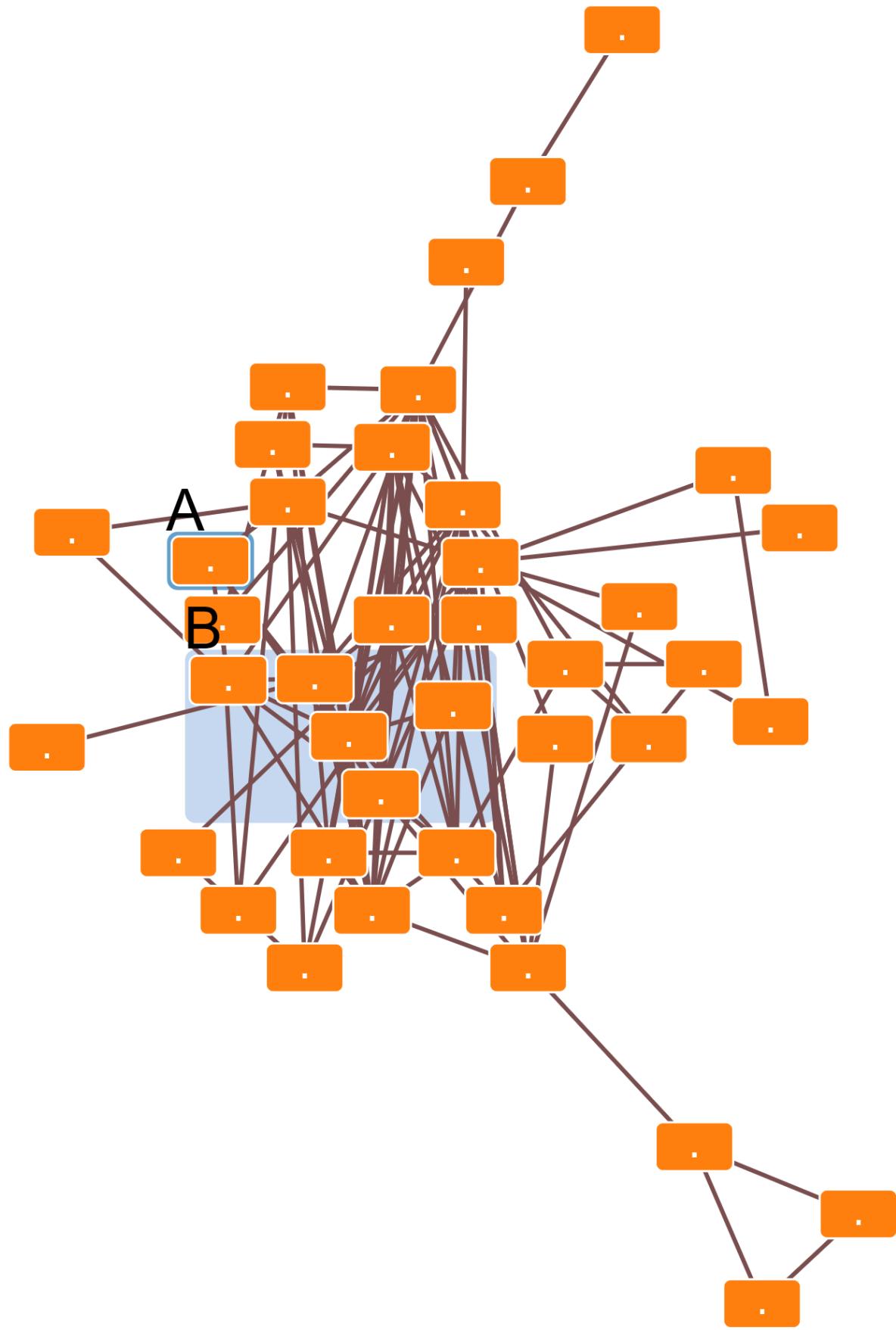
BubbleSets (with graph)



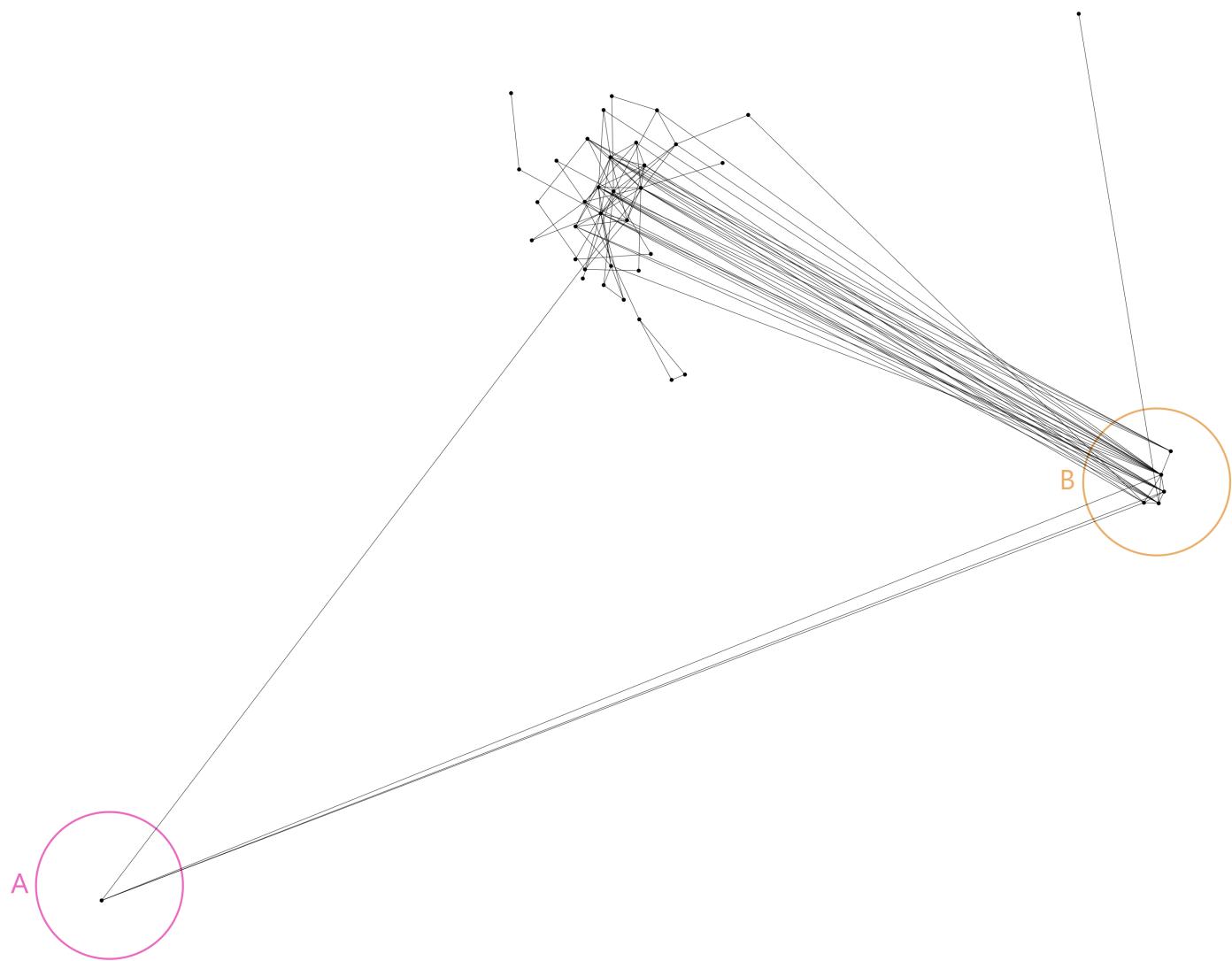
WebCola (without graph)



WebCola (with graph)



GroupNet

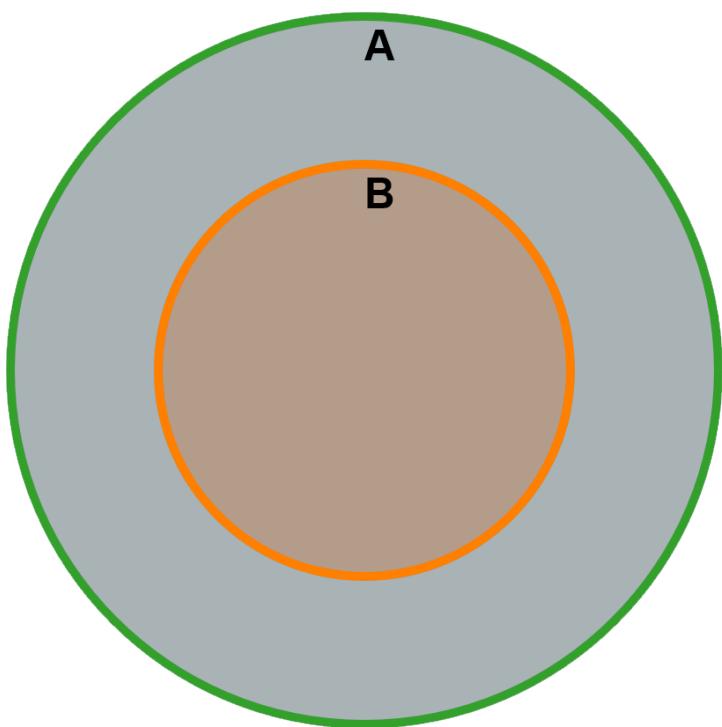


2-set data set 2 : SNAP ID: 143661263

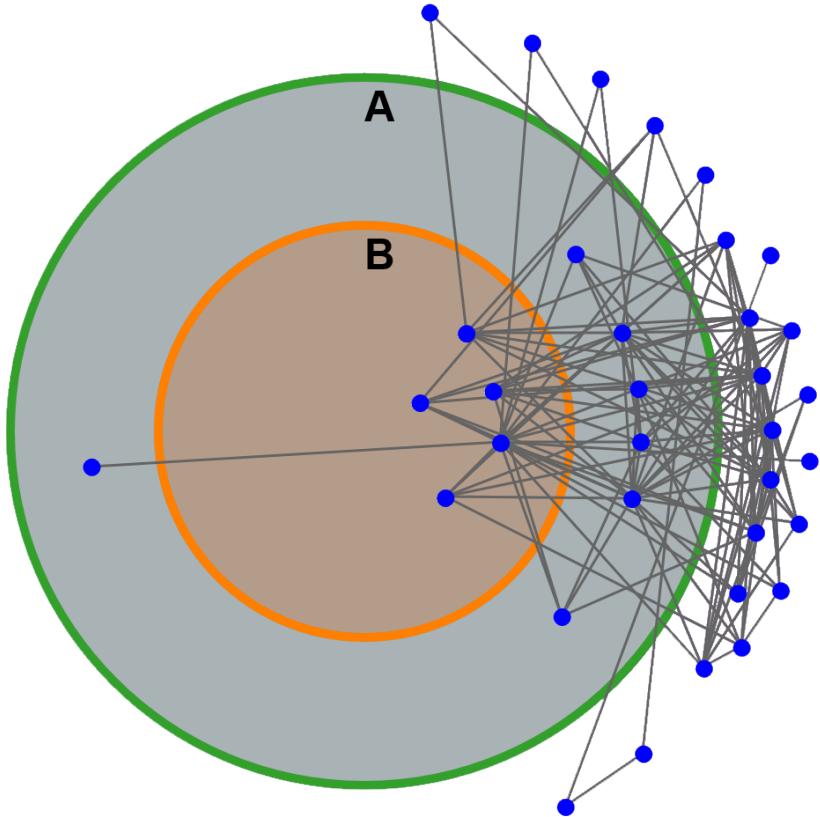
Number of Sets: 2
 Number of Zones: 3
 Number of Nodes: 34
 Number of Edges: 133
 Zones high: no
 Nodes high: no
 Edges high: yes

	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

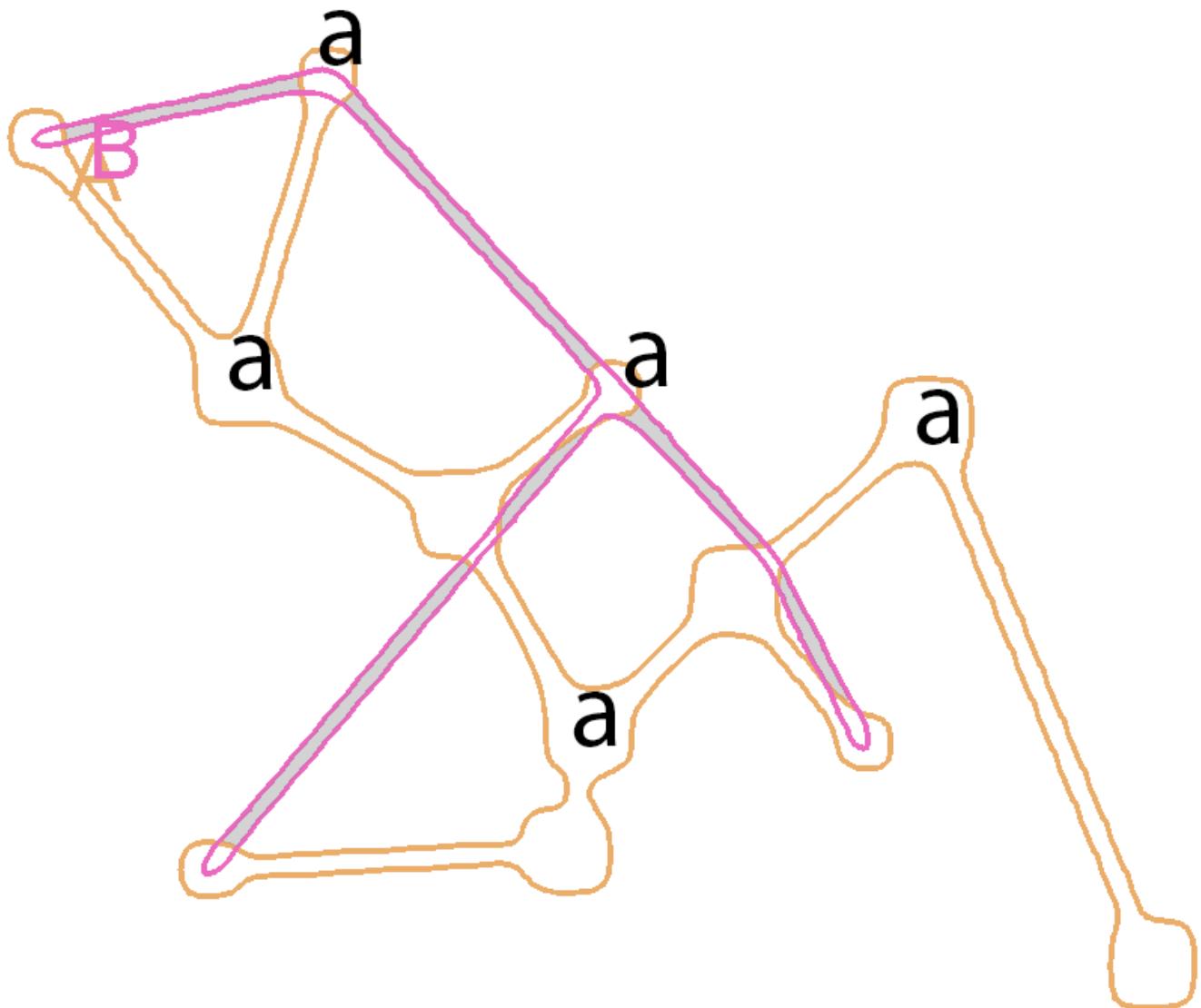
SetNet (without graph)



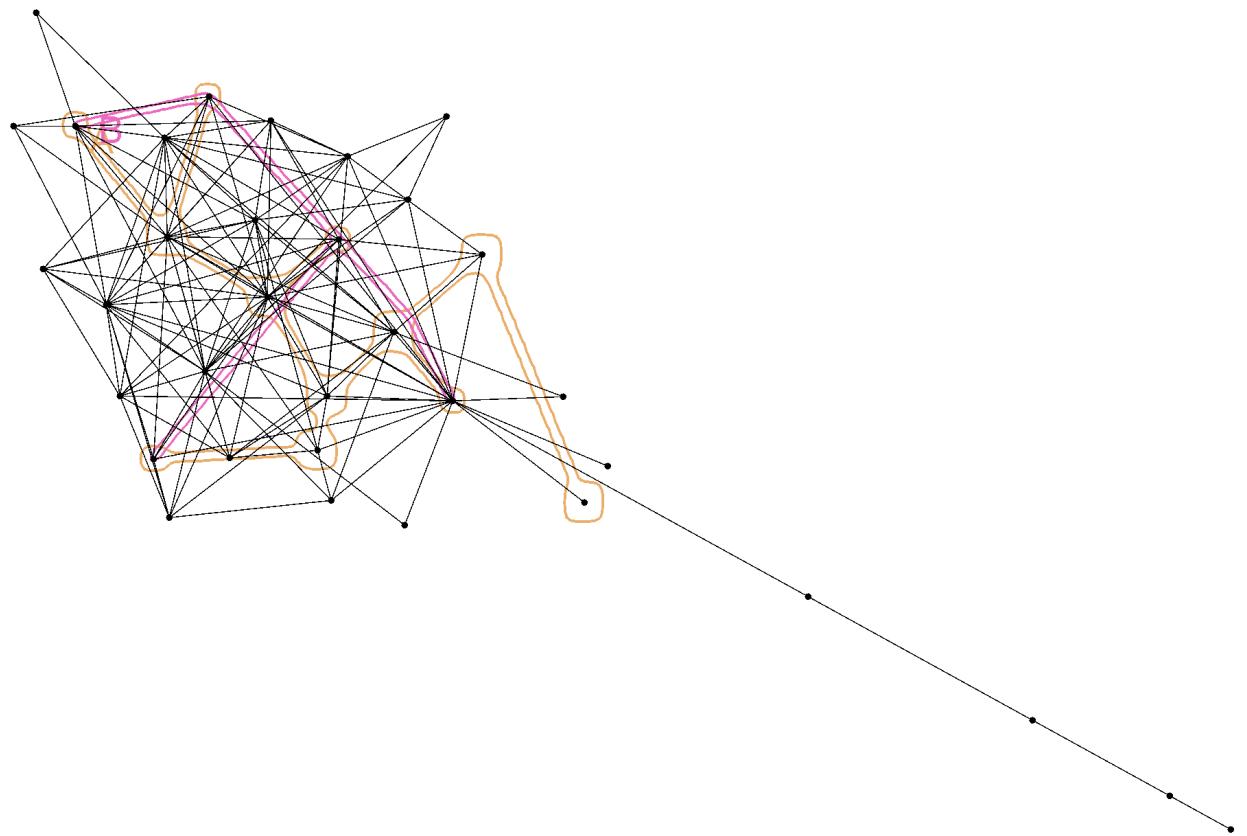
SetNet (with graph)



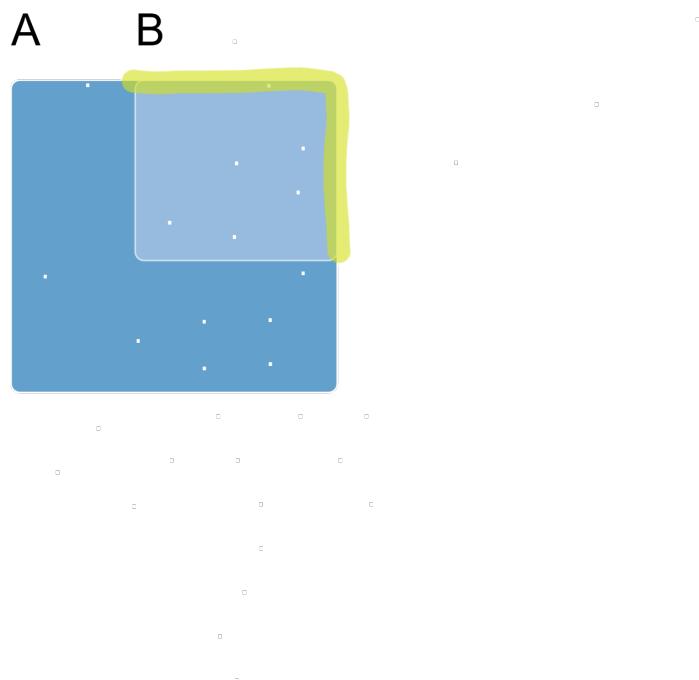
BubbleSets (without graph)



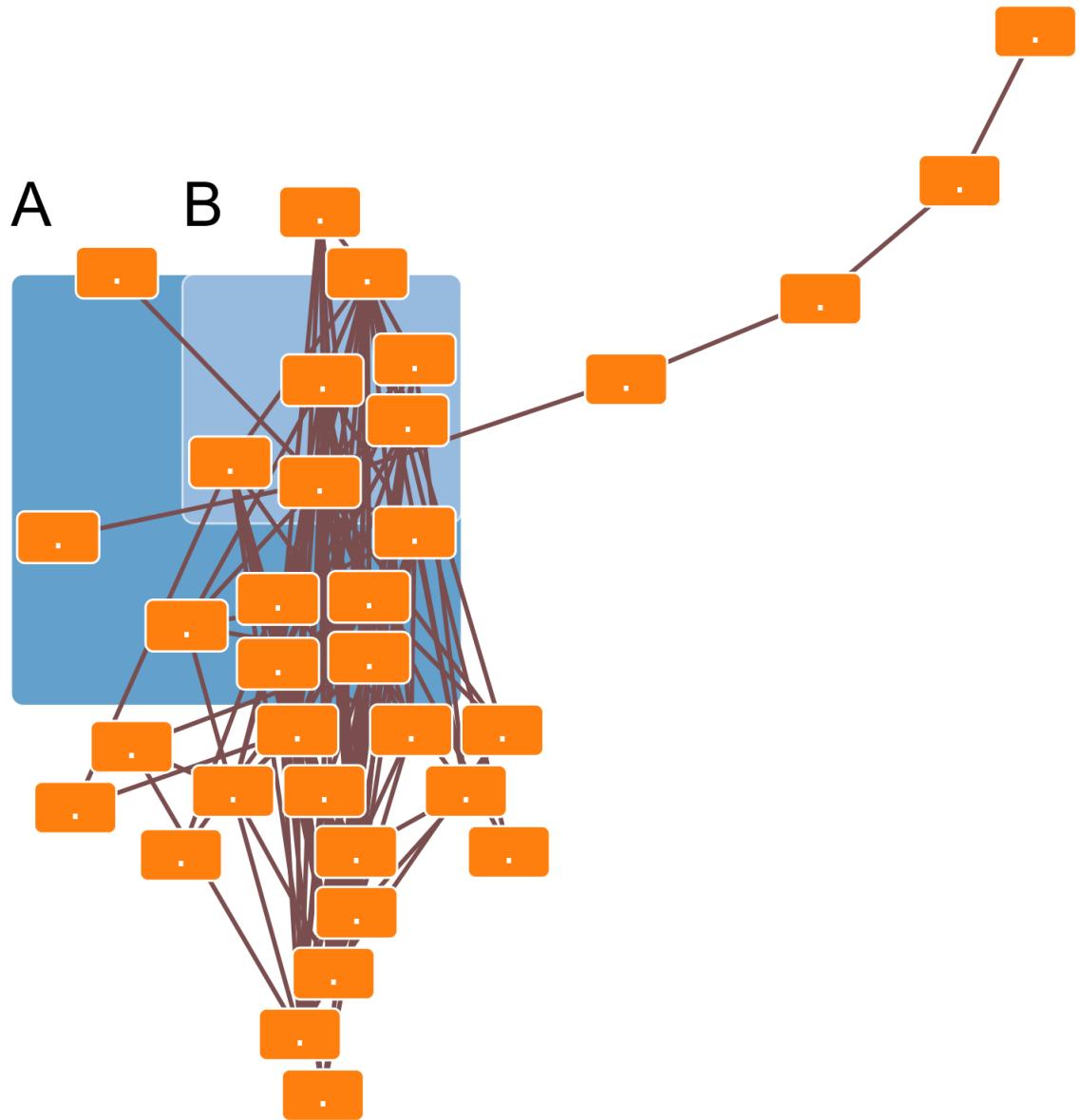
BubbleSets (with graph)



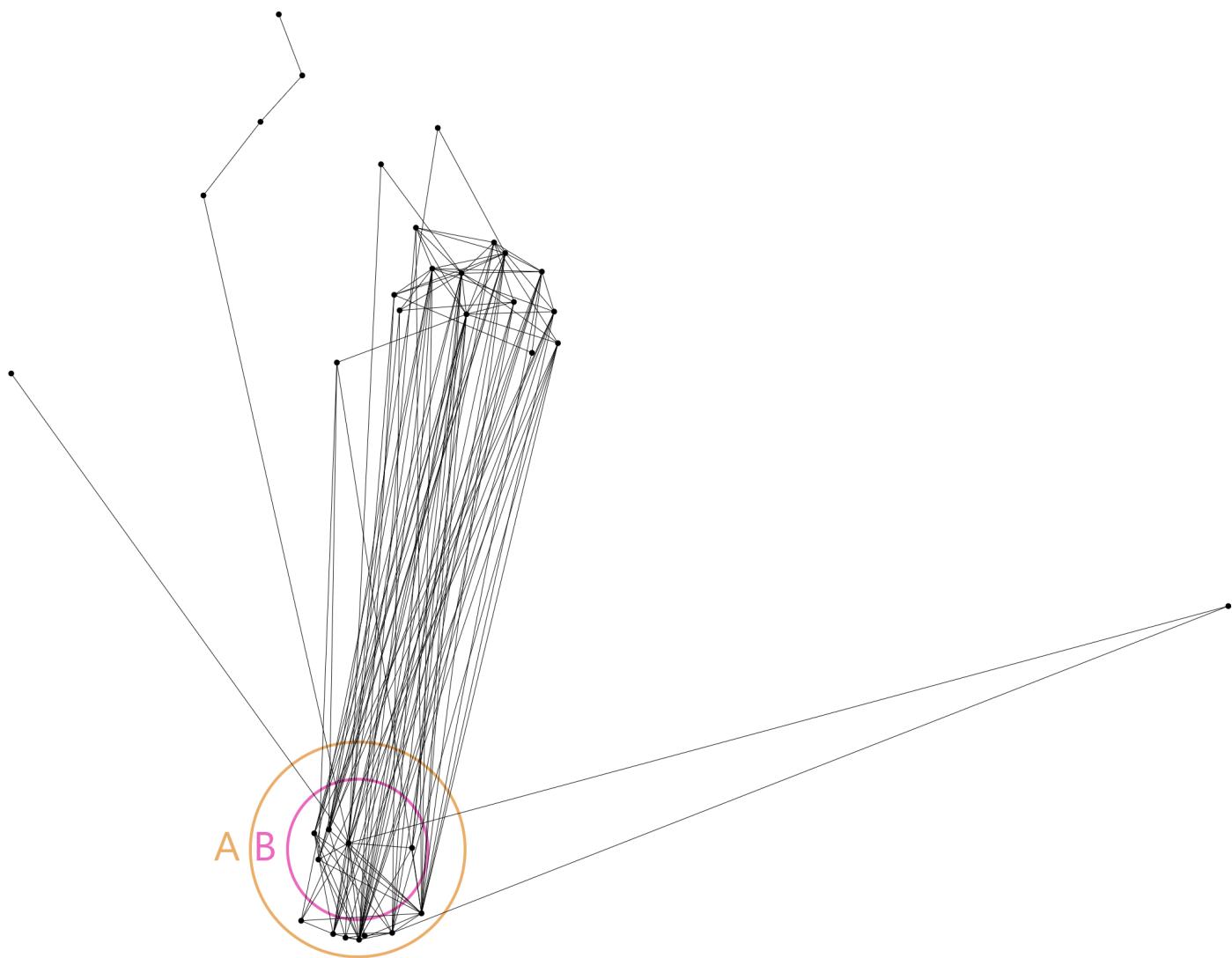
WebCola (without graph)



WebCola (with graph)



GroupNet

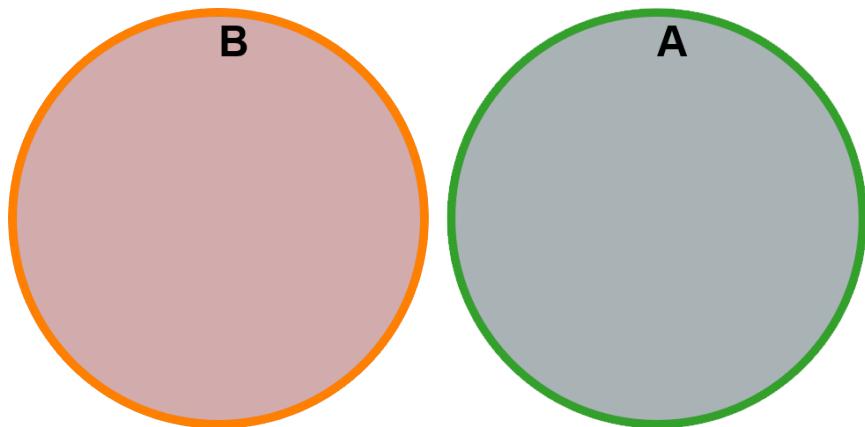


2-set data set 3 : SNAP ID: 15938936

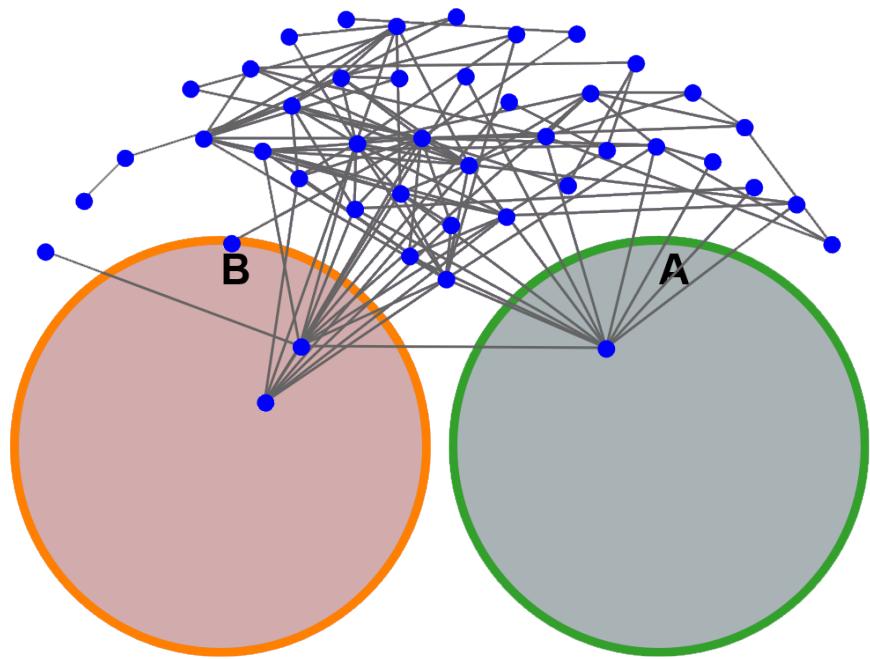
Number of Sets: 2
 Number of Zones: 3
 Number of Nodes: 44
 Number of Edges: 120
 Zones high: no
 Nodes high: yes
 Edges high: no

	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

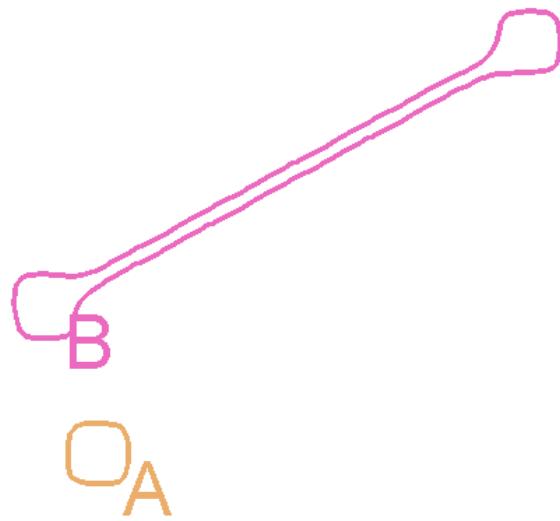
SetNet (without graph)



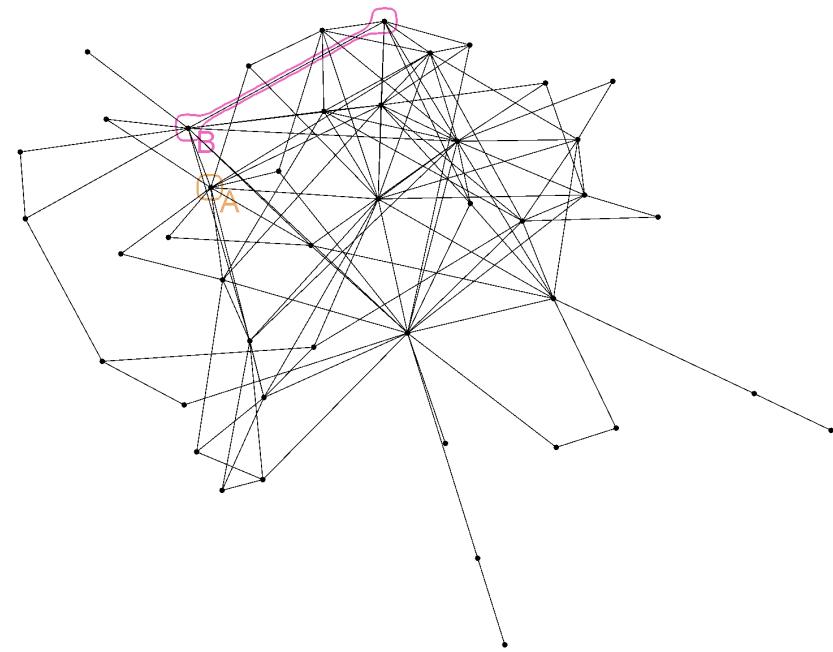
SetNet (with graph)



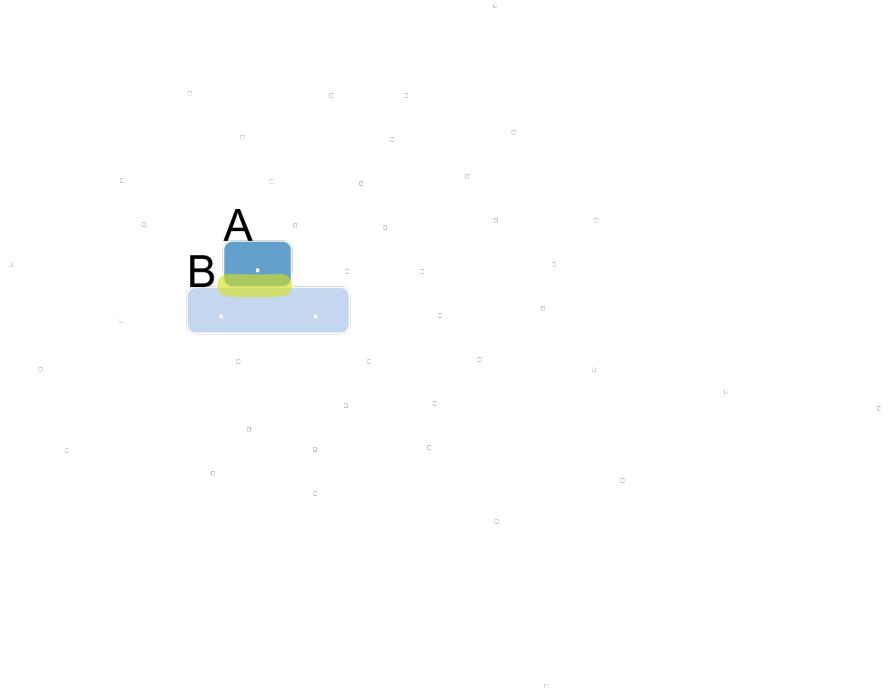
BubbleSets (without graph)



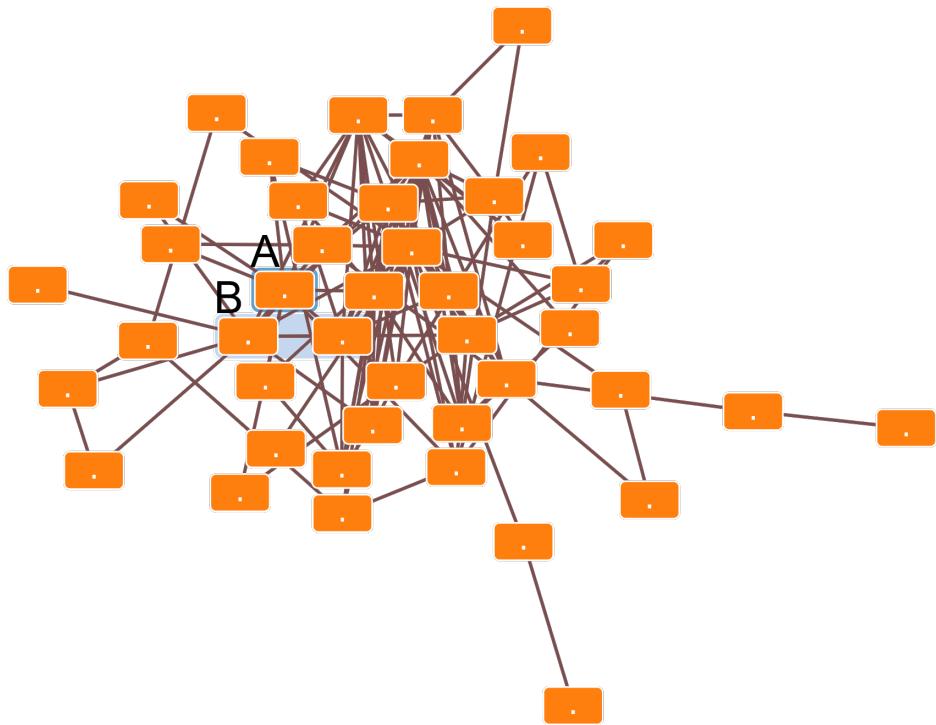
BubbleSets (with graph)



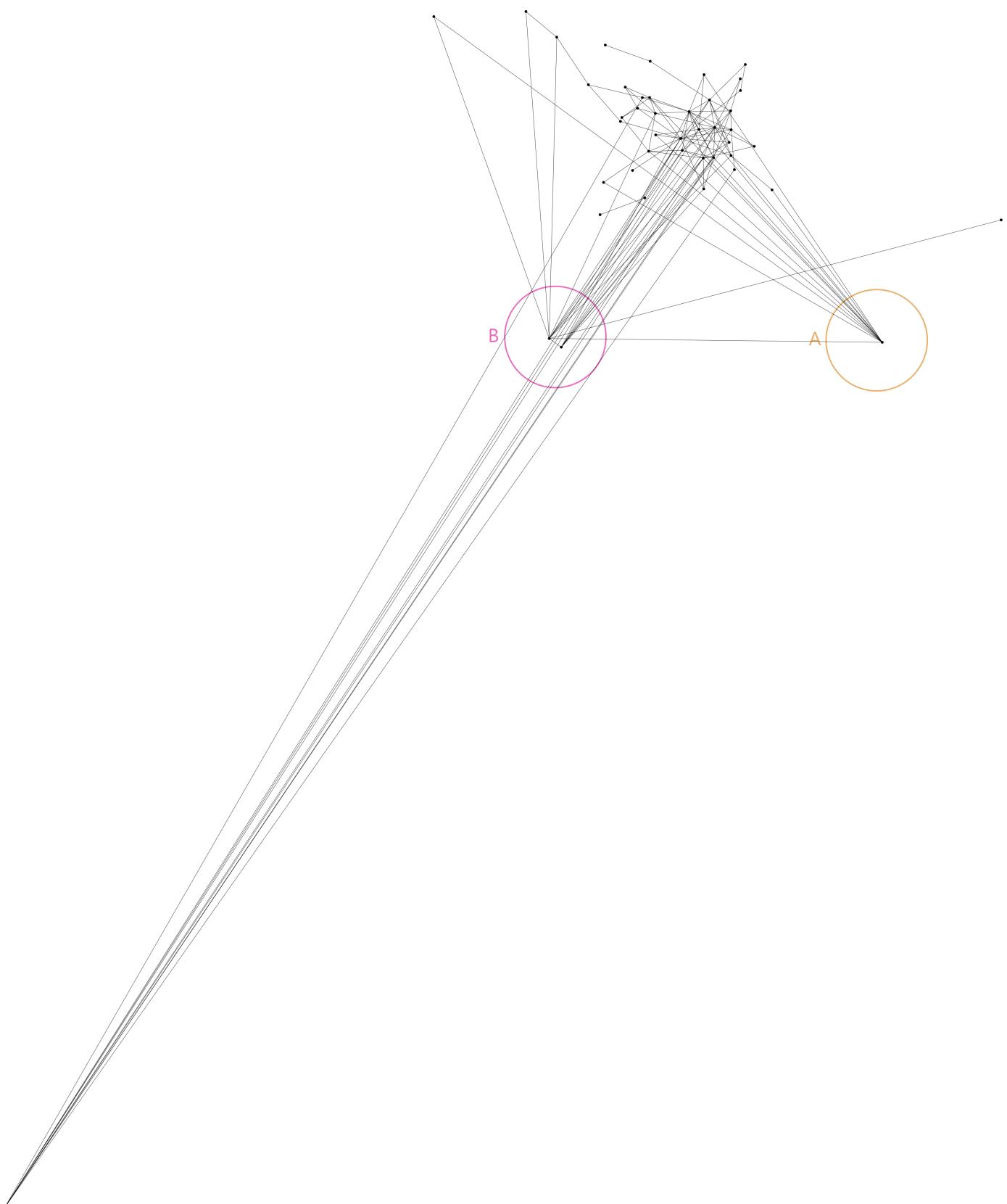
WebCola (without graph)



WebCola (with graph)



GroupNet

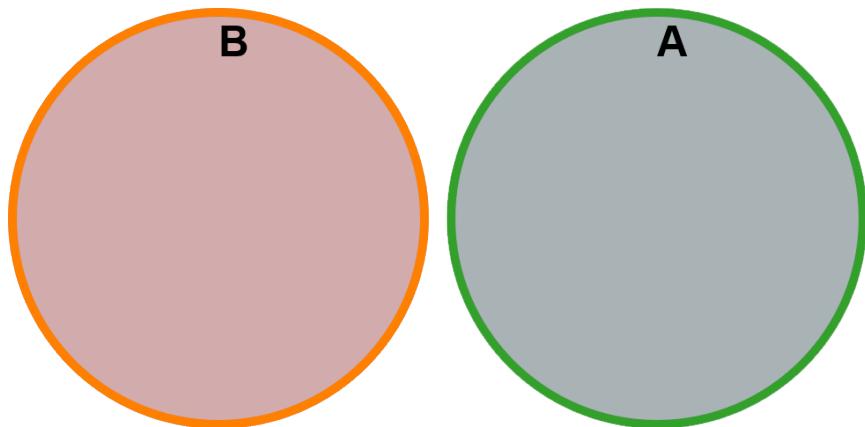


2-set data set 4 : SNAP ID: 15507297

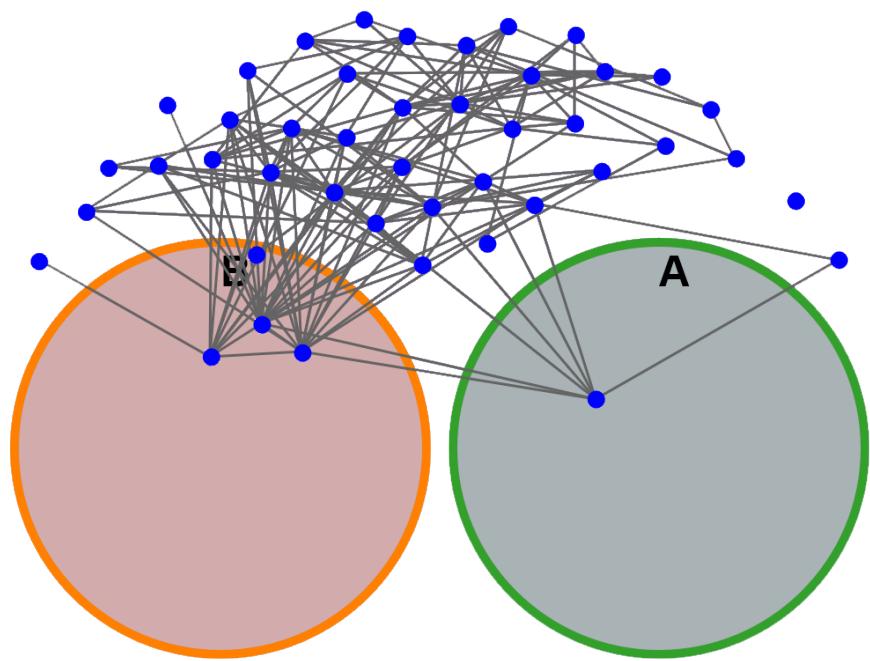
Number of Sets: 2
 Number of Zones: 3
 Number of Nodes: 45
 Number of Edges: 163
 Zones high: no
 Nodes high: yes
 Edges high: yes

	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)

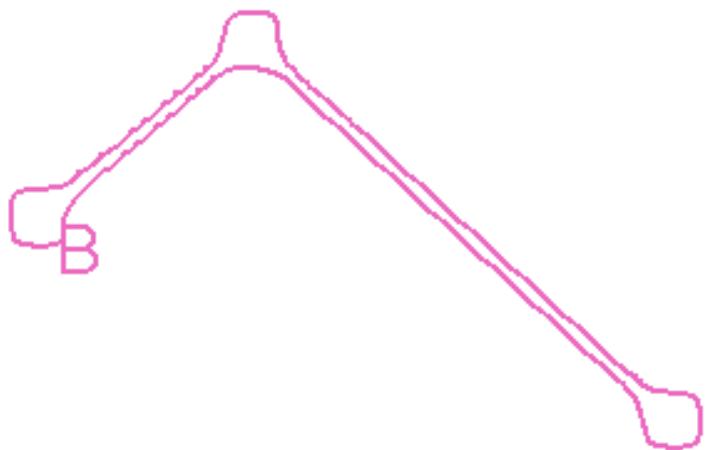


SetNet (with graph)

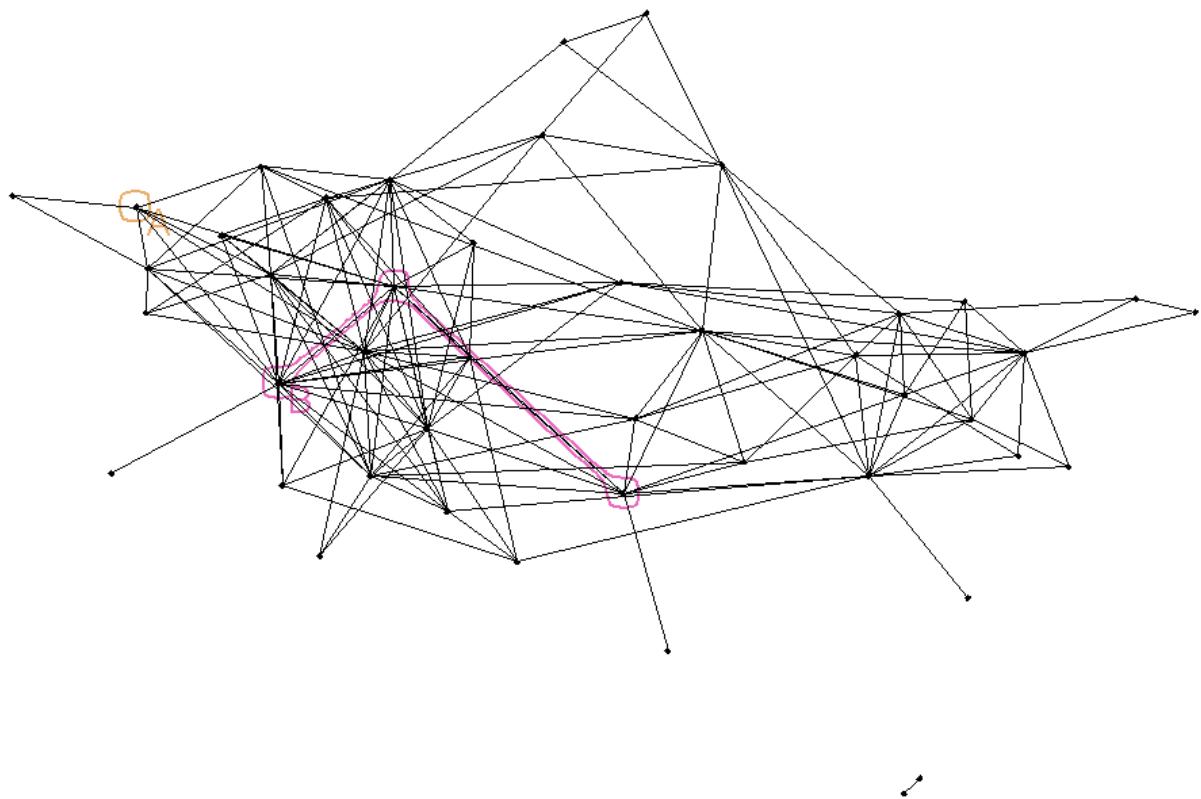


BubbleSets (without graph)

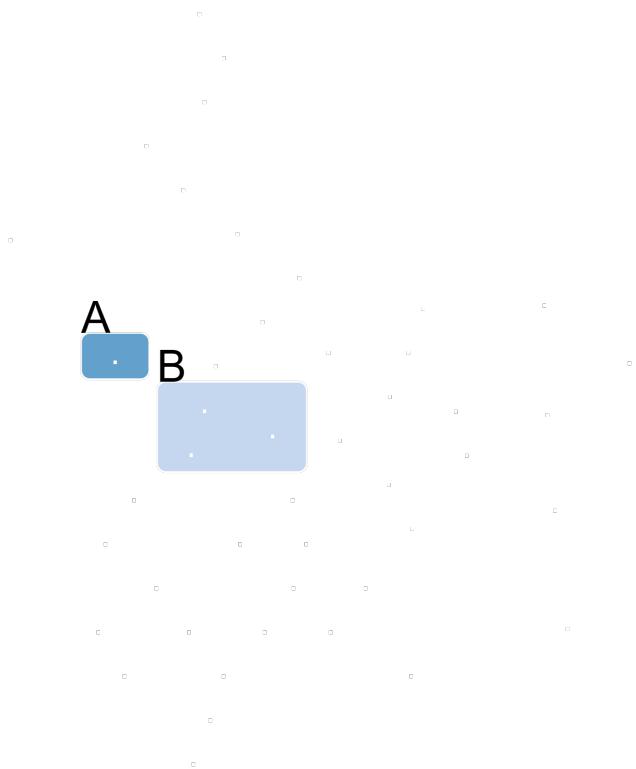
Q_A



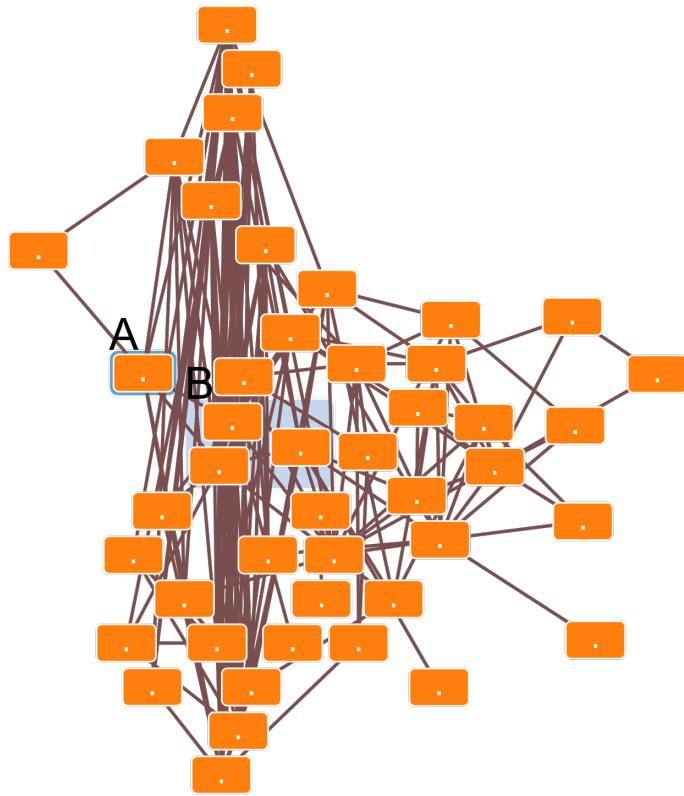
BubbleSets (with graph)



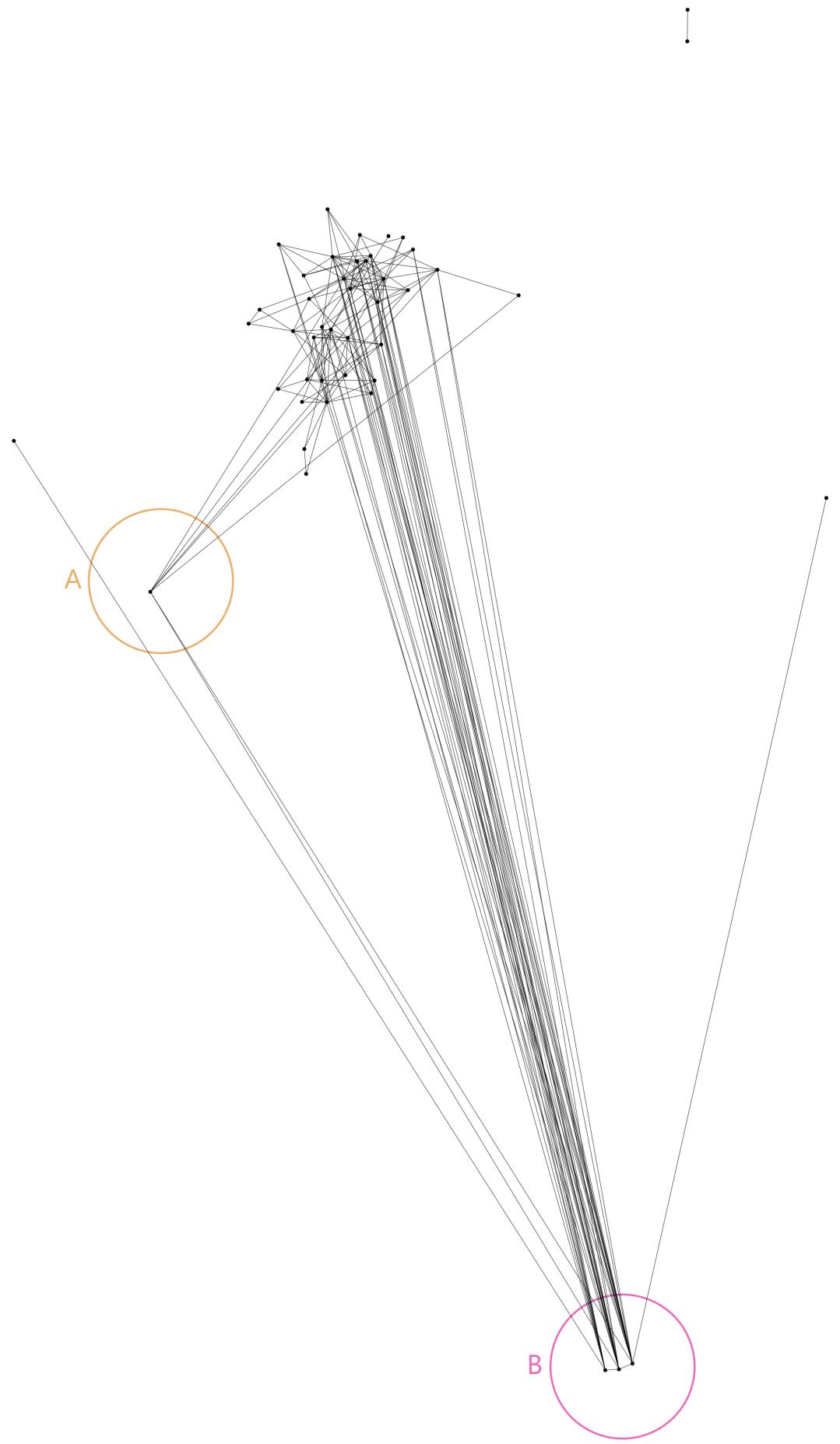
WebCola (without graph)



WebCola (with graph)



GroupNet

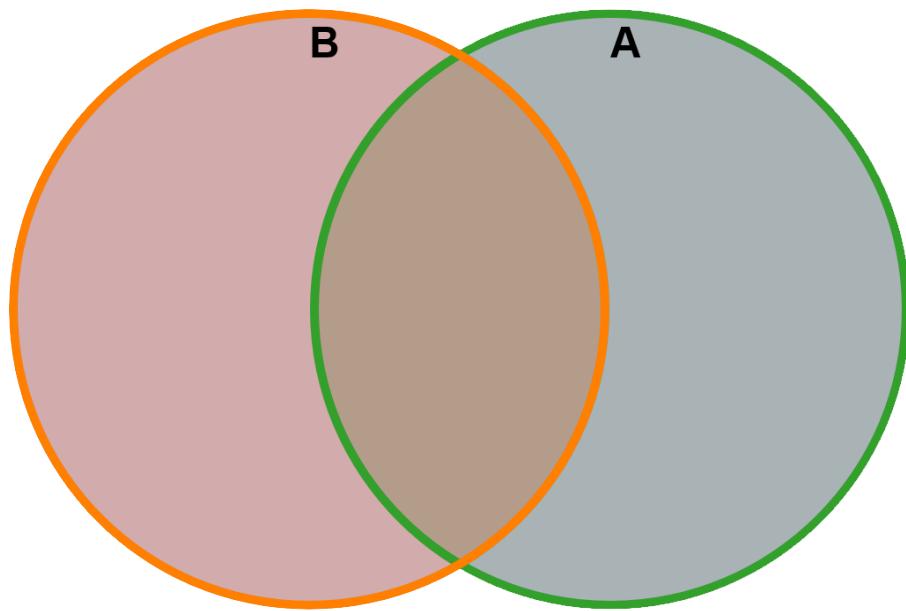


2-set data set 5 : SNAP ID: 20060293

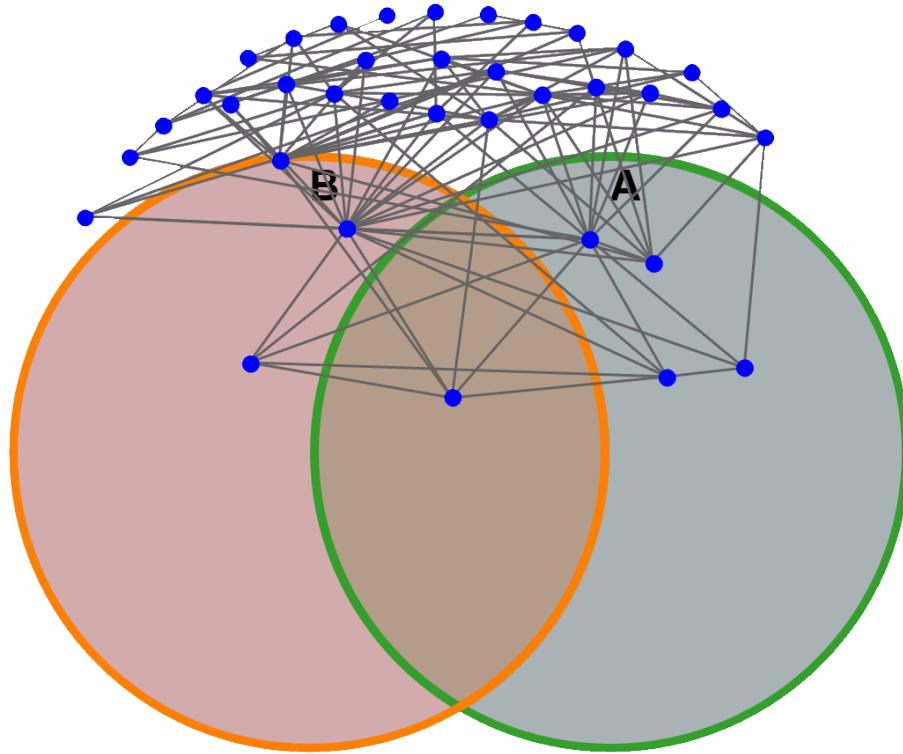
Number of Sets: 2
 Number of Zones: 4
 Number of Nodes: 36
 Number of Edges: 111
 Zones high: yes
 Nodes high: no
 Edges high: no

	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

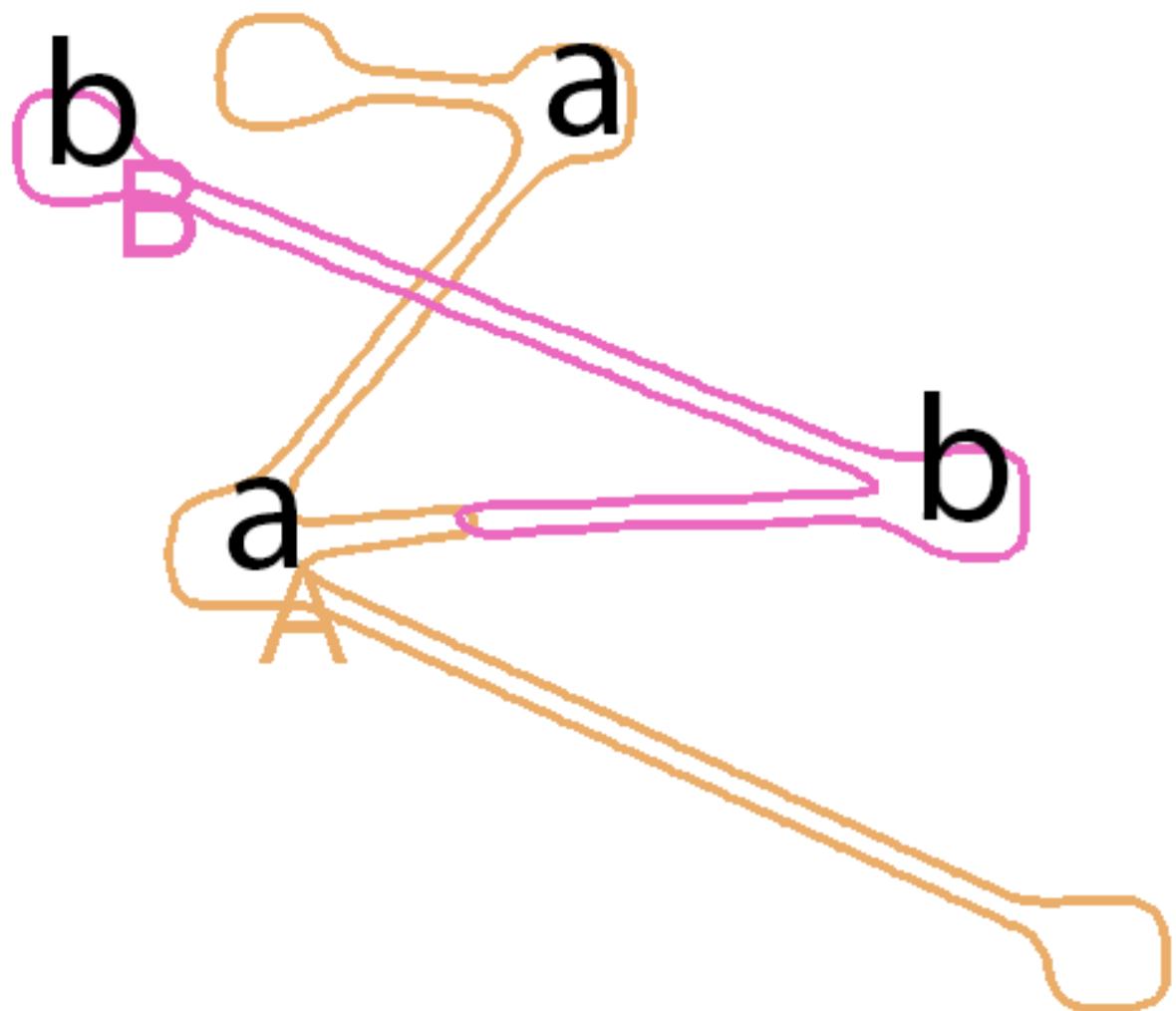
SetNet (without graph)



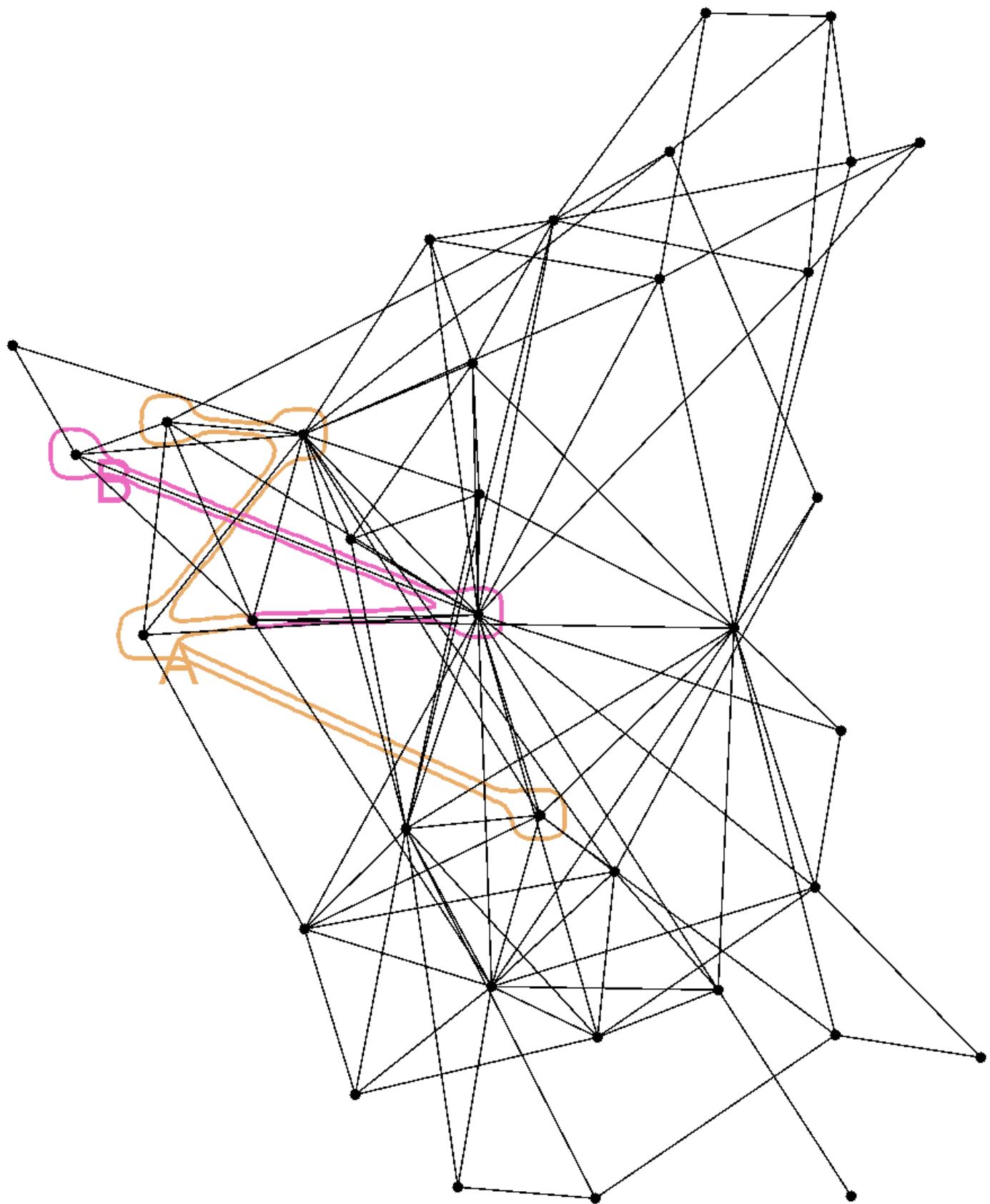
SetNet (with graph)



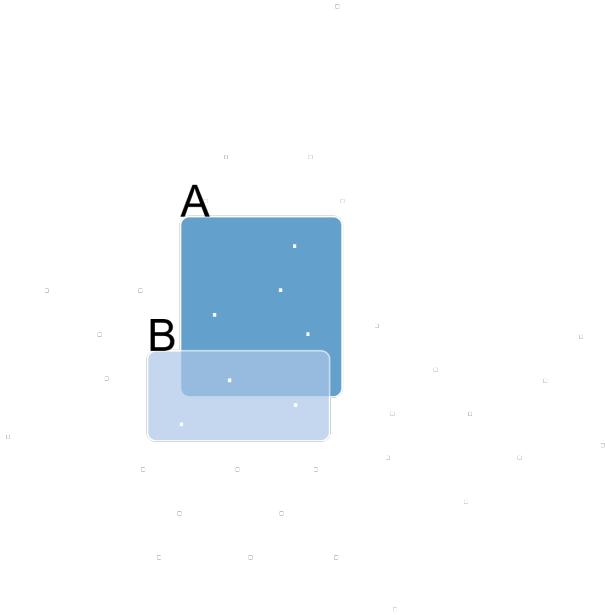
BubbleSets (without graph)



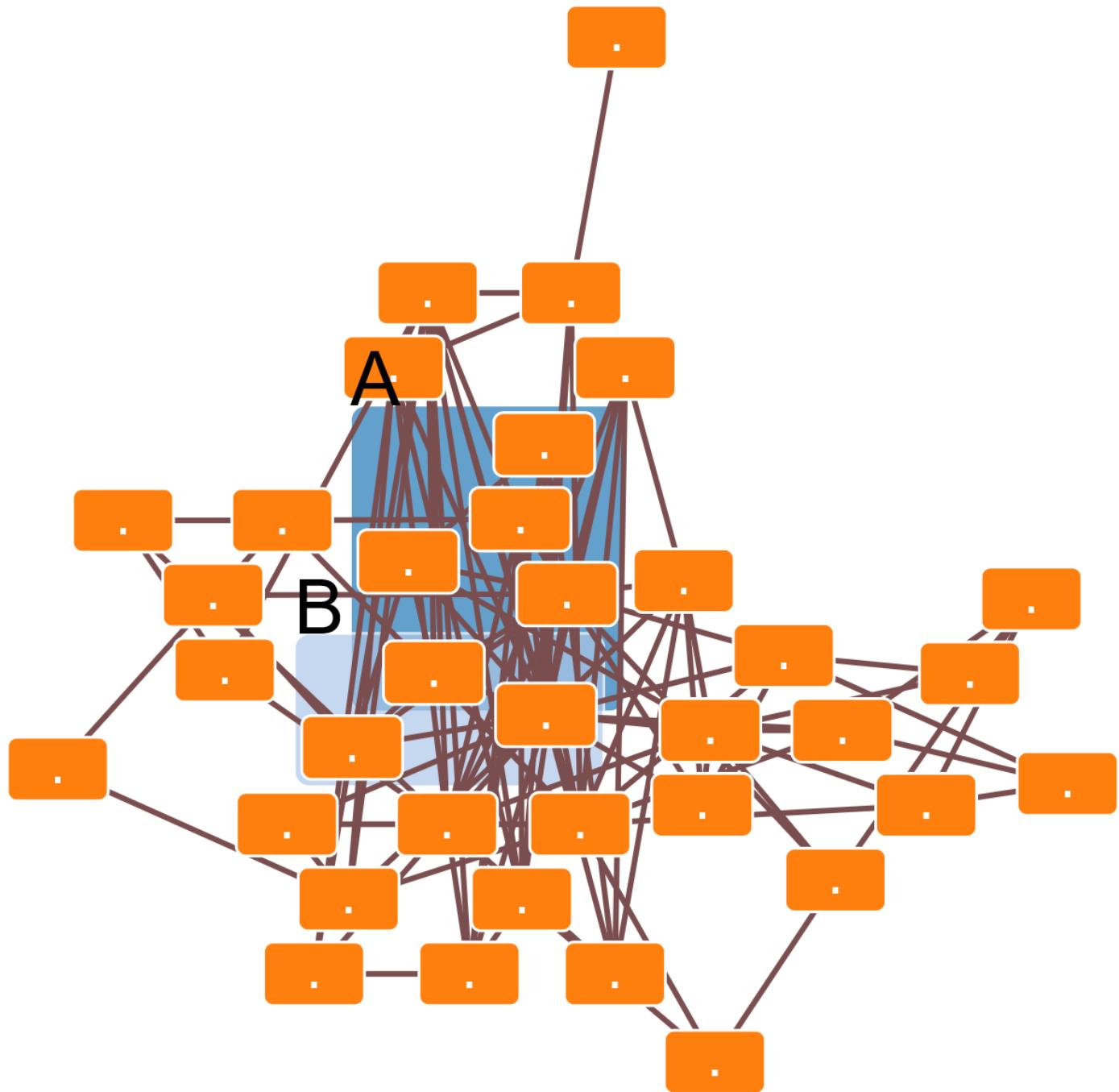
BubbleSets (with graph)



WebCola (without graph)



WebCola (with graph)



GroupNet

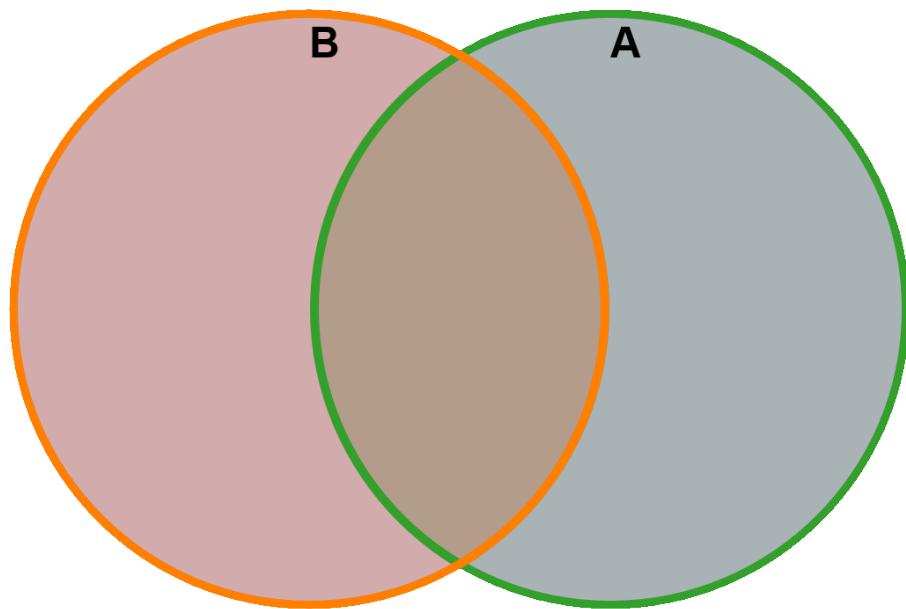


2-set data set 6 : SNAP ID: 242024994

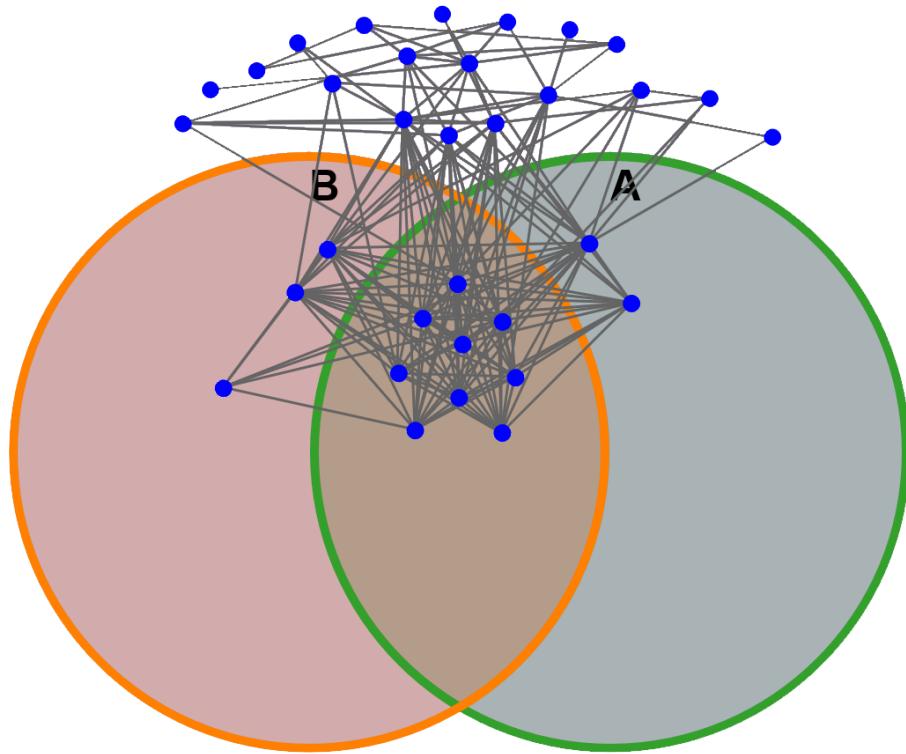
Number of Sets: 2
 Number of Zones: 4
 Number of Nodes: 33
 Number of Edges: 170
 Zones high: yes
 Nodes high: no
 Edges high: yes

	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

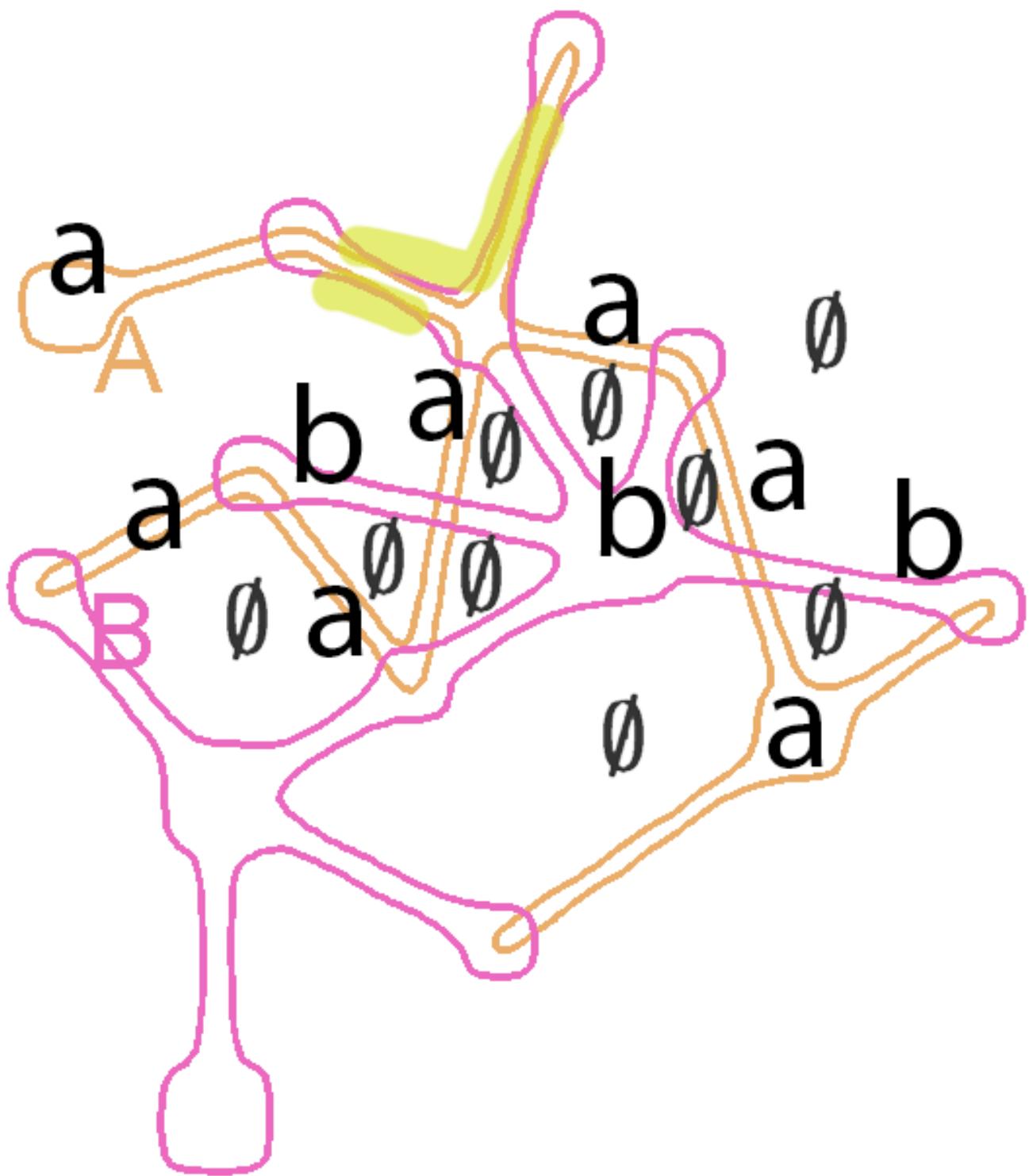
SetNet (without graph)



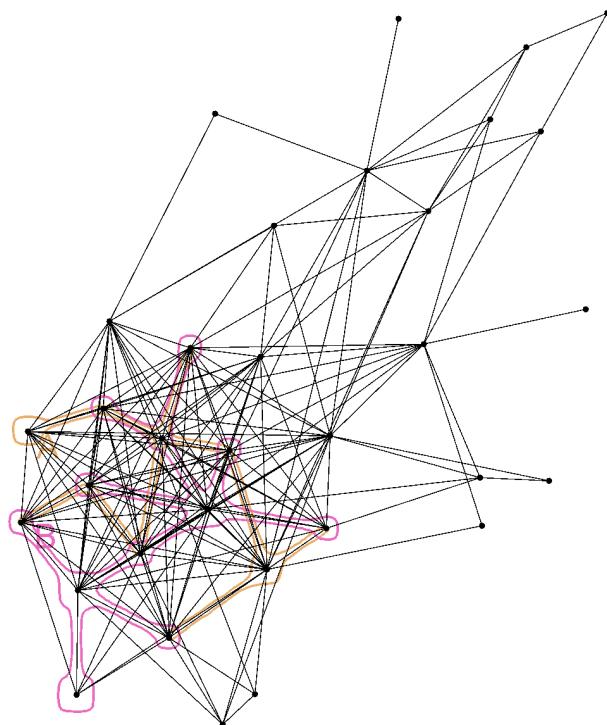
SetNet (with graph)



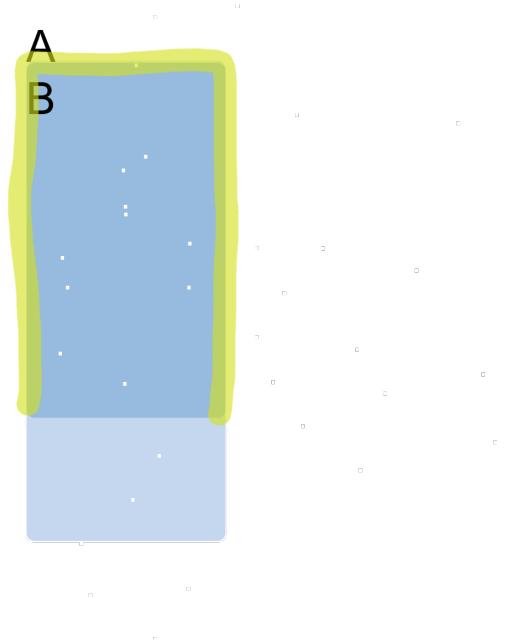
BubbleSets (without graph)



BubbleSets (with graph)

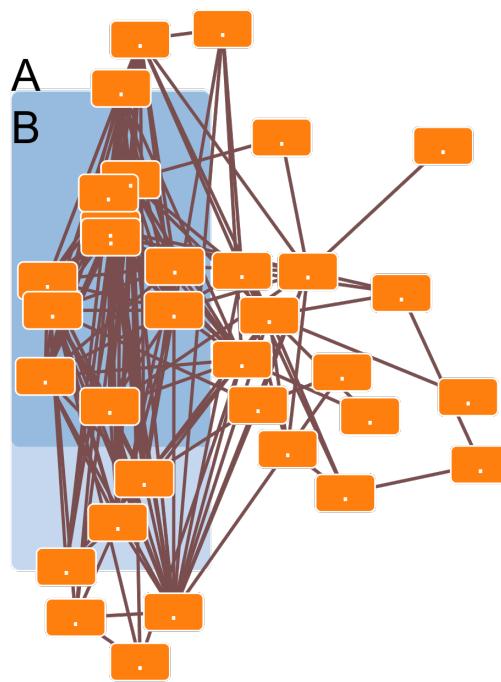


WebCola (without graph)

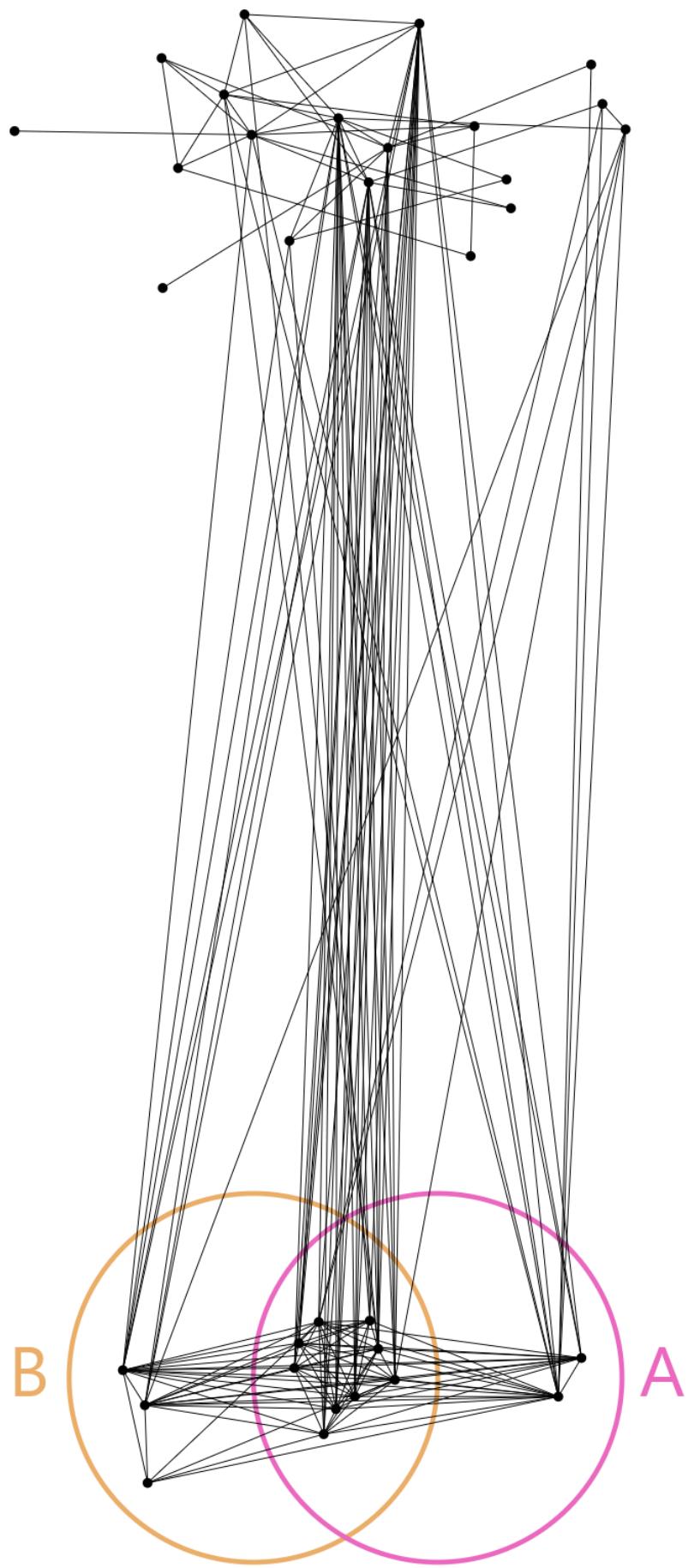


Omitted zone: A

WebCola (with graph)



GroupNet

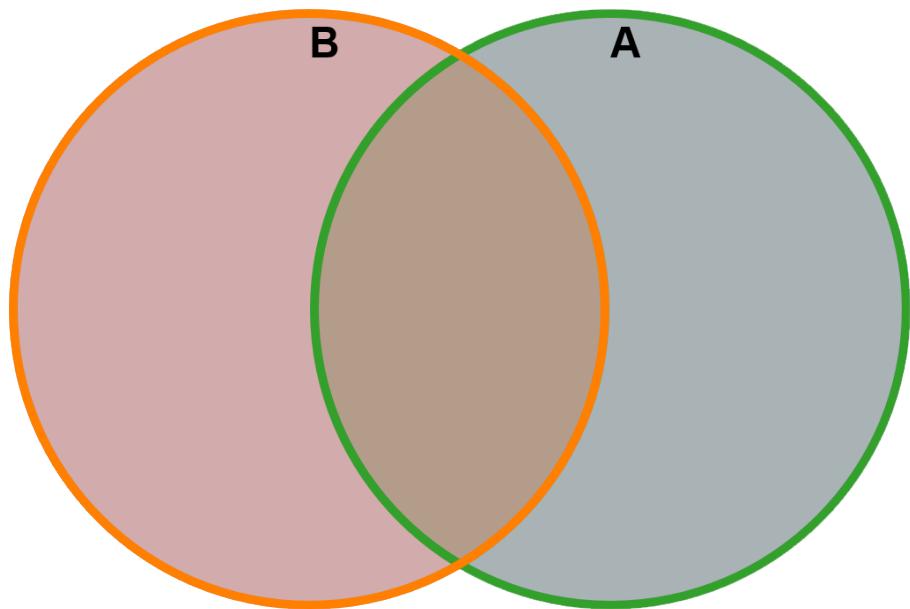


2-set data set 7 : SNAP ID: 22879382

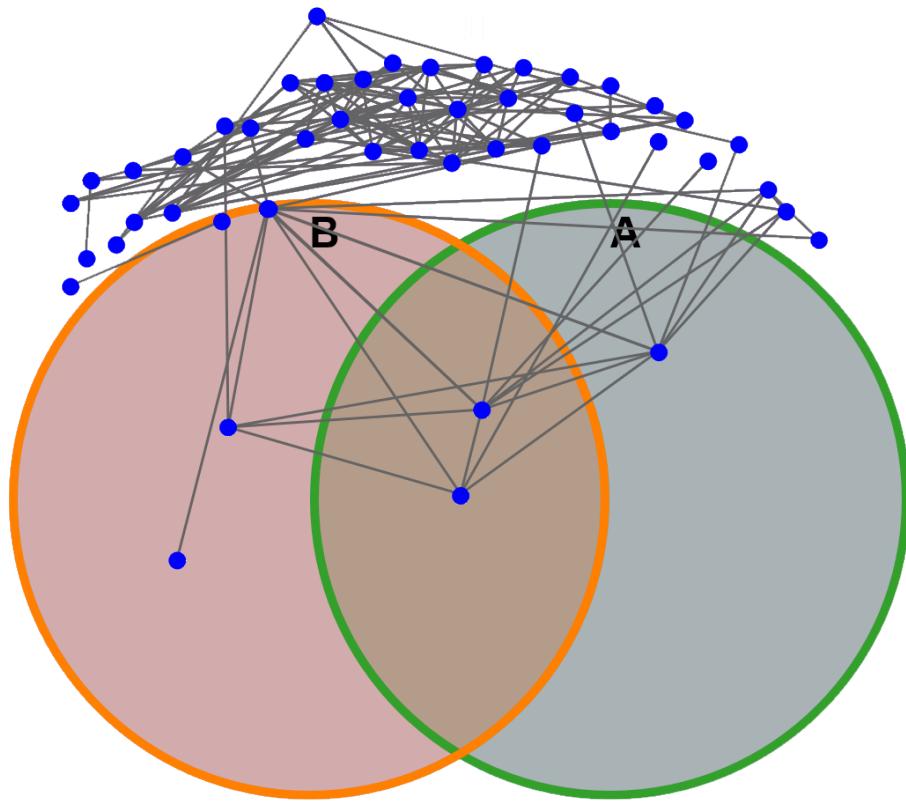
Number of Sets: 2
 Number of Zones: 4
 Number of Nodes: 49
 Number of Edges: 138
 Zones high: yes
 Nodes high: yes
 Edges high: no

	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)



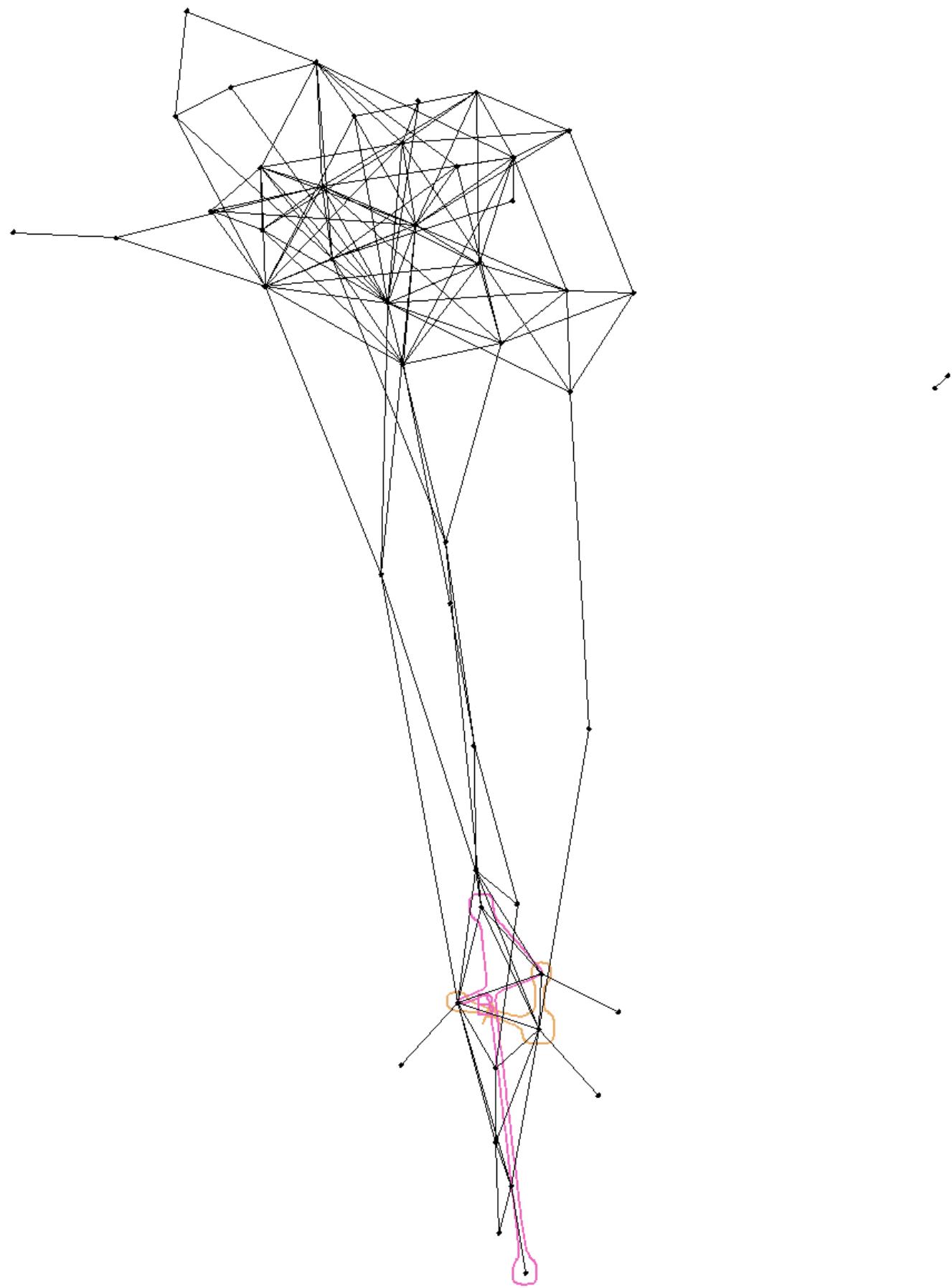
SetNet (with graph)



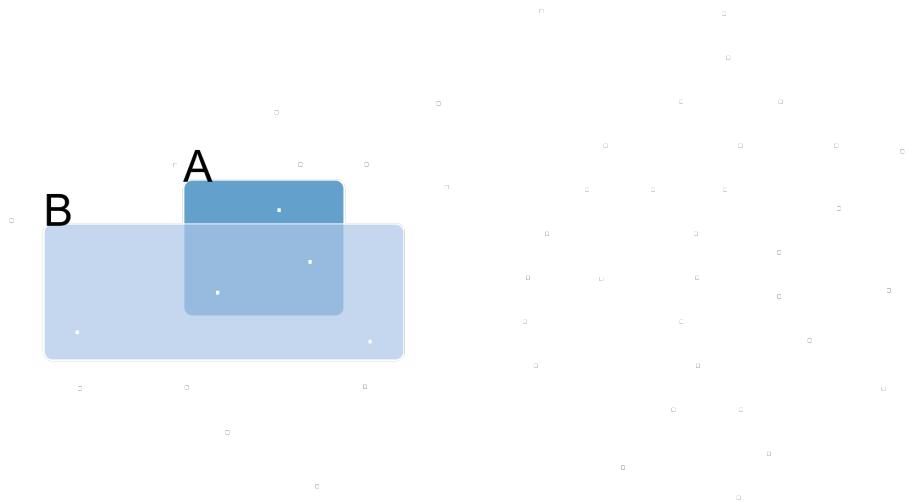
BubbleSets (without graph)



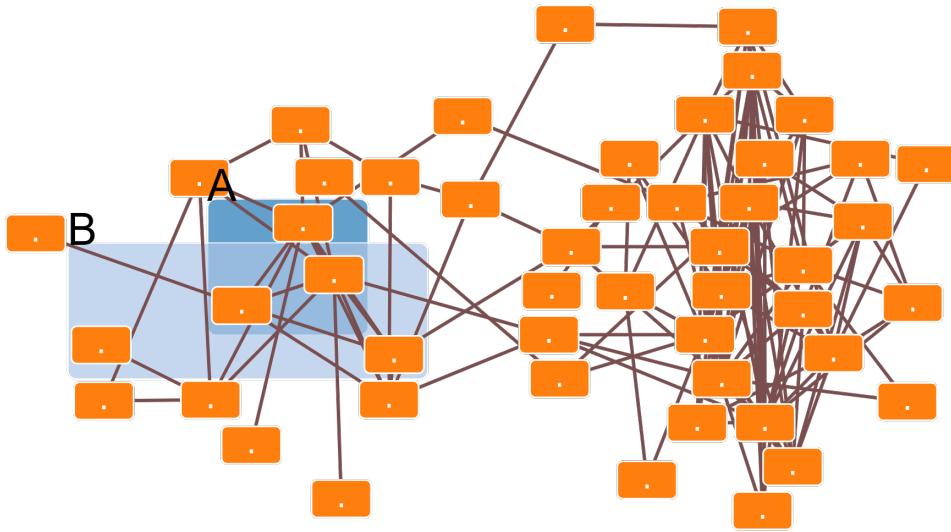
BubbleSets (with graph)



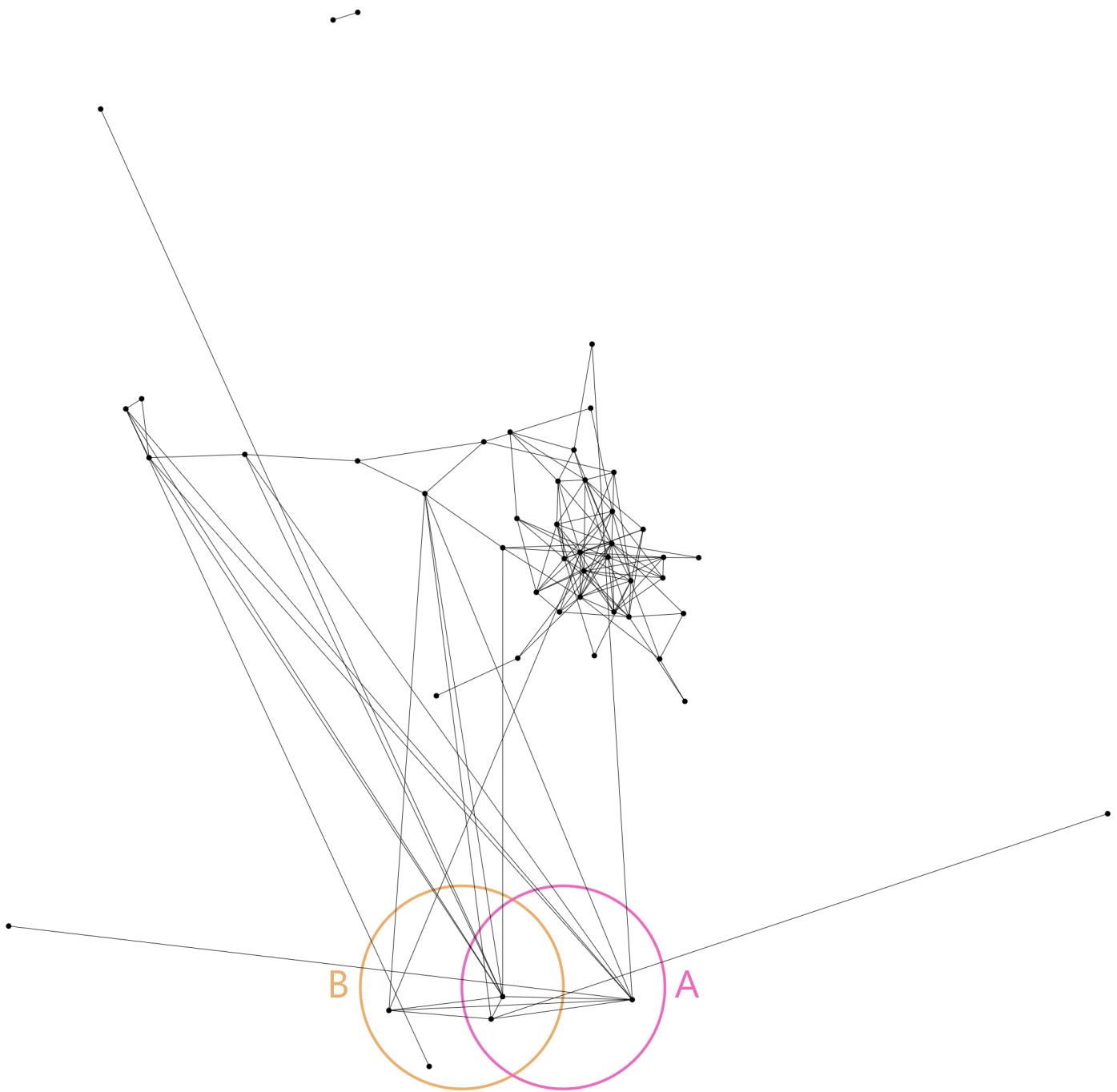
WebCola (without graph)



WebCola (with graph)



GroupNet

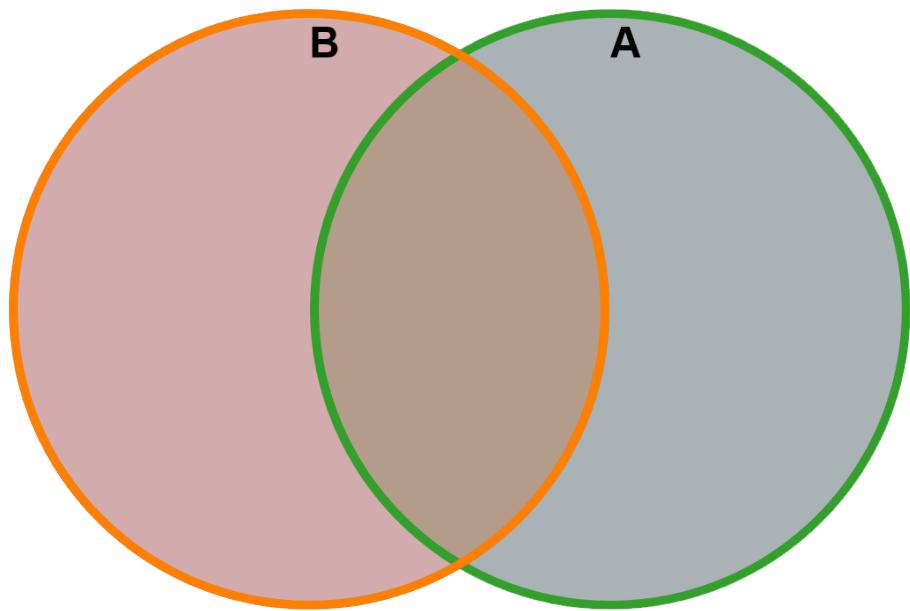


2-set data set 8 : SNAP ID: 20758393

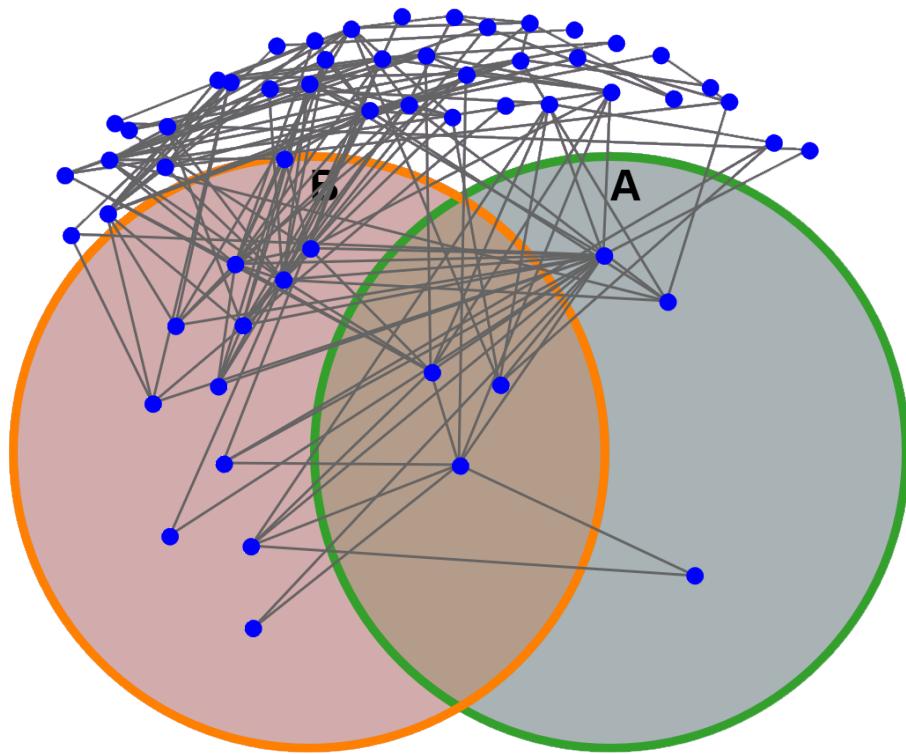
Number of Sets: 2
 Number of Zones: 4
 Number of Nodes: 57
 Number of Edges: 165
 Zones high: yes
 Nodes high: yes
 Edges high: yes

	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

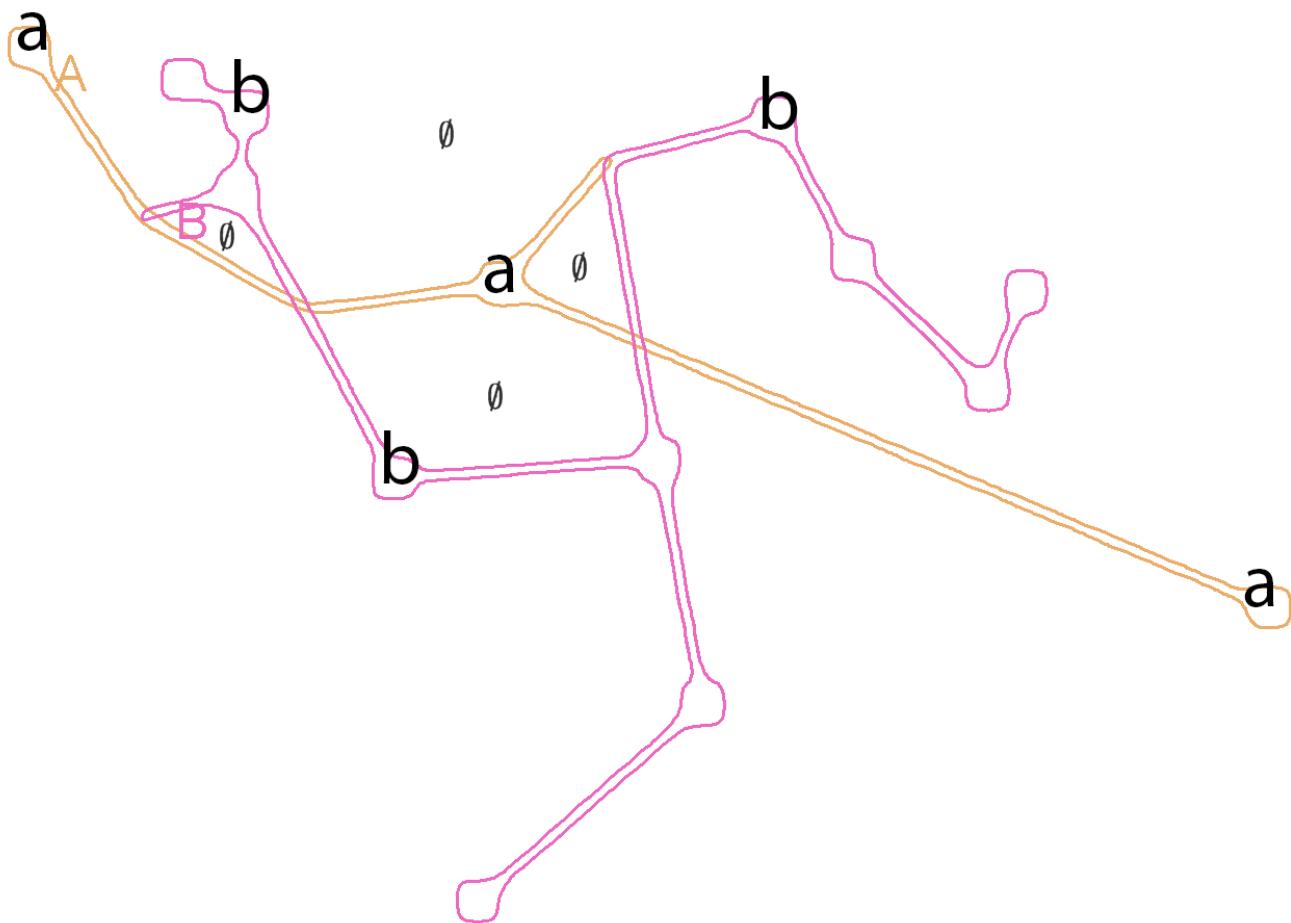
SetNet (without graph)



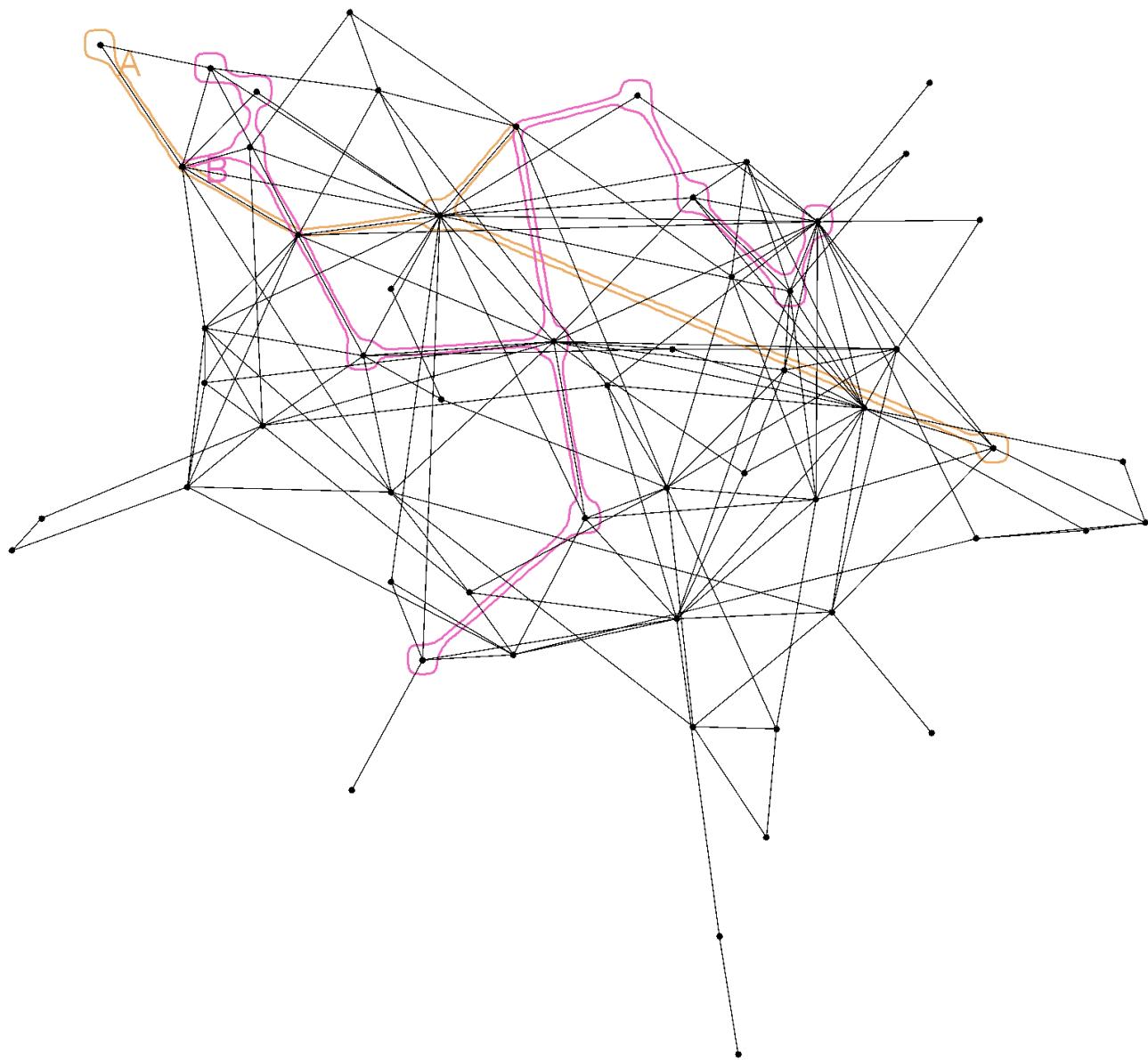
SetNet (with graph)



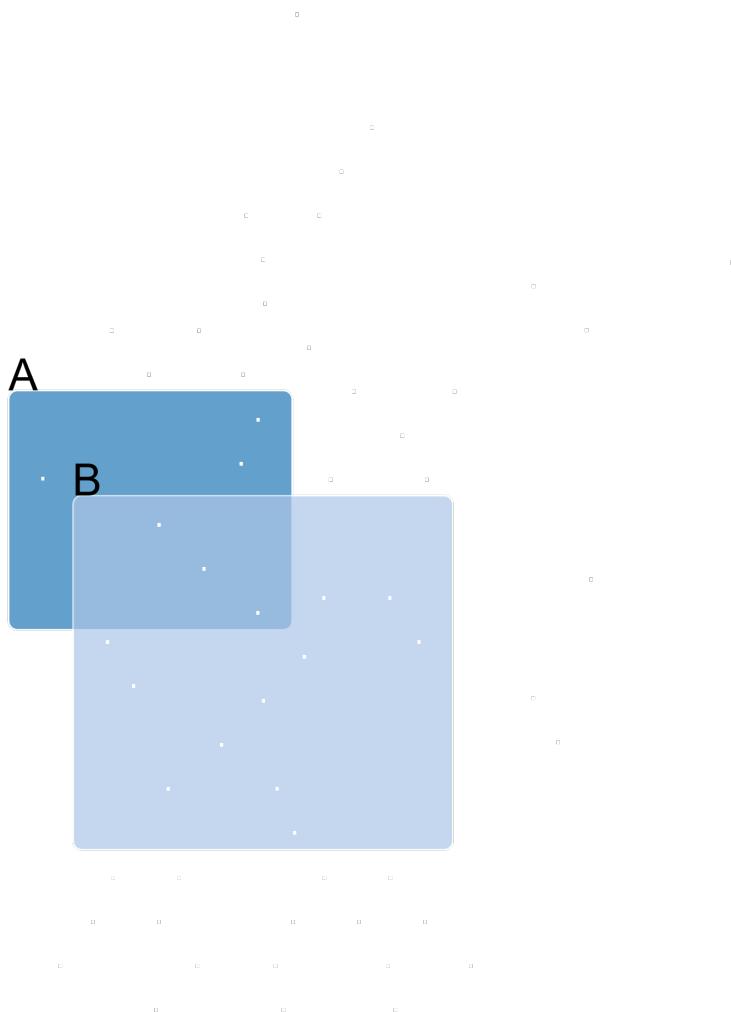
BubbleSets (without graph)



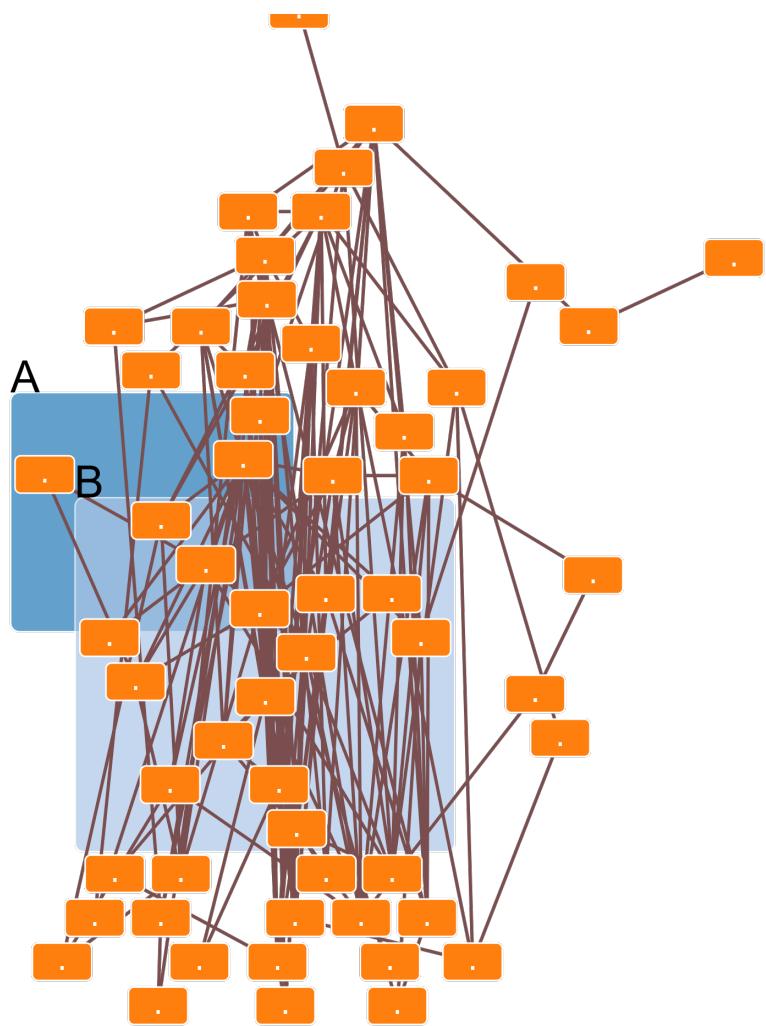
BubbleSets (with graph)



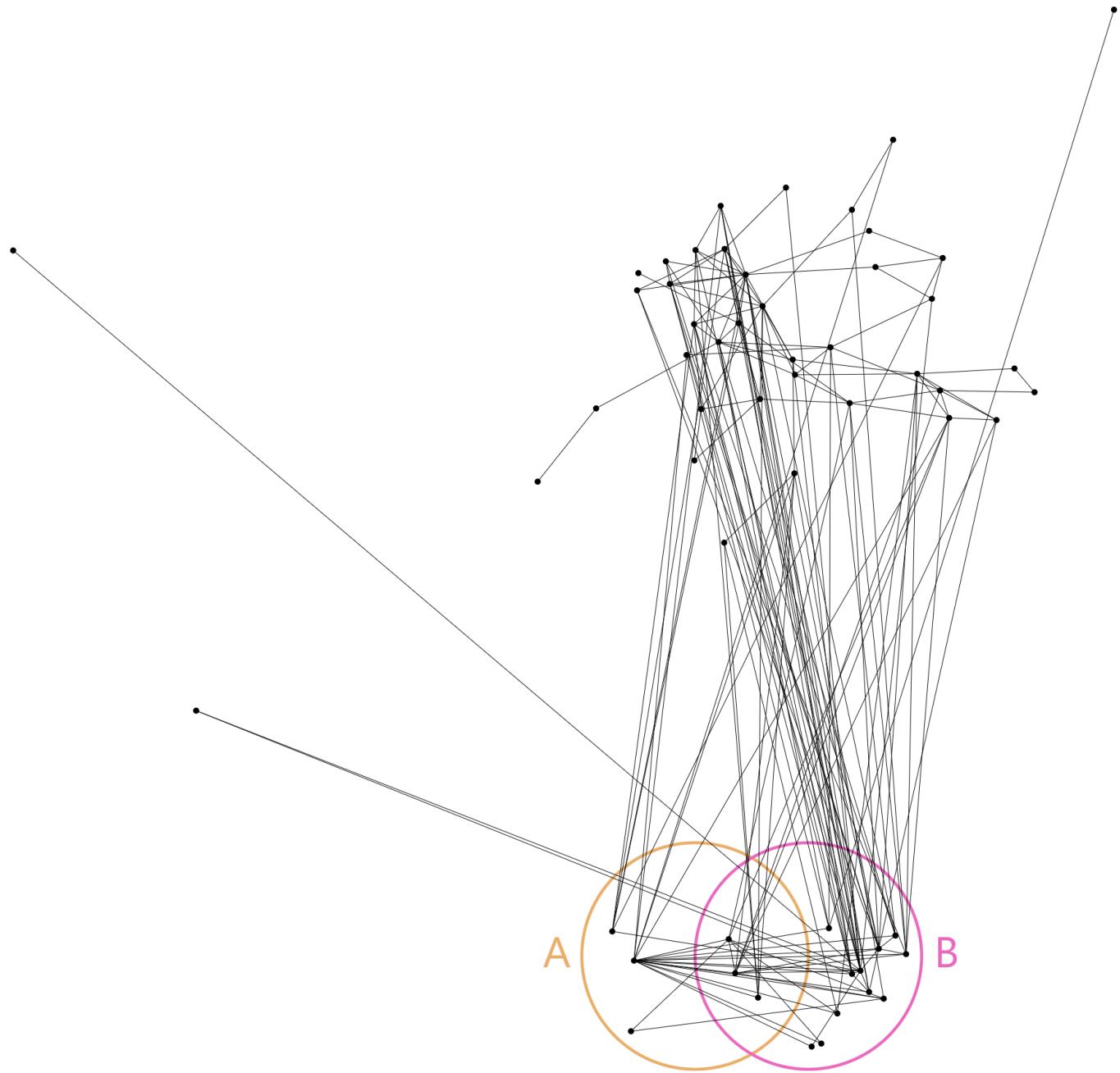
WebCola (without graph)



WebCola (with graph)



GroupNet

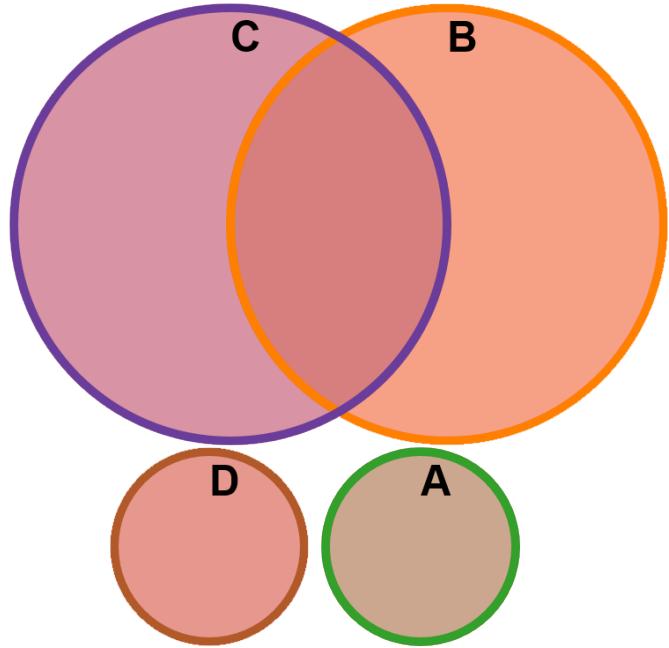


4-set data set 1 : SNAP ID: 198628427

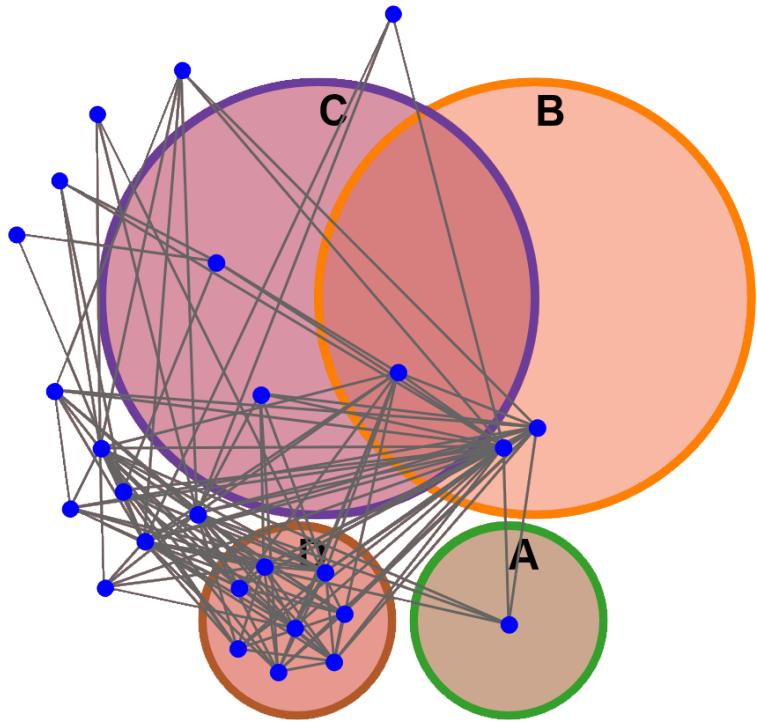
Number of Sets: 4
 Number of Zones: 6
 Number of Nodes: 26
 Number of Edges: 133
 Zones high: no
 Nodes high: no
 Edges high: no

	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

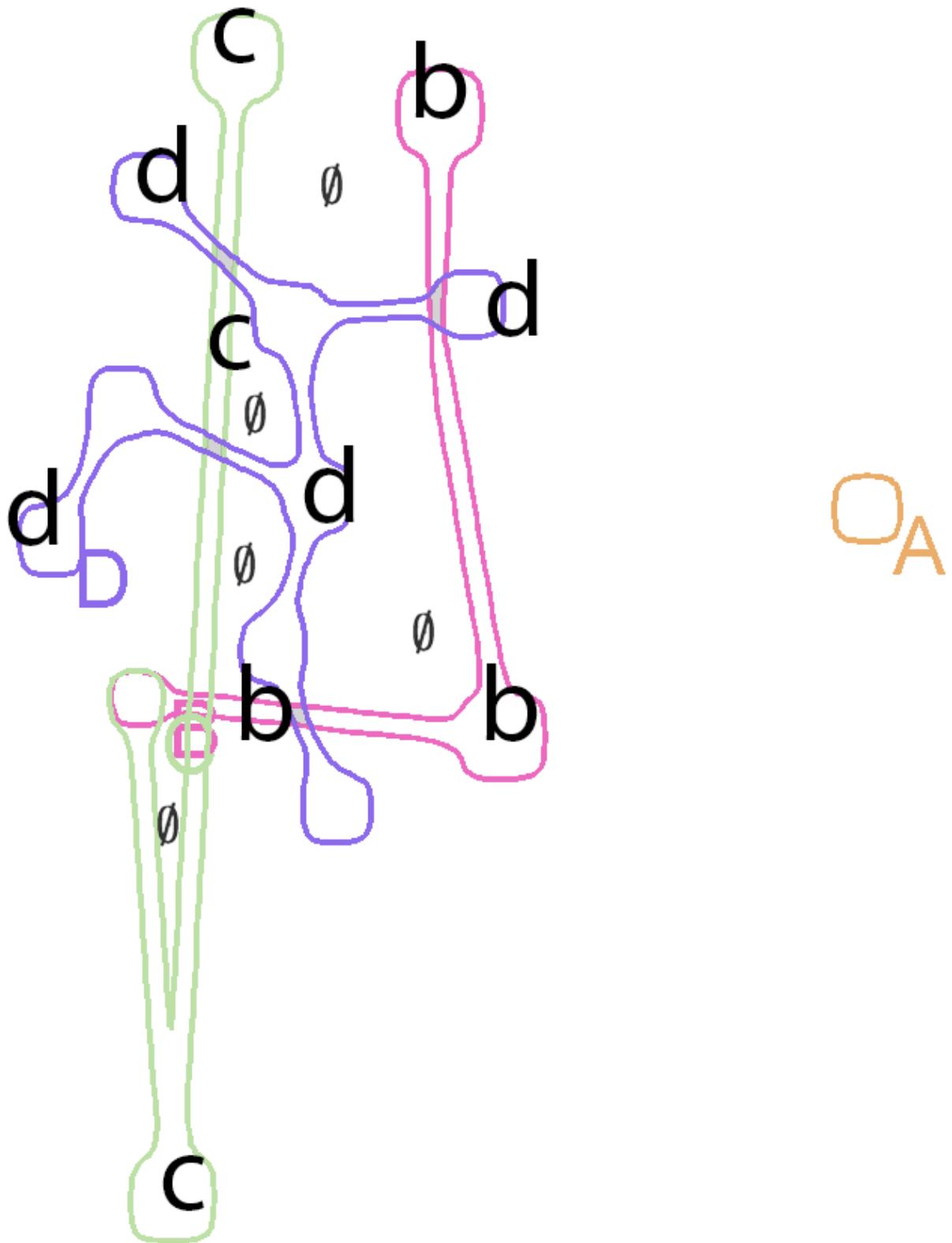
SetNet (without graph)



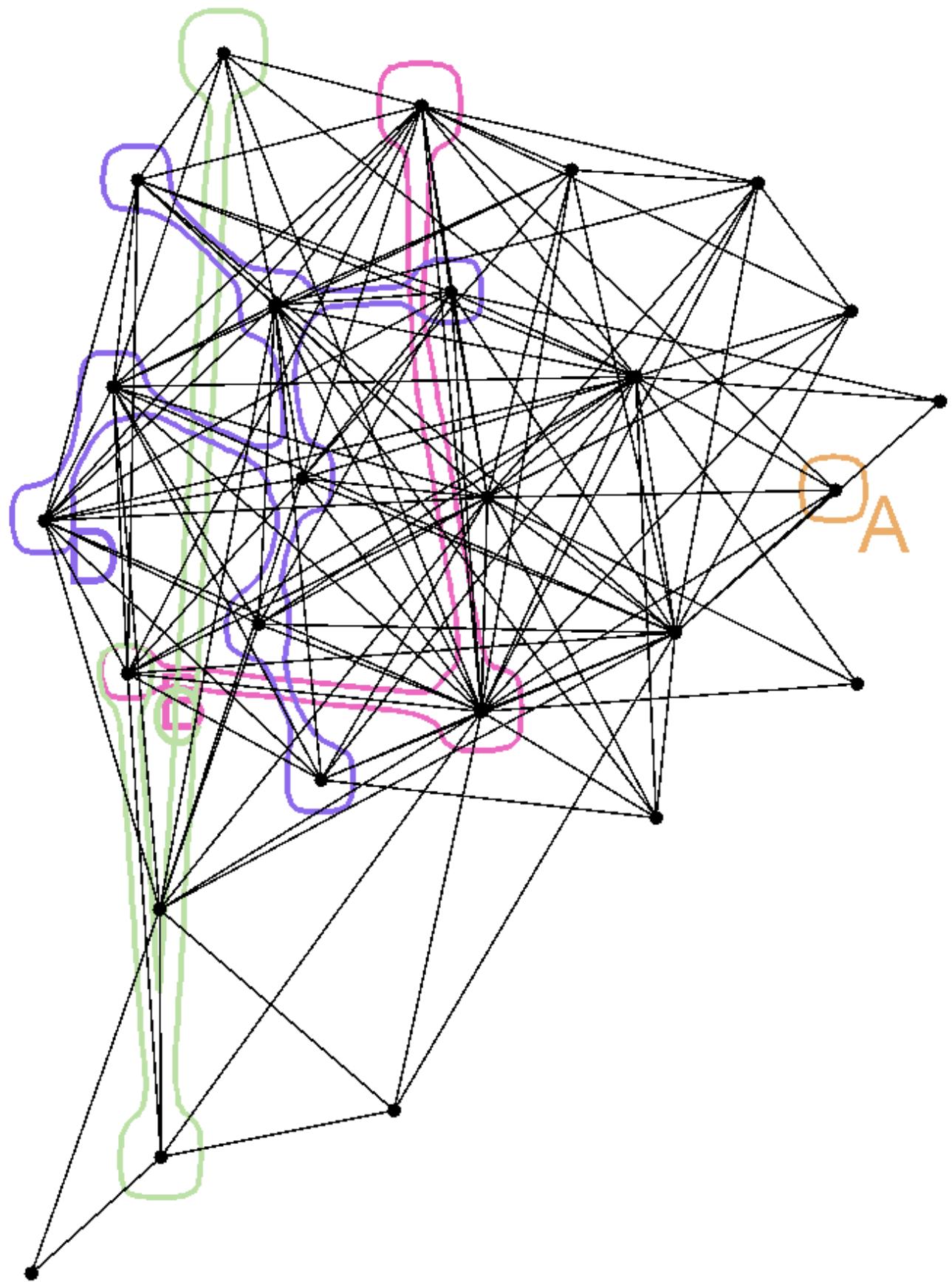
SetNet (with graph)



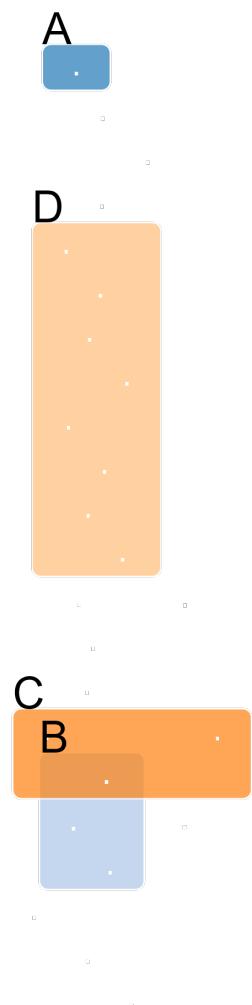
BubbleSets (without graph)



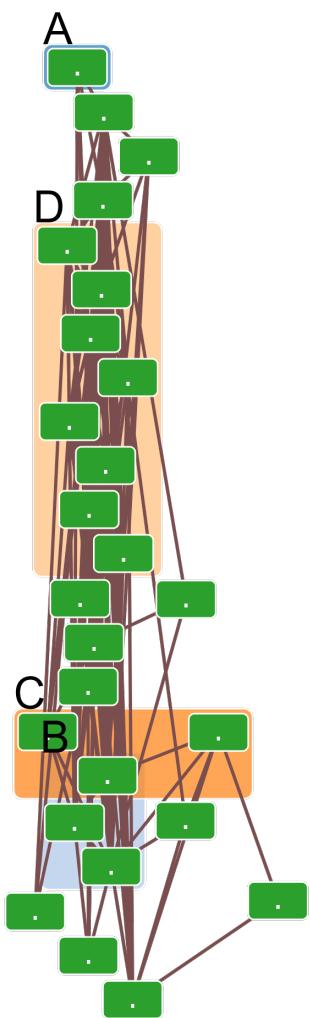
BubbleSets (with graph)



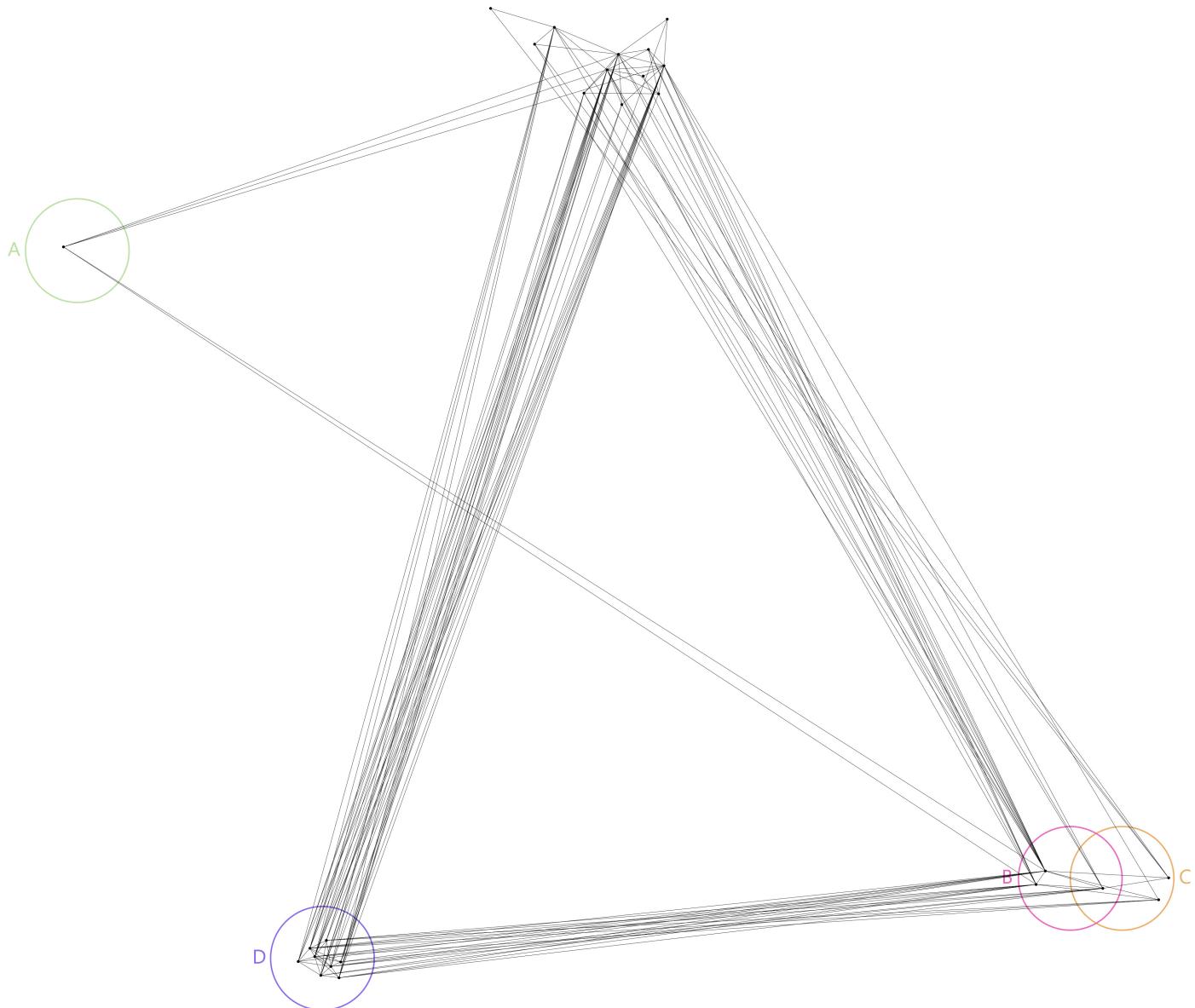
WebCola (without graph)



WebCola (with graph)



GroupNet

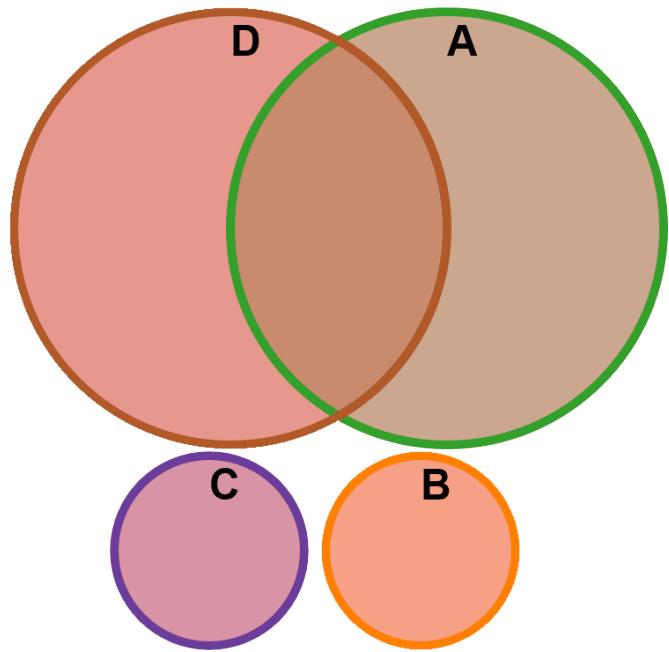


4-set data set 2 : SNAP ID: 351092905

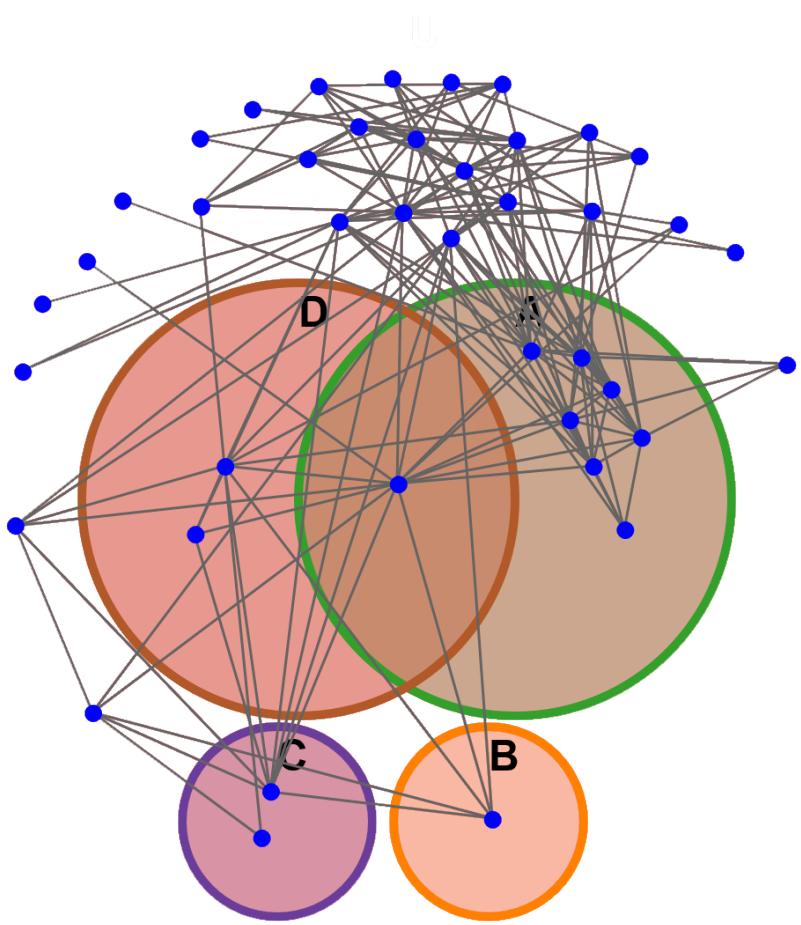
Number of Sets: 4
 Number of Zones: 6
 Number of Nodes: 41
 Number of Edges: 159
 Zones high: no
 Nodes high: no
 Edges high: yes

	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

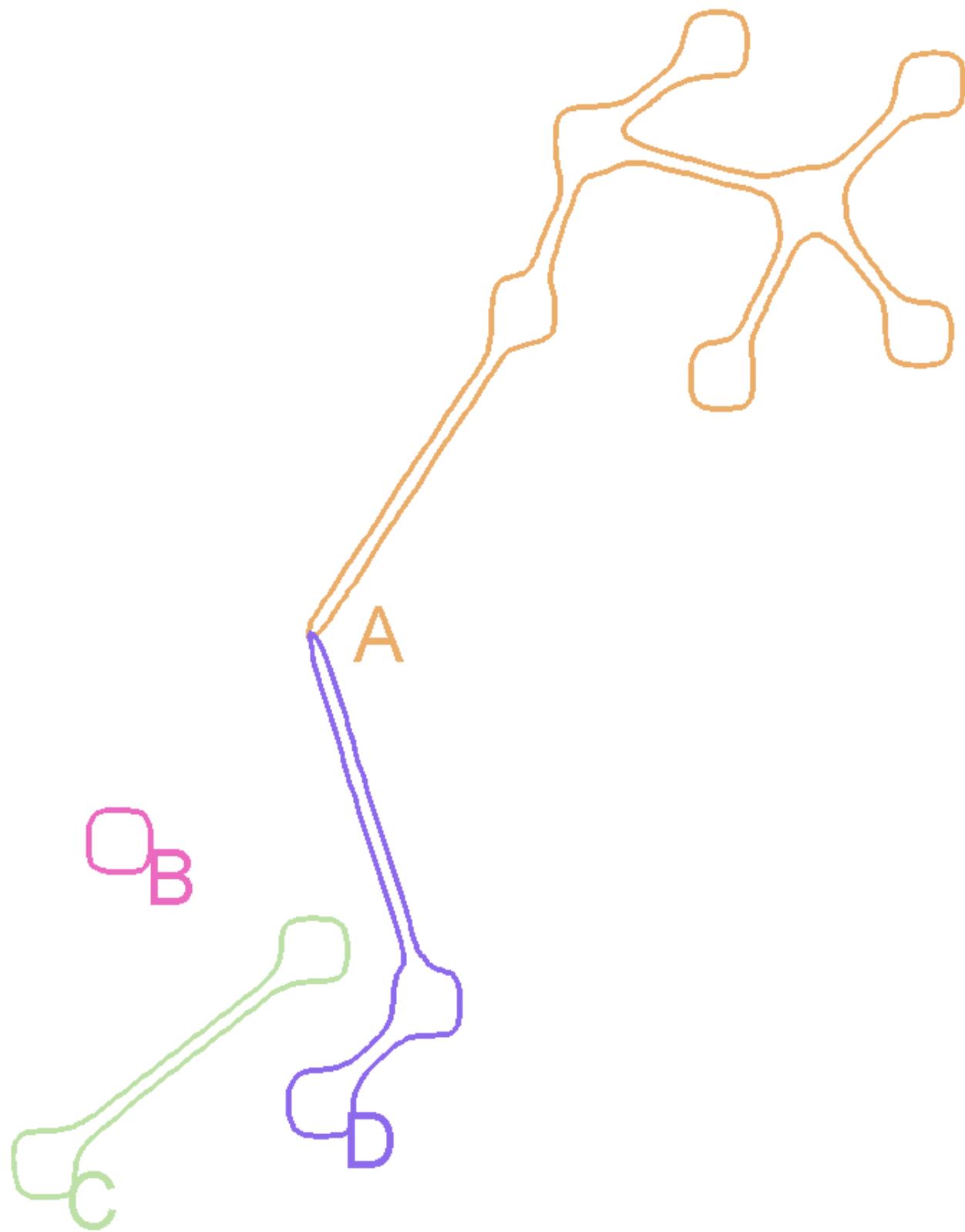
SetNet (without graph)



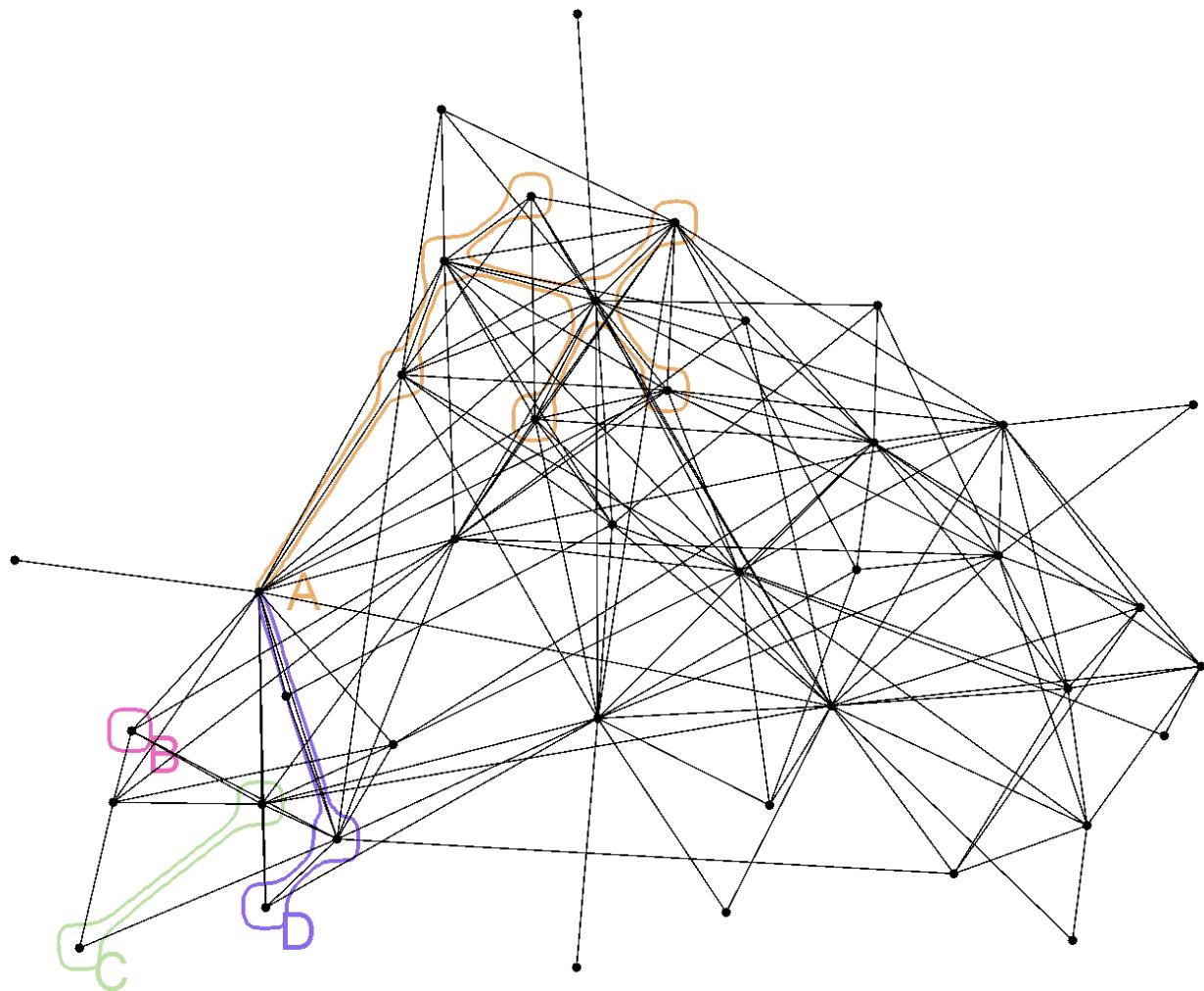
SetNet (with graph)



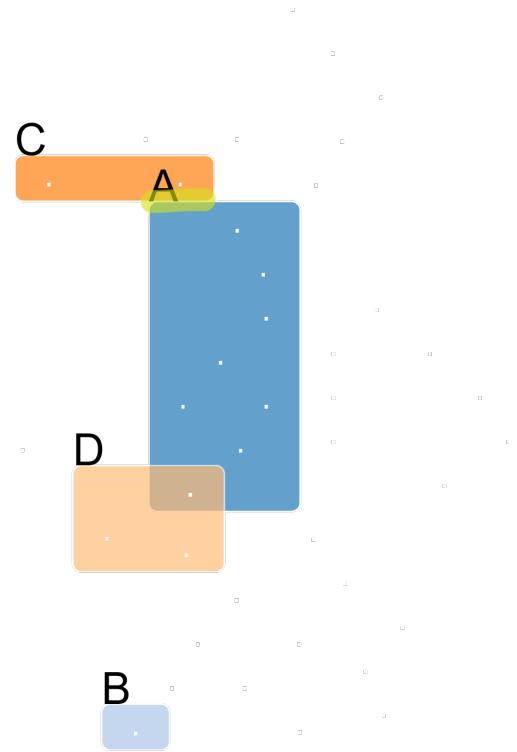
BubbleSets (without graph)



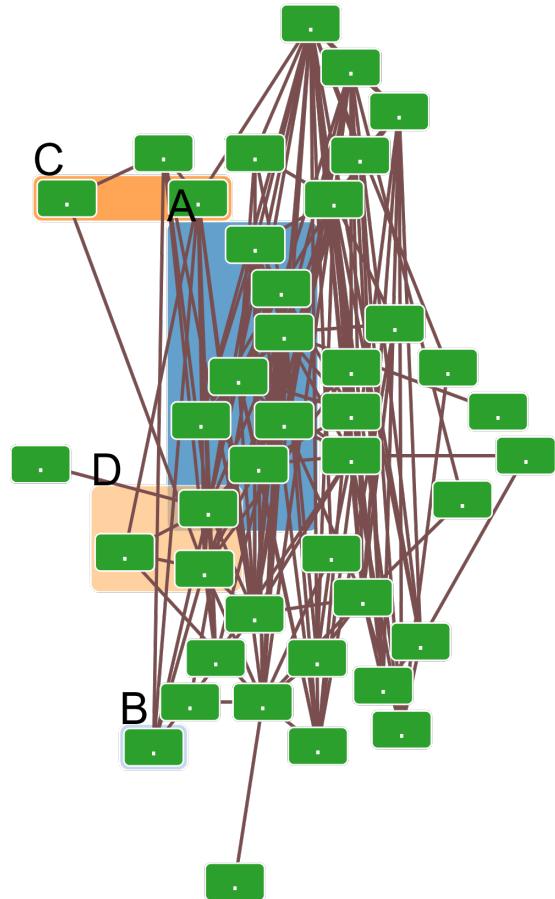
BubbleSets (with graph)



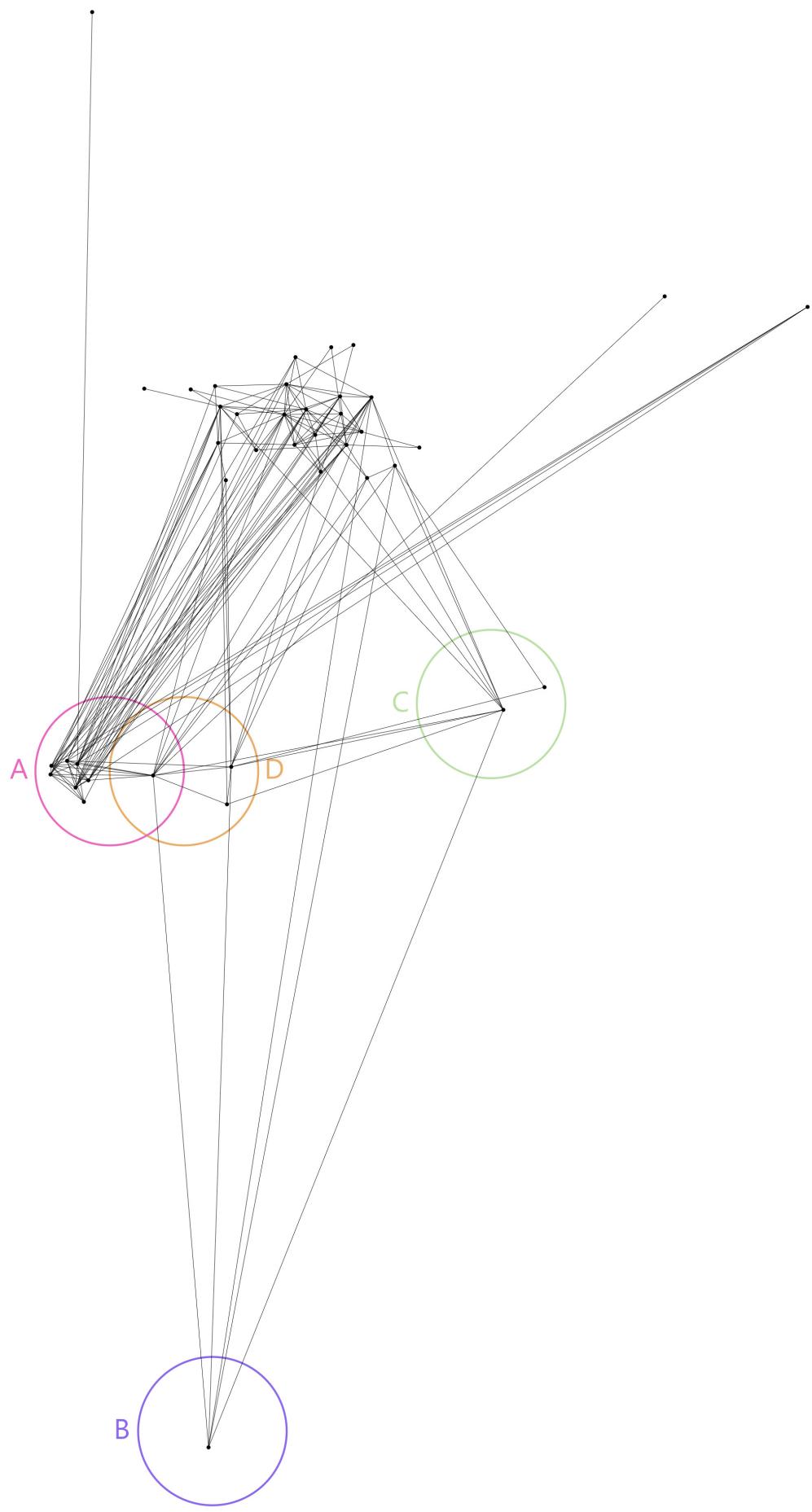
WebCola (without graph)



WebCola (with graph)



GroupNet

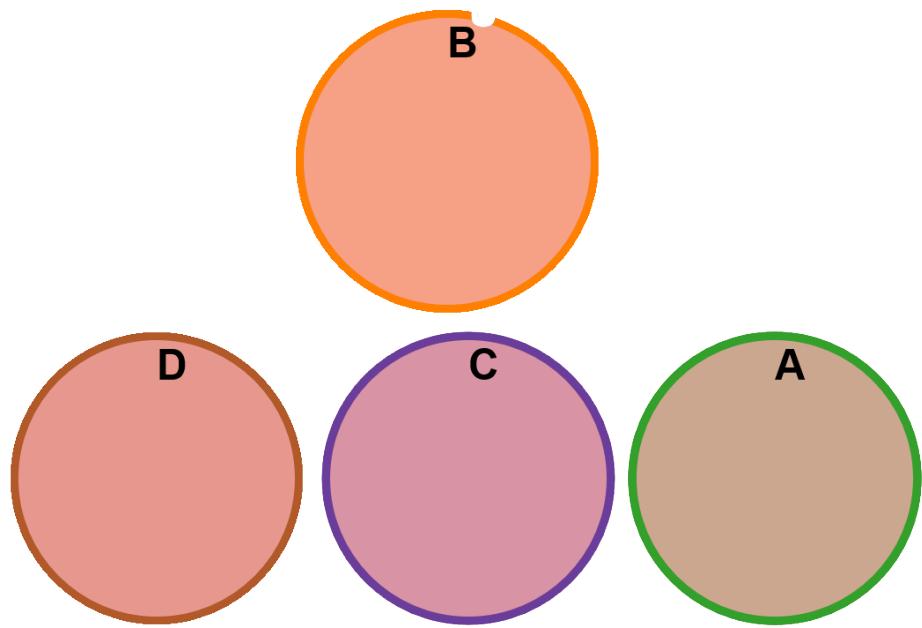


4-set data set 3 : SNAP ID: 31246395

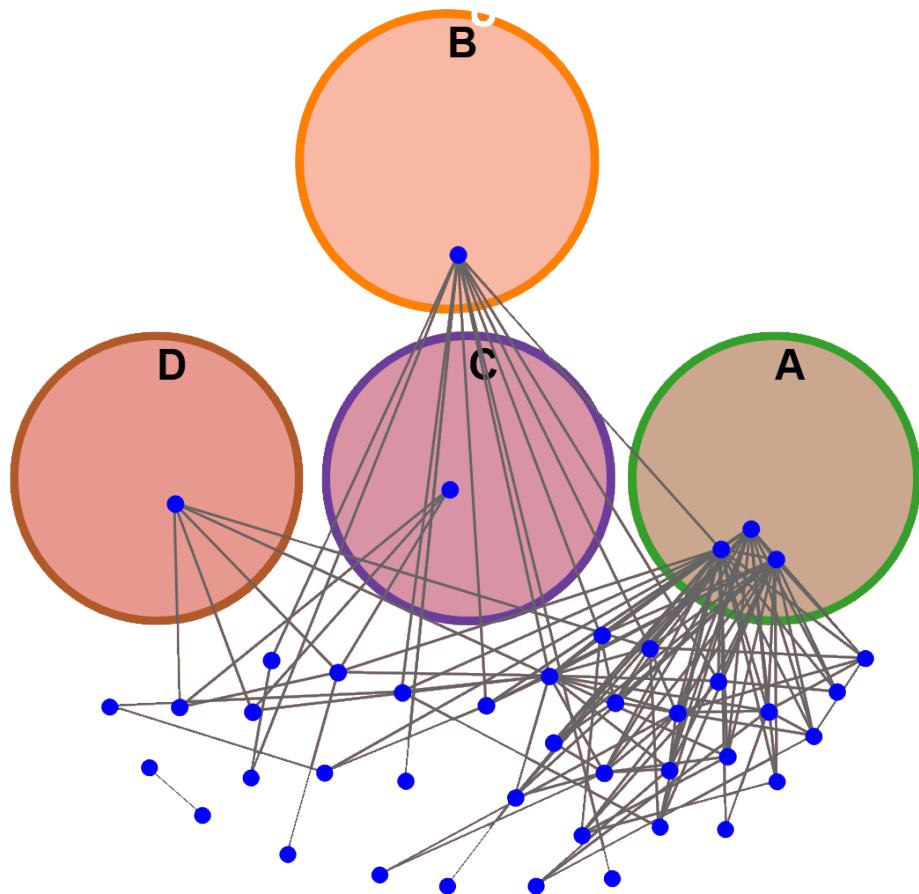
Number of Sets: 4
 Number of Zones: 5
 Number of Nodes: 43
 Number of Edges: 132
 Zones high: no
 Nodes high: yes
 Edges high: no

	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)

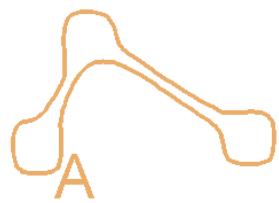


SetNet (with graph)



BubbleSets (without graph)

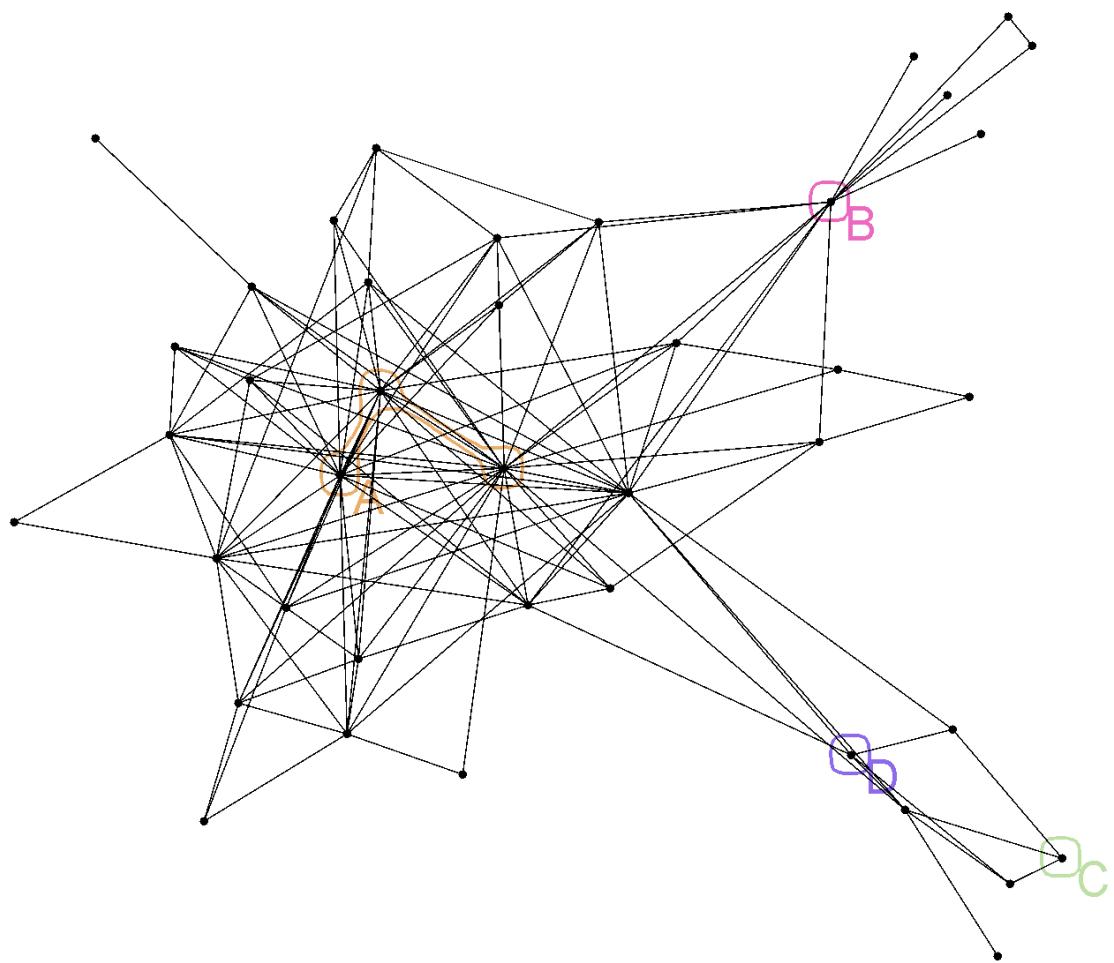
□_B



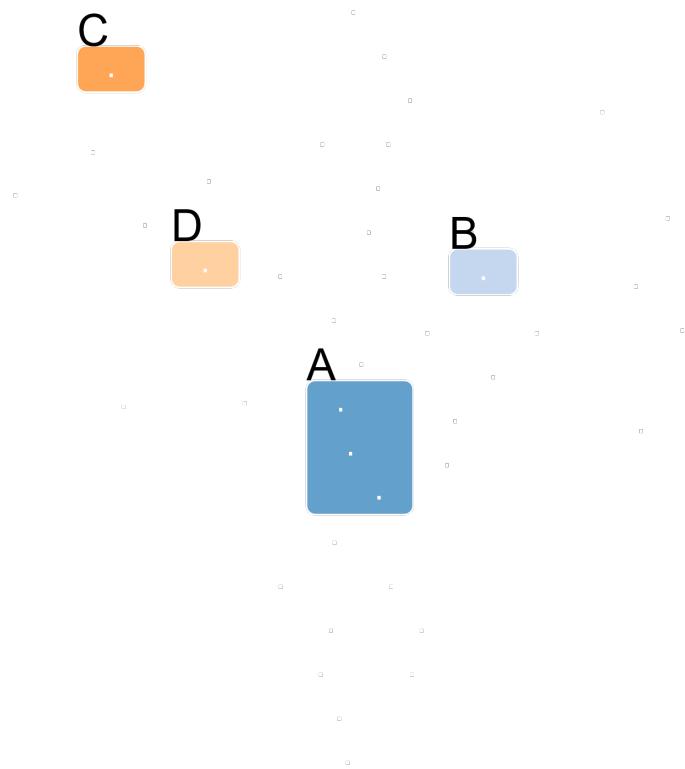
□_D

□_C

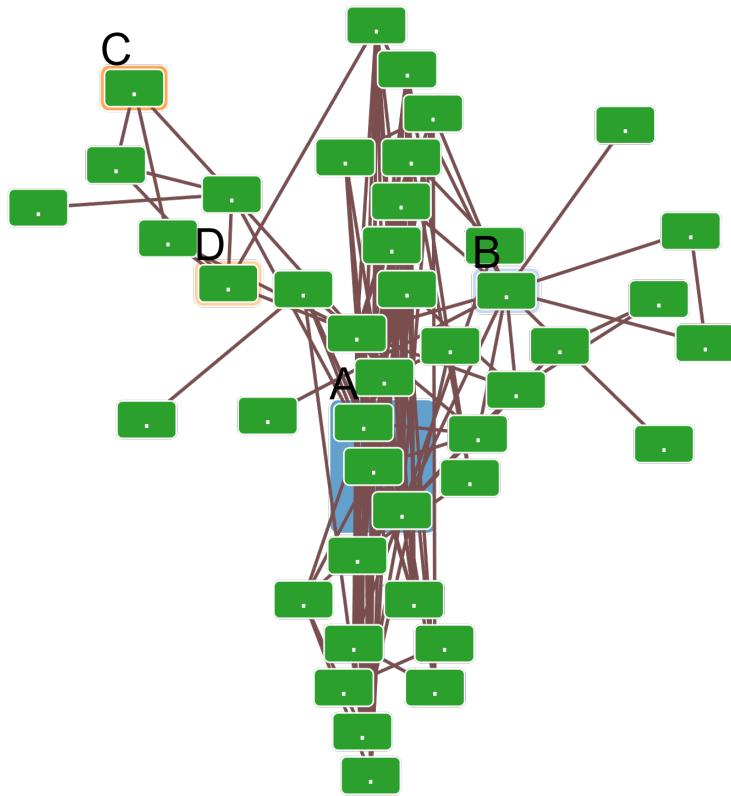
BubbleSets (with graph)



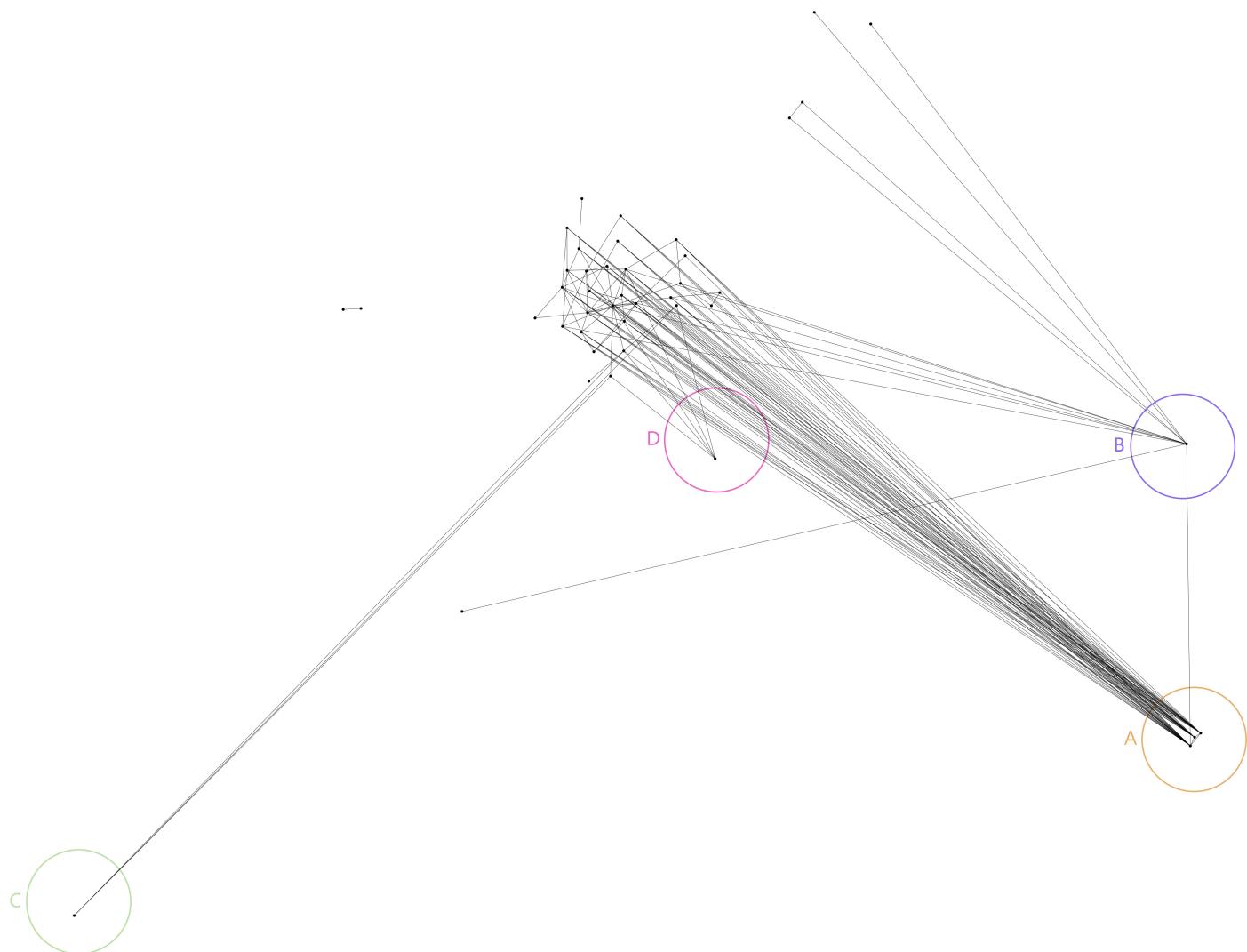
WebCola (without graph)



WebCola (with graph)



GroupNet

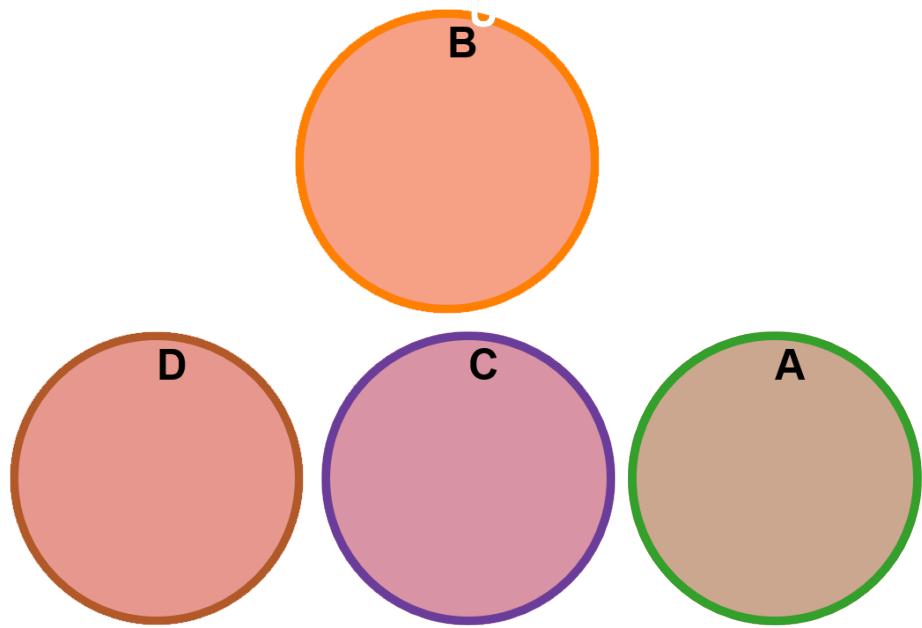


4-set data set 4 : SNAP ID: 15481789

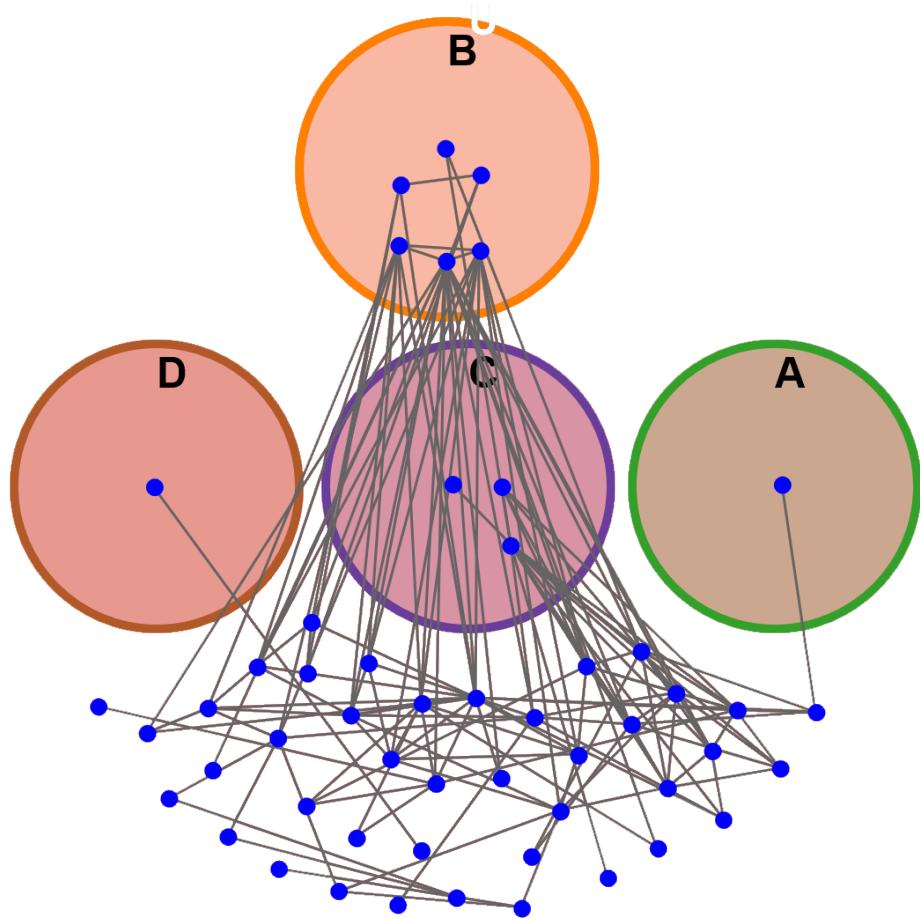
Number of Sets: 4
 Number of Zones: 5
 Number of Nodes: 52
 Number of Edges: 145
 Zones high: no
 Nodes high: yes
 Edges high: yes

	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

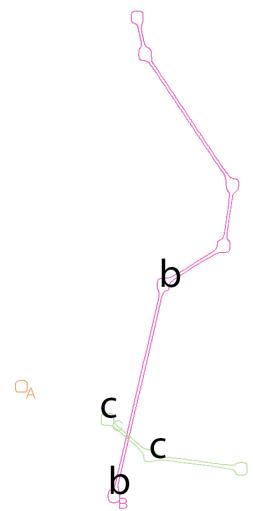
SetNet (without graph)



SetNet (with graph)

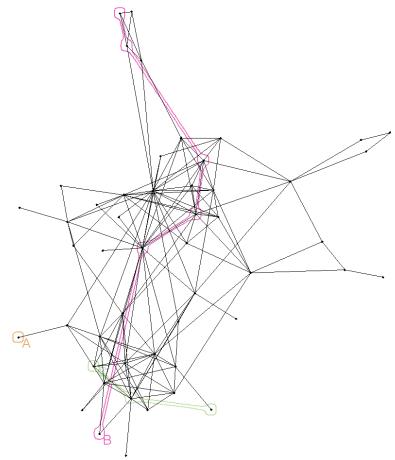


BubbleSets (without graph)



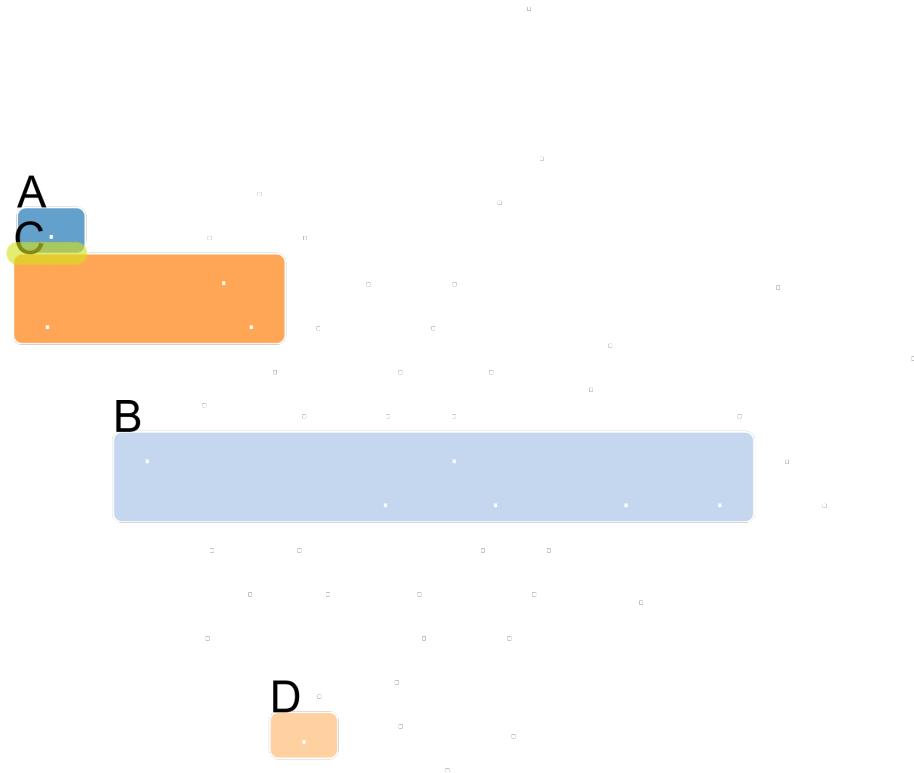
Q_B

BubbleSets (with graph)

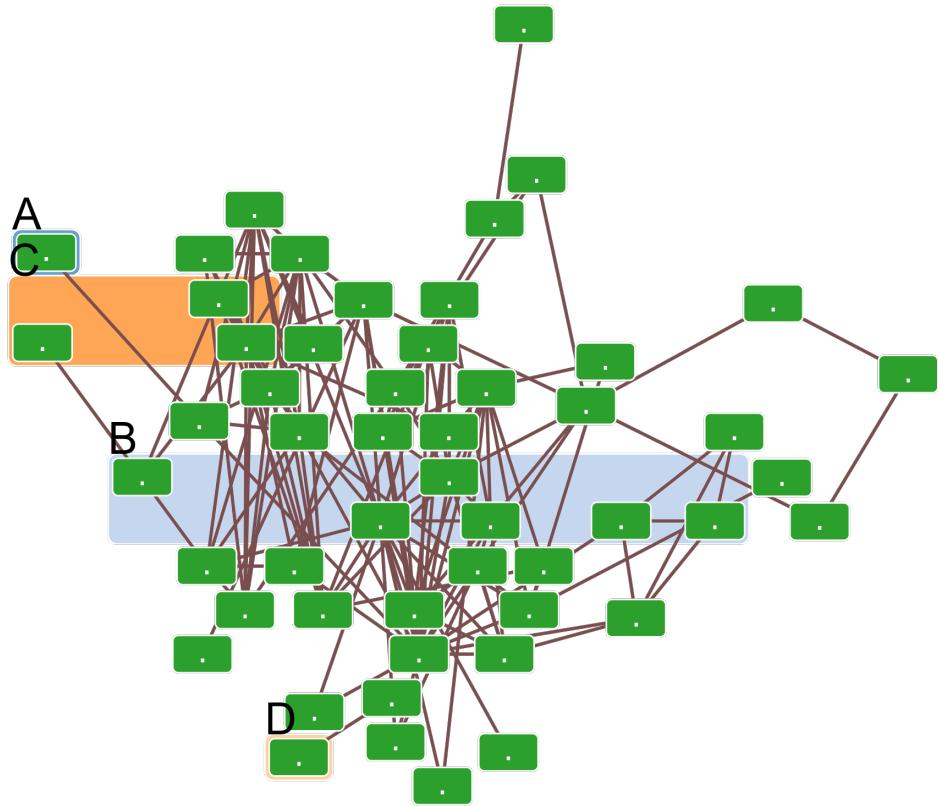


G_b

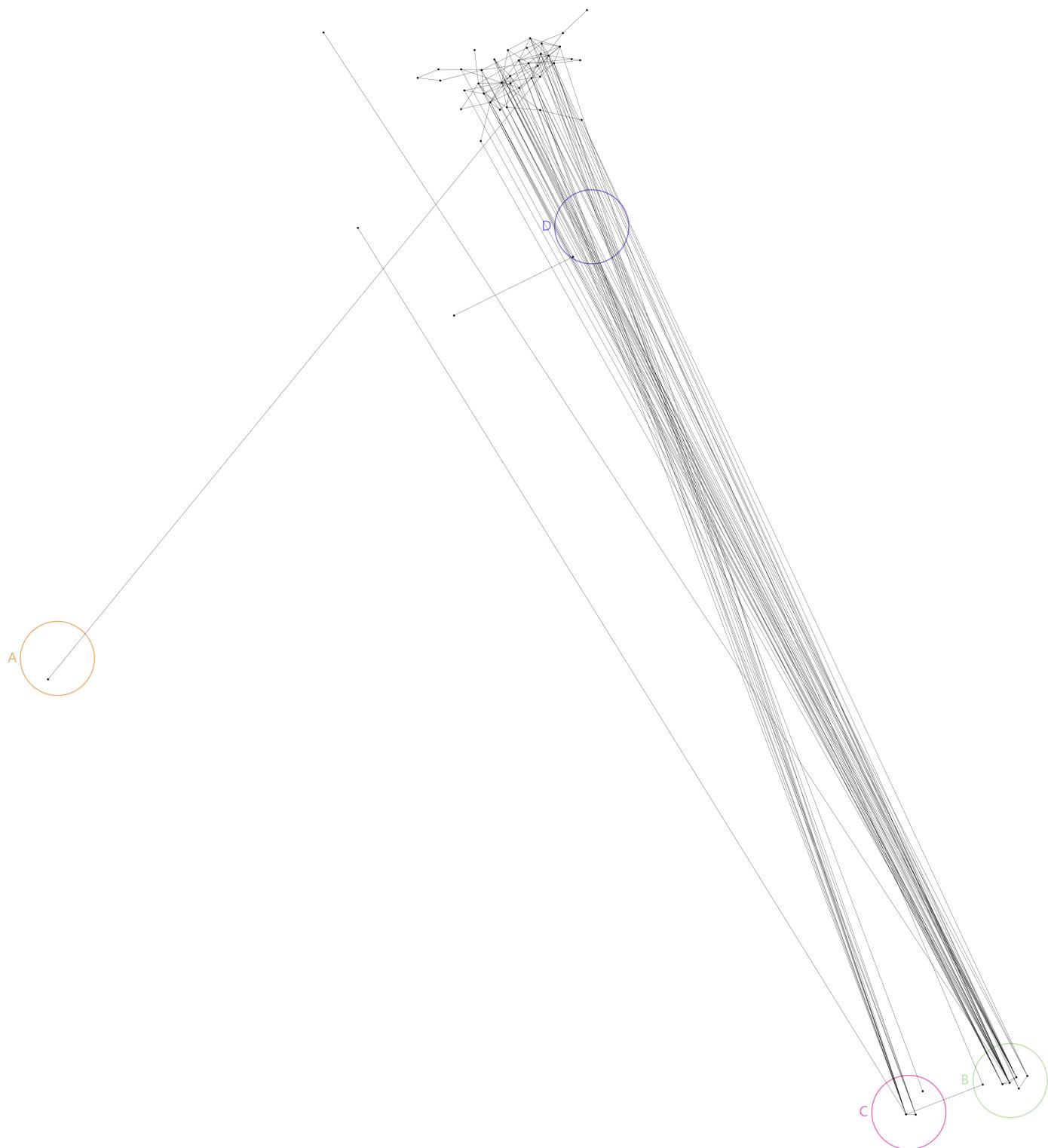
WebCola (without graph)



WebCola (with graph)



GroupNet

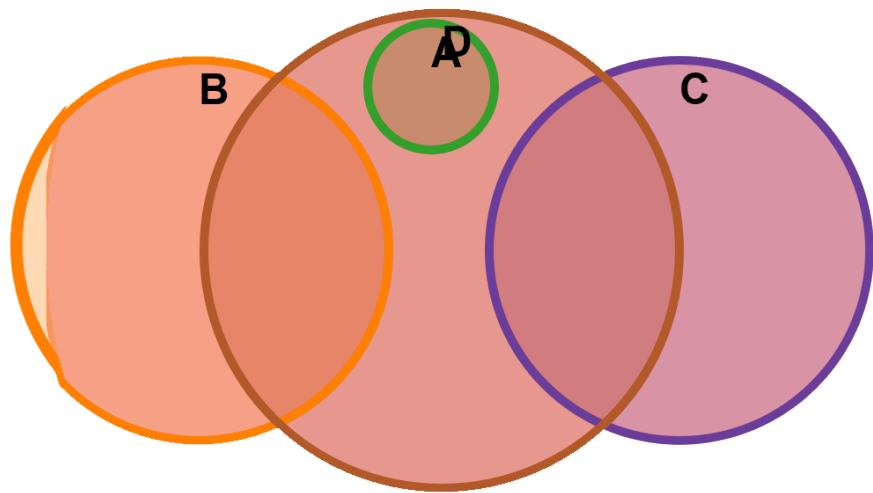


4-set data set 5 : SNAP ID: 428333

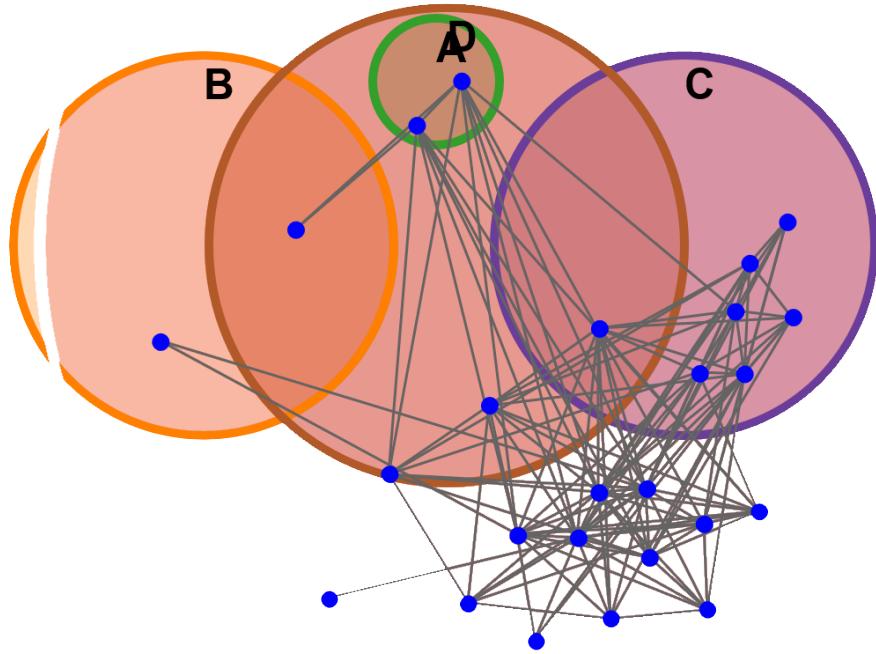
Number of Sets: 4
 Number of Zones: 7
 Number of Nodes: 25
 Number of Edges: 125
 Zones high: yes
 Nodes high: no
 Edges high: no

	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

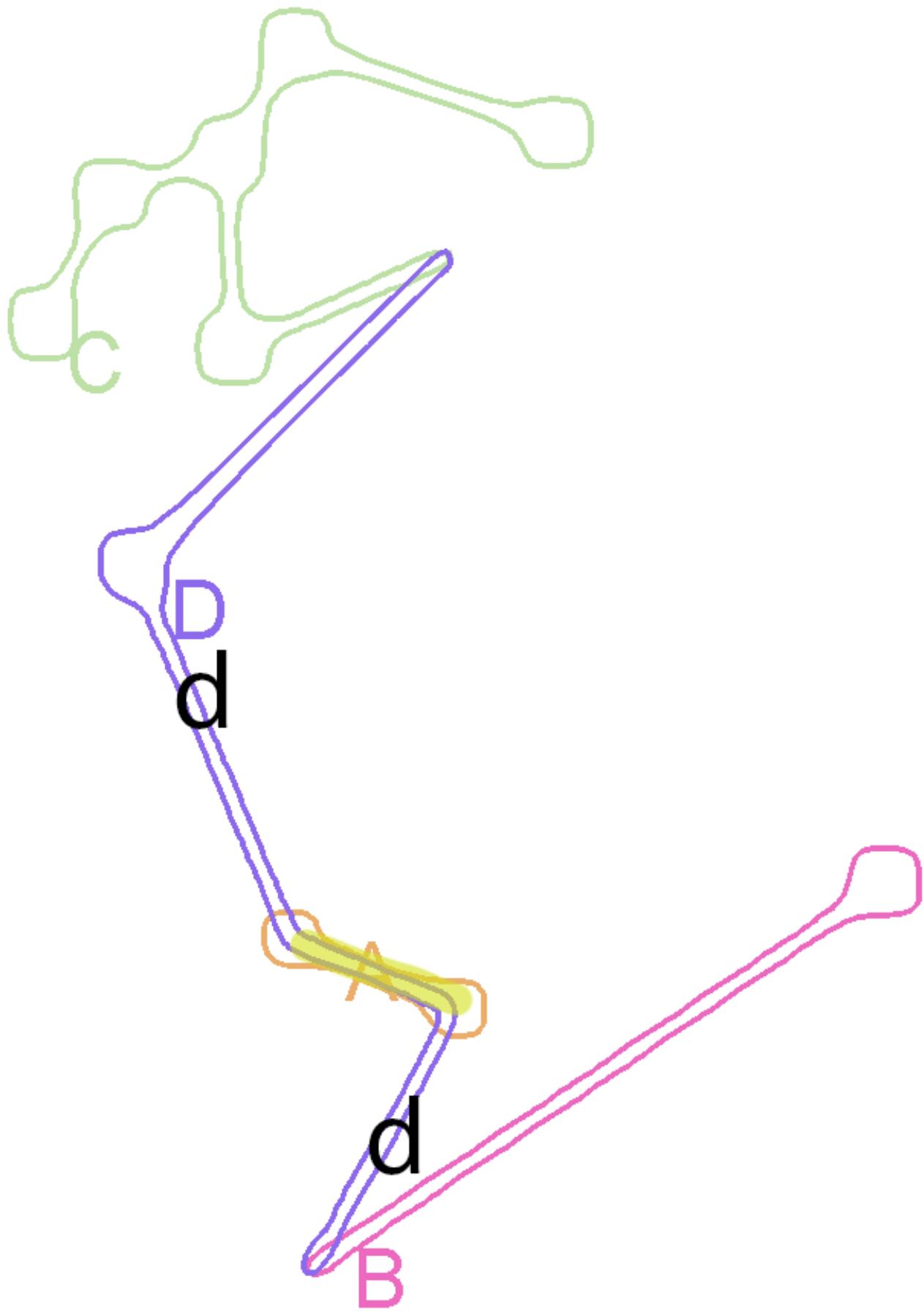
SetNet (without graph)



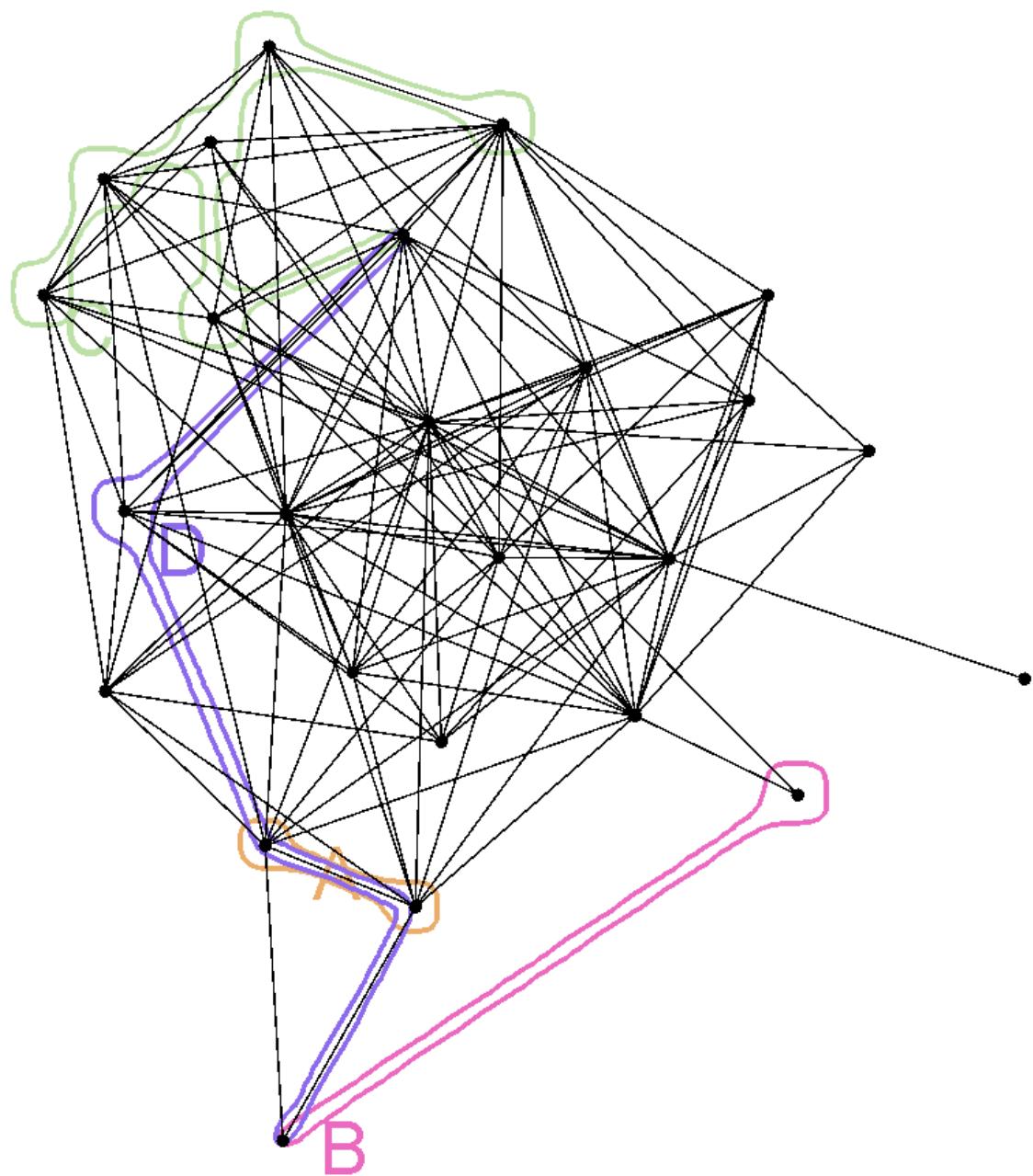
SetNet (with graph)



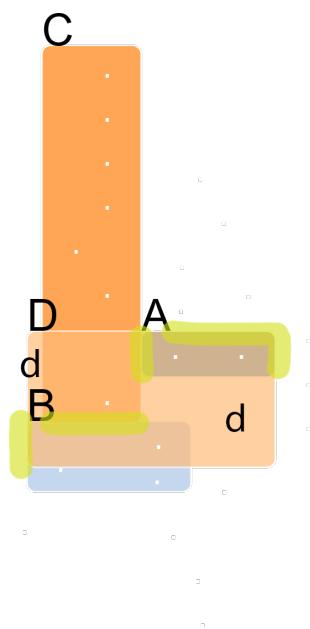
BubbleSets (without graph)



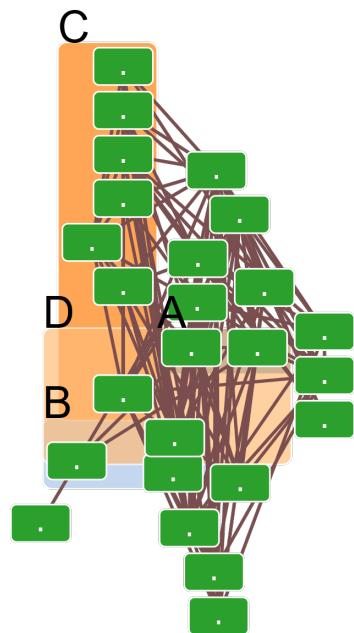
BubbleSets (with graph)



WebCola (without graph)



WebCola (with graph)



GroupNet

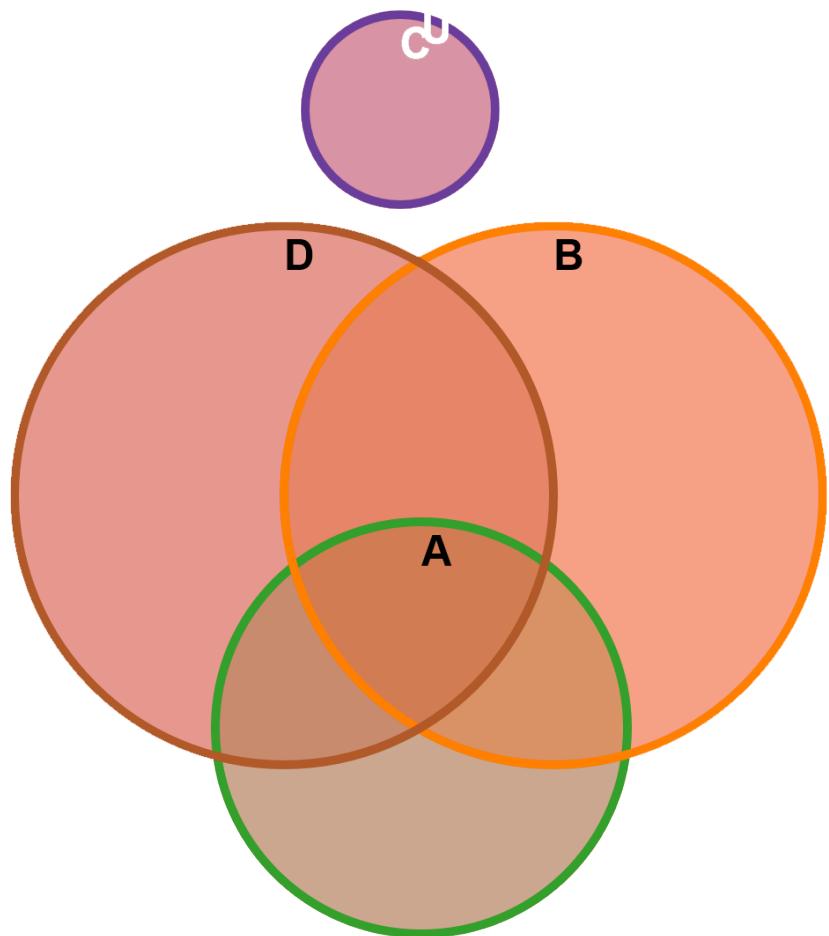


4-set data set 6 : SNAP ID: 259884200

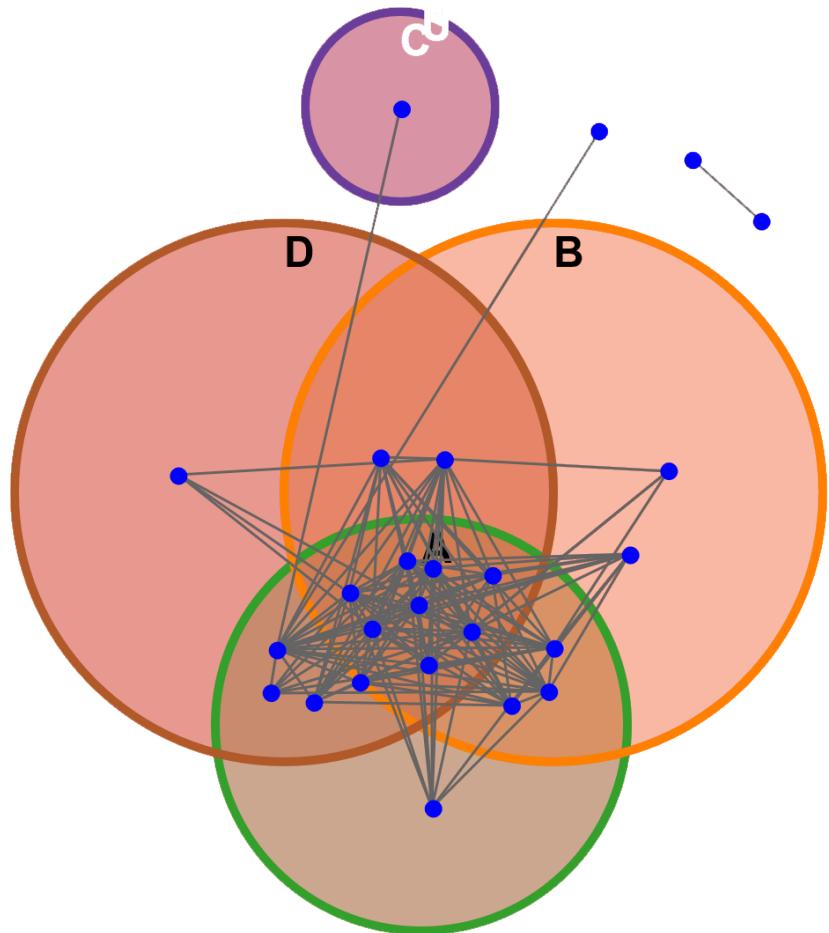
Number of Sets: 4
 Number of Zones: 9
 Number of Nodes: 25
 Number of Edges: 145
 Zones high: yes
 Nodes high: no
 Edges high: yes

	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

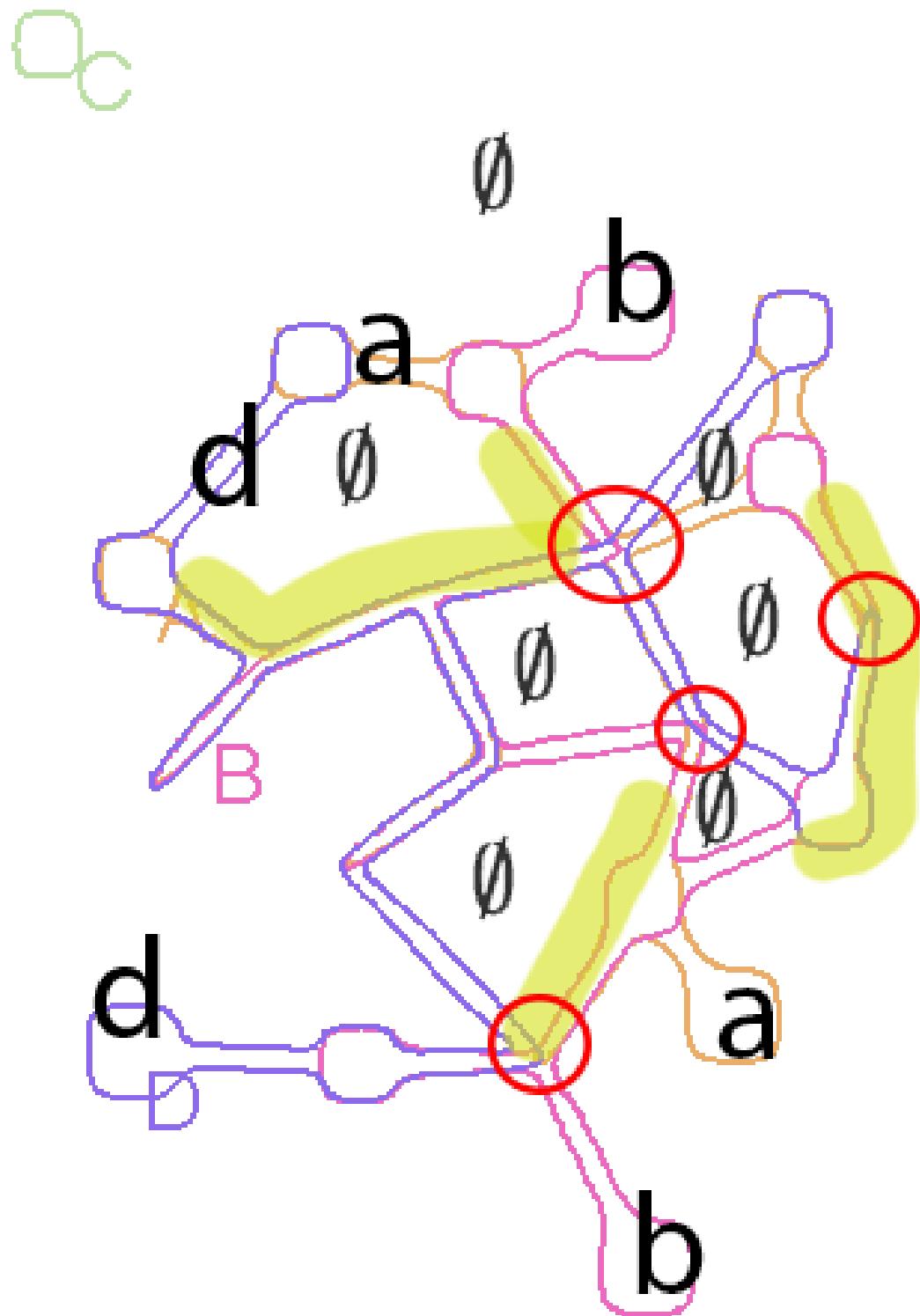
SetNet (without graph)



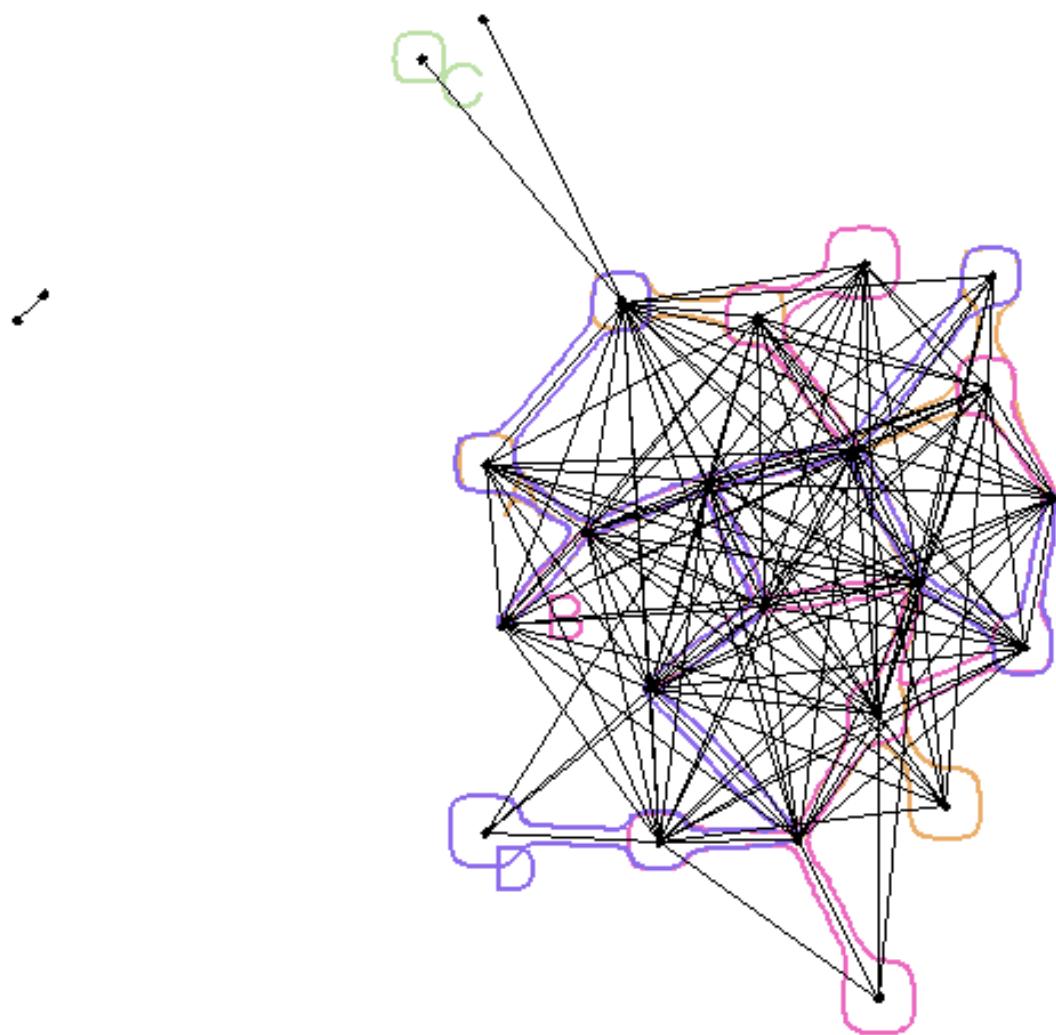
SetNet (with graph)



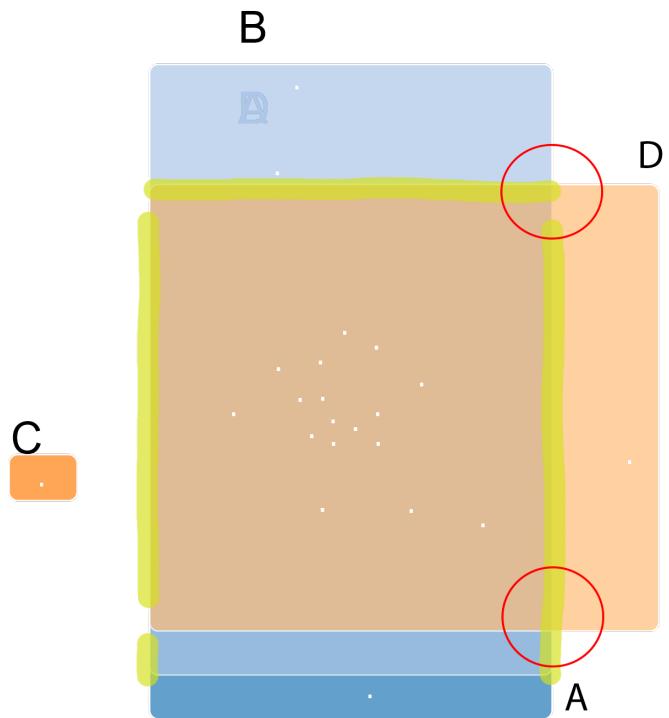
BubbleSets (without graph)



BubbleSets (with graph)

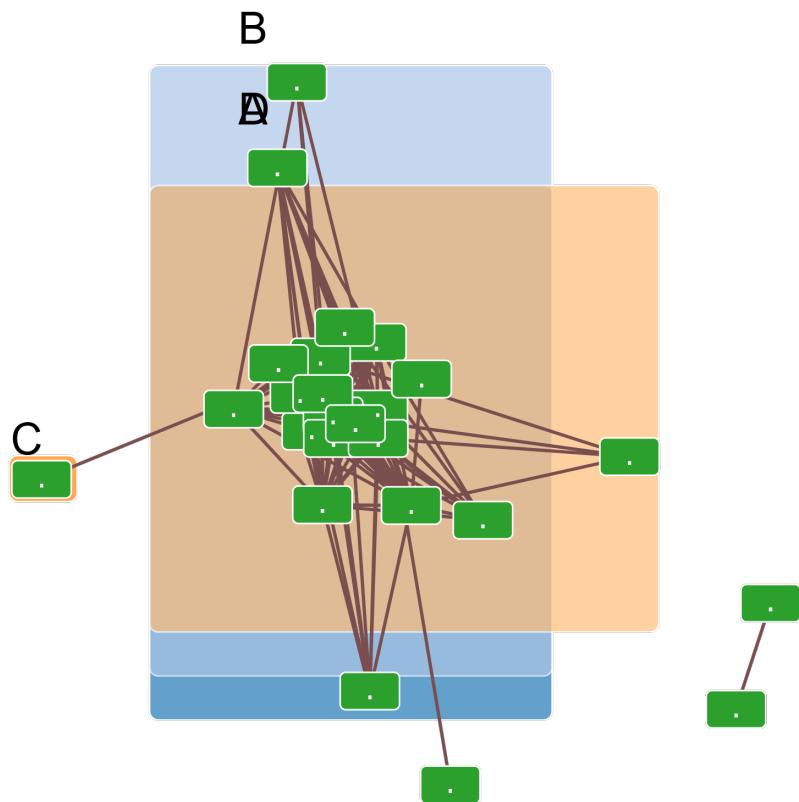


WebCola (without graph)

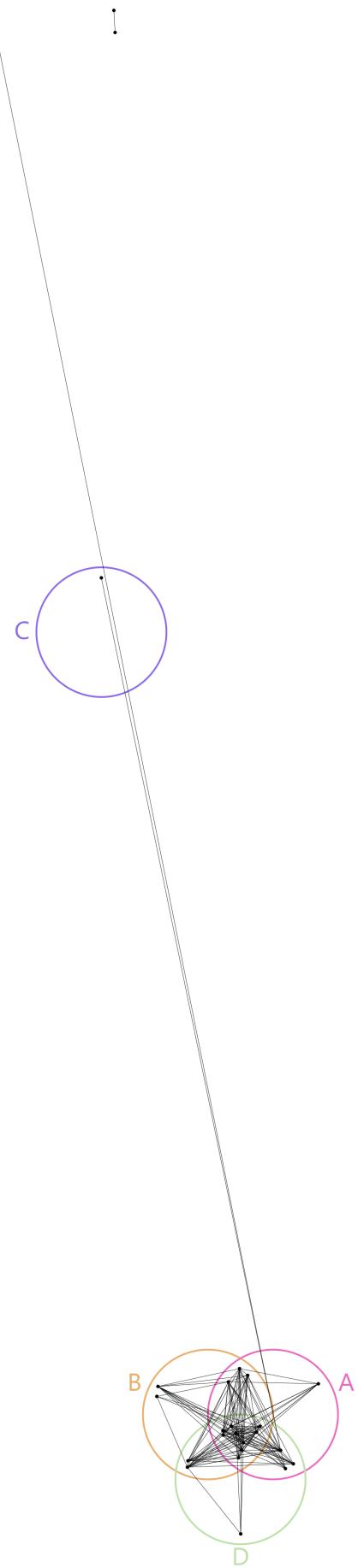


Omitted zones: AD, BD

WebCola (with graph)



GroupNet

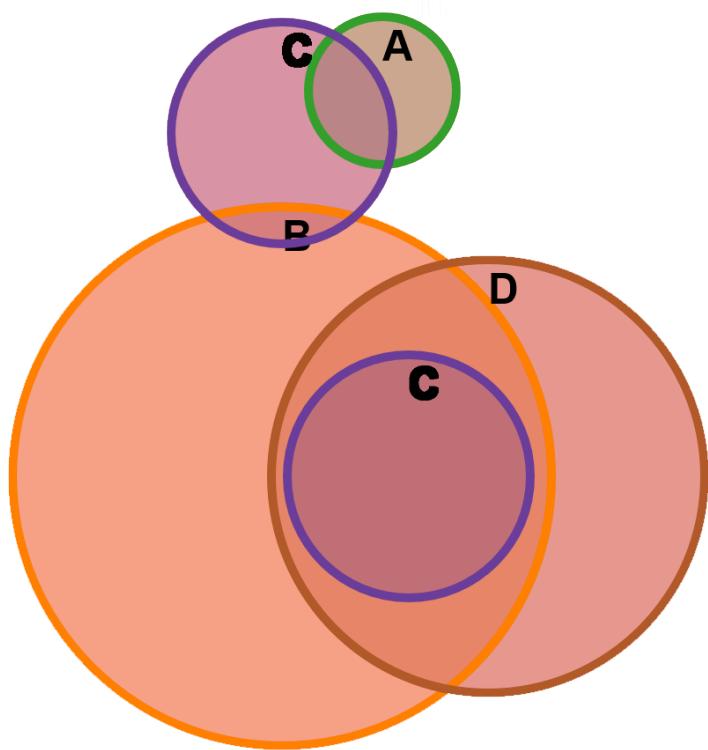


4-set data set 7 : SNAP ID: 1548841

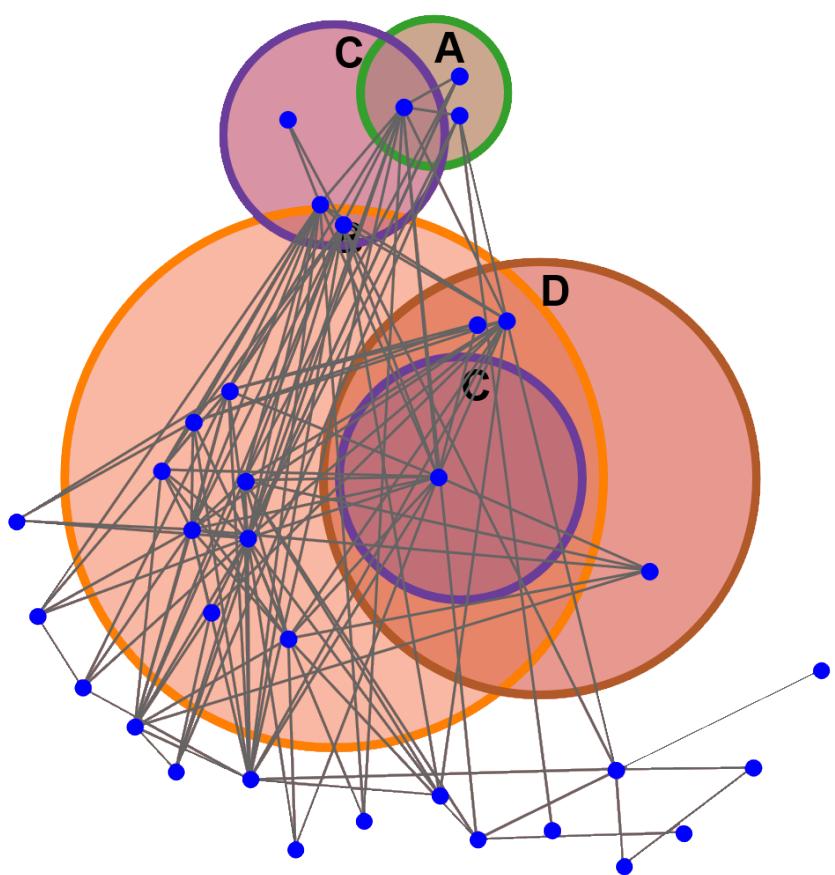
Number of Sets: 4
 Number of Zones: 9
 Number of Nodes: 36
 Number of Edges: 133
 Zones high: yes
 Nodes high: yes
 Edges high: no

	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

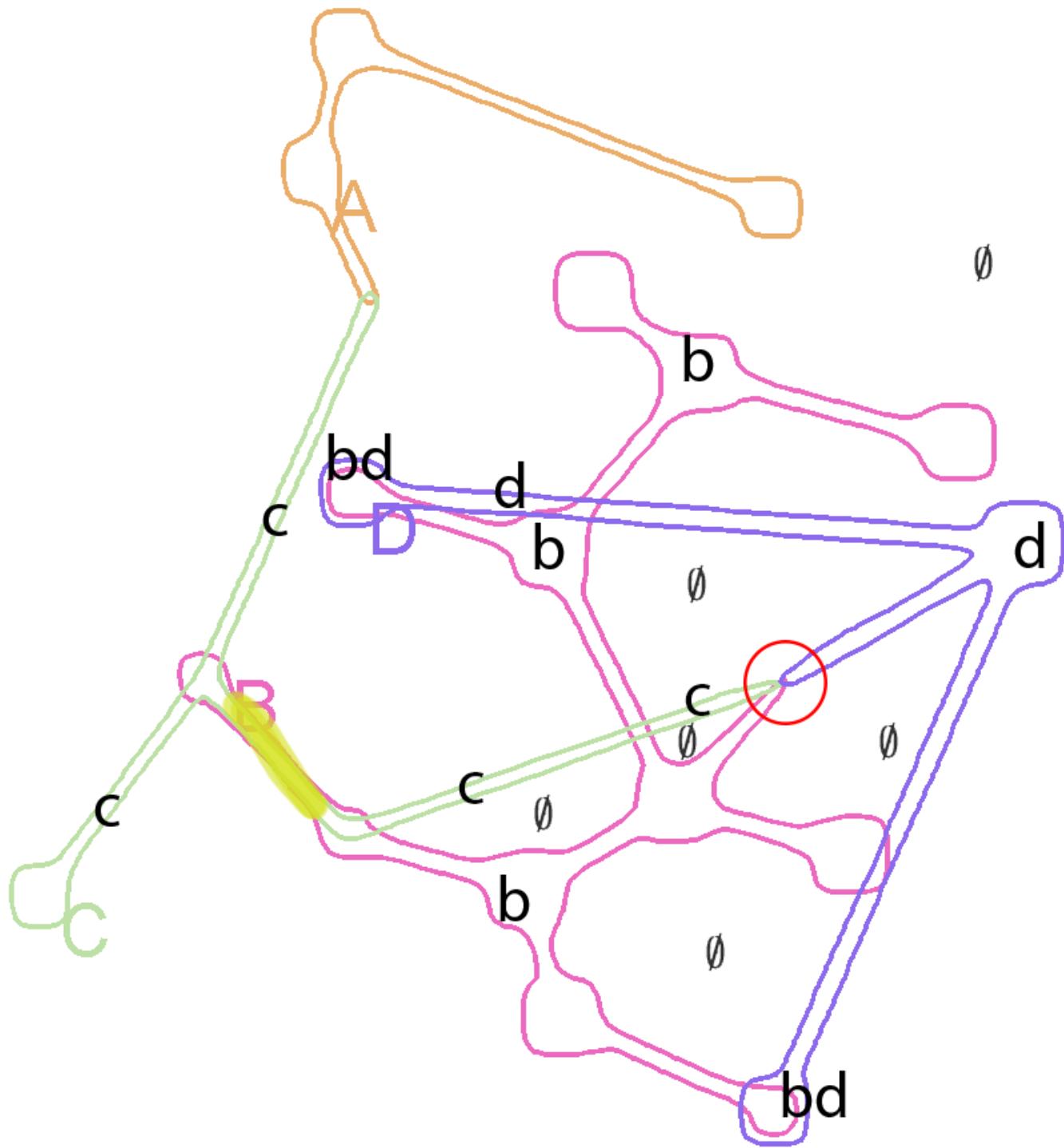
SetNet (without graph)



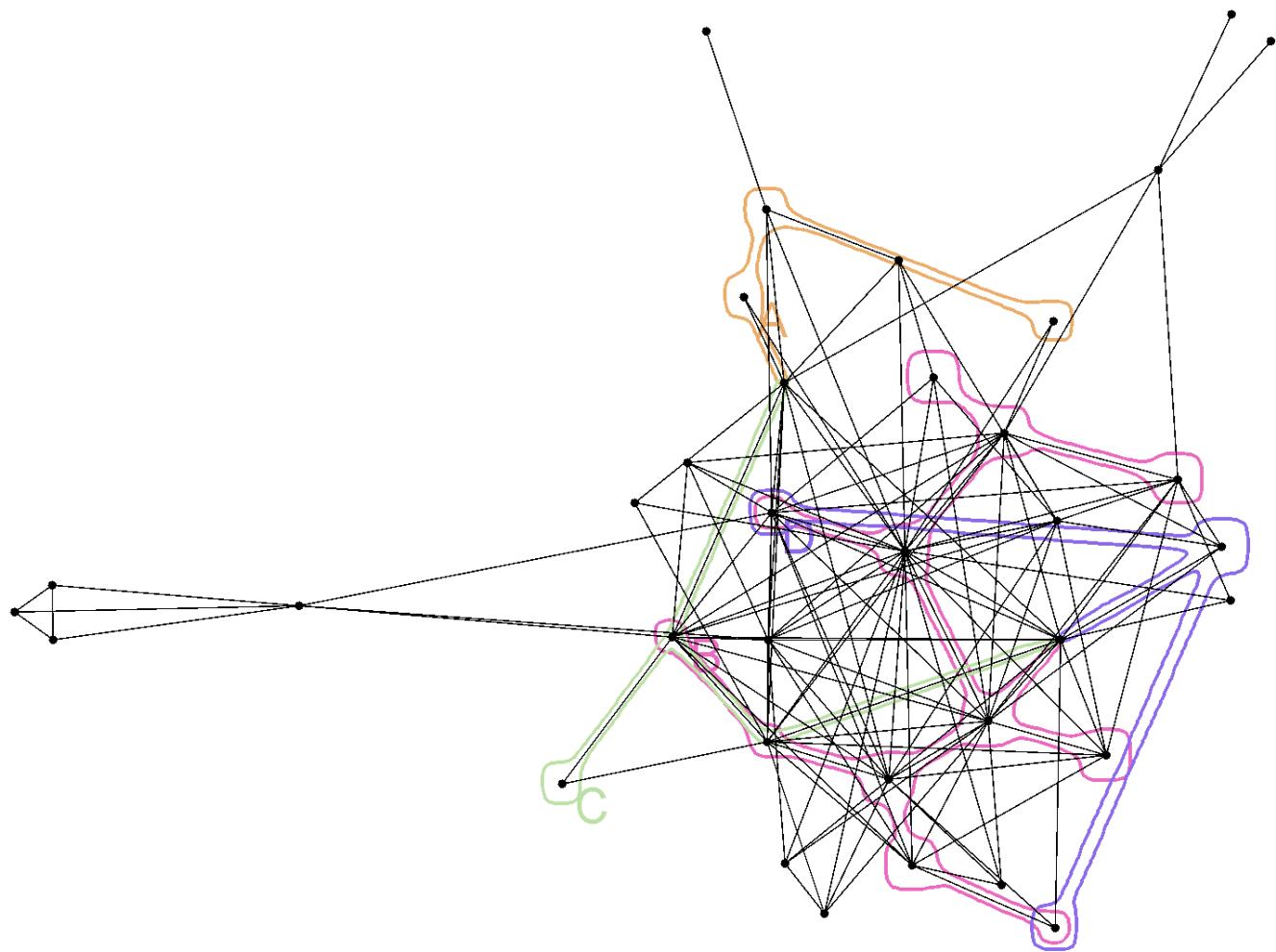
SetNet (with graph)



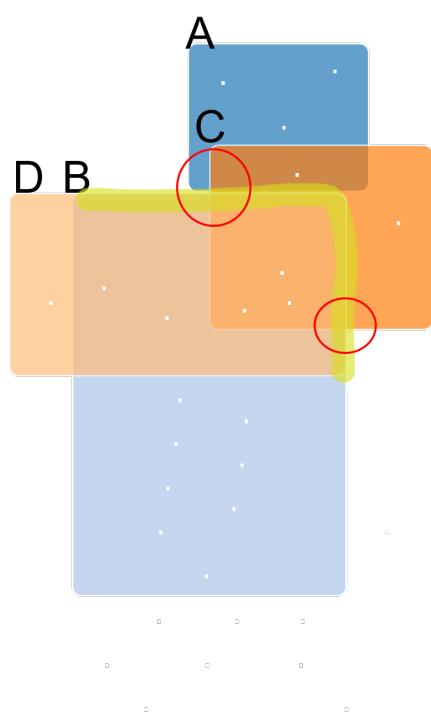
BubbleSets (without graph)



BubbleSets (with graph)

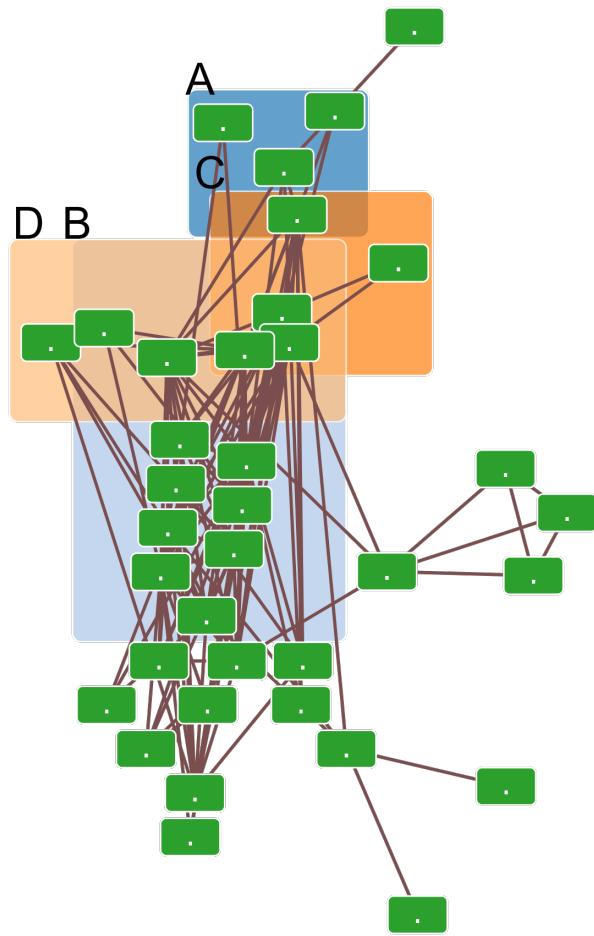


WebCola (without graph)

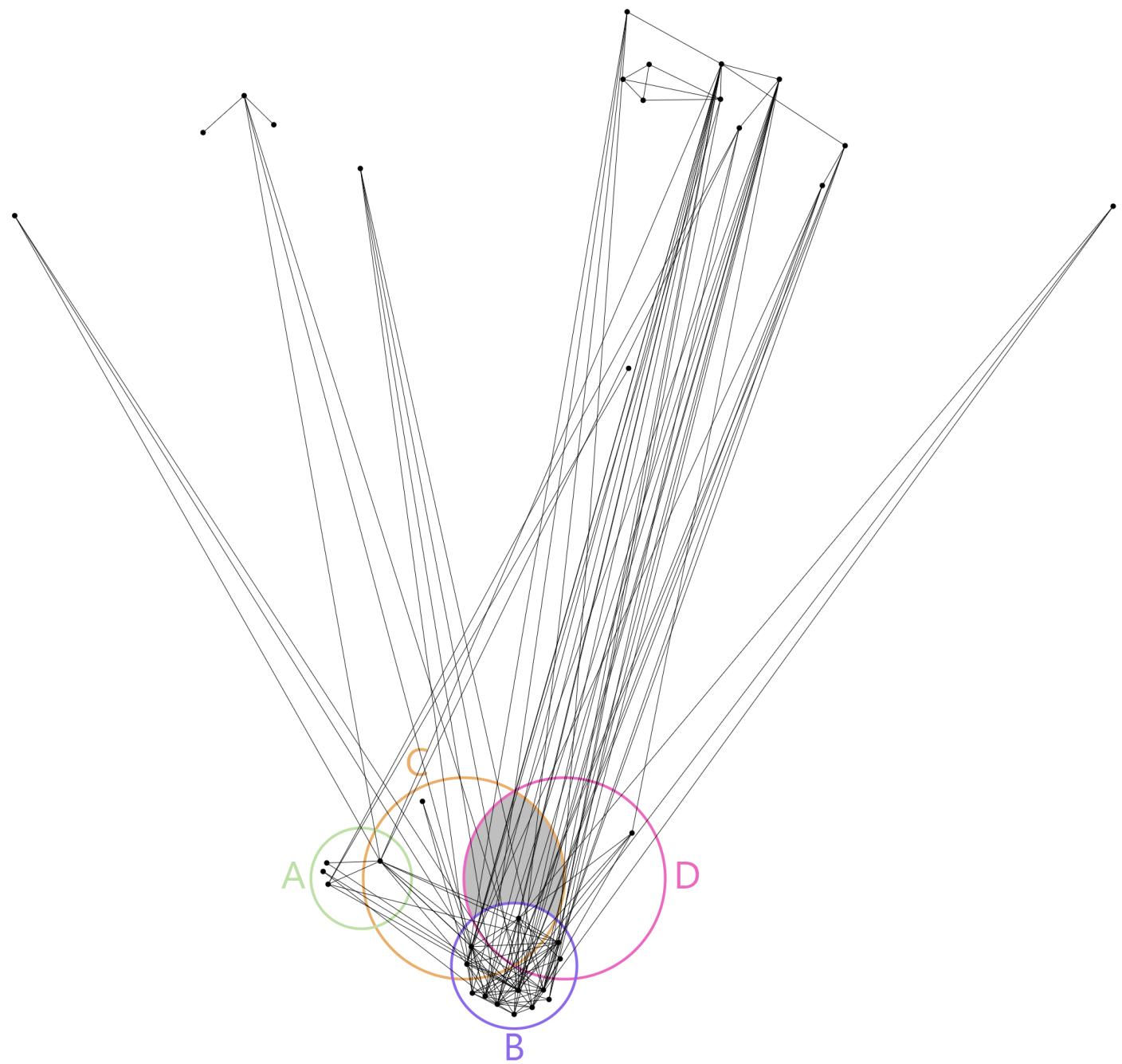


Omitted zones: BC

WebCola (with graph)



GroupNet

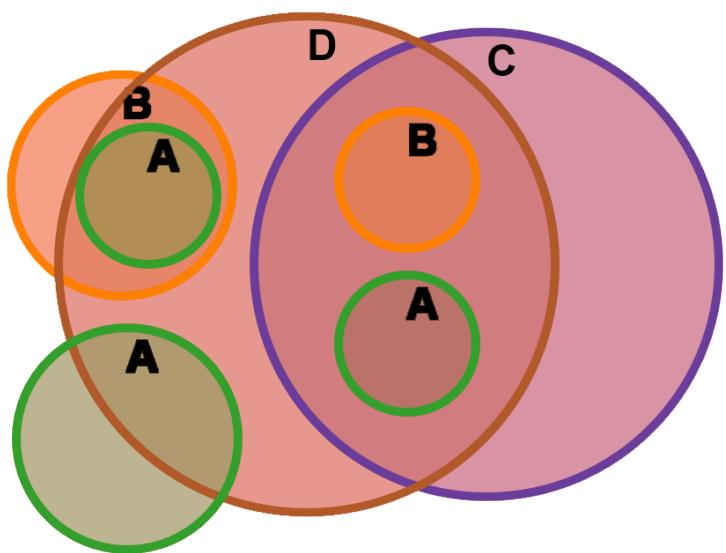


4-set data set 8 : SNAP ID: 232006900

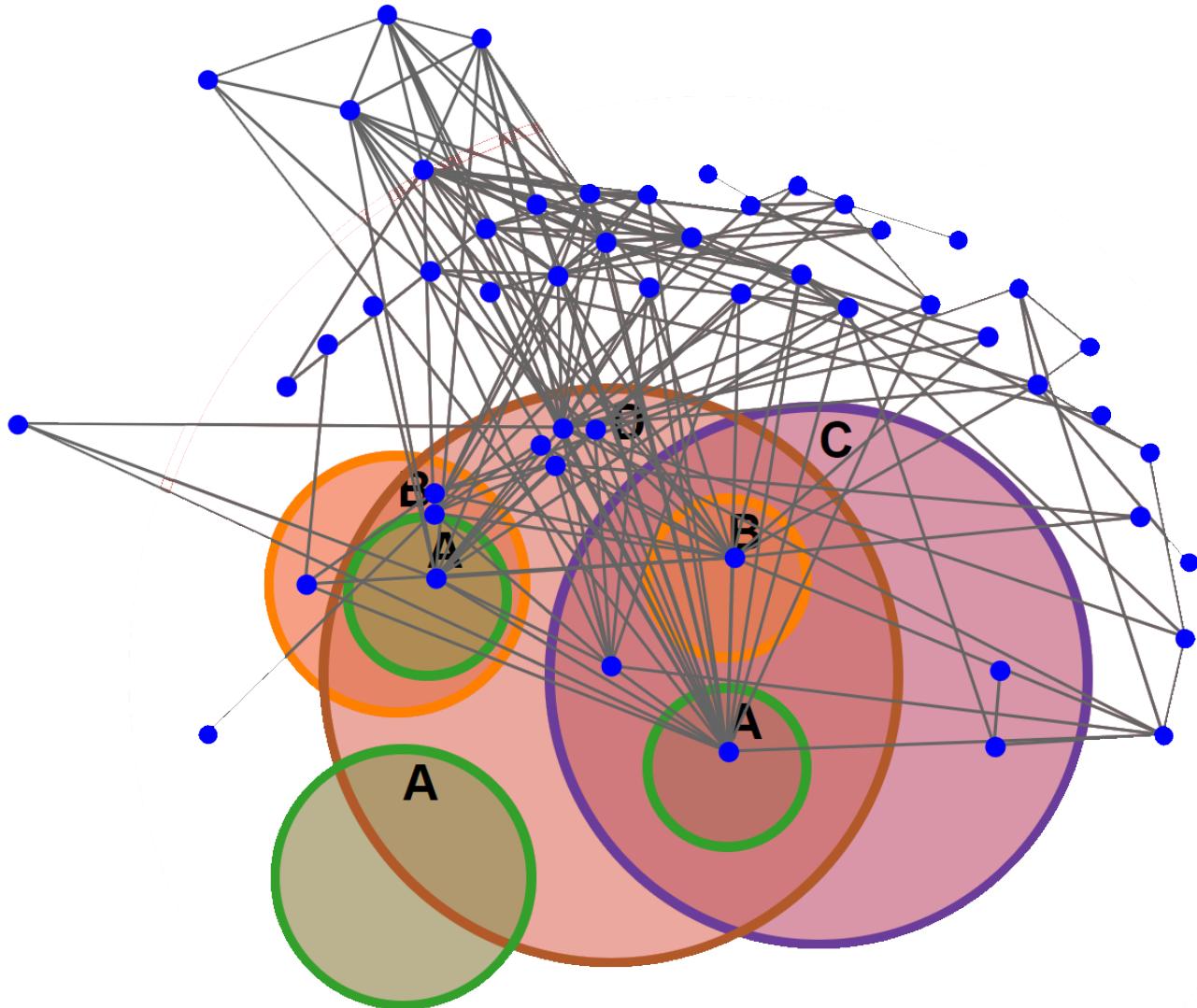
Number of Sets: 4
 Number of Zones: 11
 Number of Nodes: 53
 Number of Edges: 168
 Zones high: yes
 Nodes high: yes
 Edges high: yes

	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

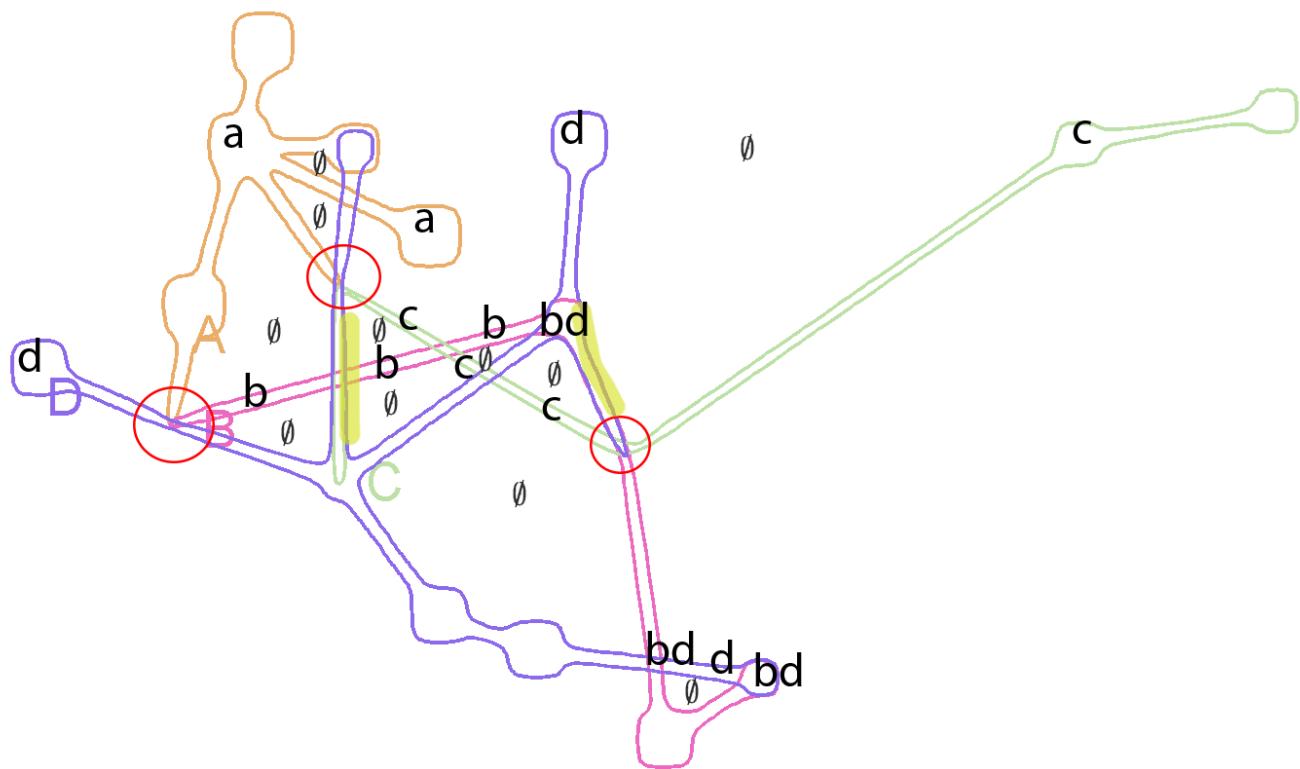
SetNet (without graph)



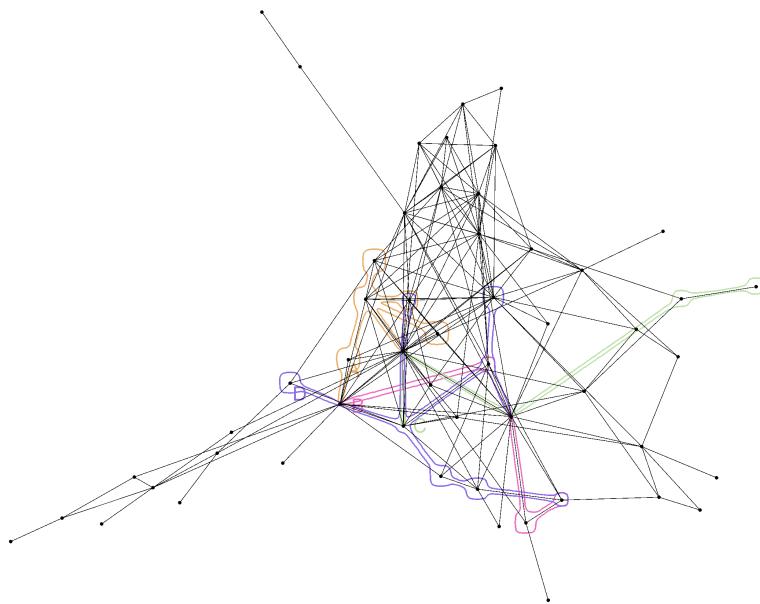
SetNet (with graph)



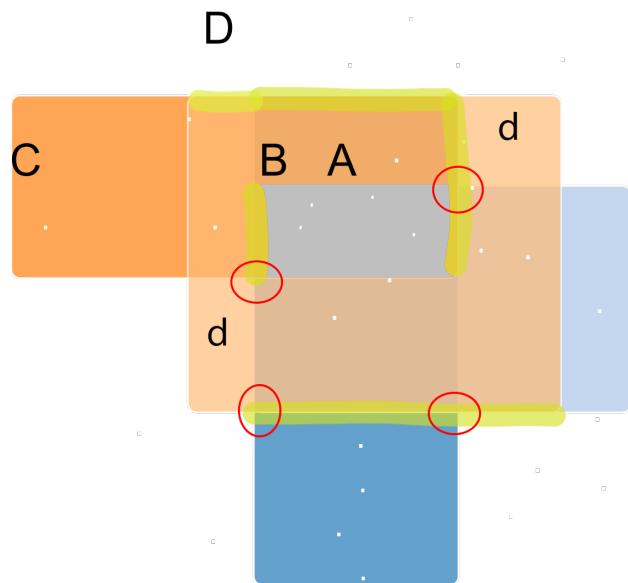
BubbleSets (without graph)



BubbleSets (with graph)

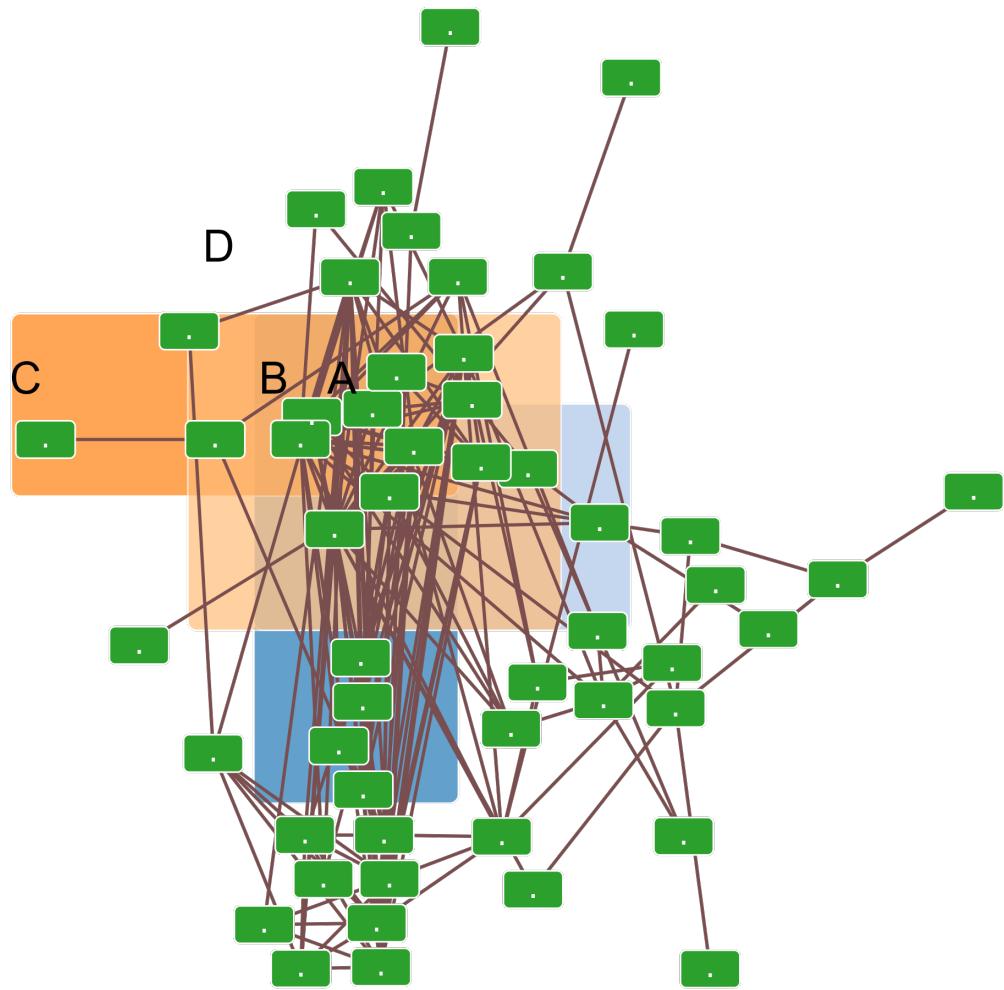


WebCola (without graph)

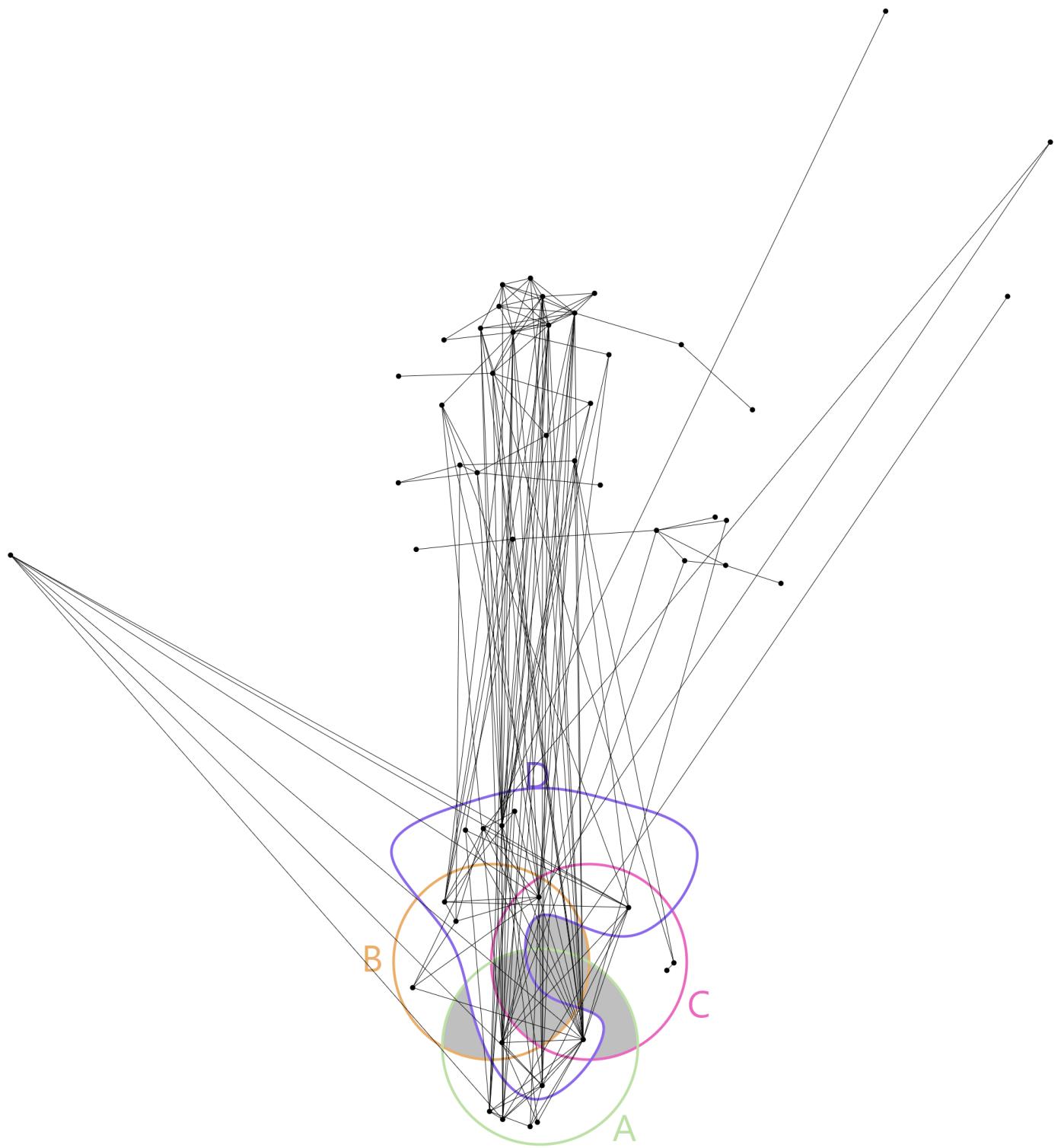


Omitted zones: AD, BCD

WebCola (with graph)



GroupNet

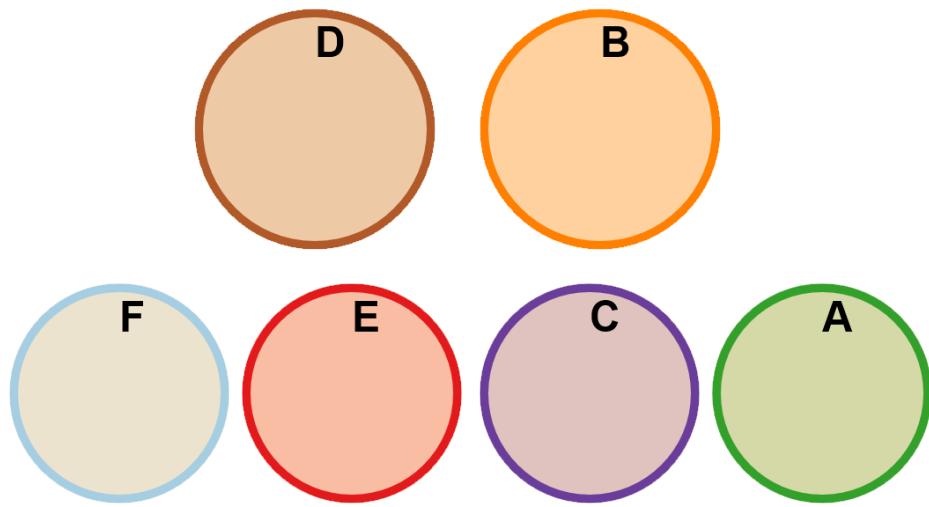


6-set data set 1 : SNAP ID: 80297299

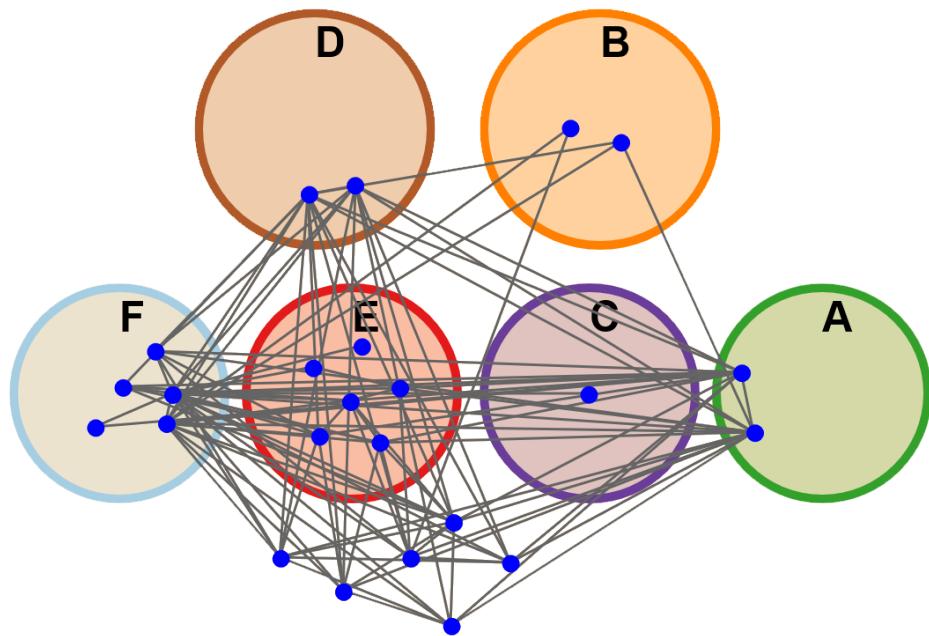
Number of Sets: 6
Number of Zones: 7
Number of Nodes: 24
Number of Edges: 103
Zones high: no
Nodes high: no
Edges high: no

	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

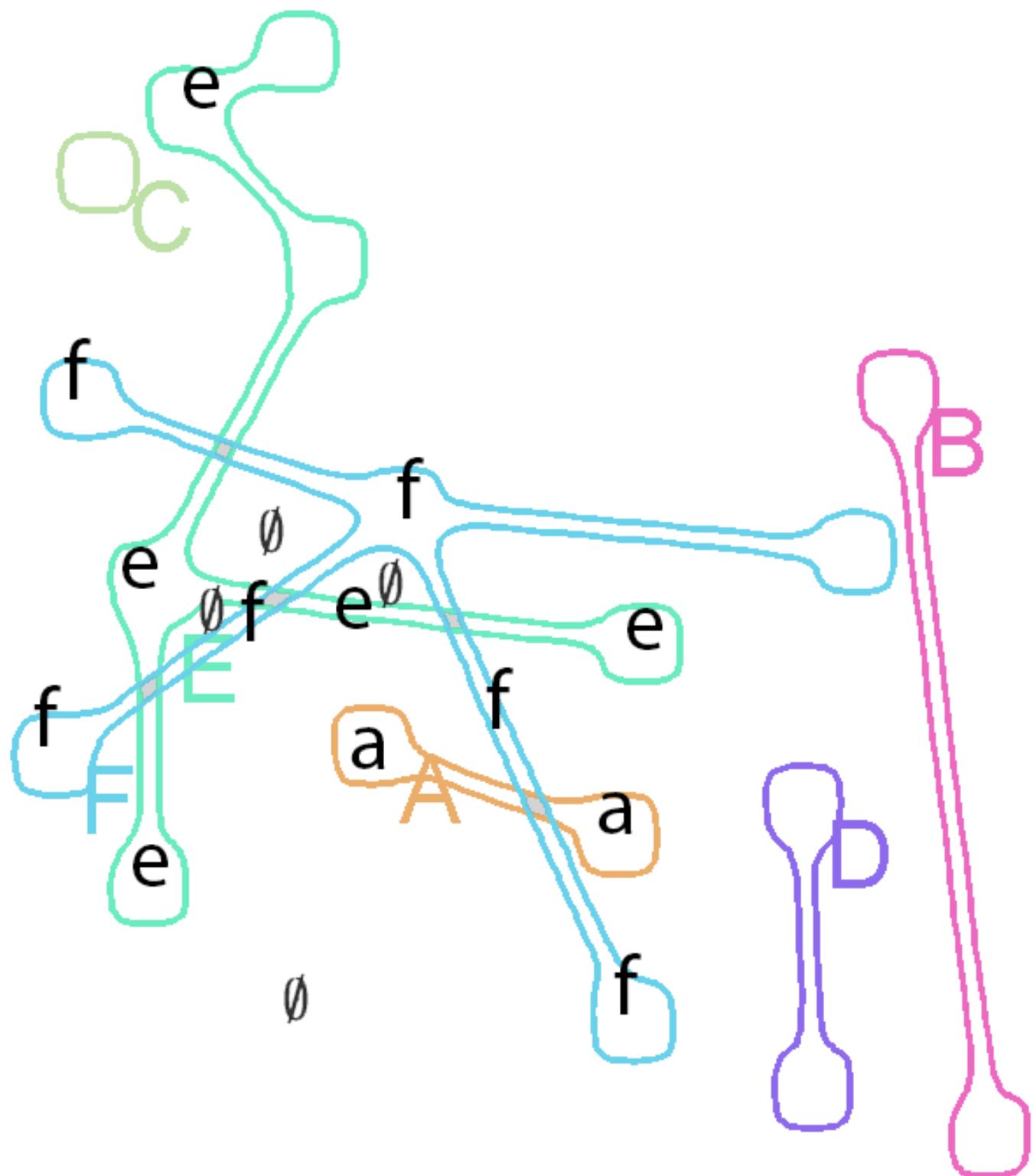
SetNet (without graph)



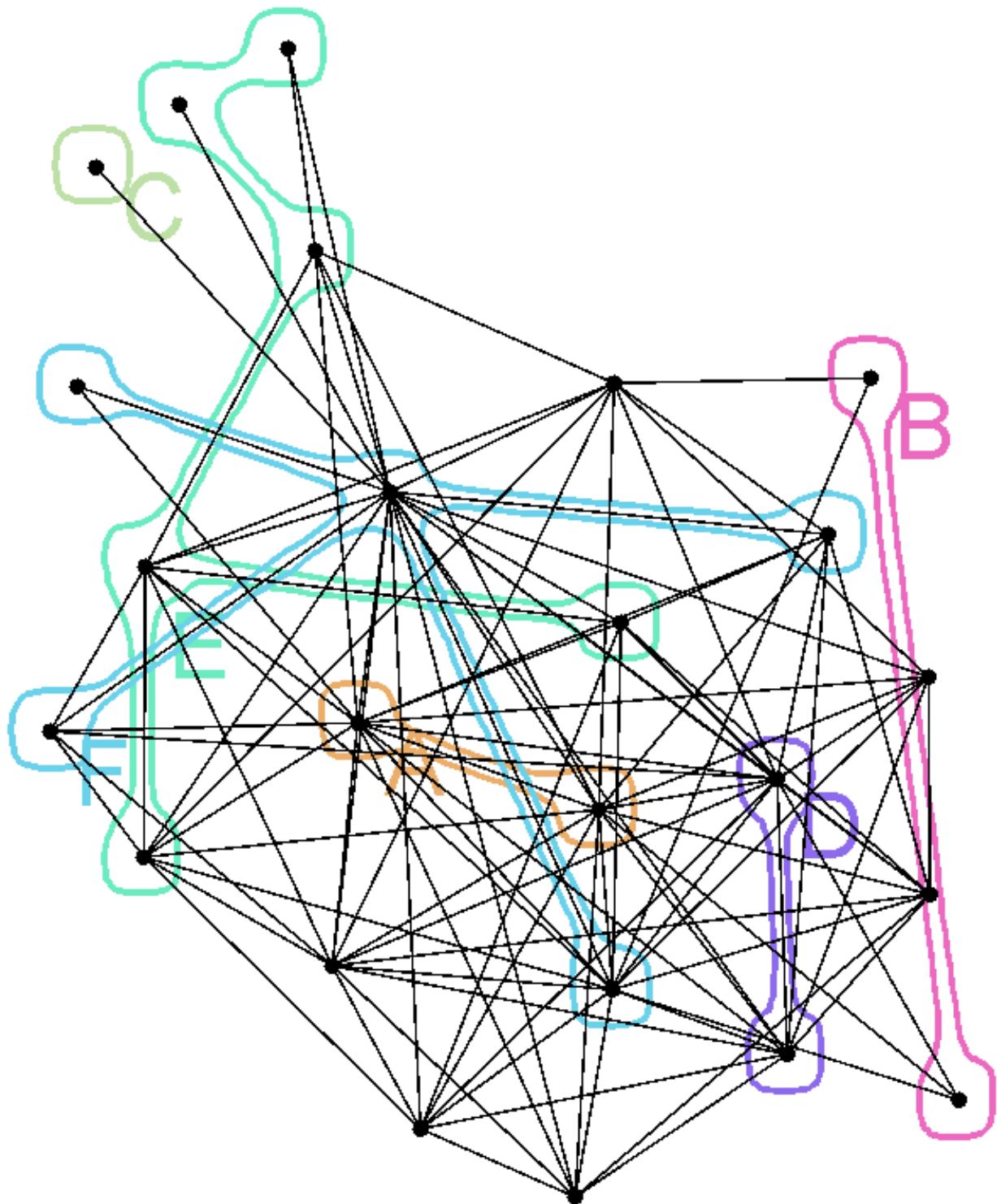
SetNet (with graph)



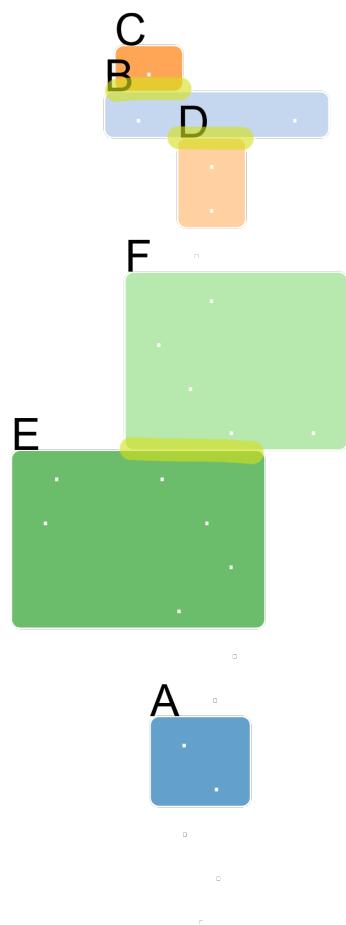
BubbleSets (without graph)



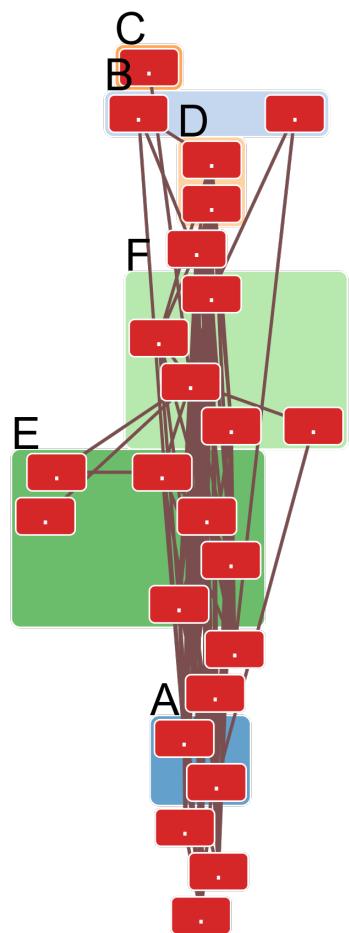
BubbleSets (with graph)



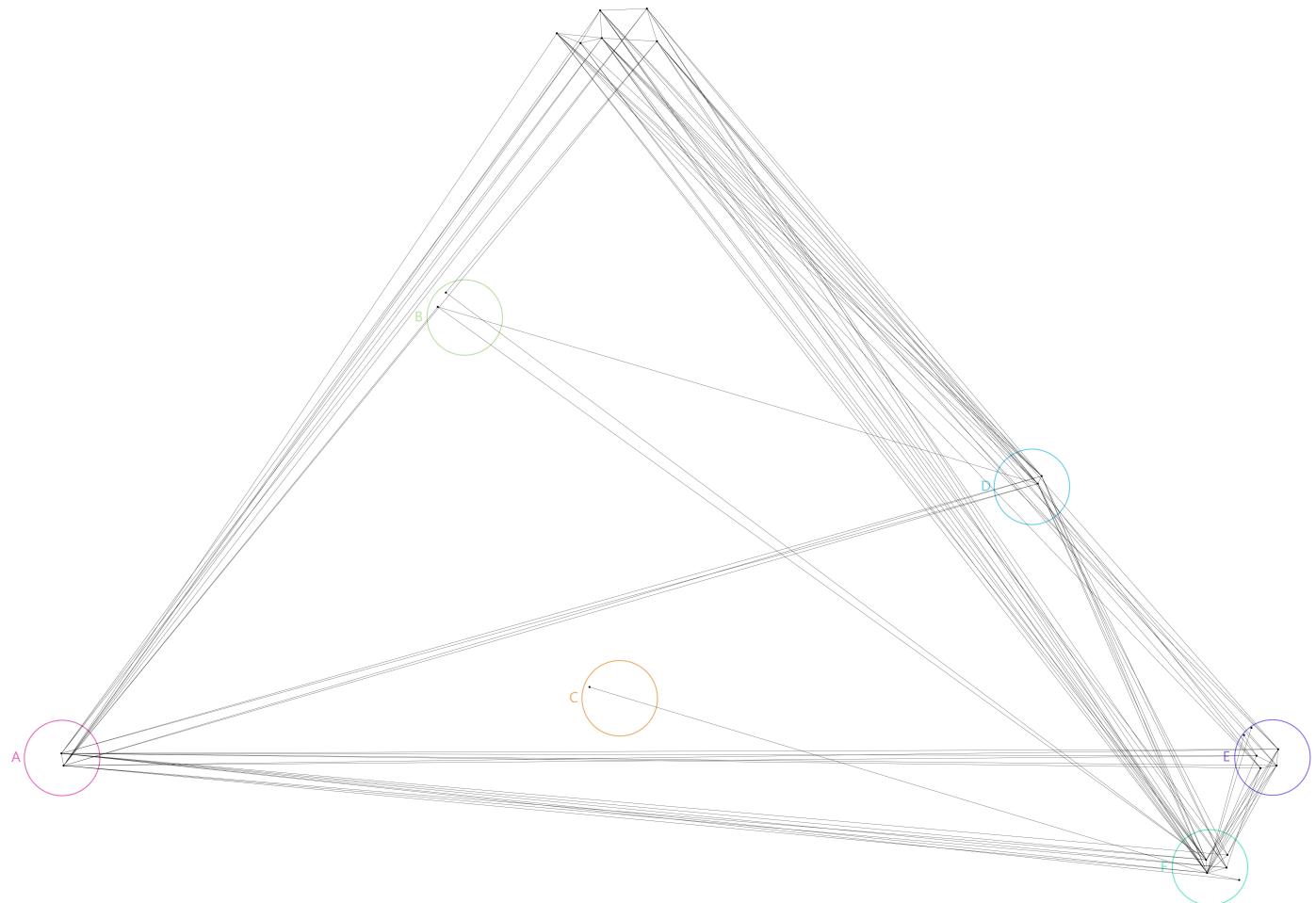
WebCola (without graph)



WebCola (with graph)



GroupNet

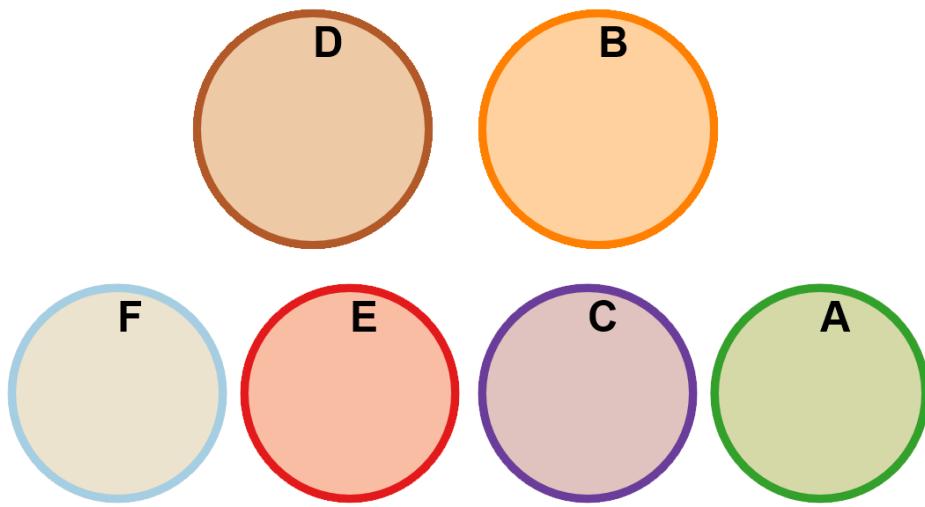


6-set data set 2 : SNAP ID: 18734310

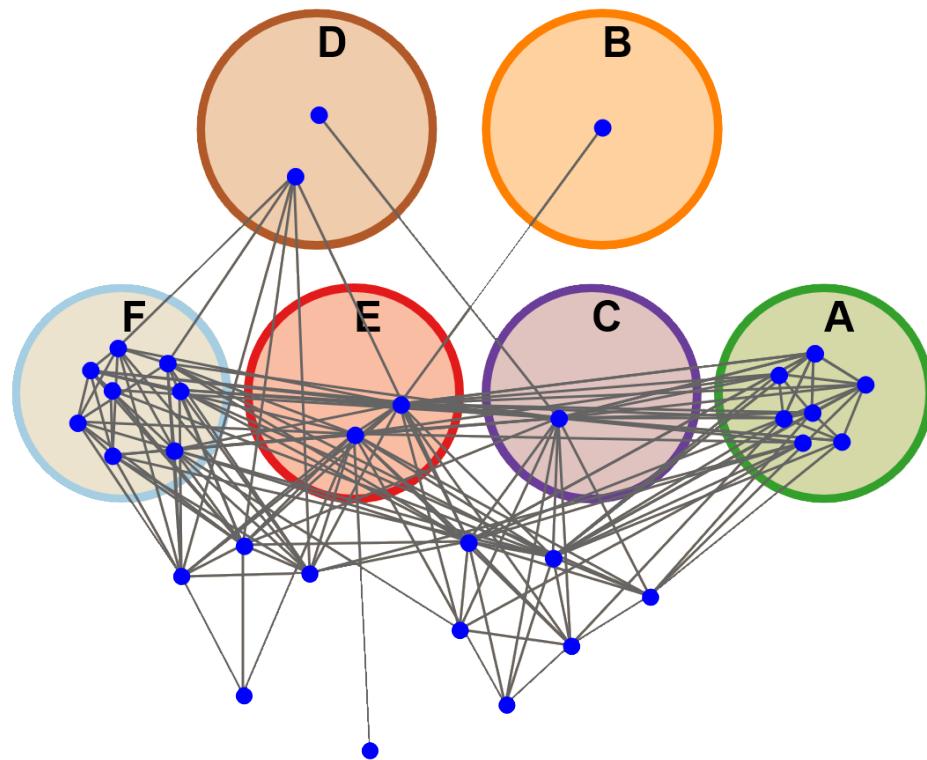
Number of Sets: 6
Number of Zones: 7
Number of Nodes: 33
Number of Edges: 160
Zones high: no
Nodes high: no
Edges high: yes

	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

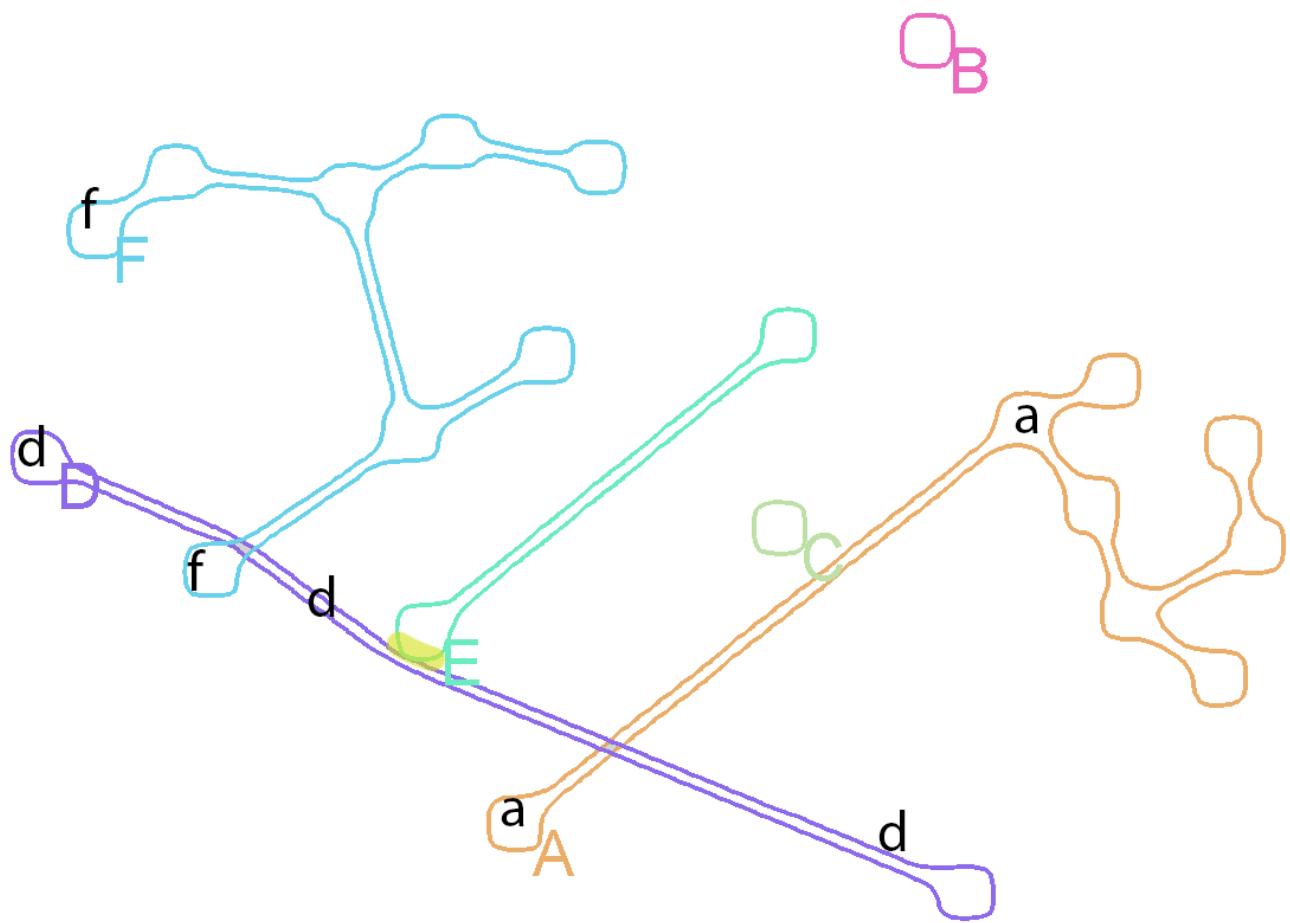
SetNet (without graph)



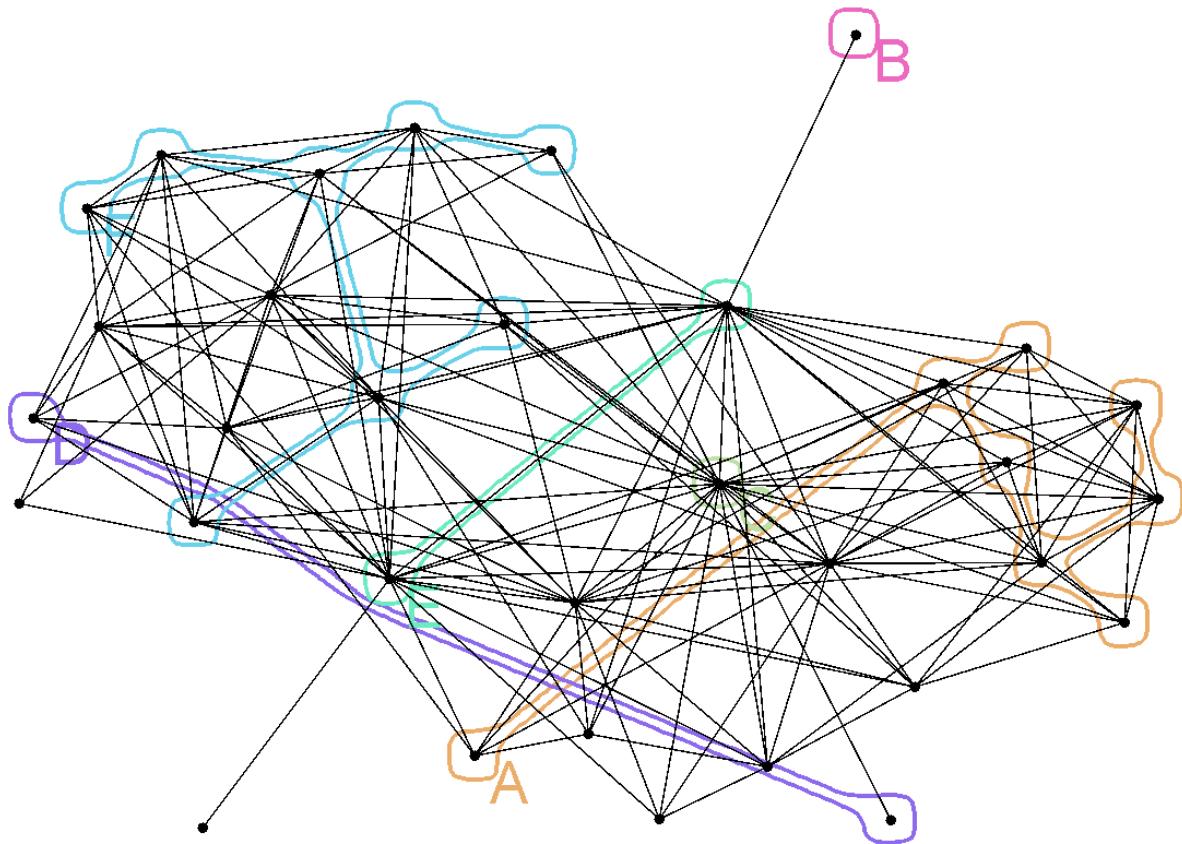
SetNet (with graph)



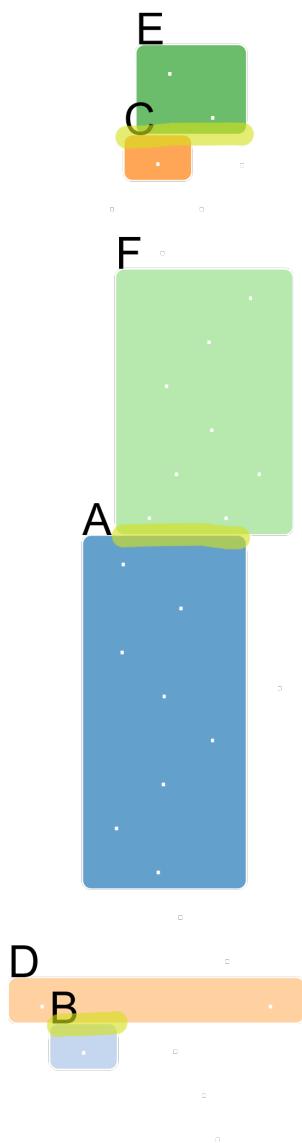
BubbleSets (without graph)



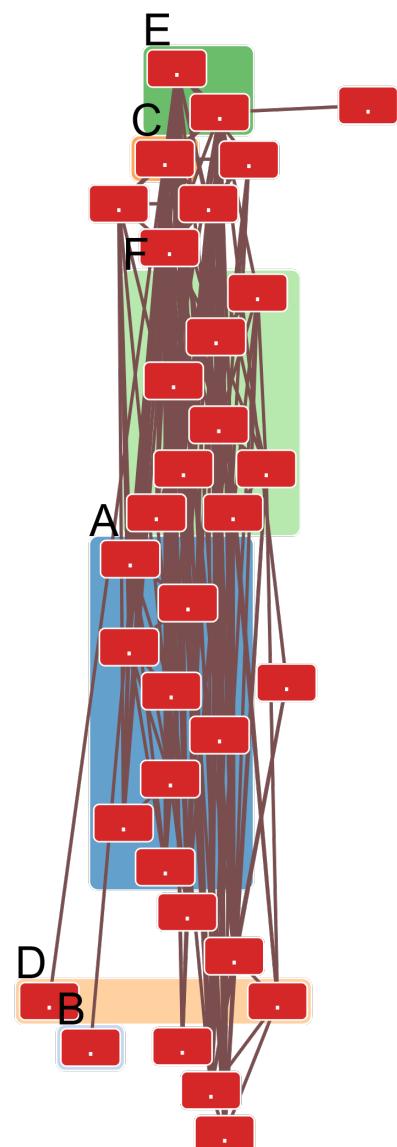
BubbleSets (with graph)



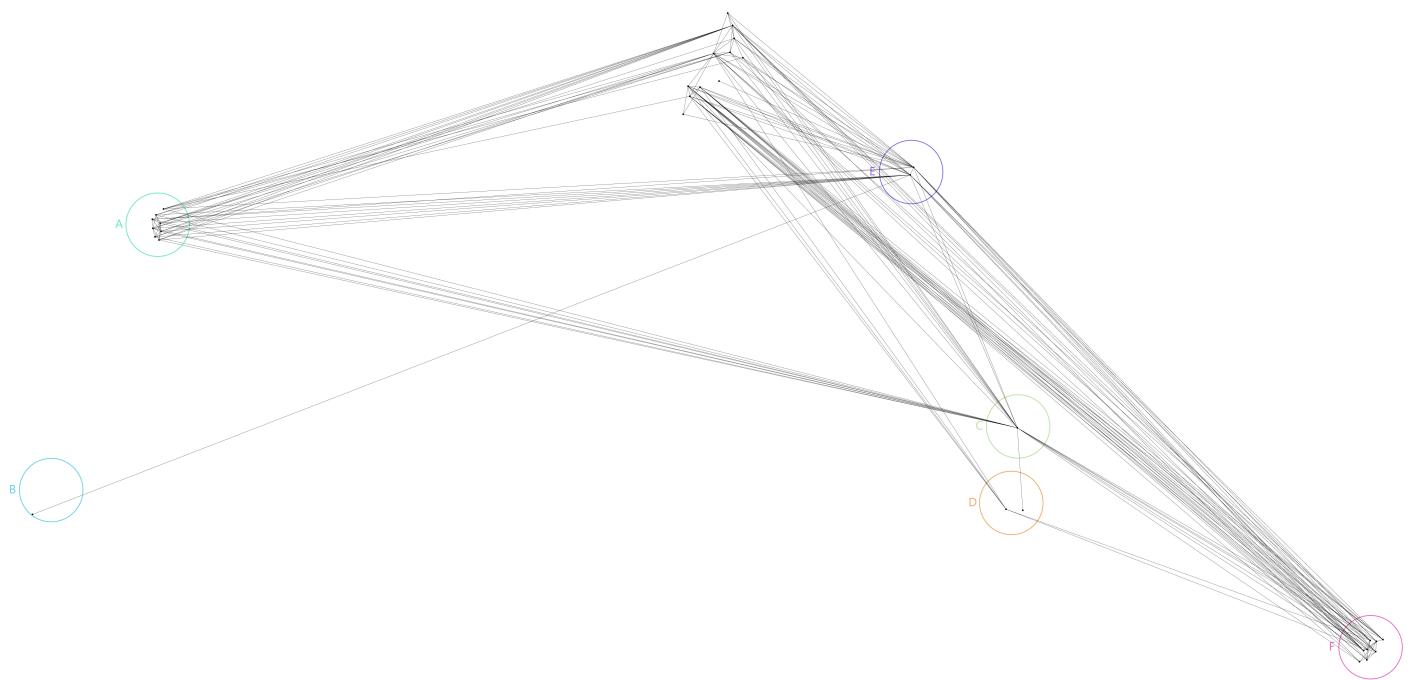
WebCola (without graph)



WebCola (with graph)



GroupNet

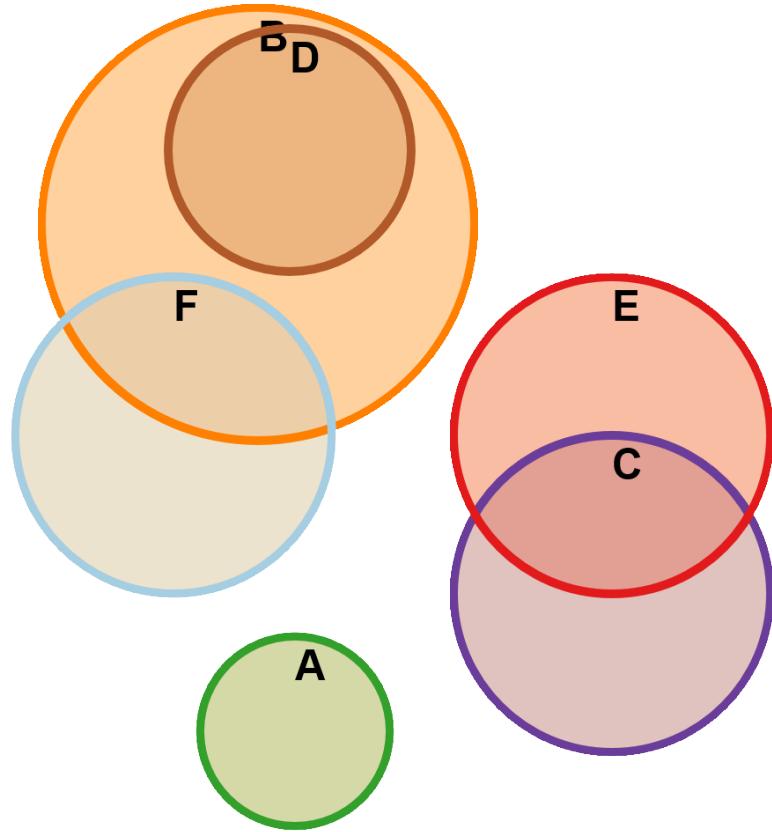


6-set data set 3 : SNAP ID: 30970675

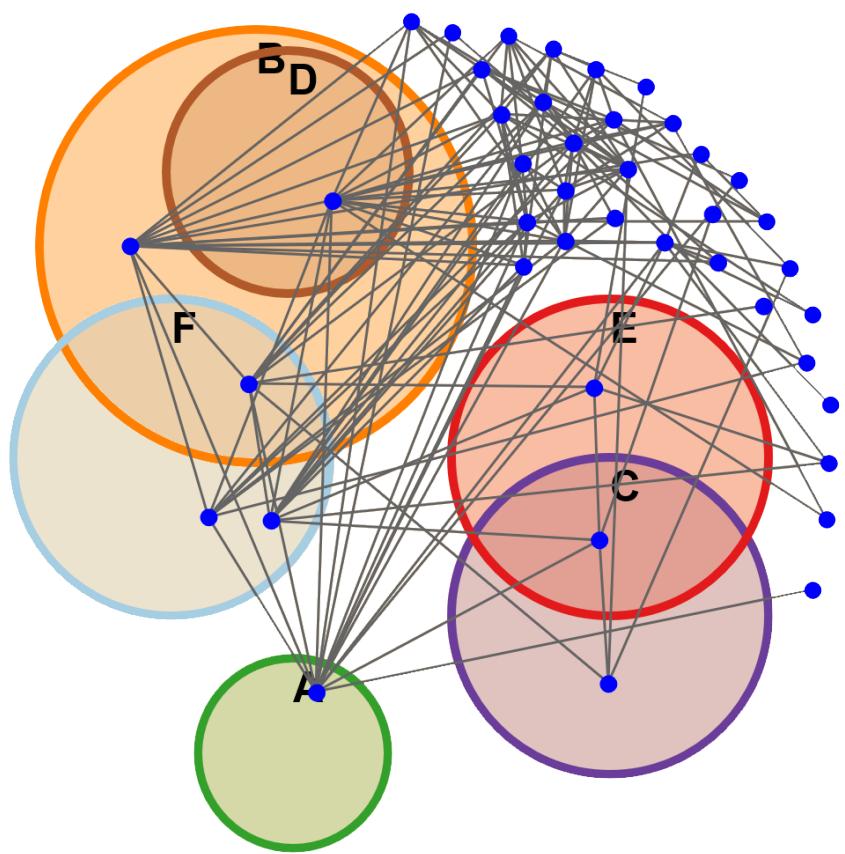
Number of Sets: 6
 Number of Zones: 9
 Number of Nodes: 42
 Number of Edges: 139
 Zones high: no
 Nodes high: yes
 Edges high: no

	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

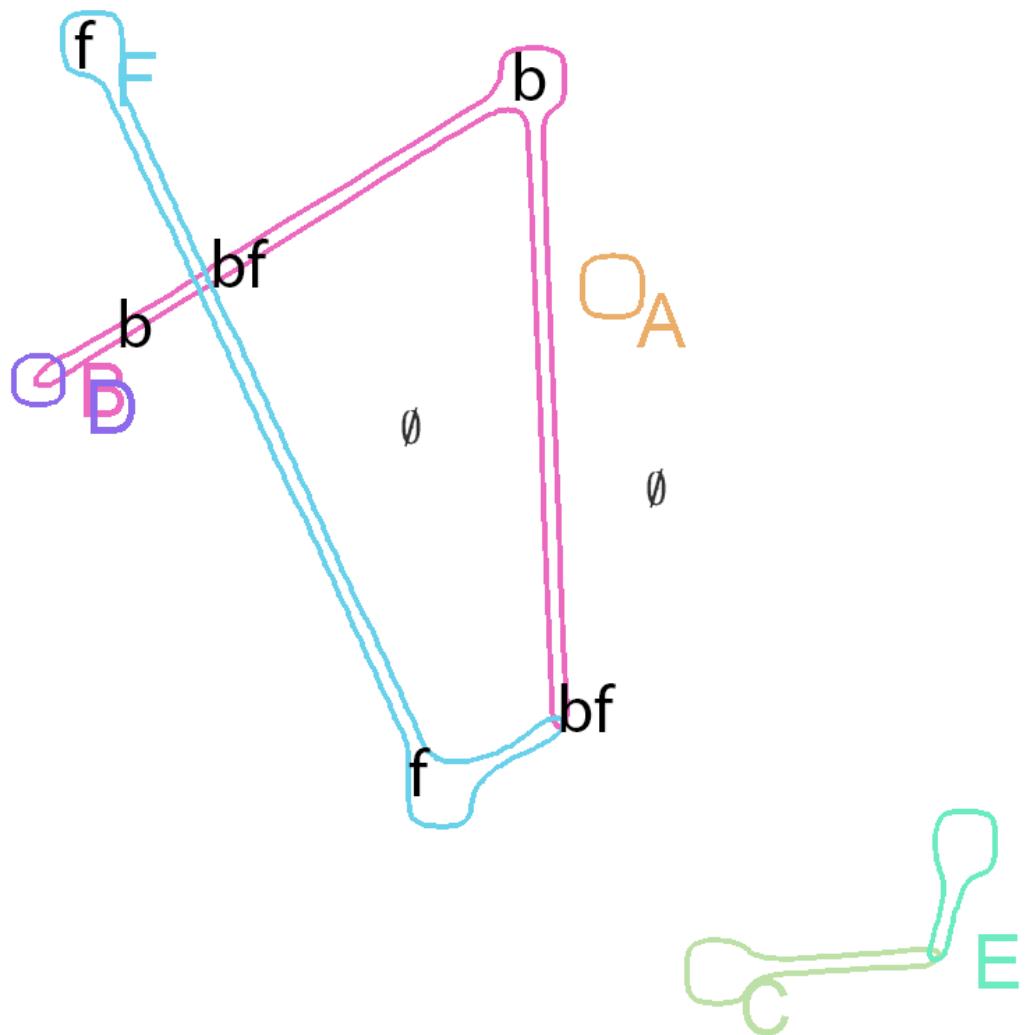
SetNet (without graph)



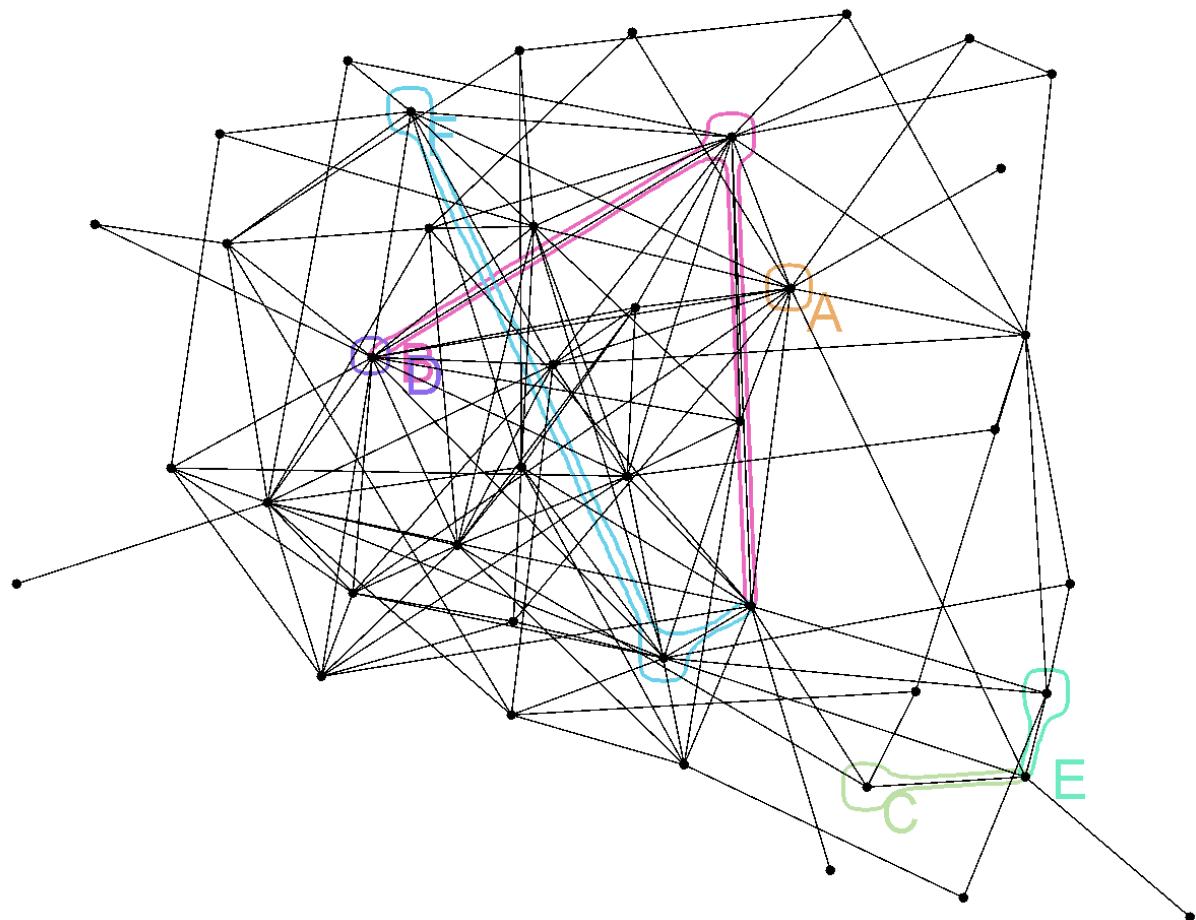
SetNet (with graph)



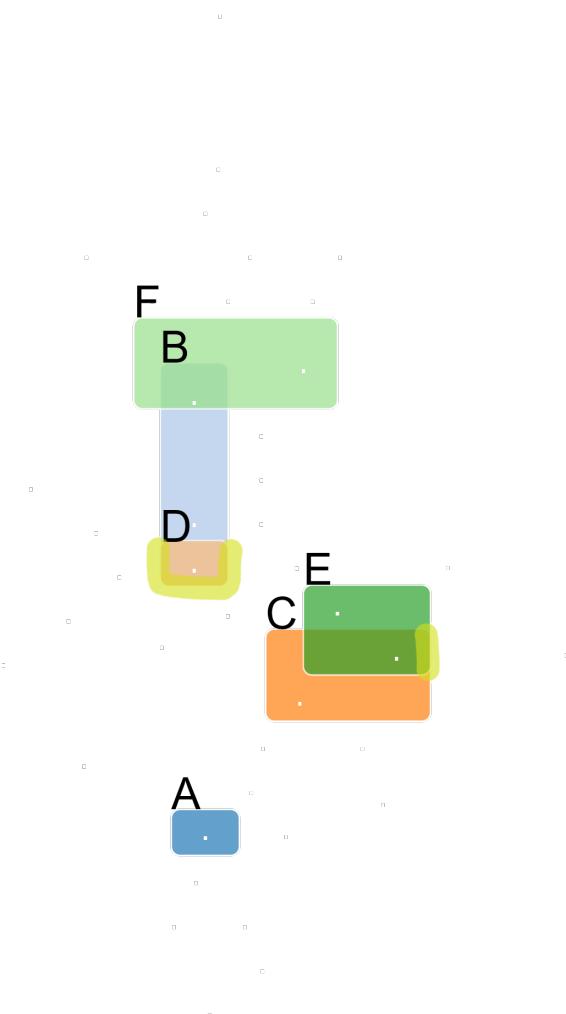
BubbleSets (without graph)



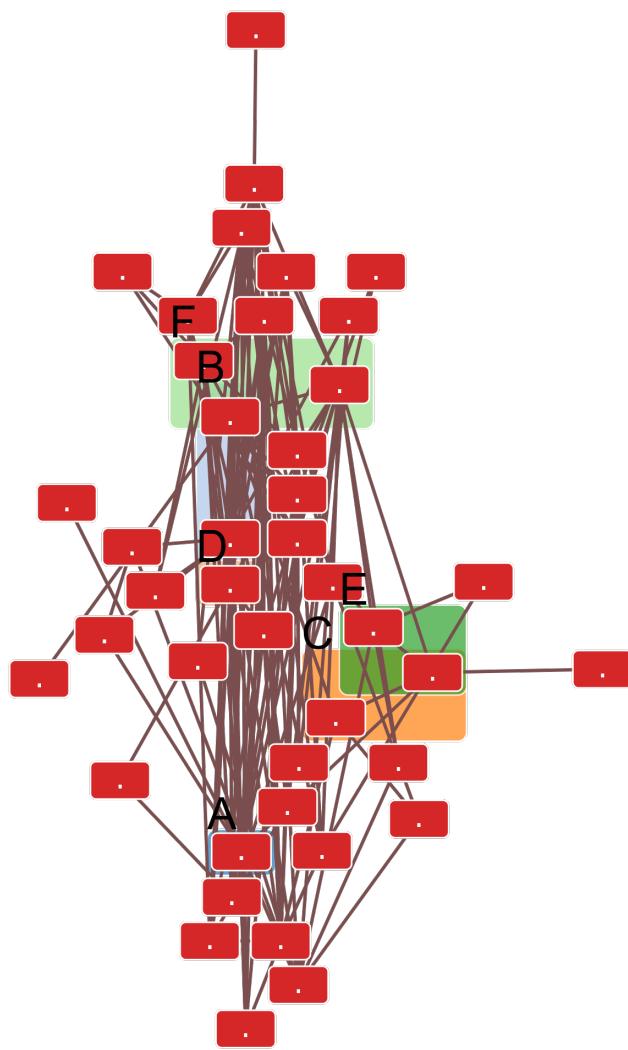
BubbleSets (with graph)



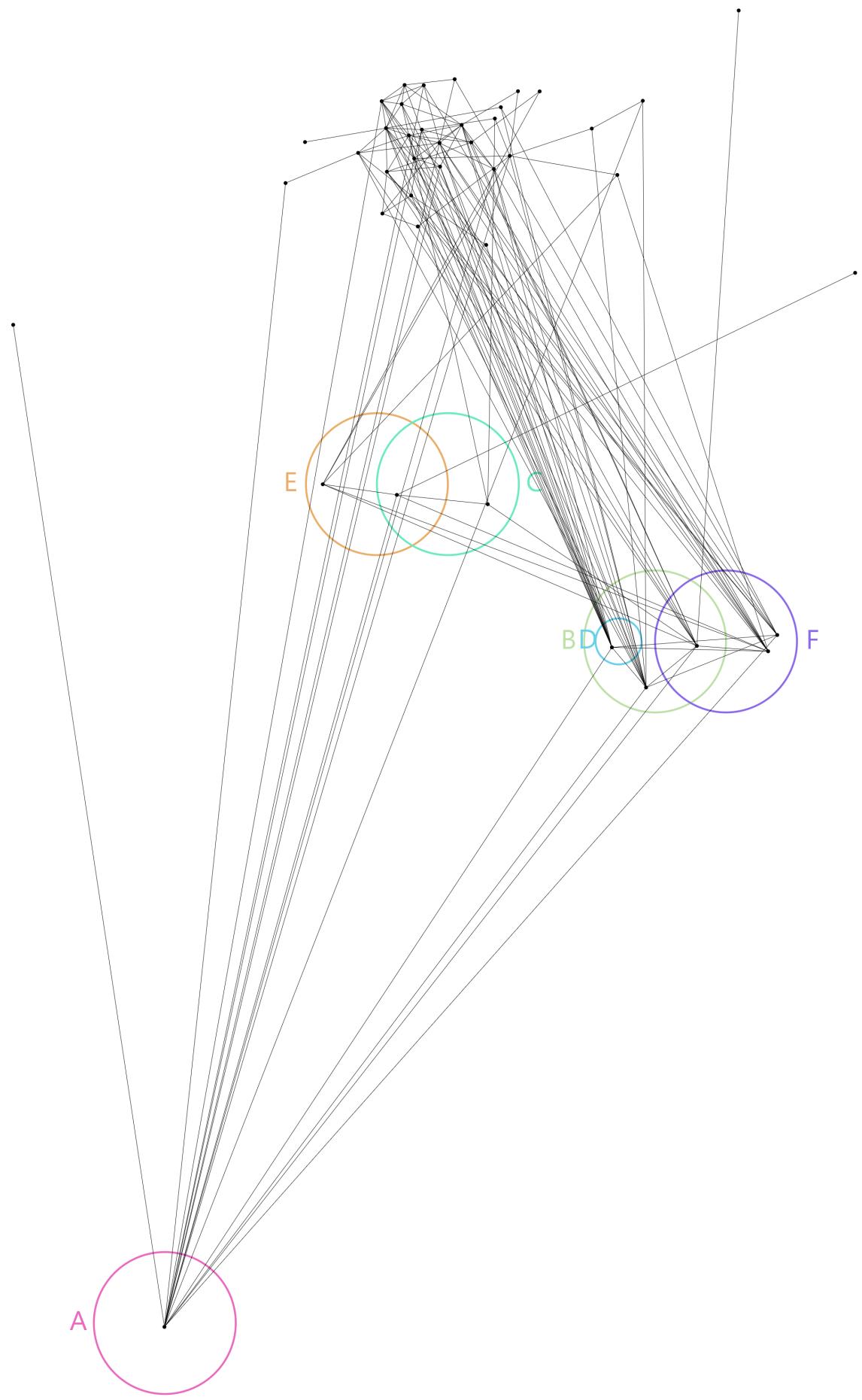
WebCola (without graph)



WebCola (with graph)



GroupNet

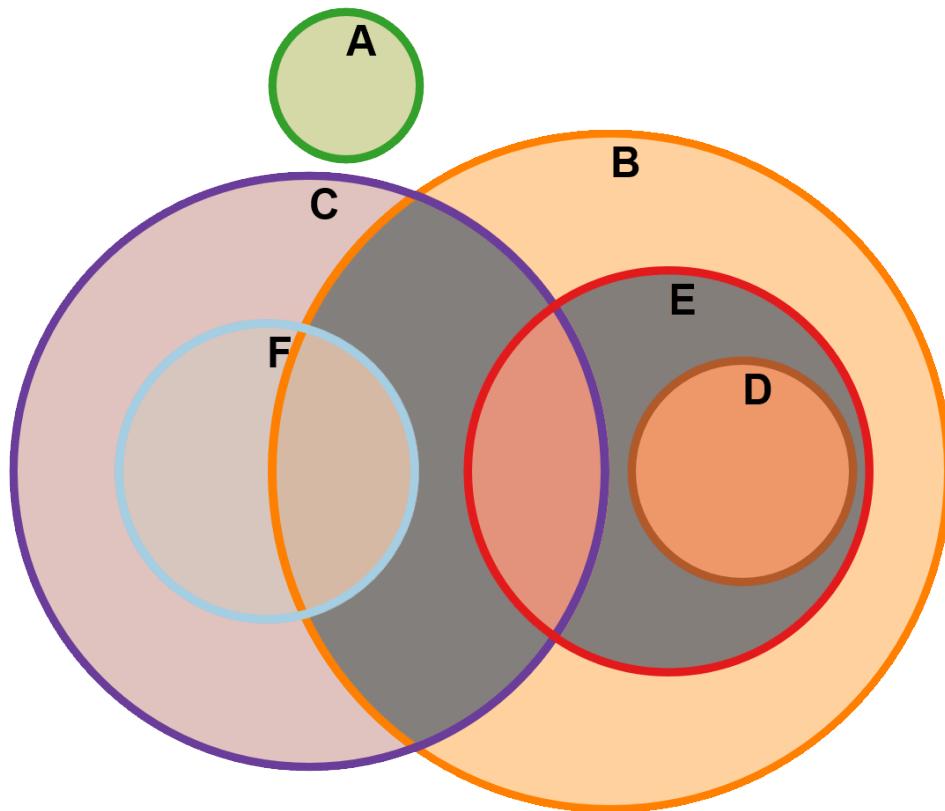


6-set data set 4 : SNAP ID: 253751053

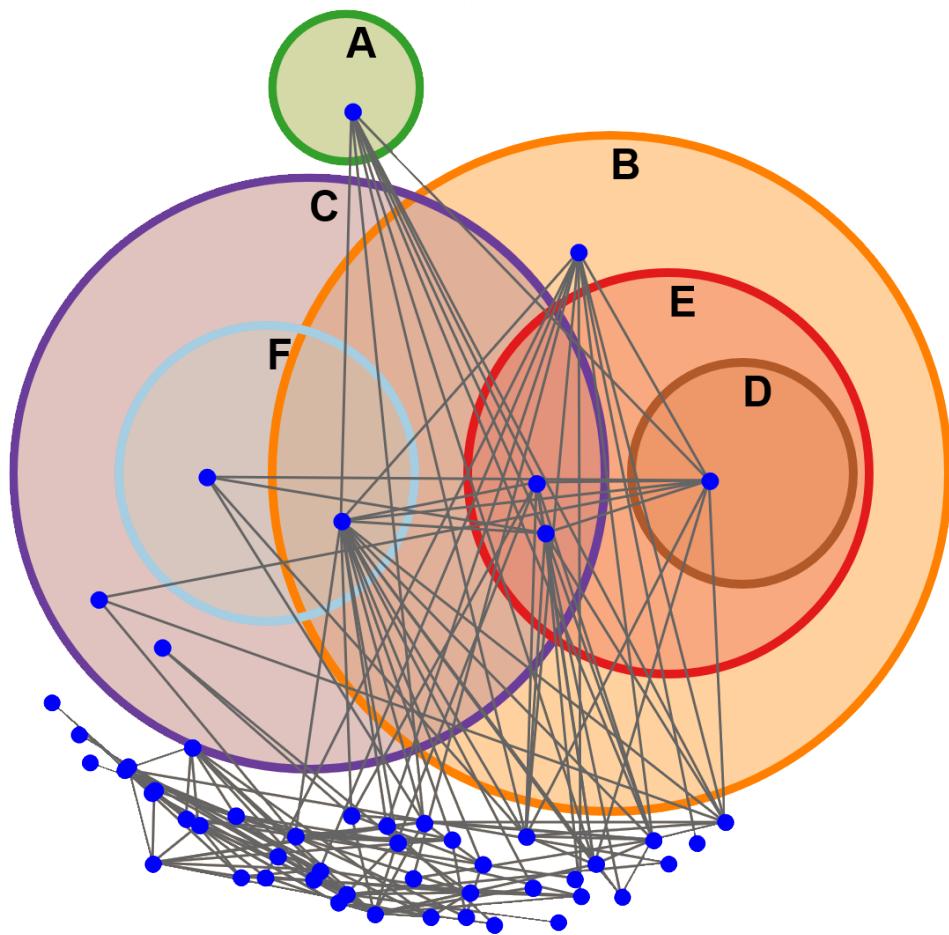
Number of Sets: 6
 Number of Zones: 8
 Number of Nodes: 52
 Number of Edges: 156
 Zones high: no
 Nodes high: yes
 Edges high: yes

	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

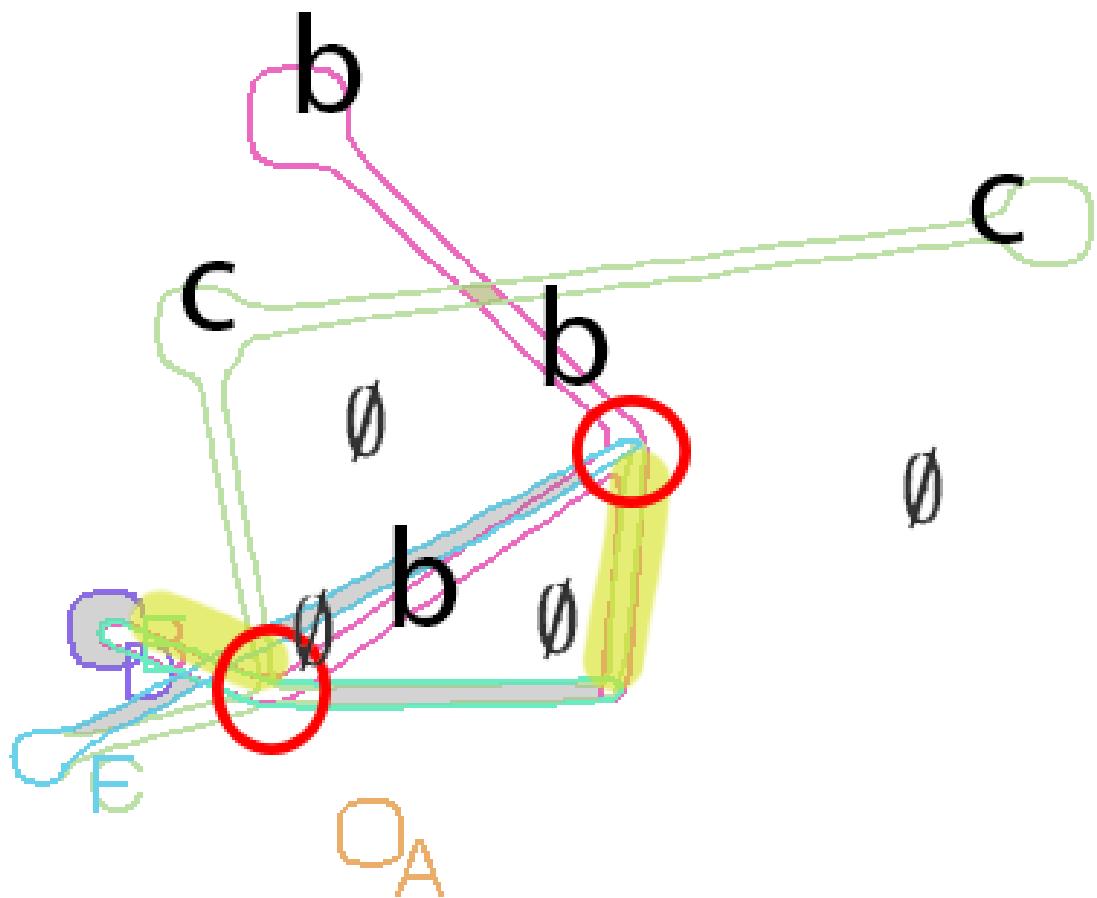
SetNet (without graph)



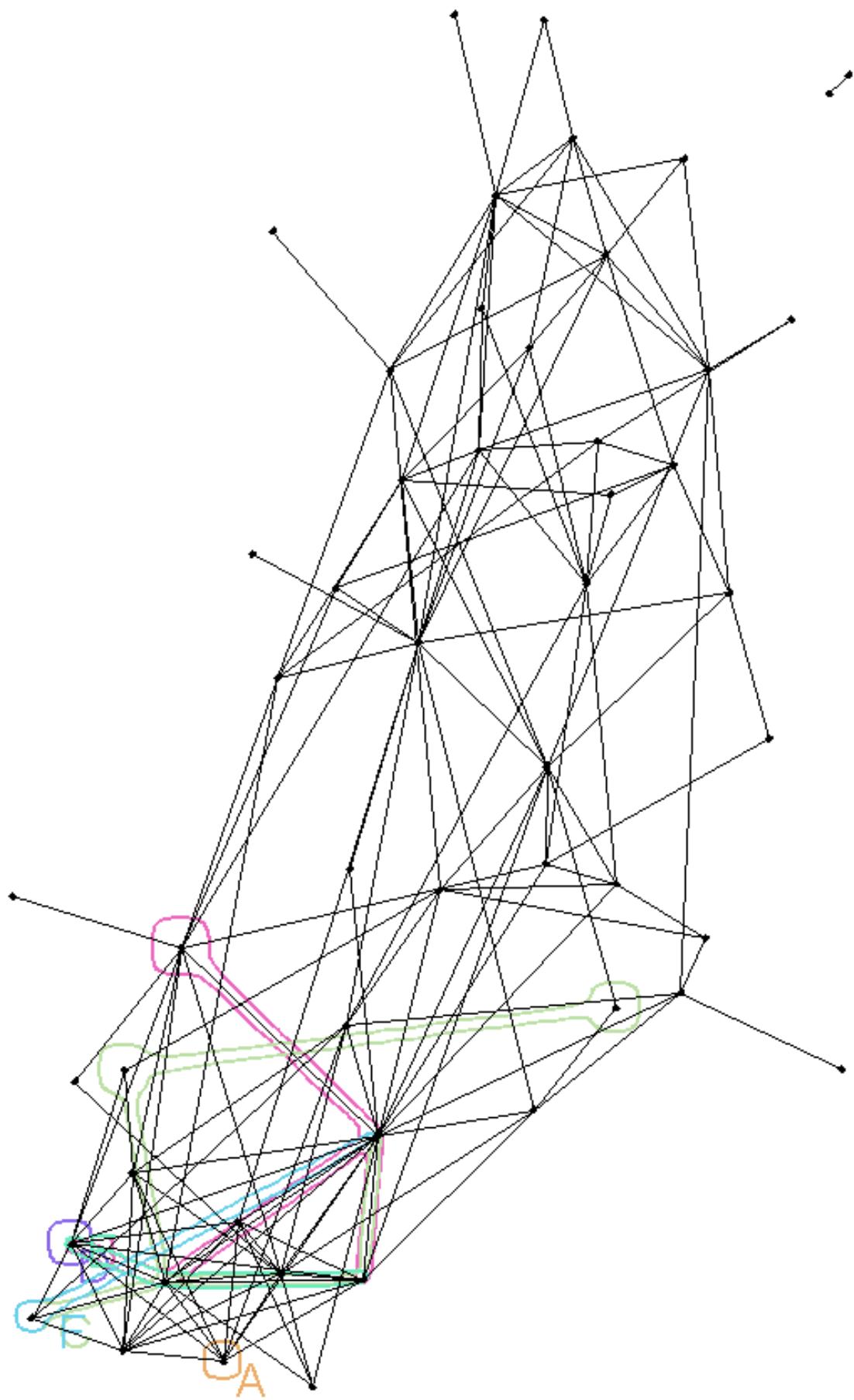
SetNet (with graph)



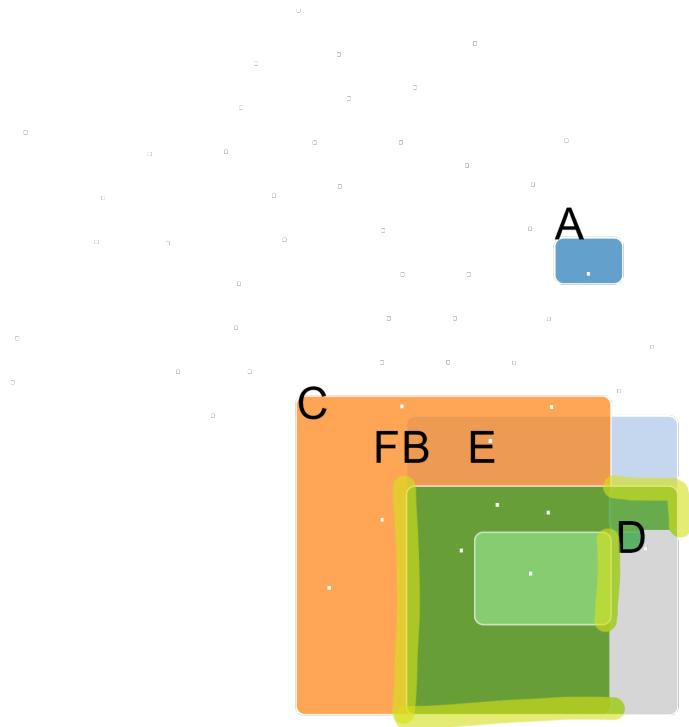
BubbleSets (without graph)



BubbleSets (with graph)

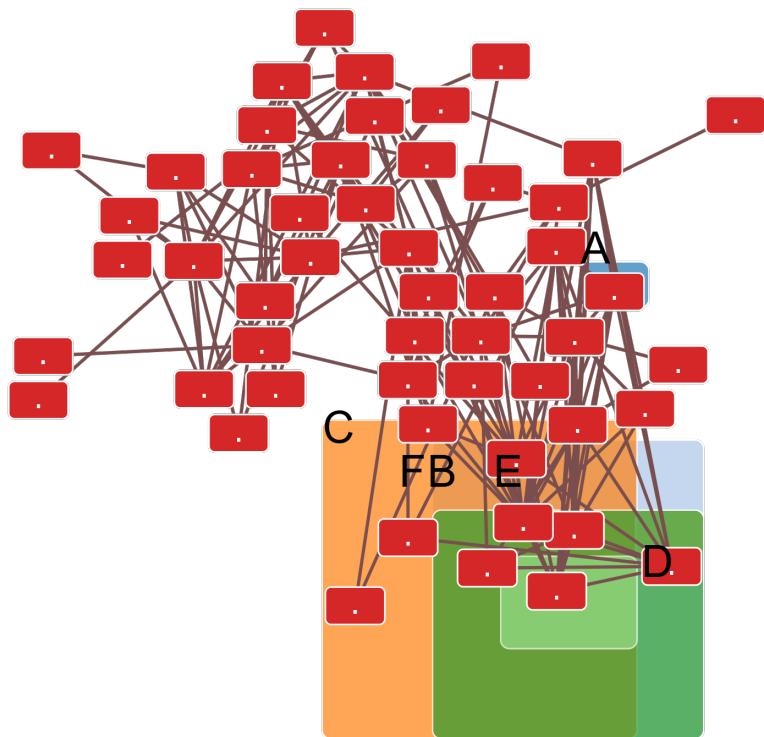


WebCola (without graph)

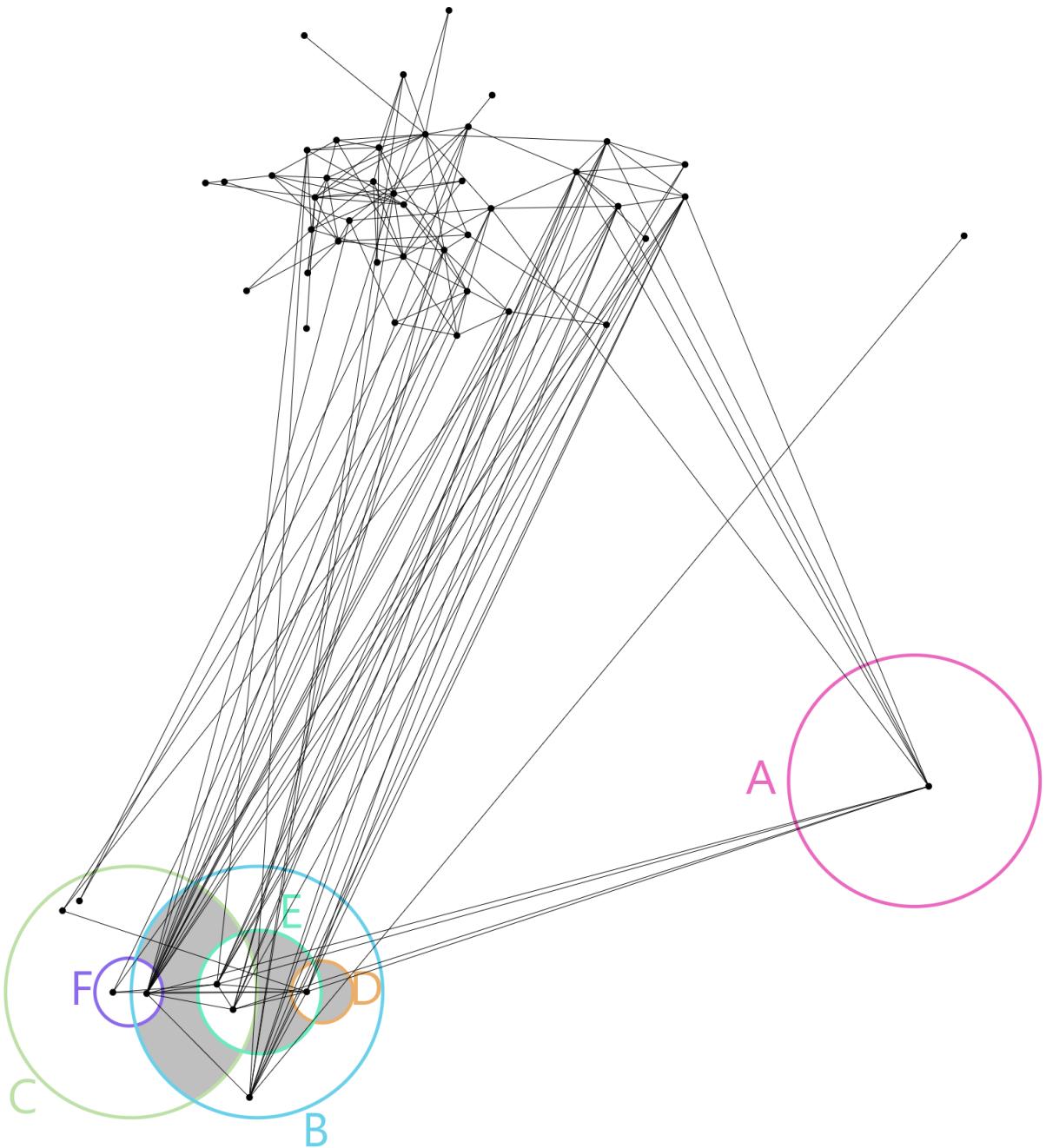


Omitted zones: BCF

WebCola (with graph)



GroupNet

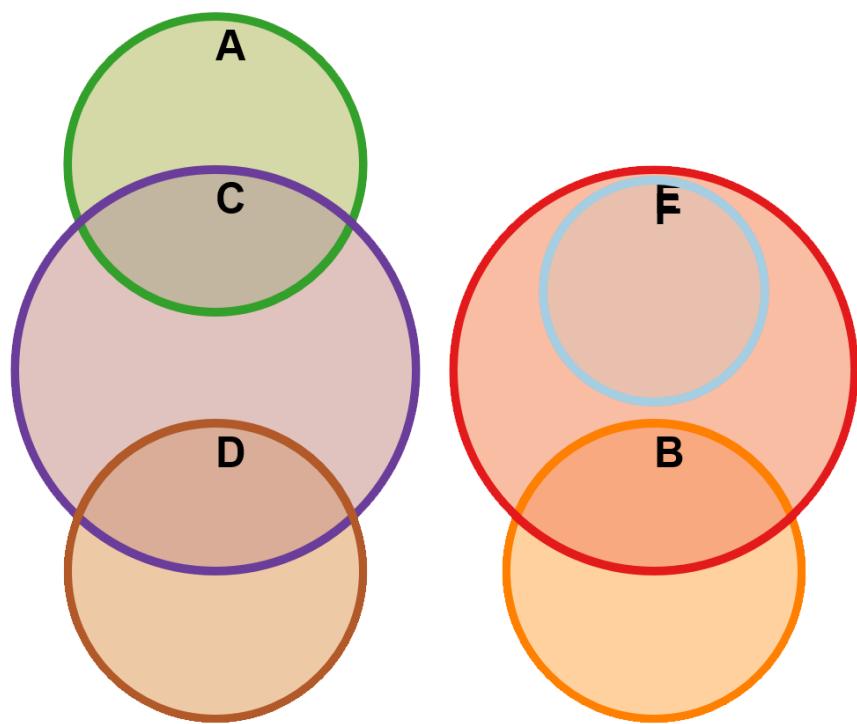


6-set data set 5 : SNAP ID: 204145356

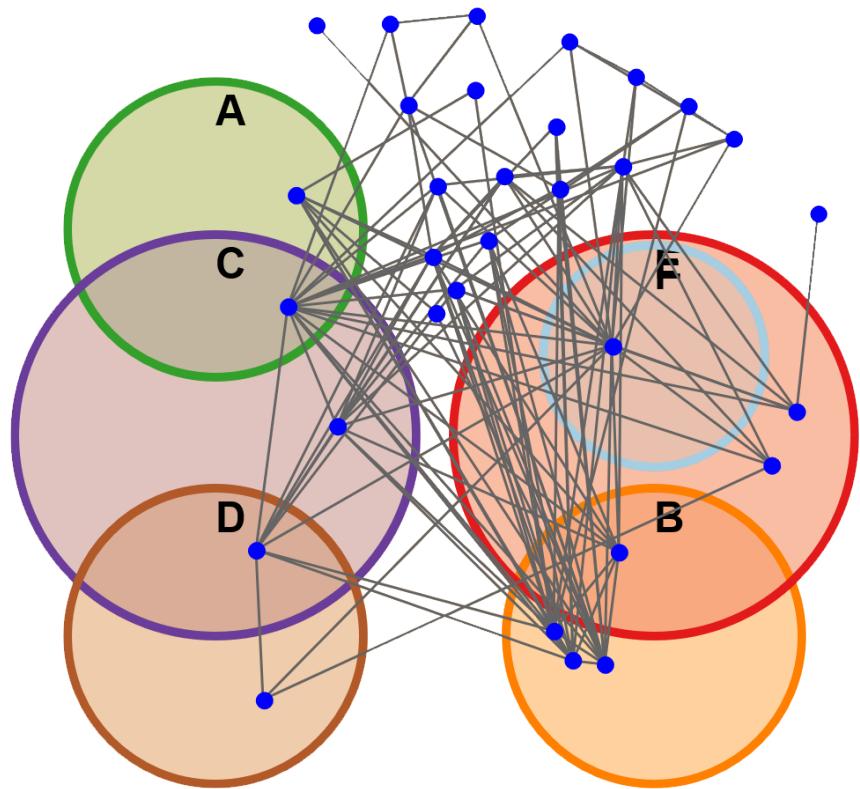
Number of Sets: 6
 Number of Zones: 10
 Number of Nodes: 31
 Number of Edges: 114
 Zones high: yes
 Nodes high: no
 Edges high: no

	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

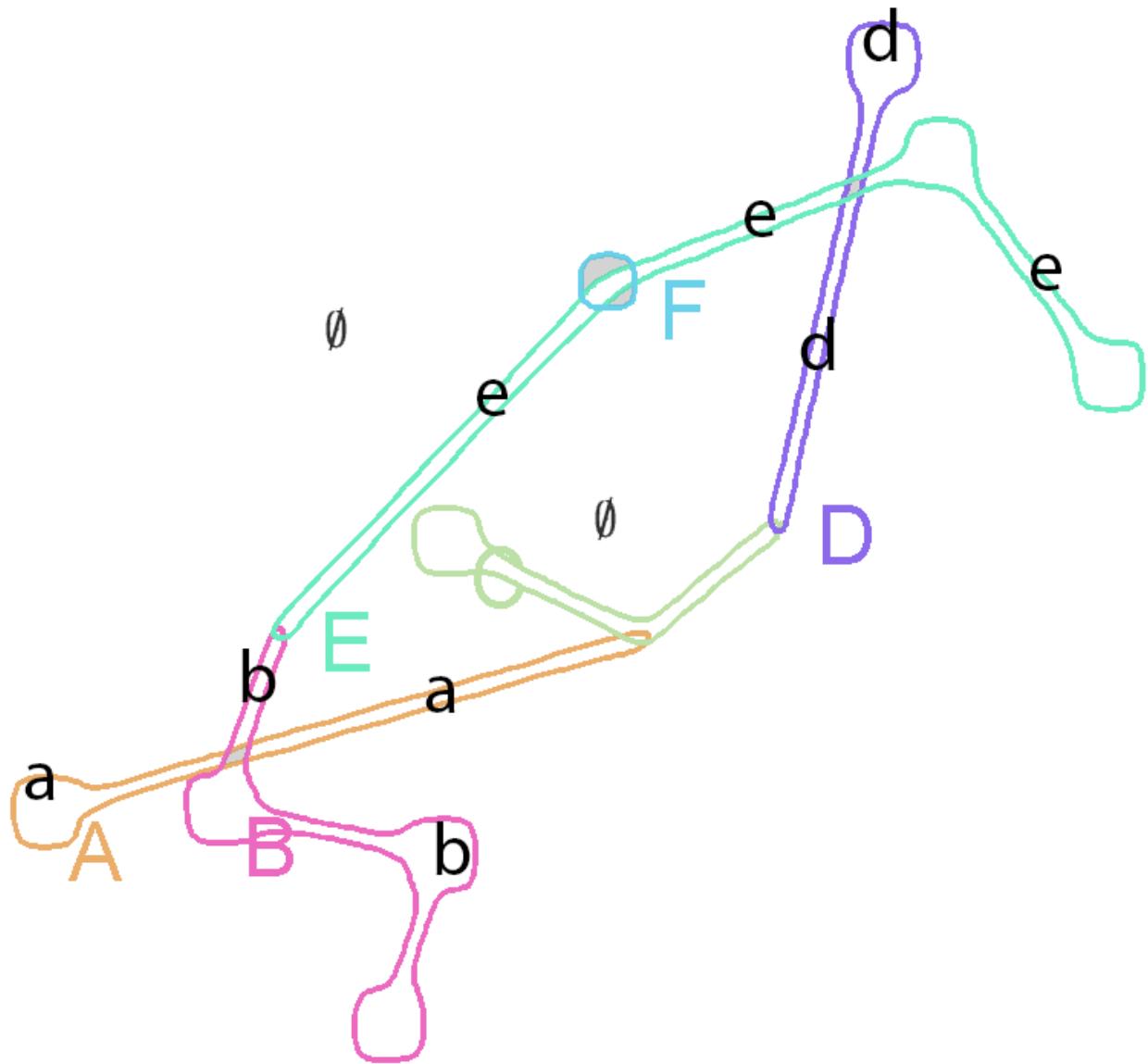
SetNet (without graph)



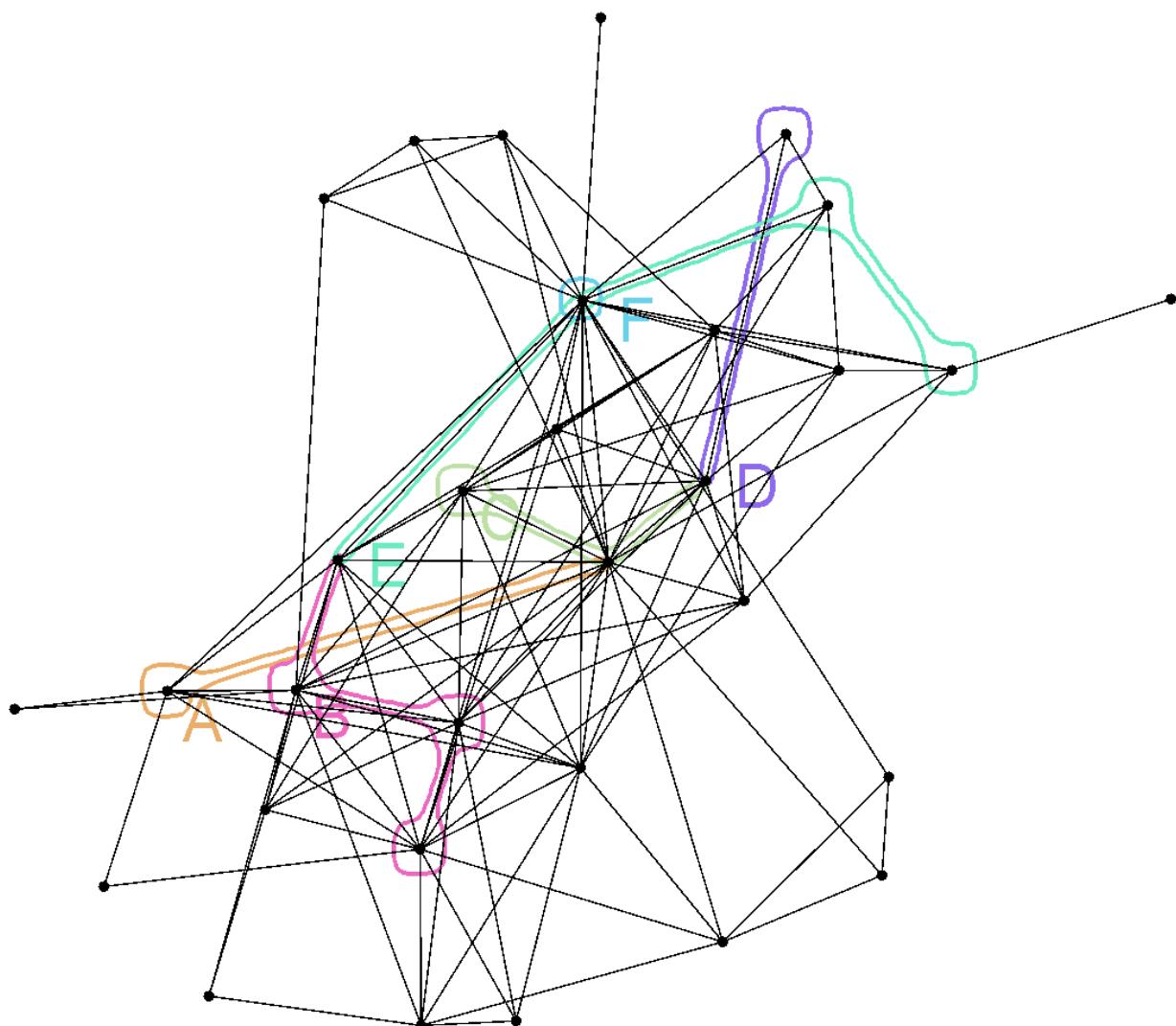
SetNet (with graph)



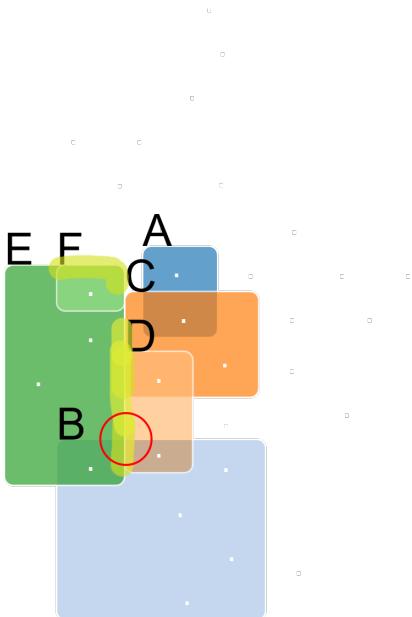
BubbleSets (without graph)



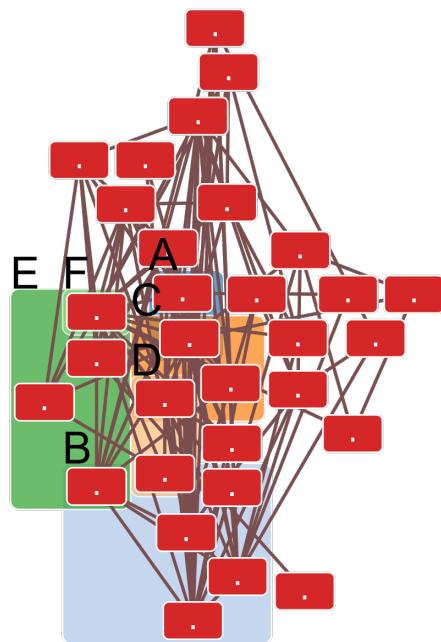
BubbleSets (with graph)



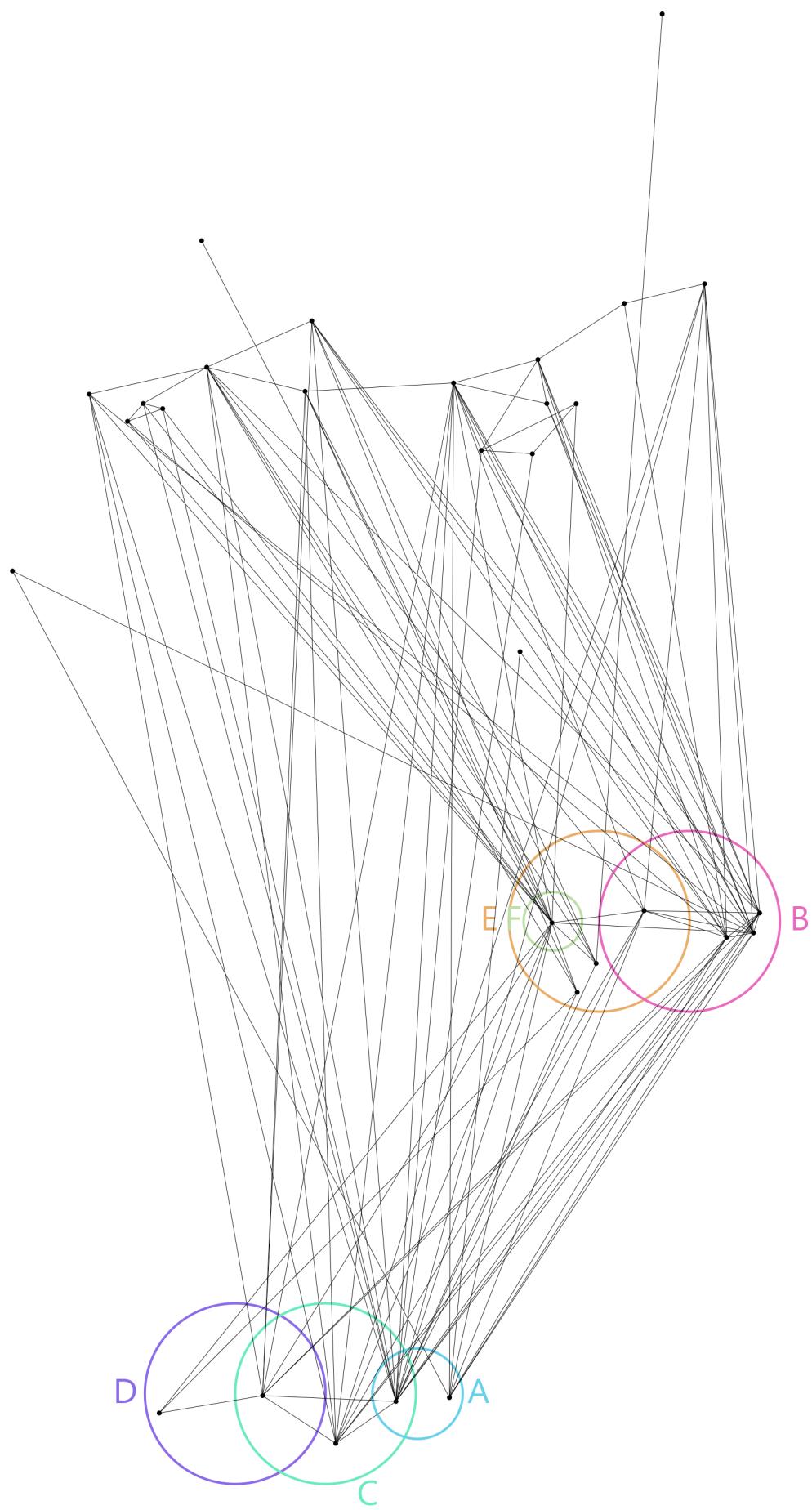
WebCola (without graph)



WebCola (with graph)



GroupNet

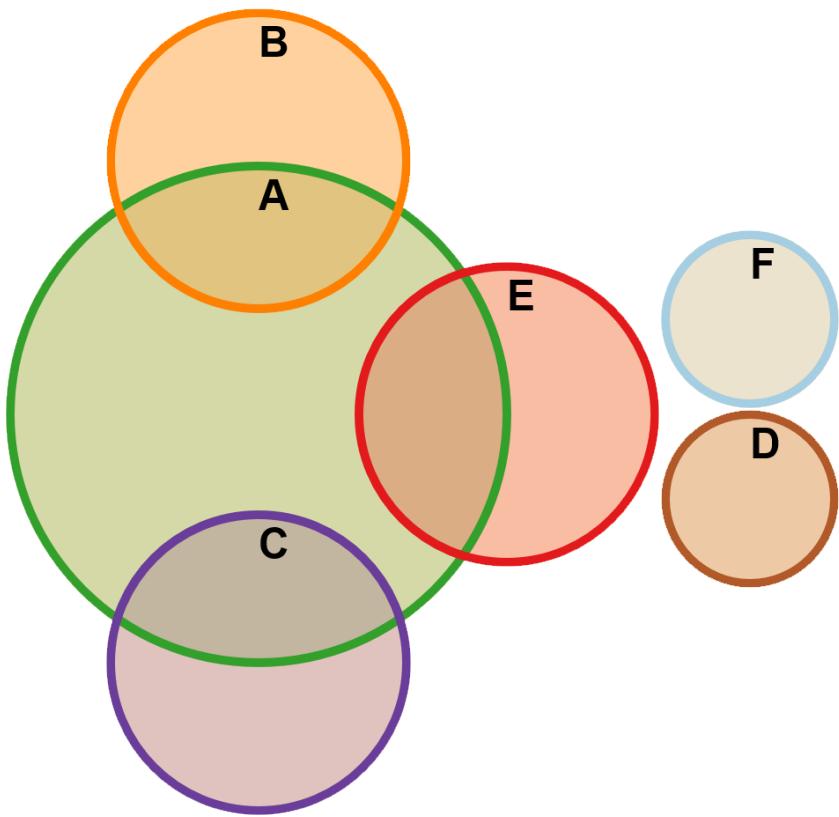


6-set data set 6 : SNAP ID: 255790981

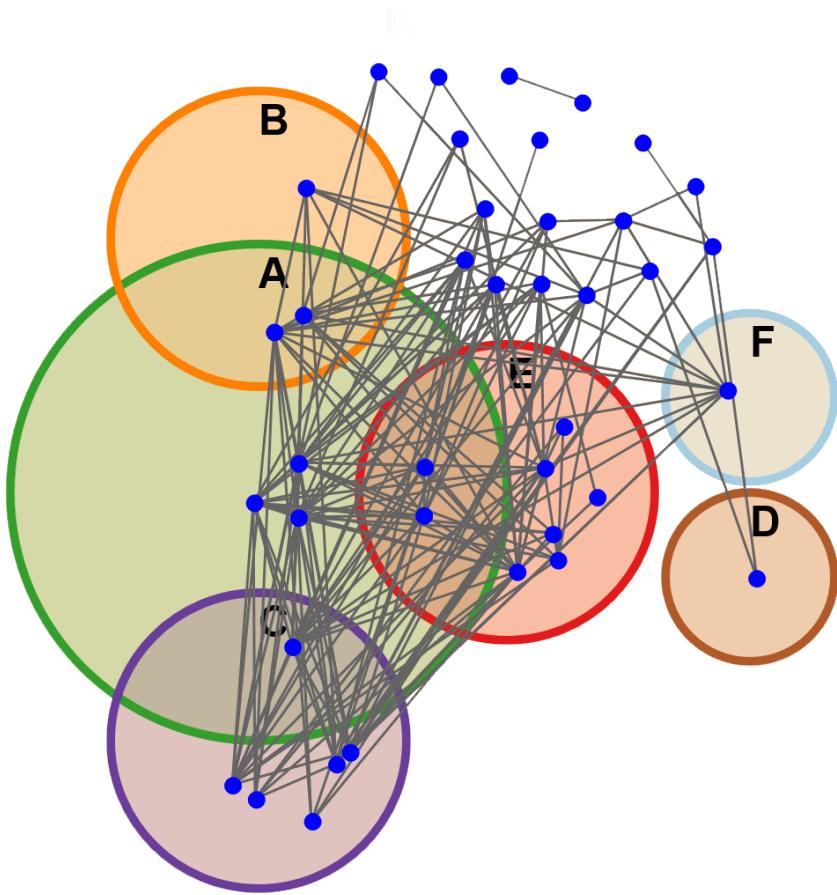
Number of Sets: 6
 Number of Zones: 10
 Number of Nodes: 39
 Number of Edges: 167
 Zones high: yes
 Nodes high: no
 Edges high: yes

	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)

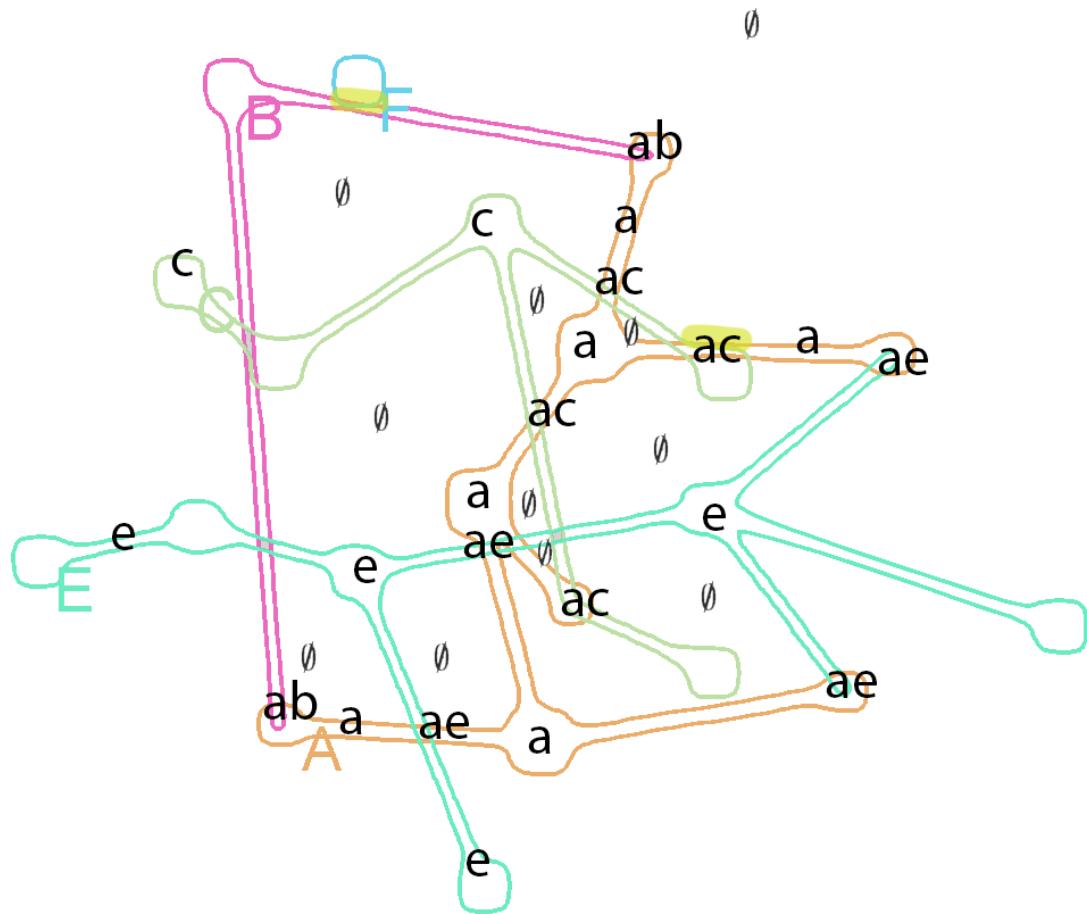


SetNet (with graph)

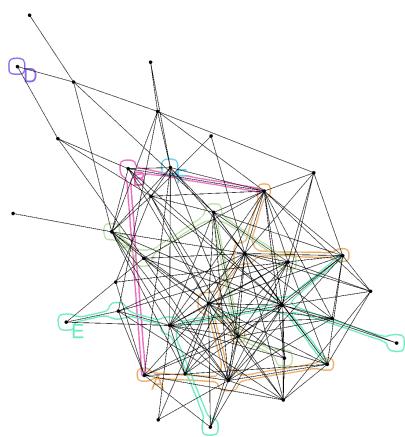


BubbleSets (without graph)

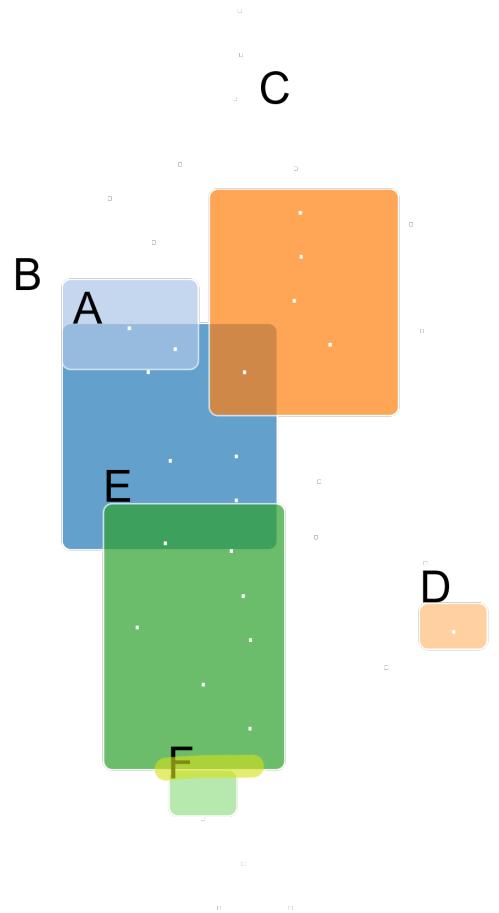
O
D



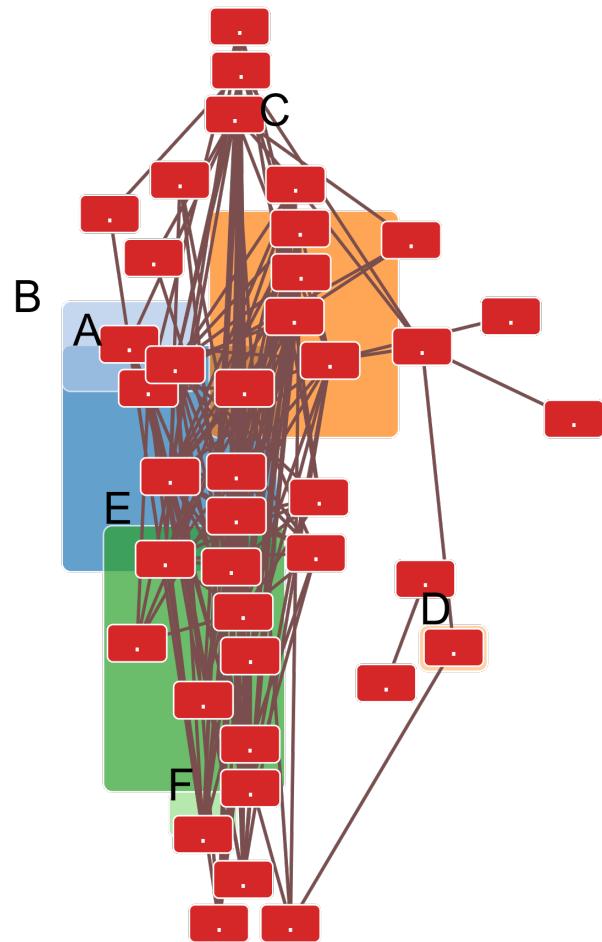
BubbleSets (with graph)



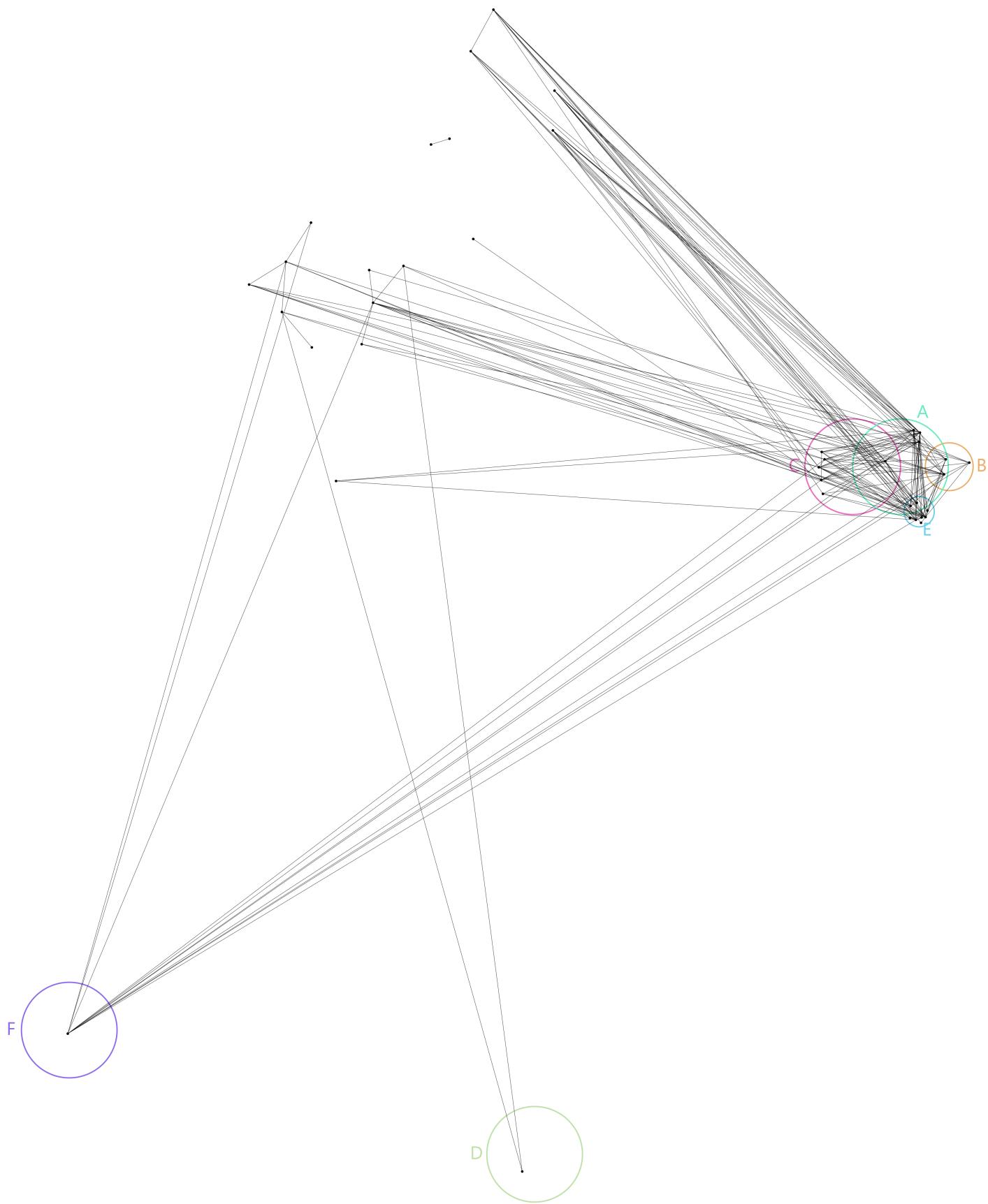
WebCola (without graph)



WebCola (with graph)



GroupNet

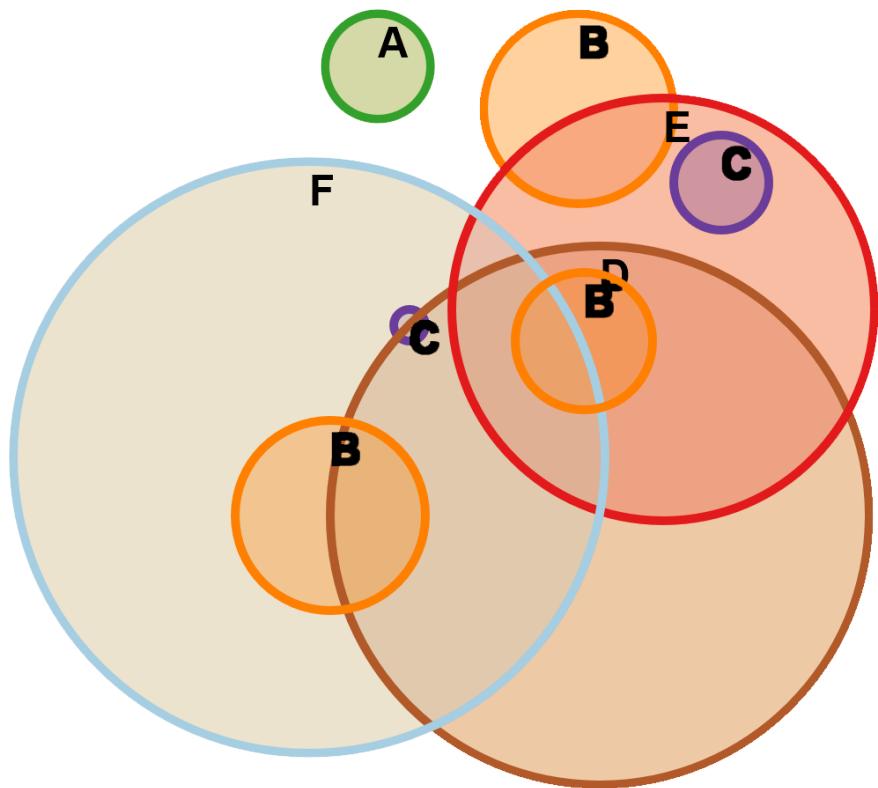


6-set data set 7 : SNAP ID: 326259198

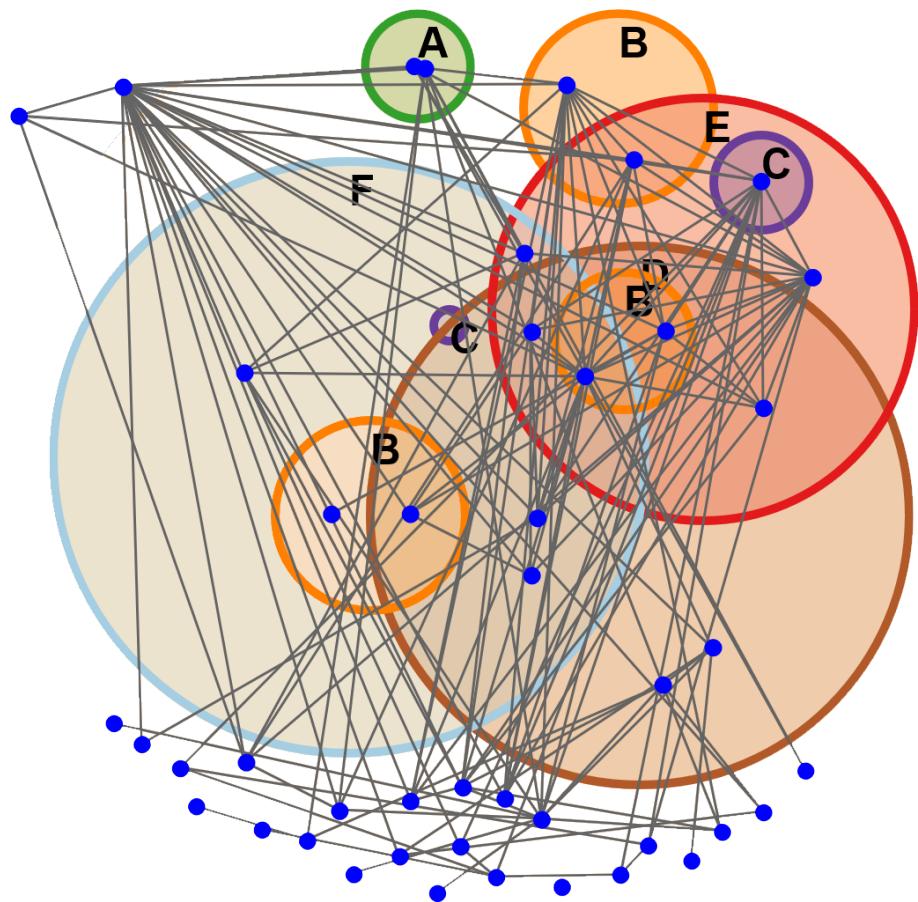
Number of Sets: 6
 Number of Zones: 18
 Number of Nodes: 45
 Number of Edges: 142
 Zones high: yes
 Nodes high: yes
 Edges high: no

	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

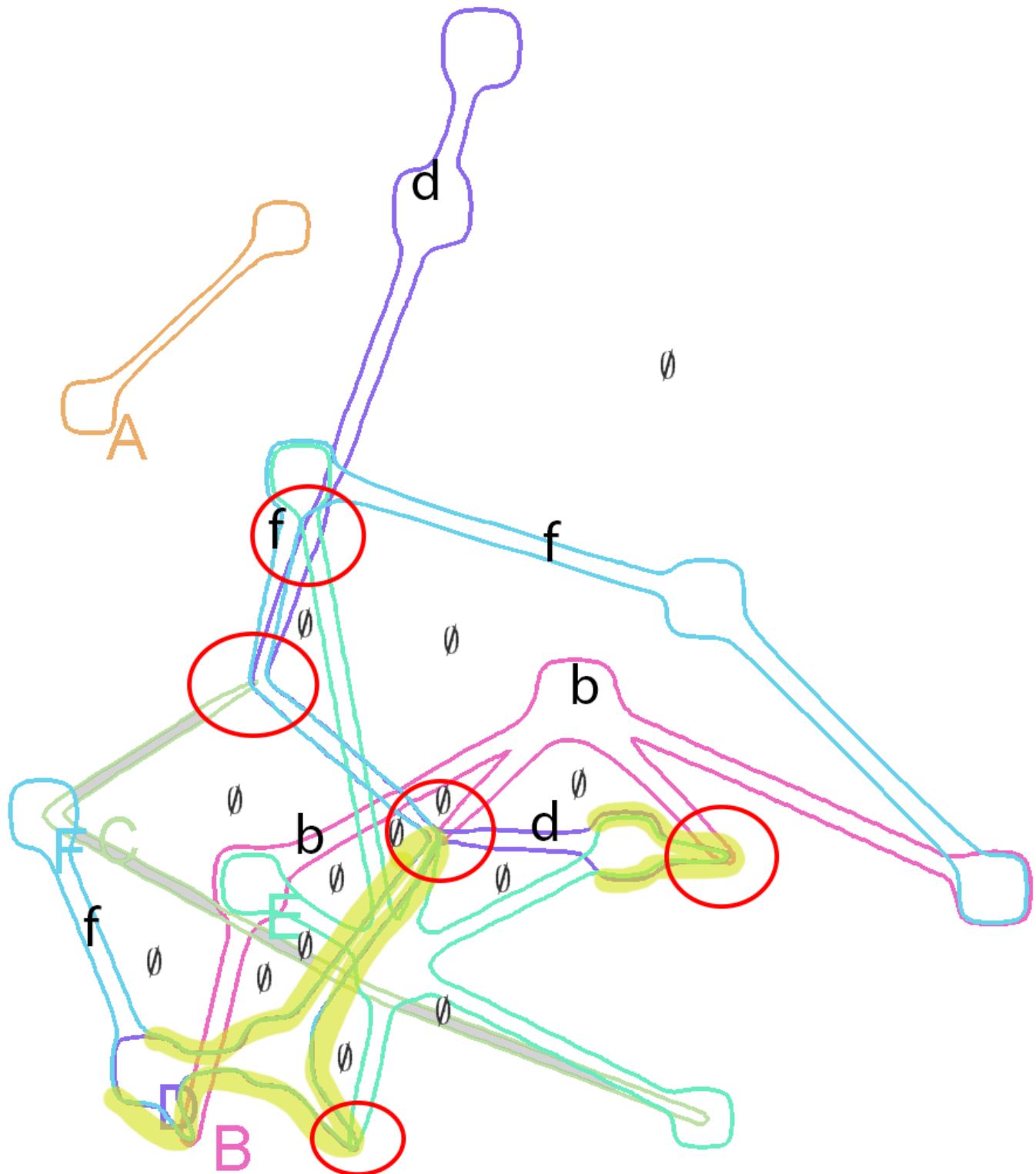
SetNet (without graph)



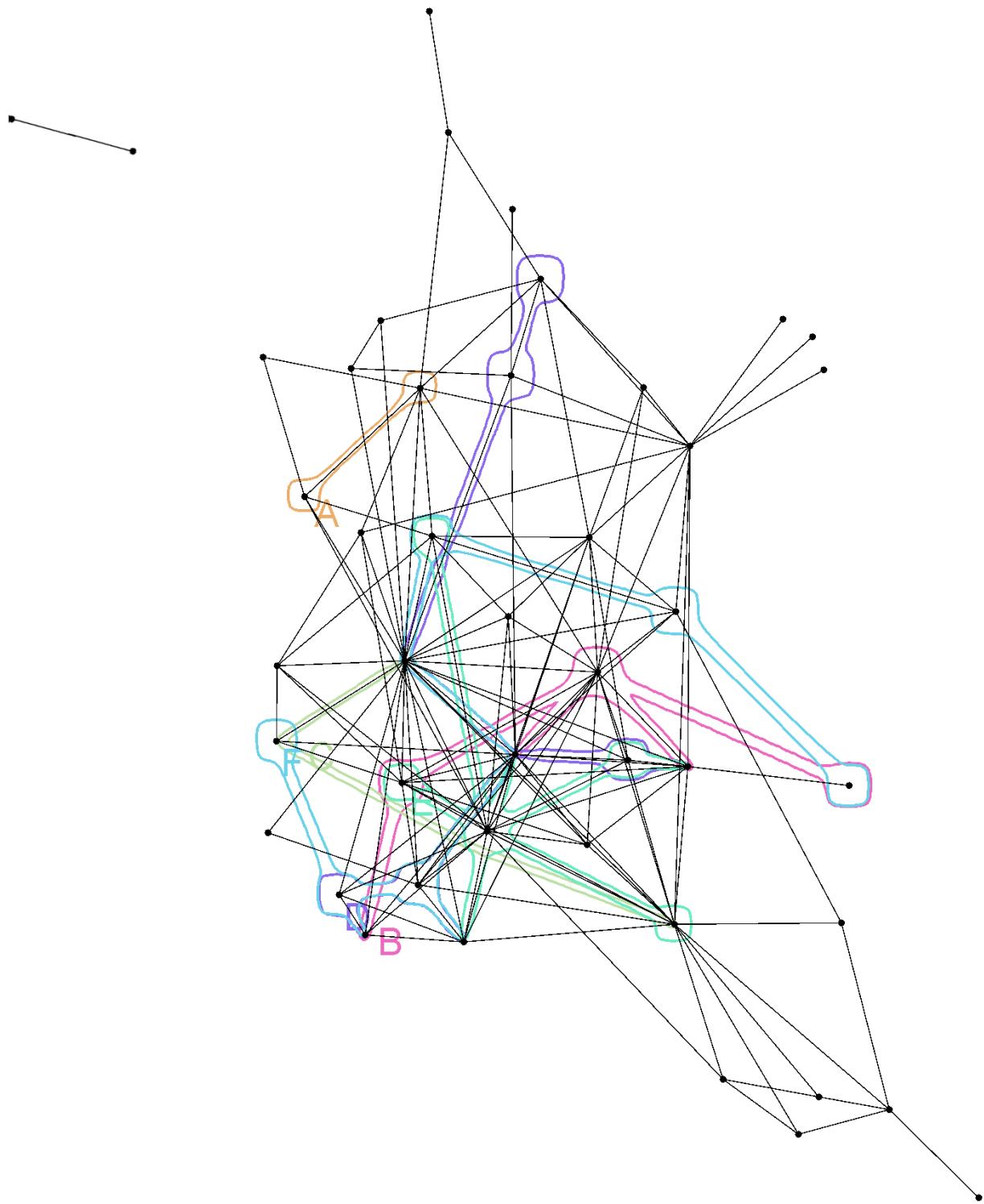
SetNet (with graph)



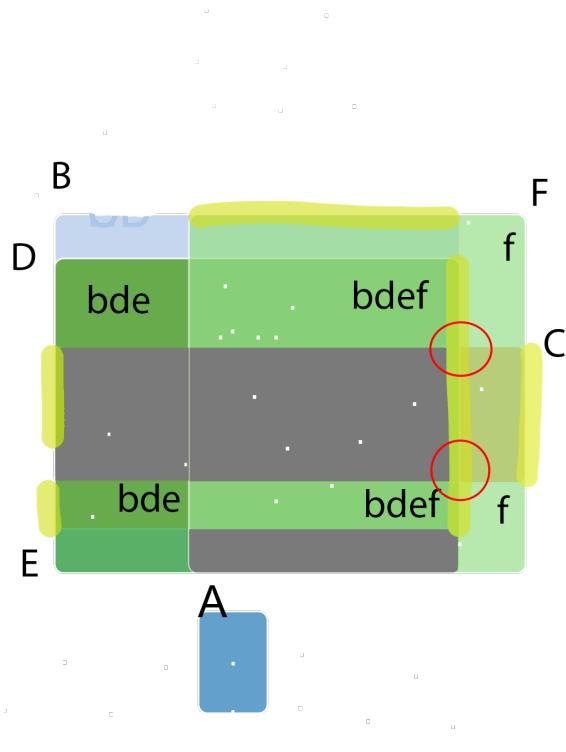
BubbleSets (without graph)



BubbleSets (with graph)

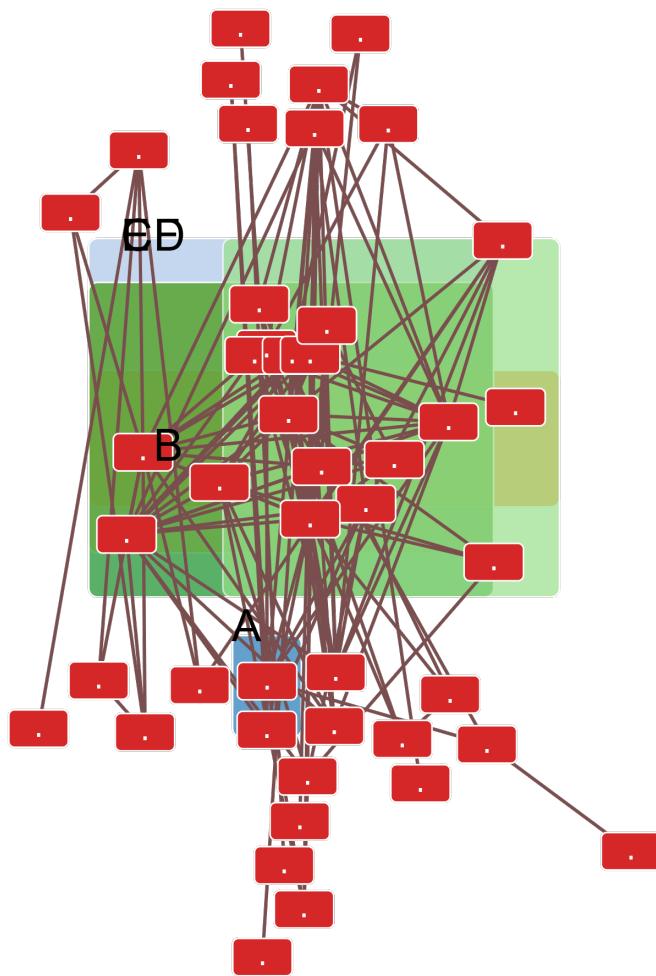


WebCola (without graph)

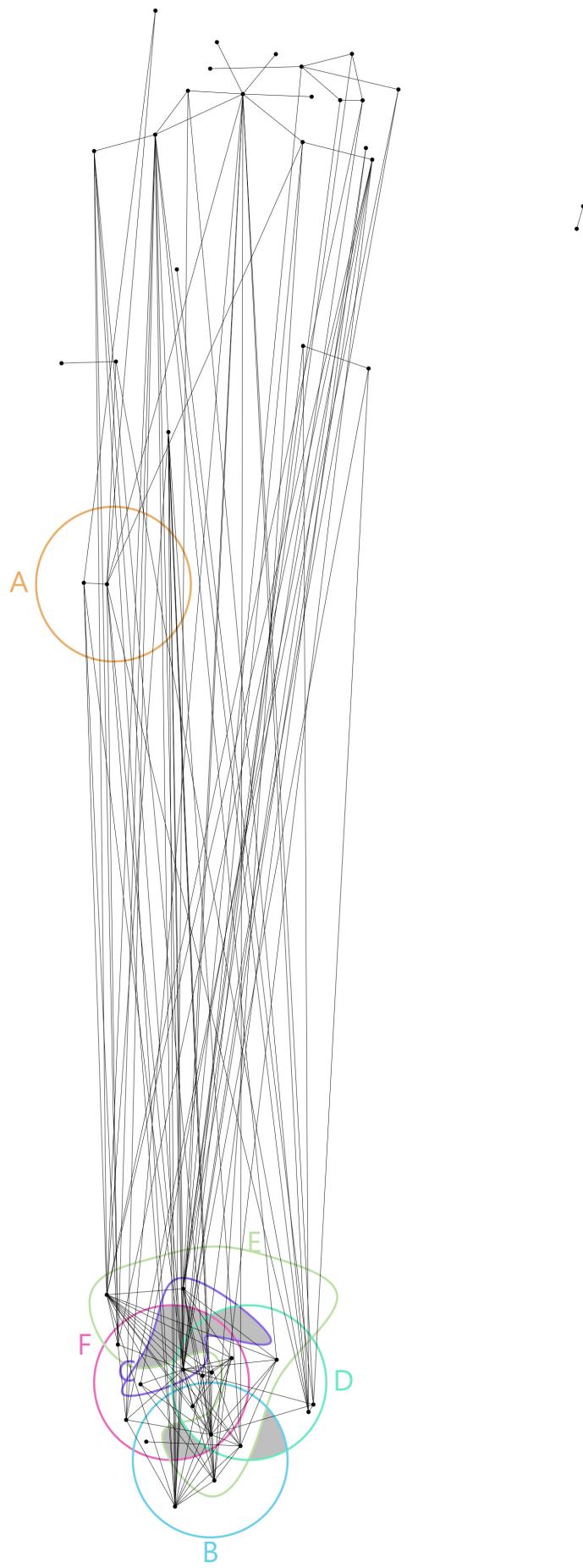


Omitted zones: D, E, CE, DE, CDF, DEF

WebCola (with graph)



GroupNet

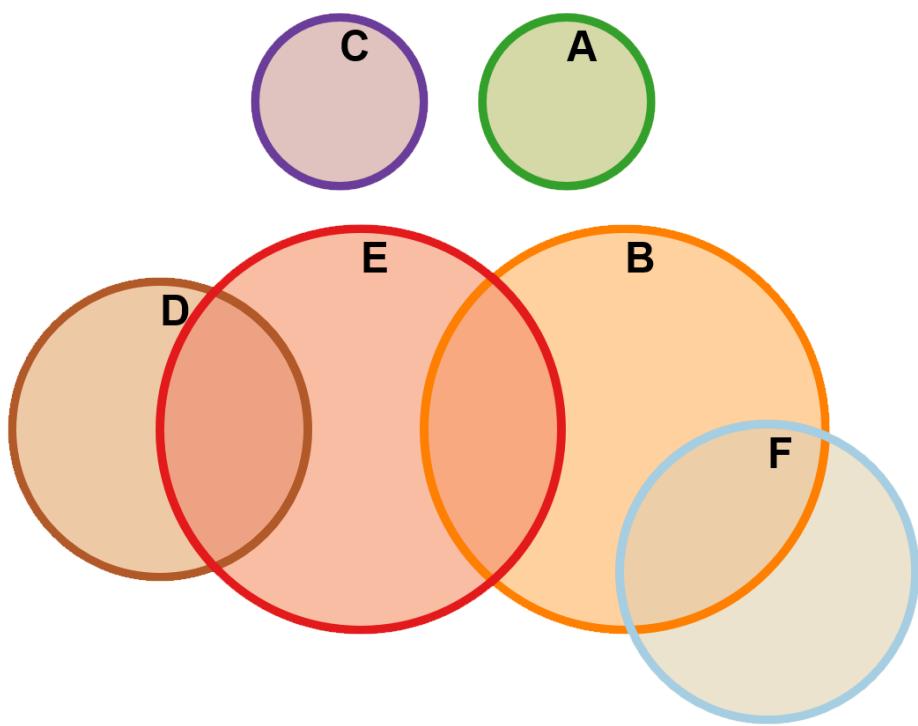


6-set data set 8 : SNAP ID: 170729553

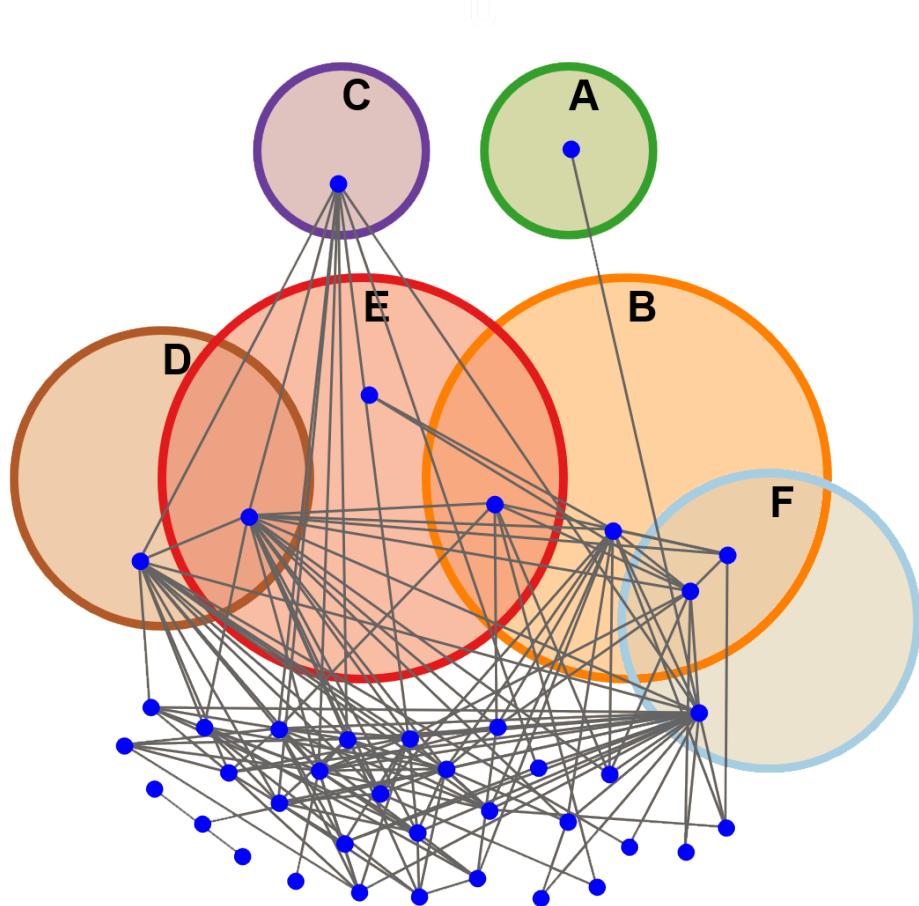
Number of Sets: 6
 Number of Zones: 10
 Number of Nodes: 40
 Number of Edges: 152
 Zones high: yes
 Nodes high: yes
 Edges high: yes

	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

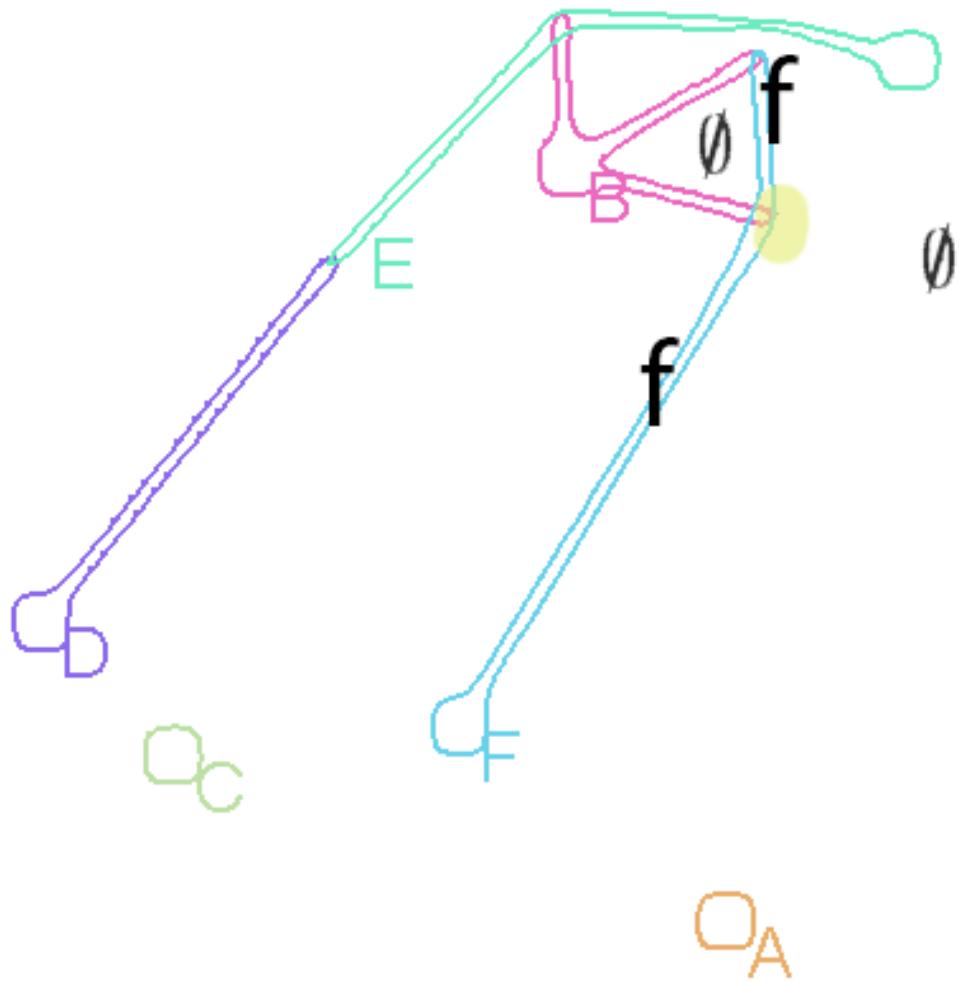
SetNet (without graph)



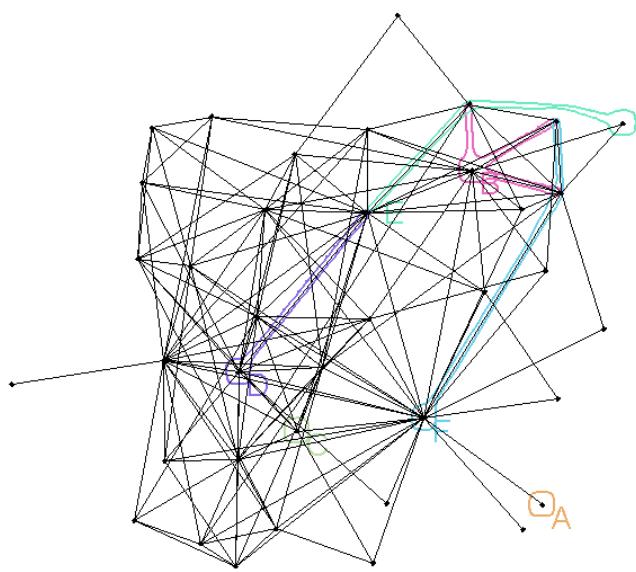
SetNet (with graph)



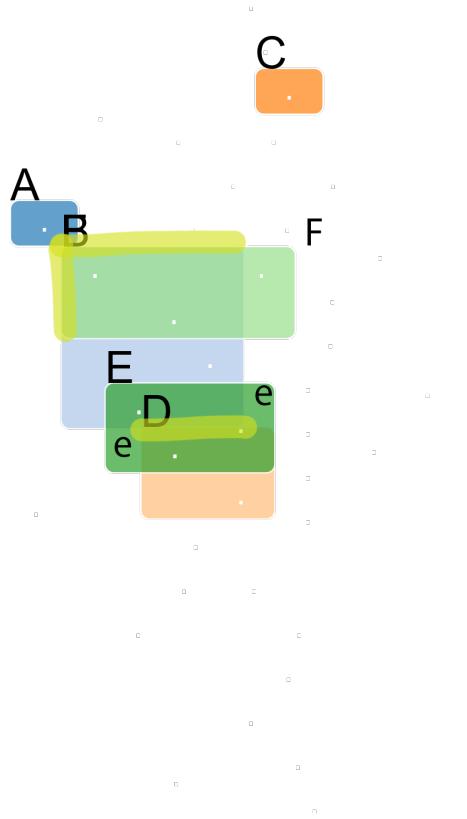
BubbleSets (without graph)



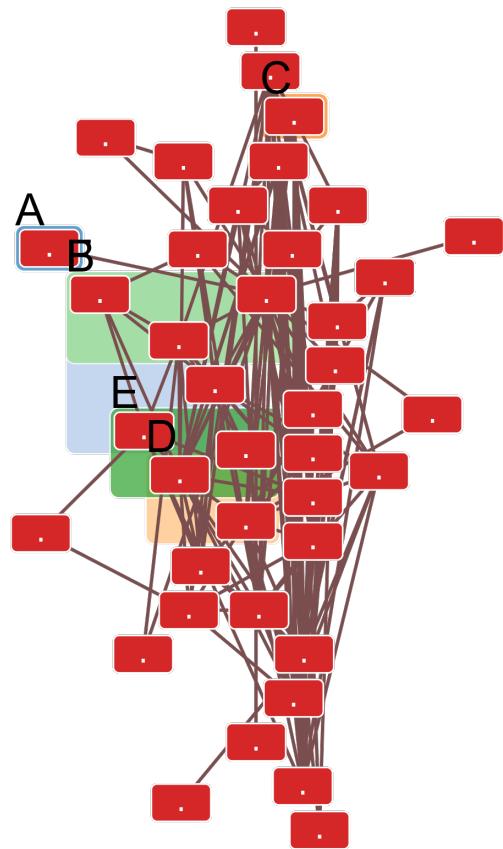
BubbleSets (with graph)



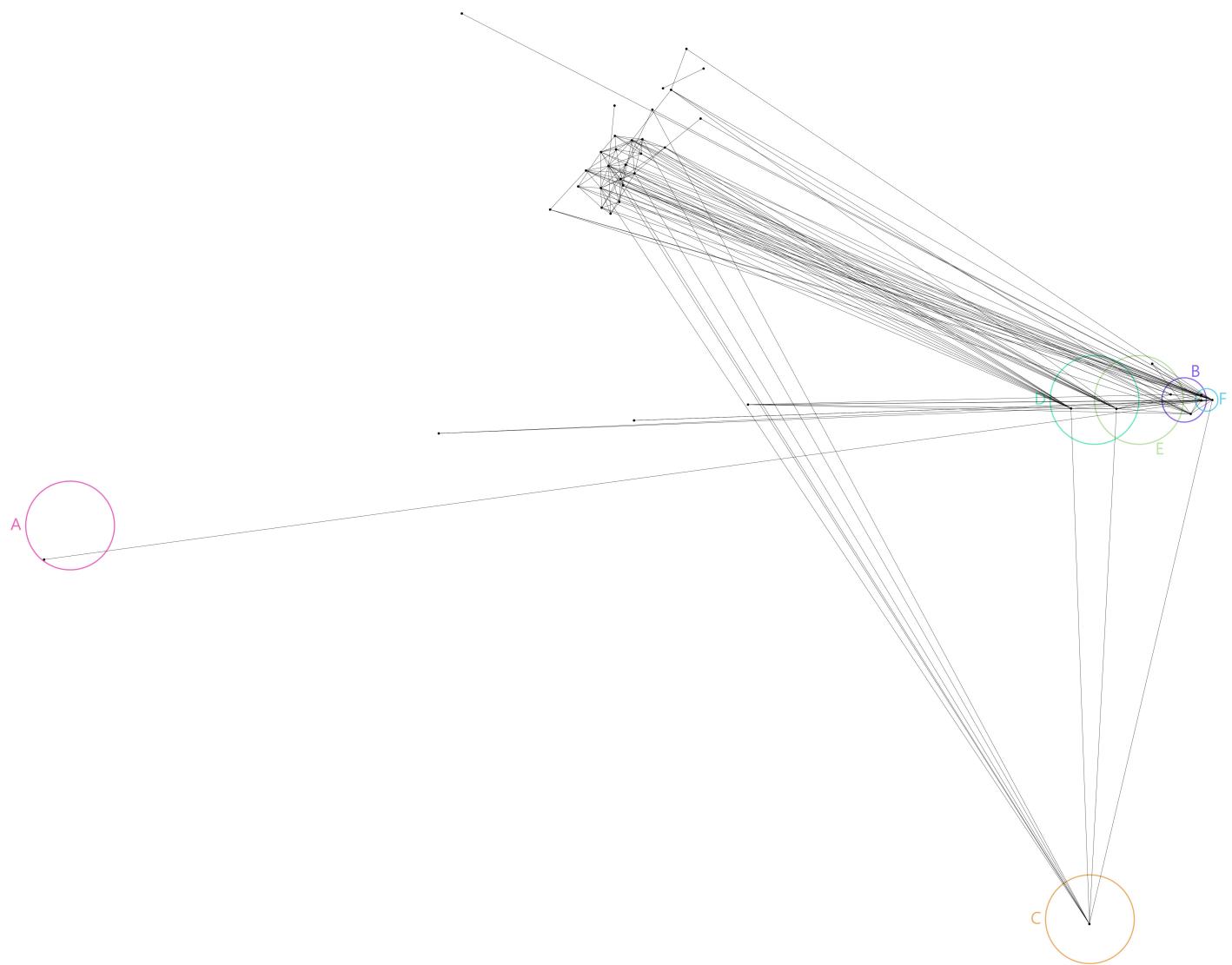
WebCola (without graph)



WebCola (with graph)



GroupNet

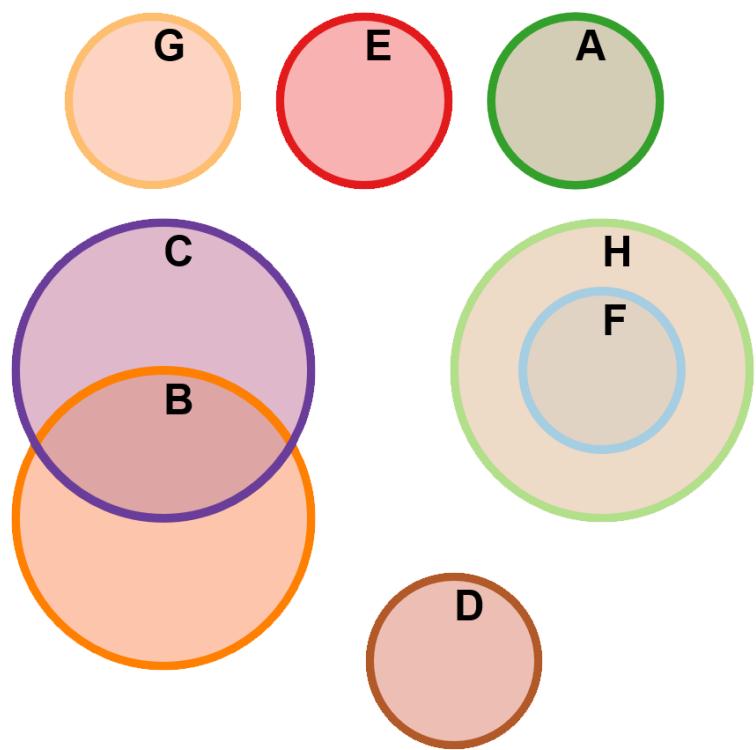


8-set data set 1 : SNAP ID: 11348282

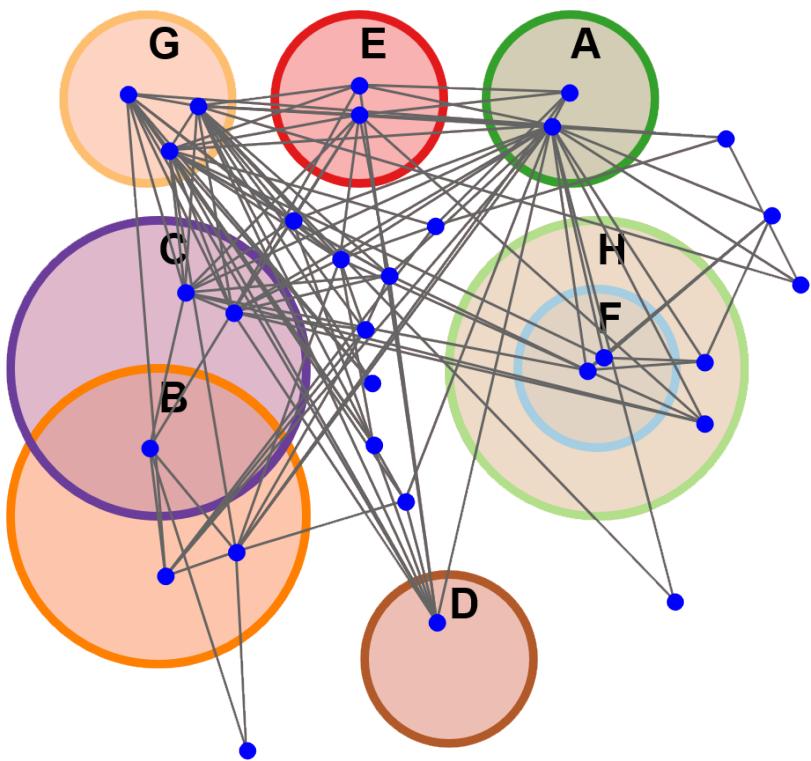
Number of Sets: 8
Number of Zones: 10
Number of Nodes: 30
Number of Edges: 118
Zones high: no
Nodes high: no
Edges high: no

	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

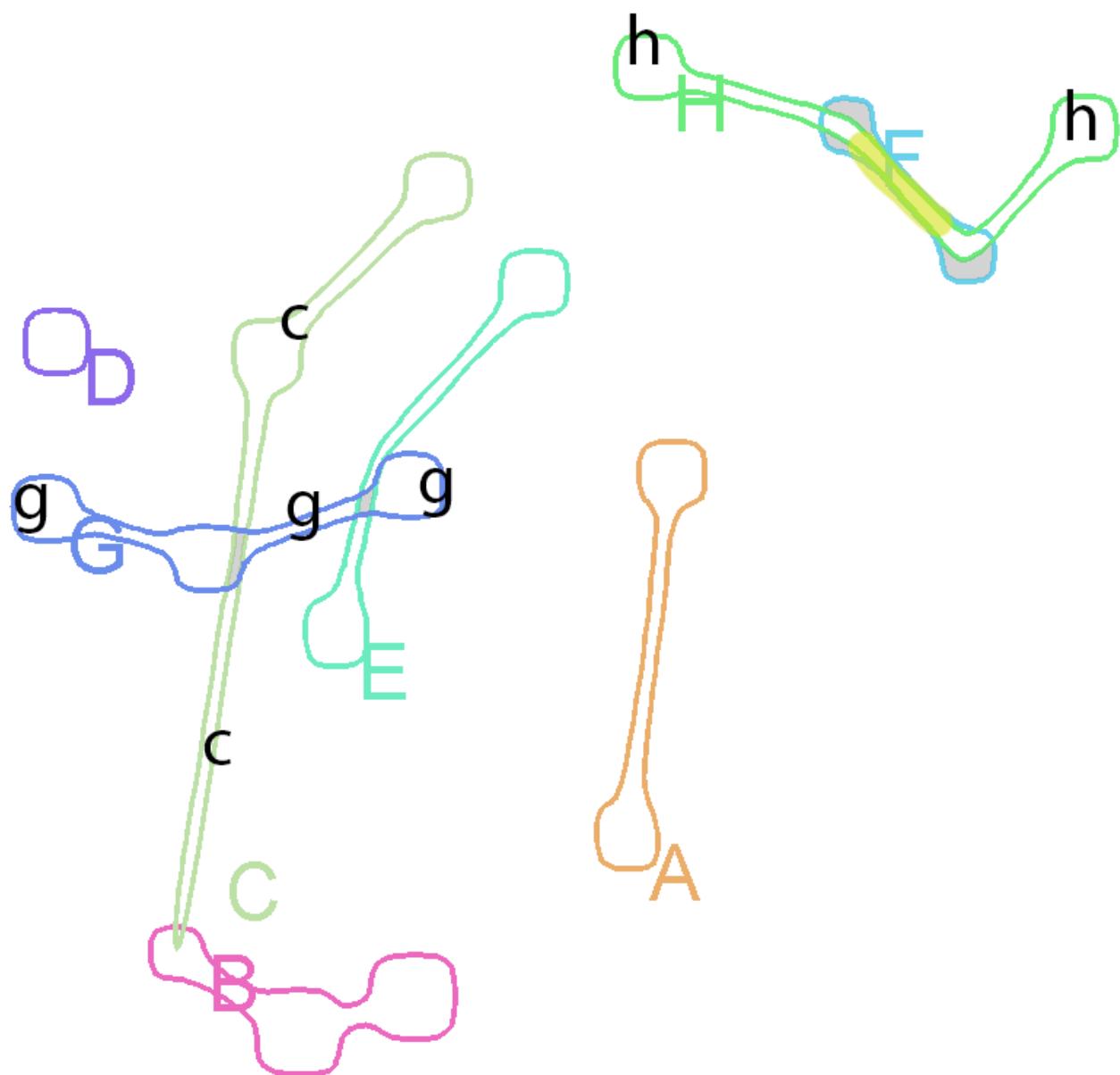
SetNet (without graph)



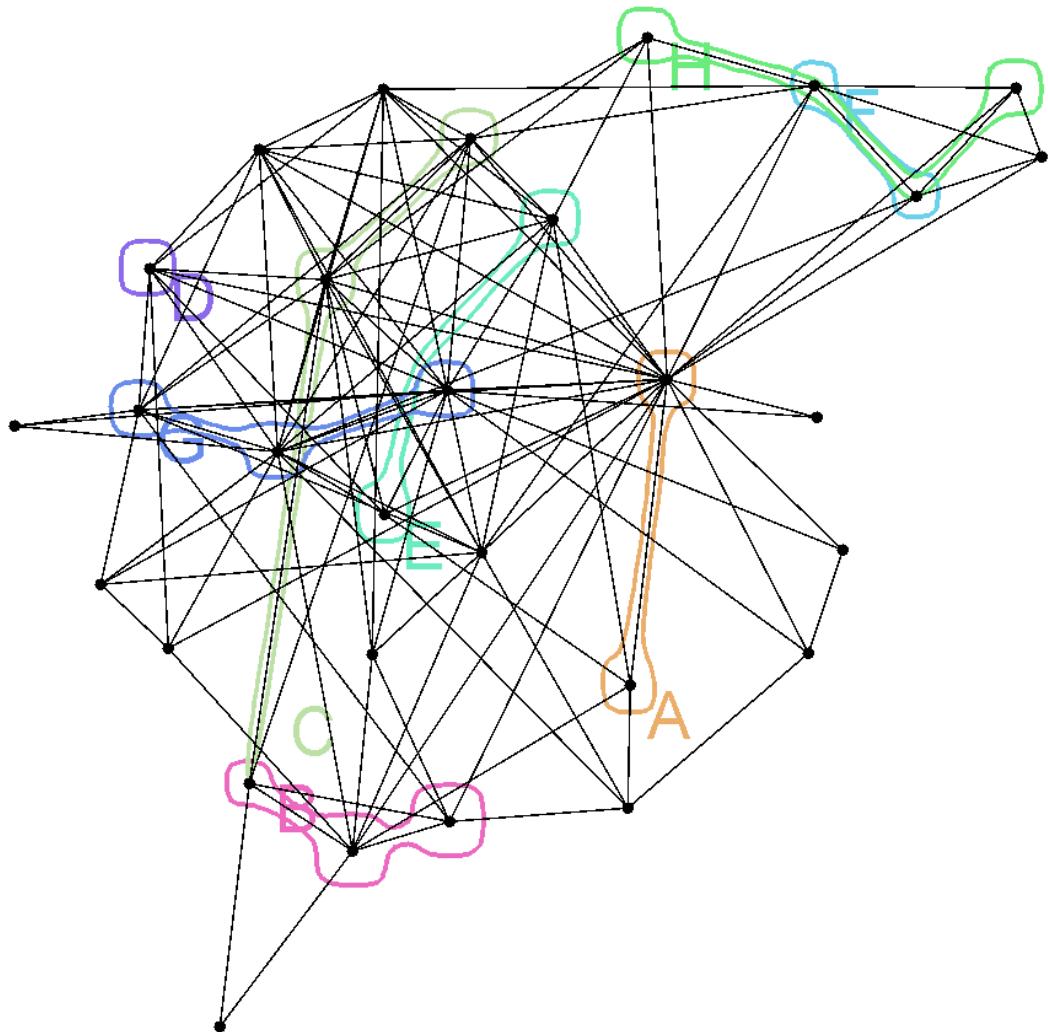
SetNet (with graph)



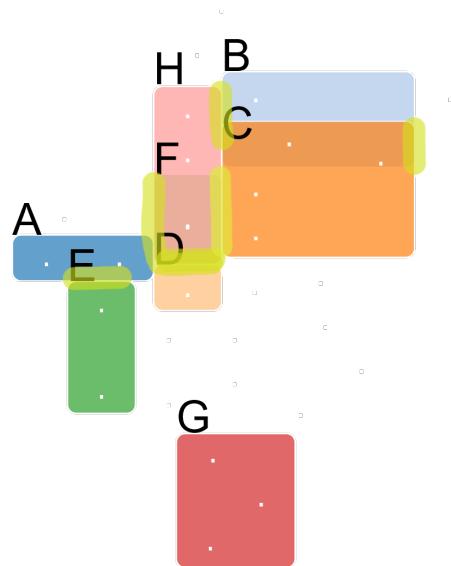
BubbleSets (without graph)



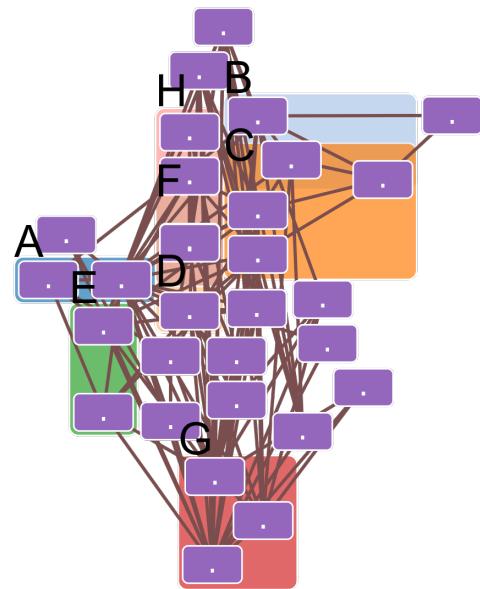
BubbleSets (with graph)



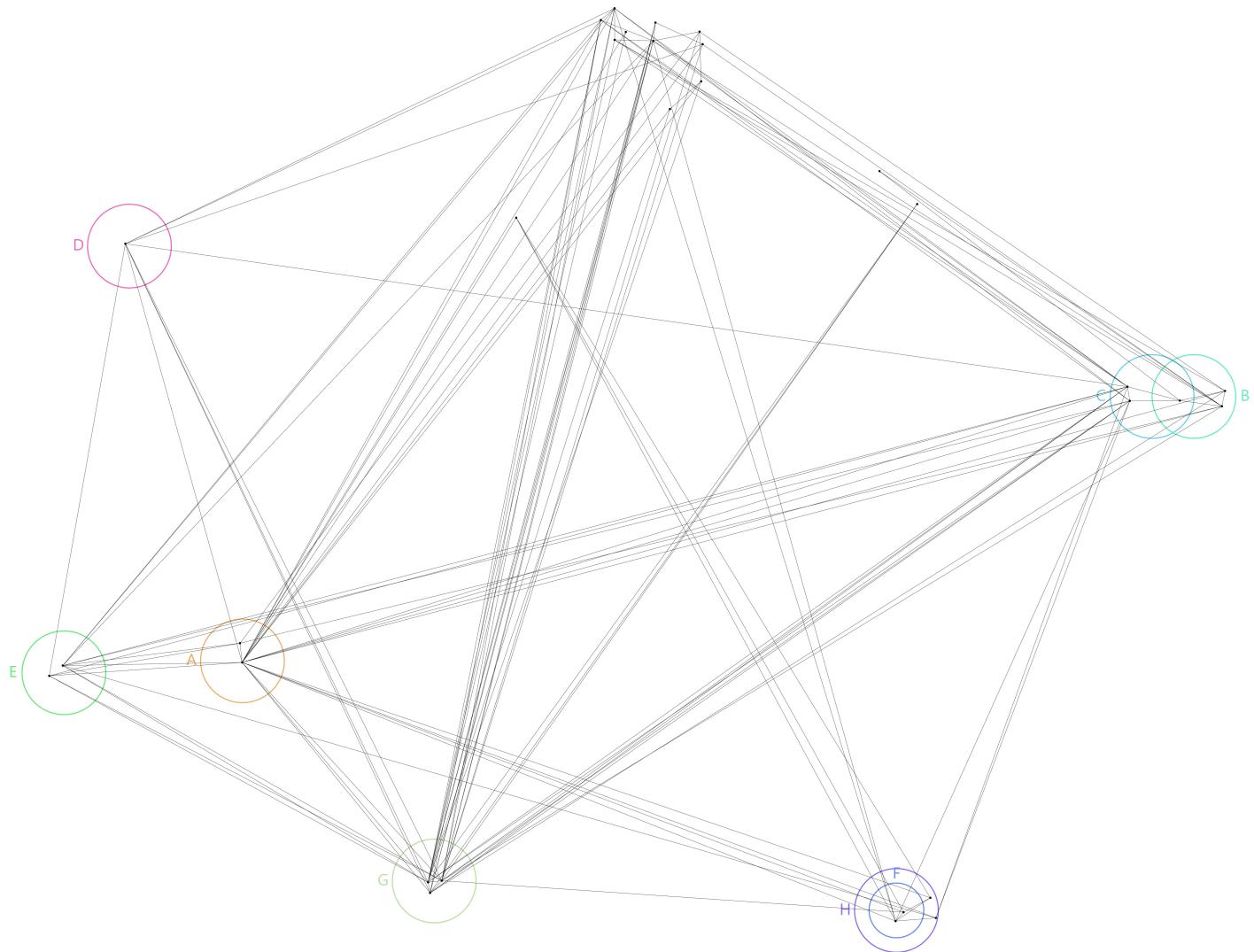
WebCola (without graph)



WebCola (with graph)



GroupNet

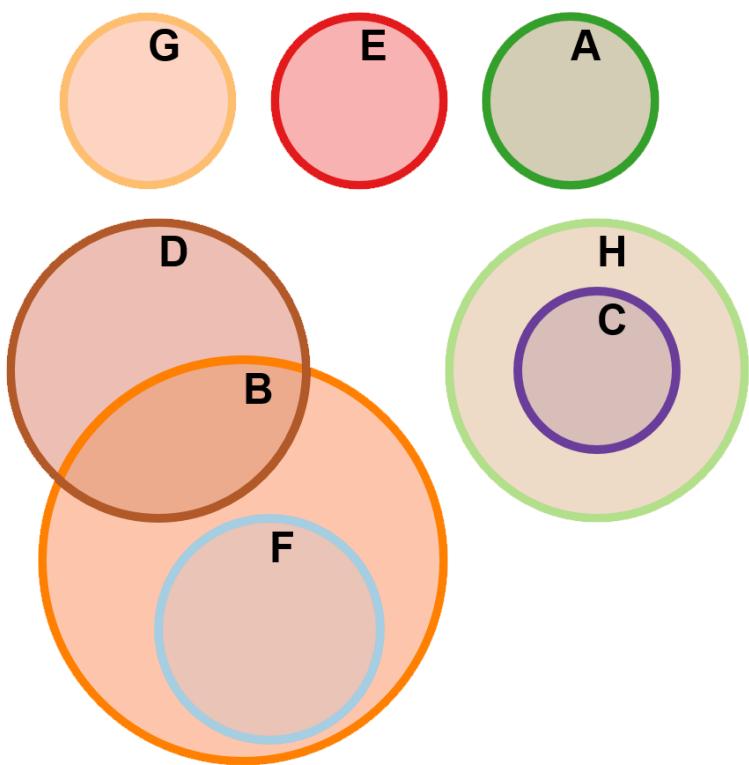


8-set data set 2 : SNAP ID: 21028234

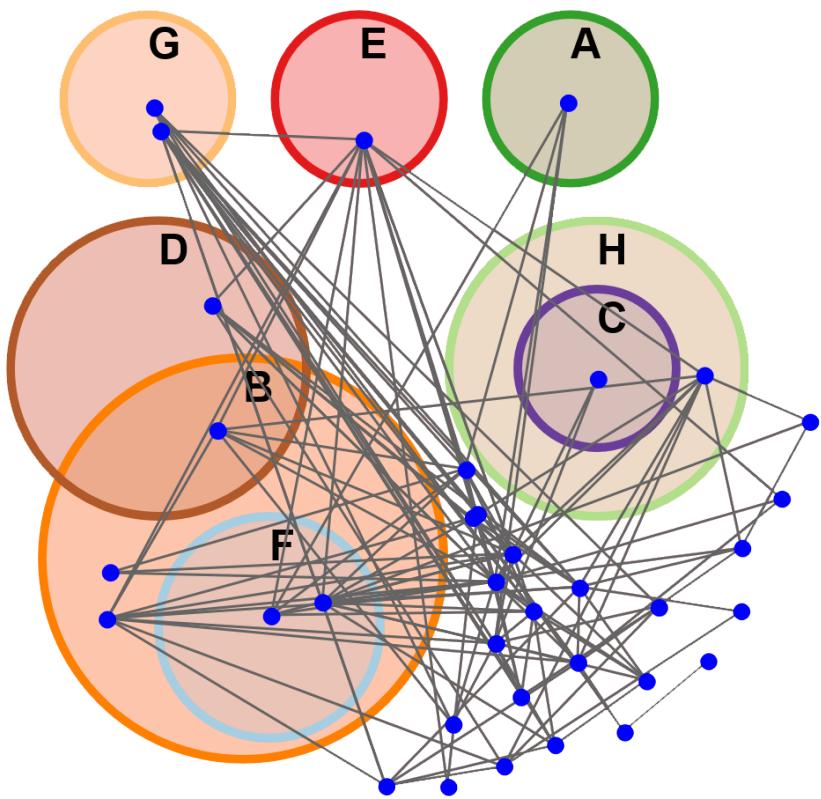
Number of Sets: 8
 Number of Zones: 10
 Number of Nodes: 35
 Number of Edges: 128
 Zones high: no
 Nodes high: no
 Edges high: yes

	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

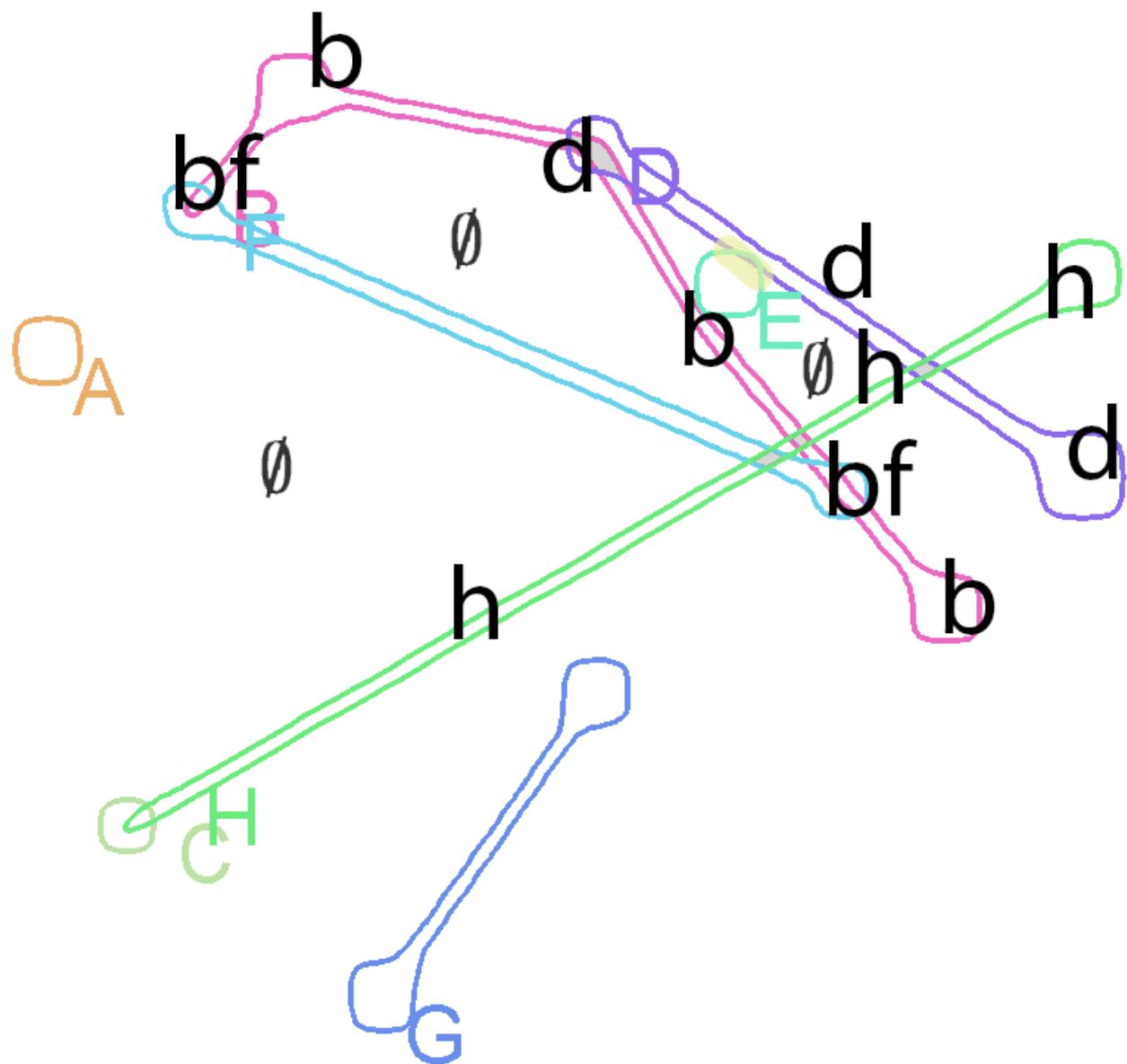
SetNet (without graph)



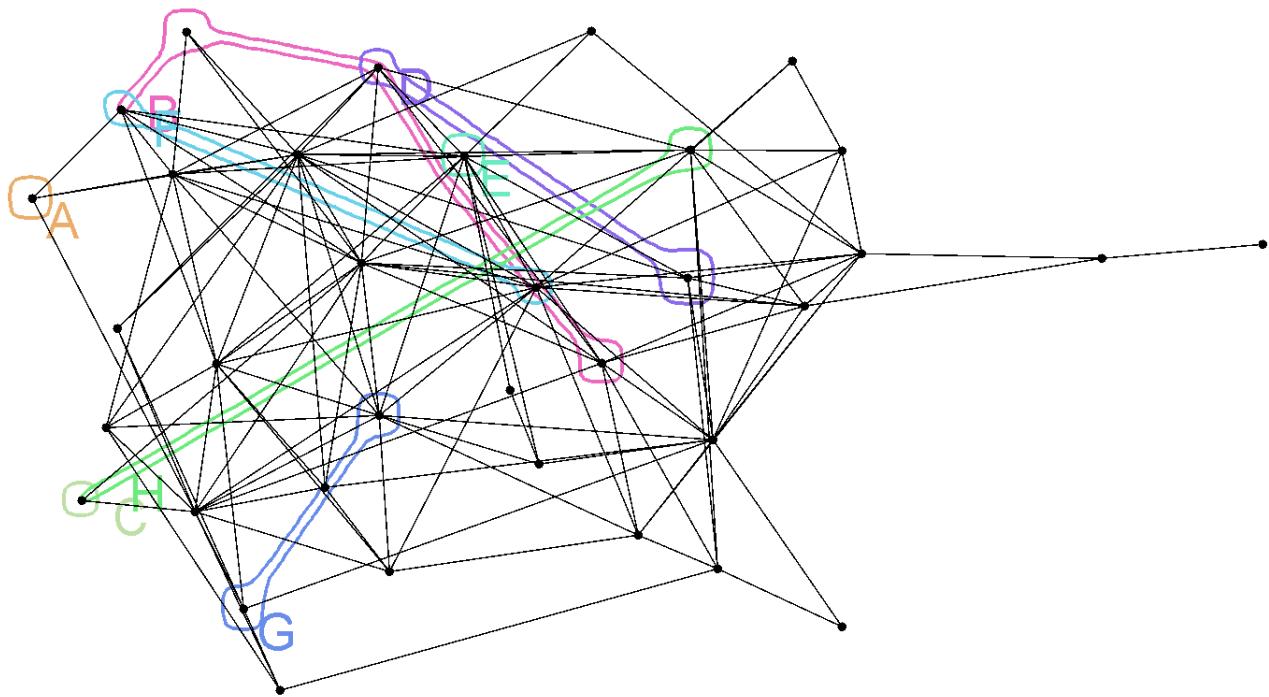
SetNet (with graph)



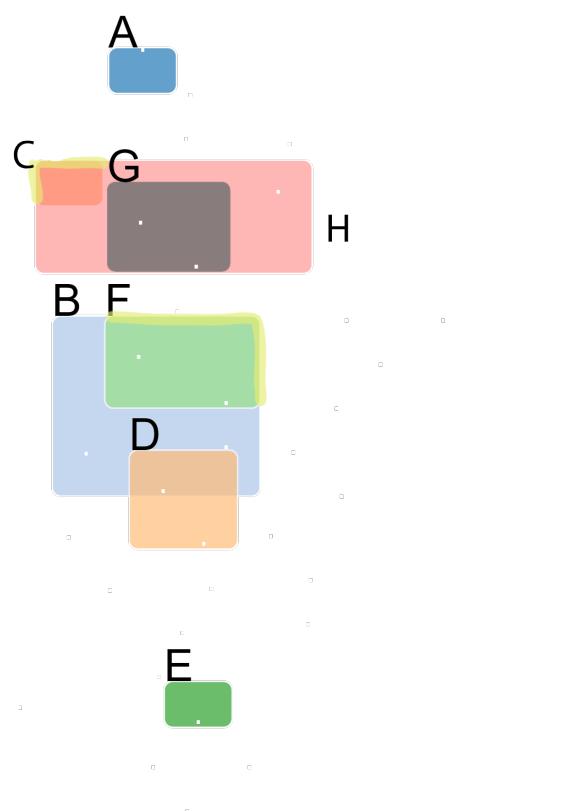
BubbleSets (without graph)



BubbleSets (with graph)

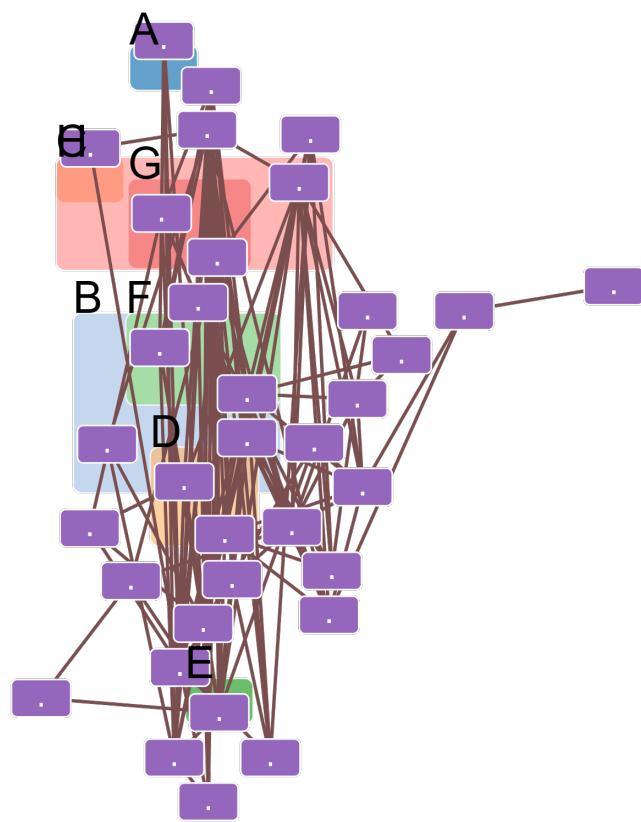


WebCola (without graph)

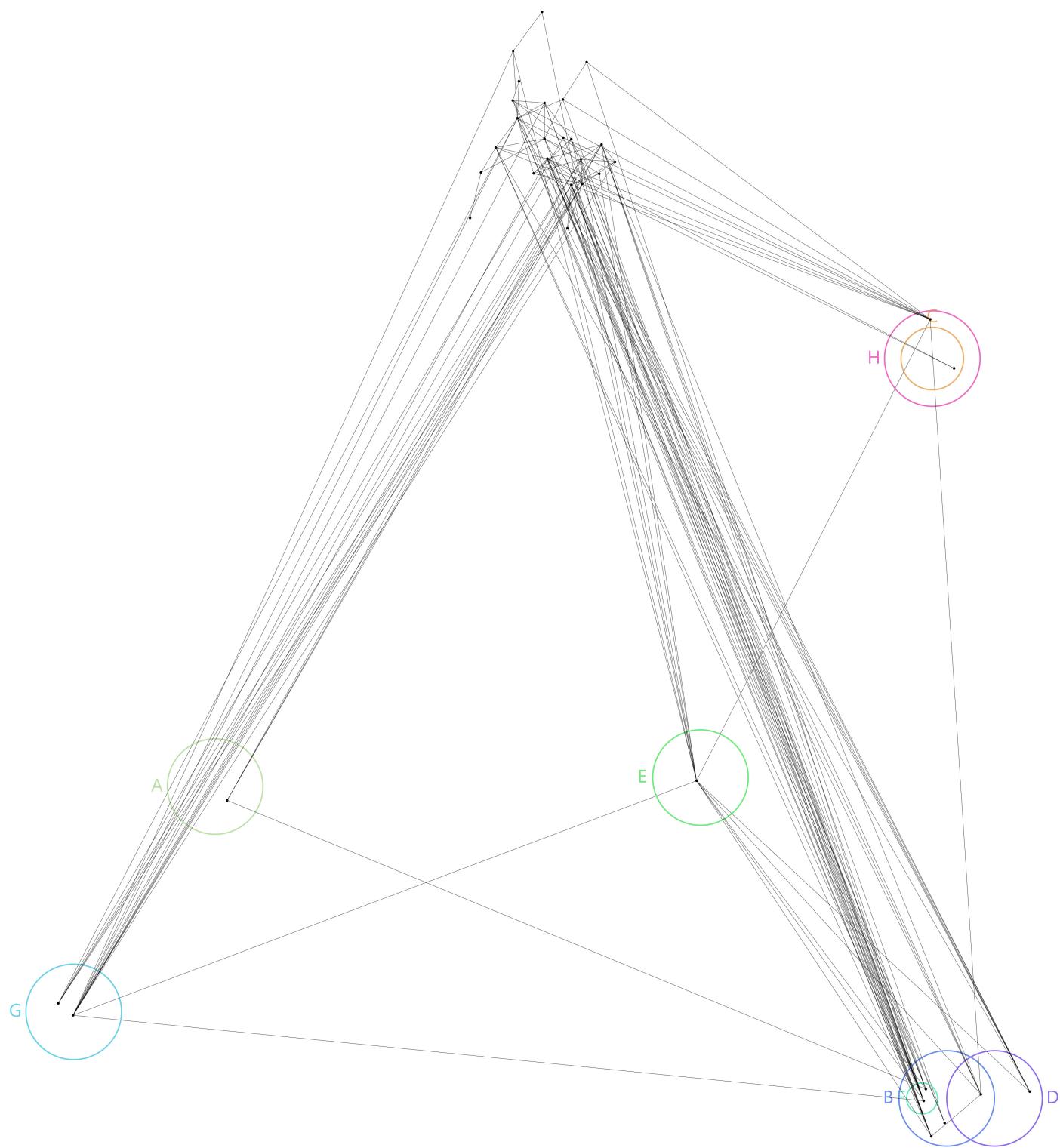


Omitted zones: G

WebCola (with graph)



GroupNet

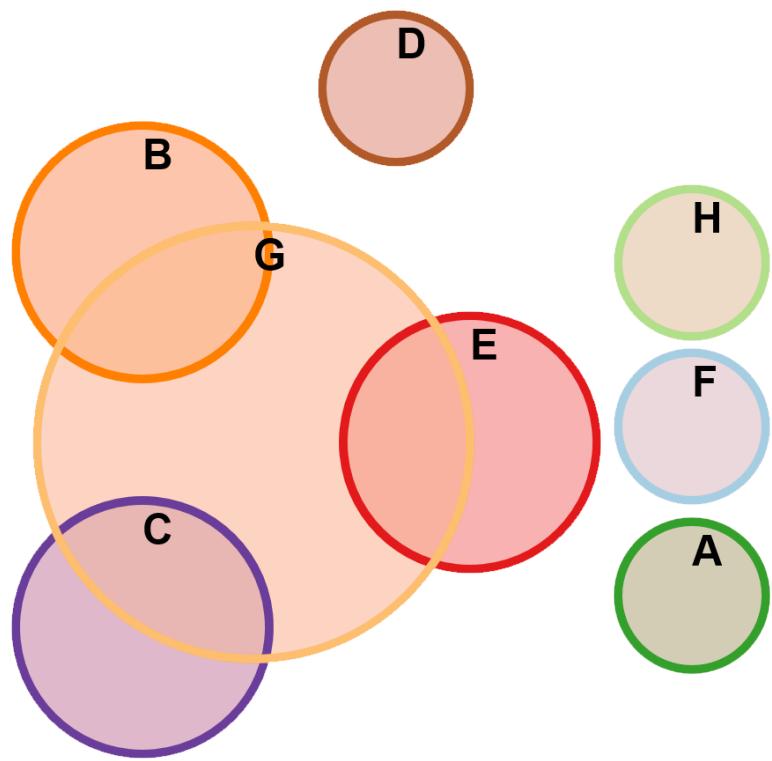


8-set data set 3 : SNAP ID: 61311054

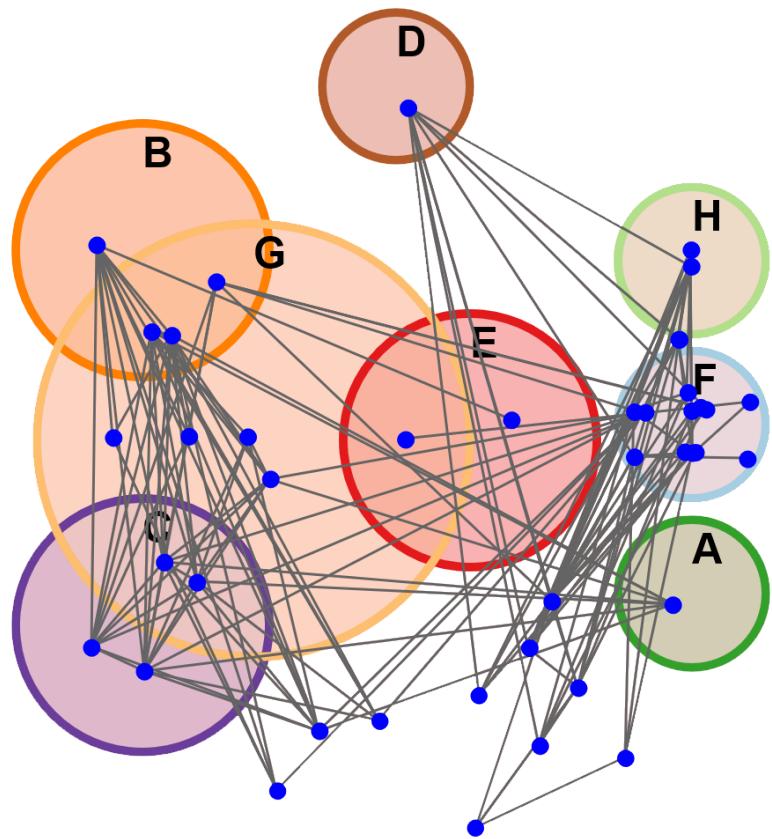
Number of Sets: 8
 Number of Zones: 12
 Number of Nodes: 43
 Number of Edges: 144
 Zones high: no
 Nodes high: yes
 Edges high: no

	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

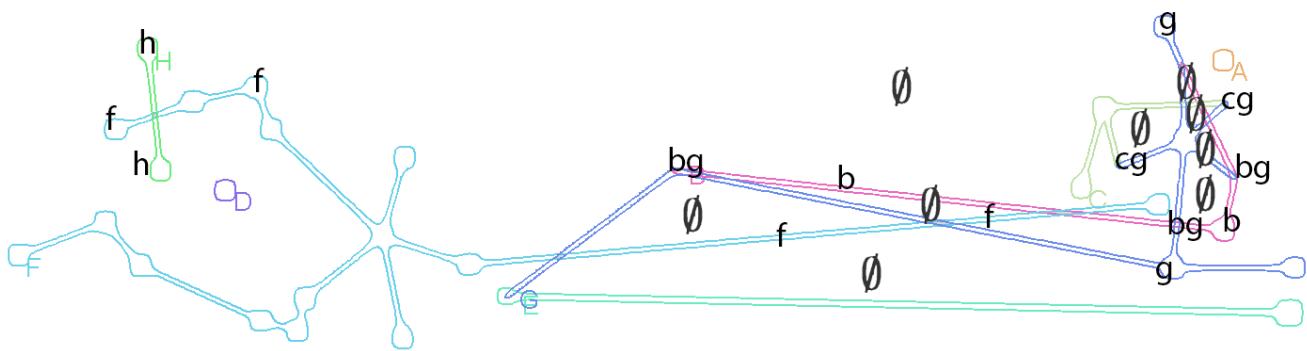
SetNet (without graph)



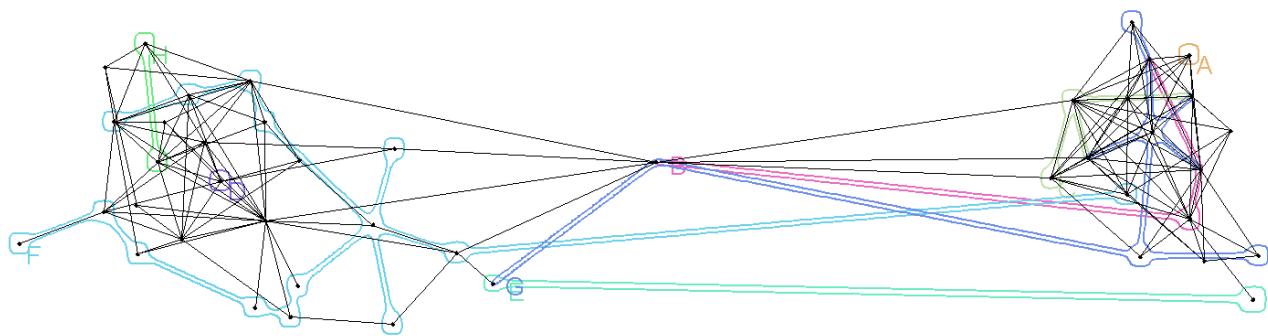
SetNet (with graph)



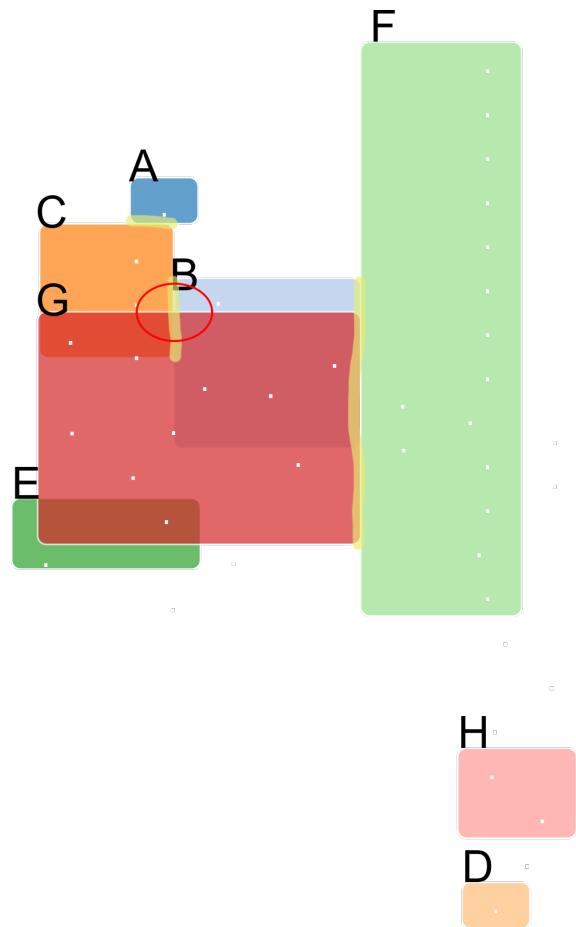
BubbleSets (without graph)



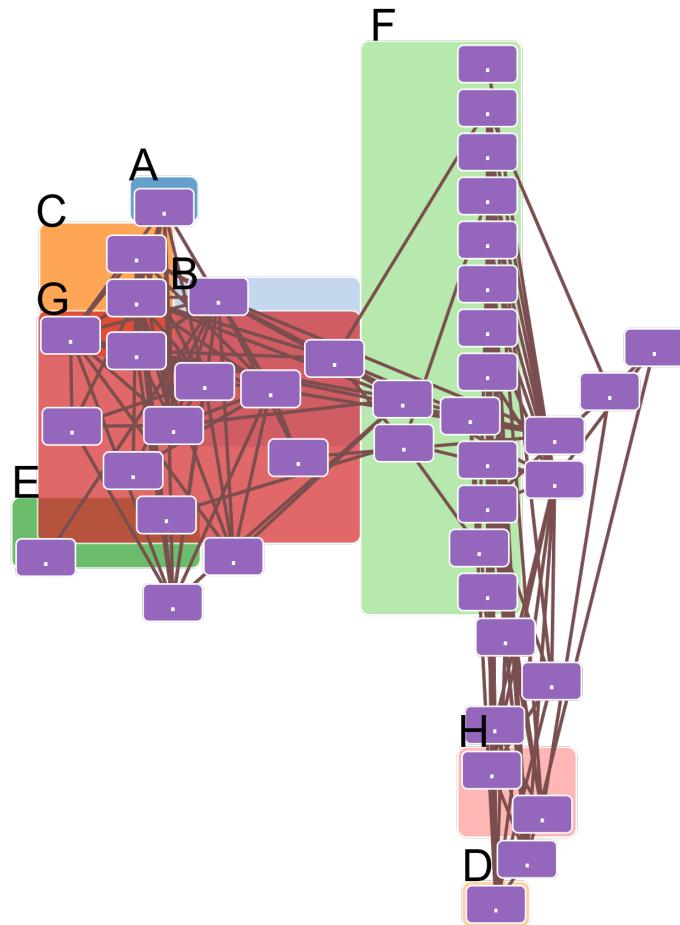
BubbleSets (with graph)



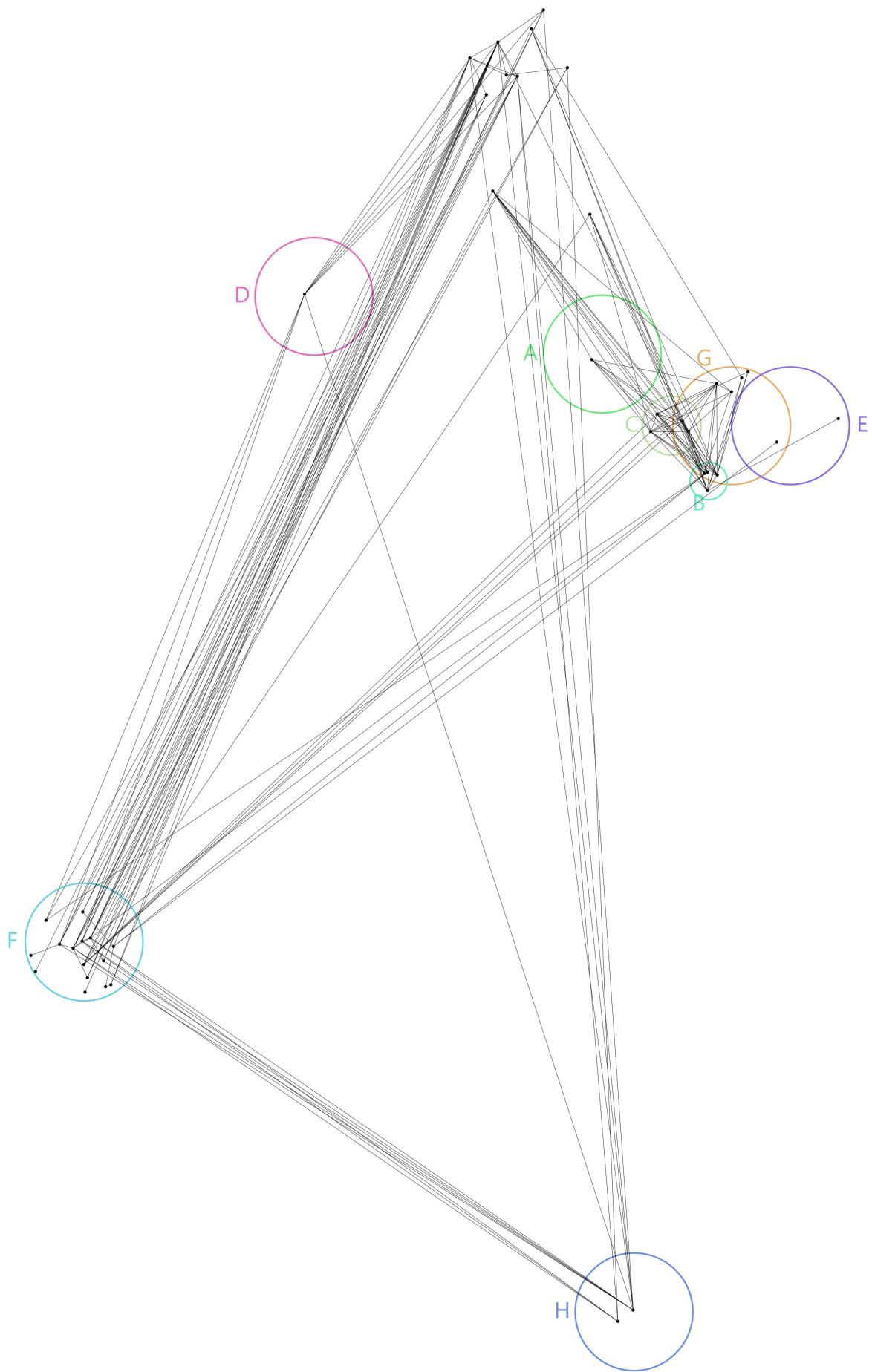
WebCola (without graph)



WebCola (with graph)



GroupNet

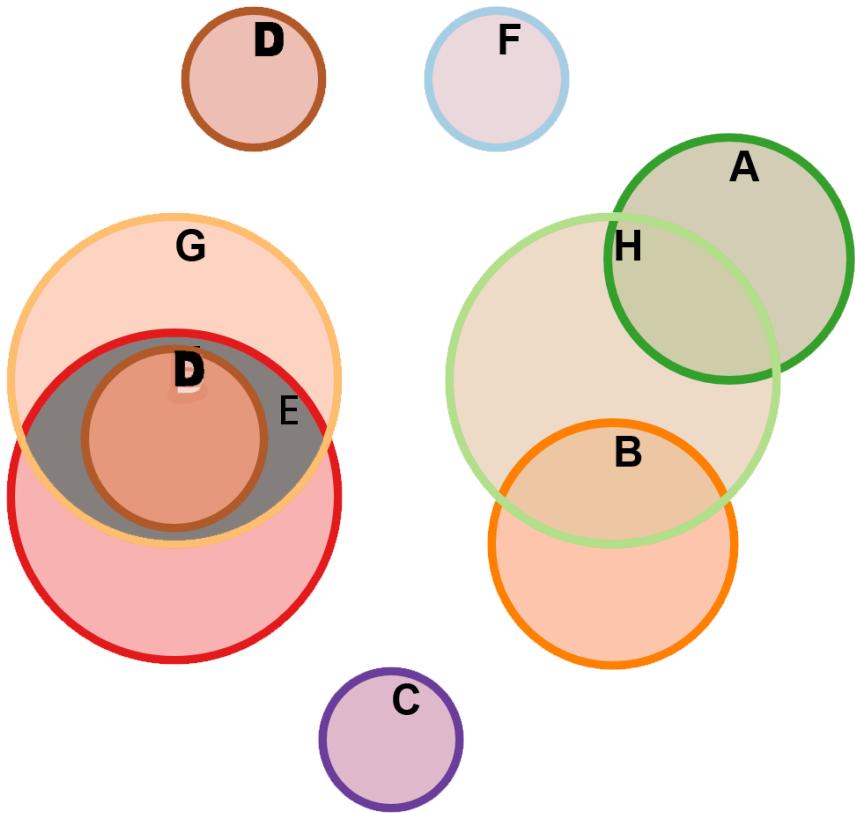


8-set data set 4 : SNAP ID: 13274152

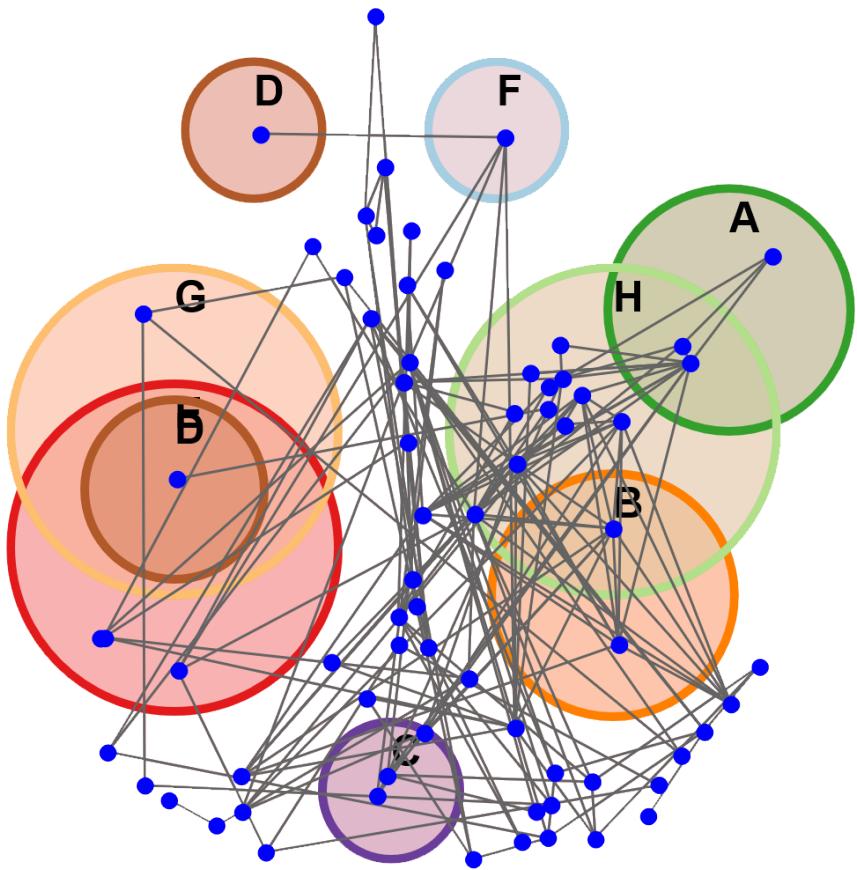
Number of Sets: 8
 Number of Zones: 12
 Number of Nodes: 70
 Number of Edges: 157
 Zones high: no
 Nodes high: yes
 Edges high: yes

	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

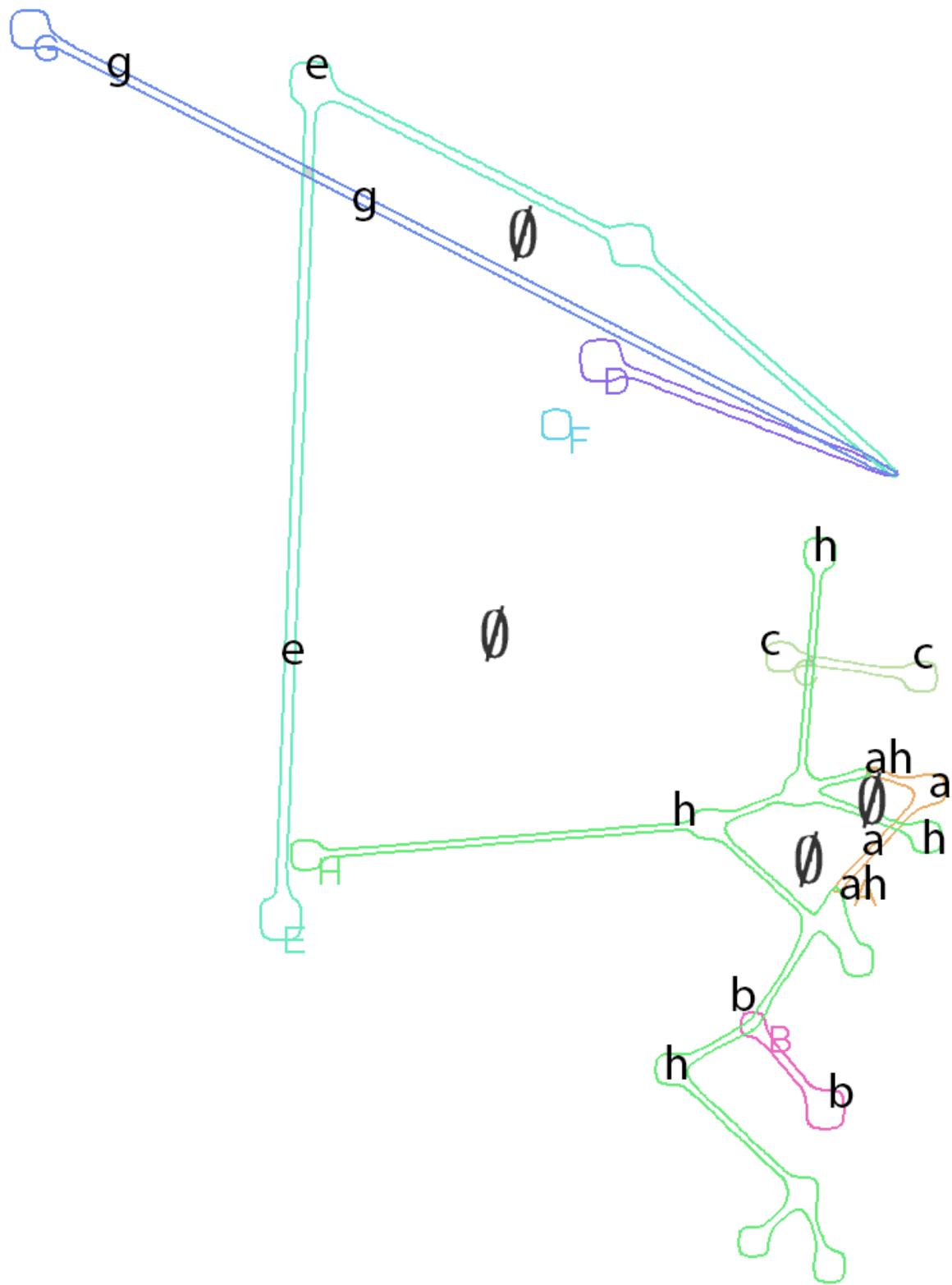
SetNet (without graph)



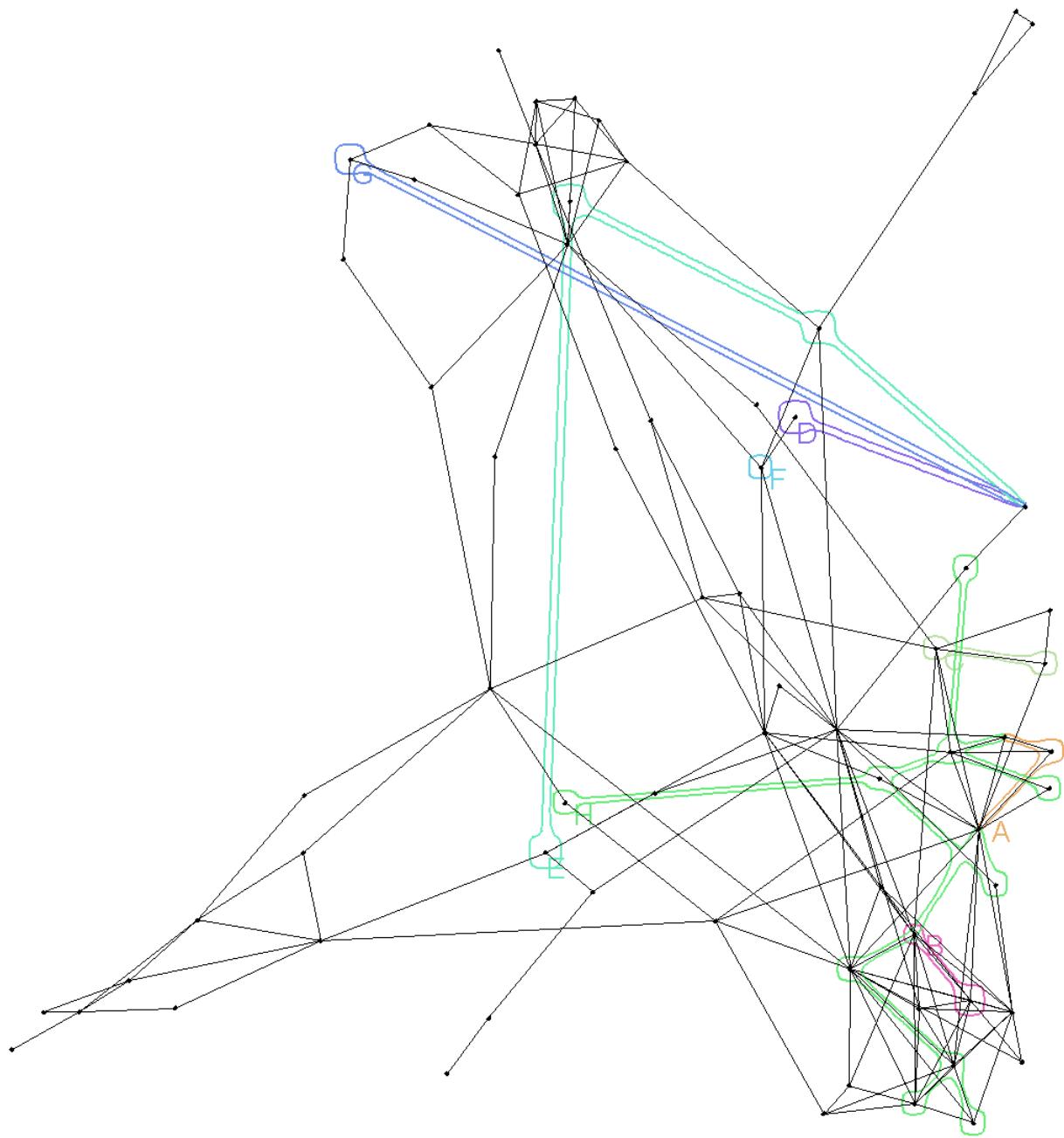
SetNet (with graph)



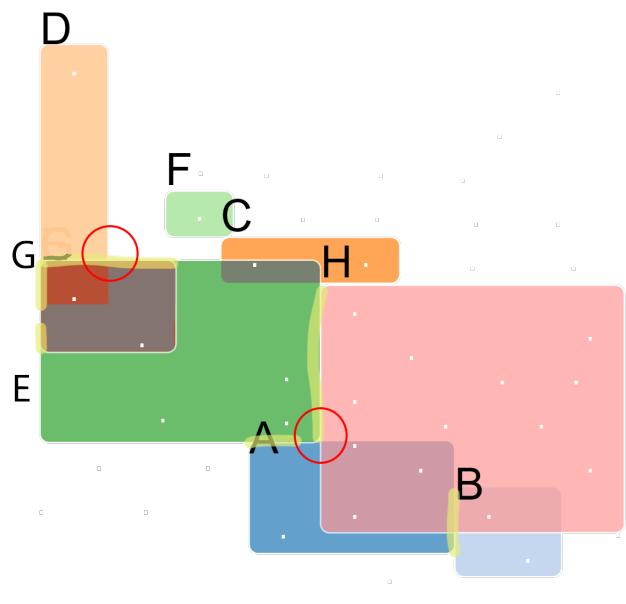
BubbleSets (without graph)



BubbleSets (with graph)

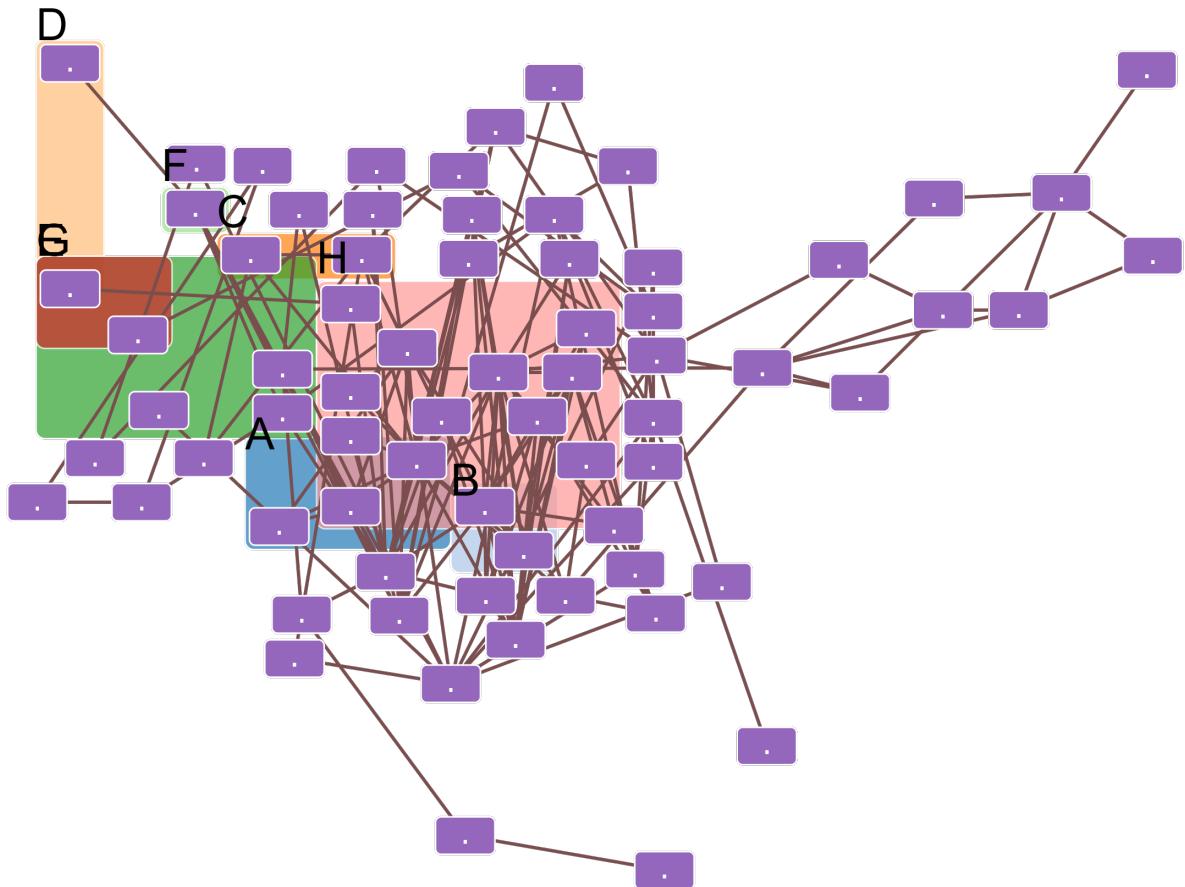


WebCola (without graph)

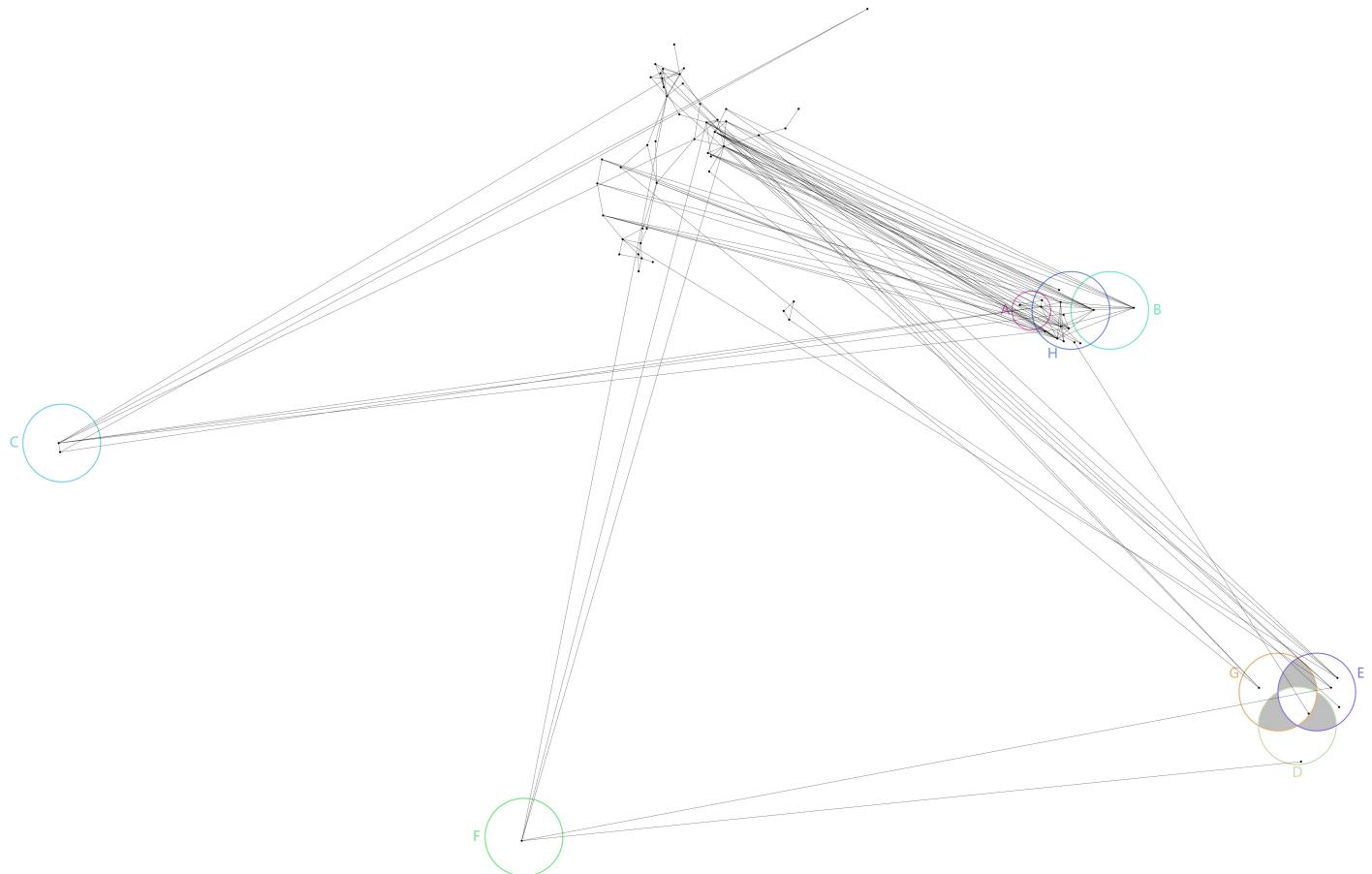


Omitted zones: G

WebCola (with graph)



GroupNet

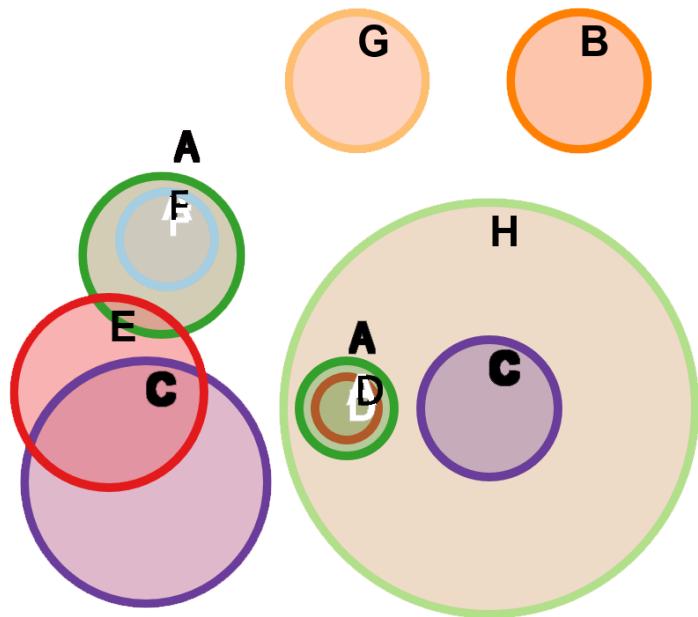


8-set data set 5 : SNAP ID: 77843323

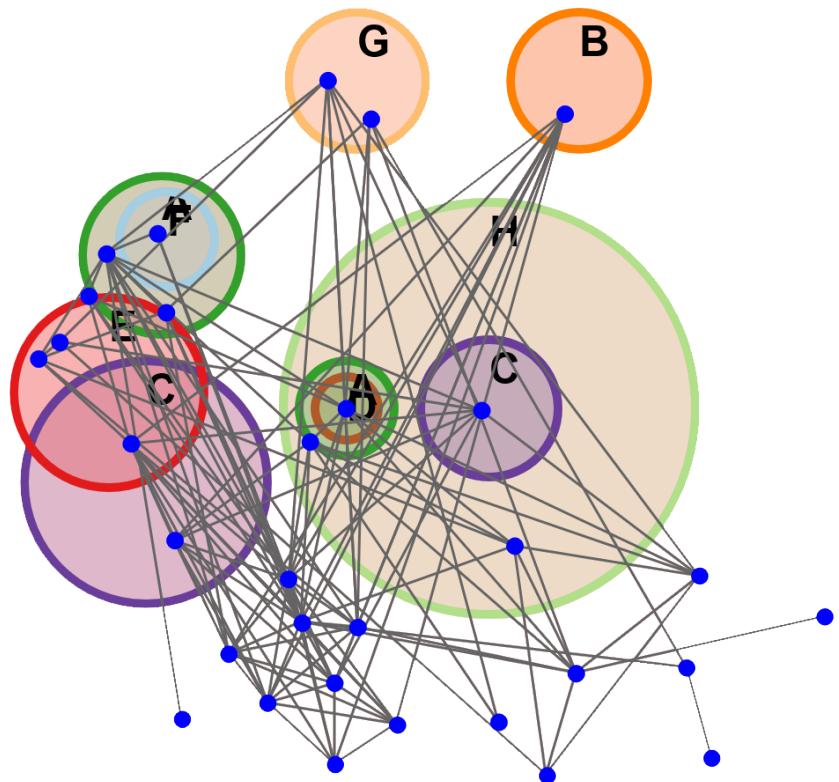
Number of Sets: 8
 Number of Zones: 13
 Number of Nodes: 31
 Number of Edges: 122
 Zones high: yes
 Nodes high: no
 Edges high: no

	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

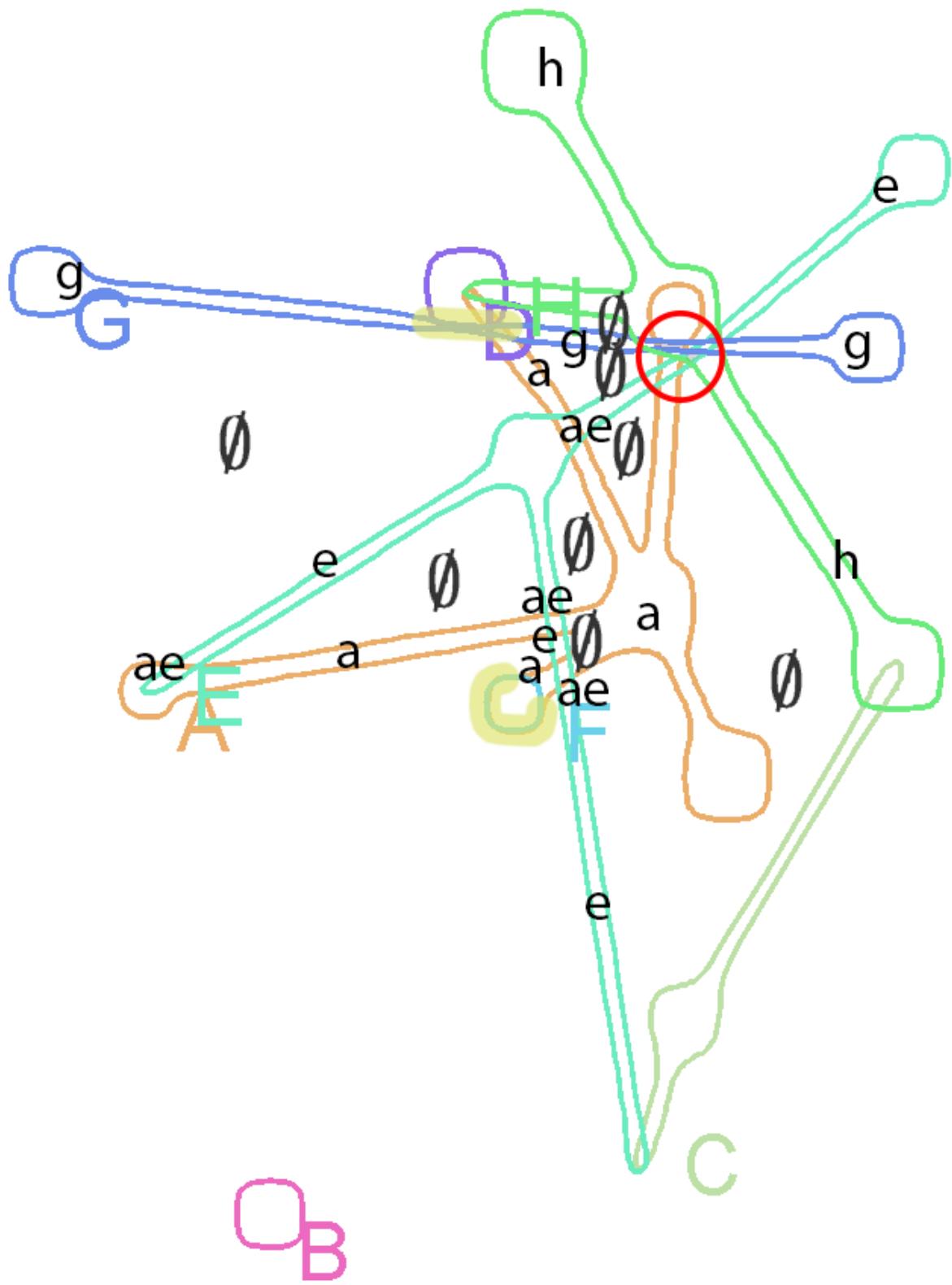
SetNet (without graph)



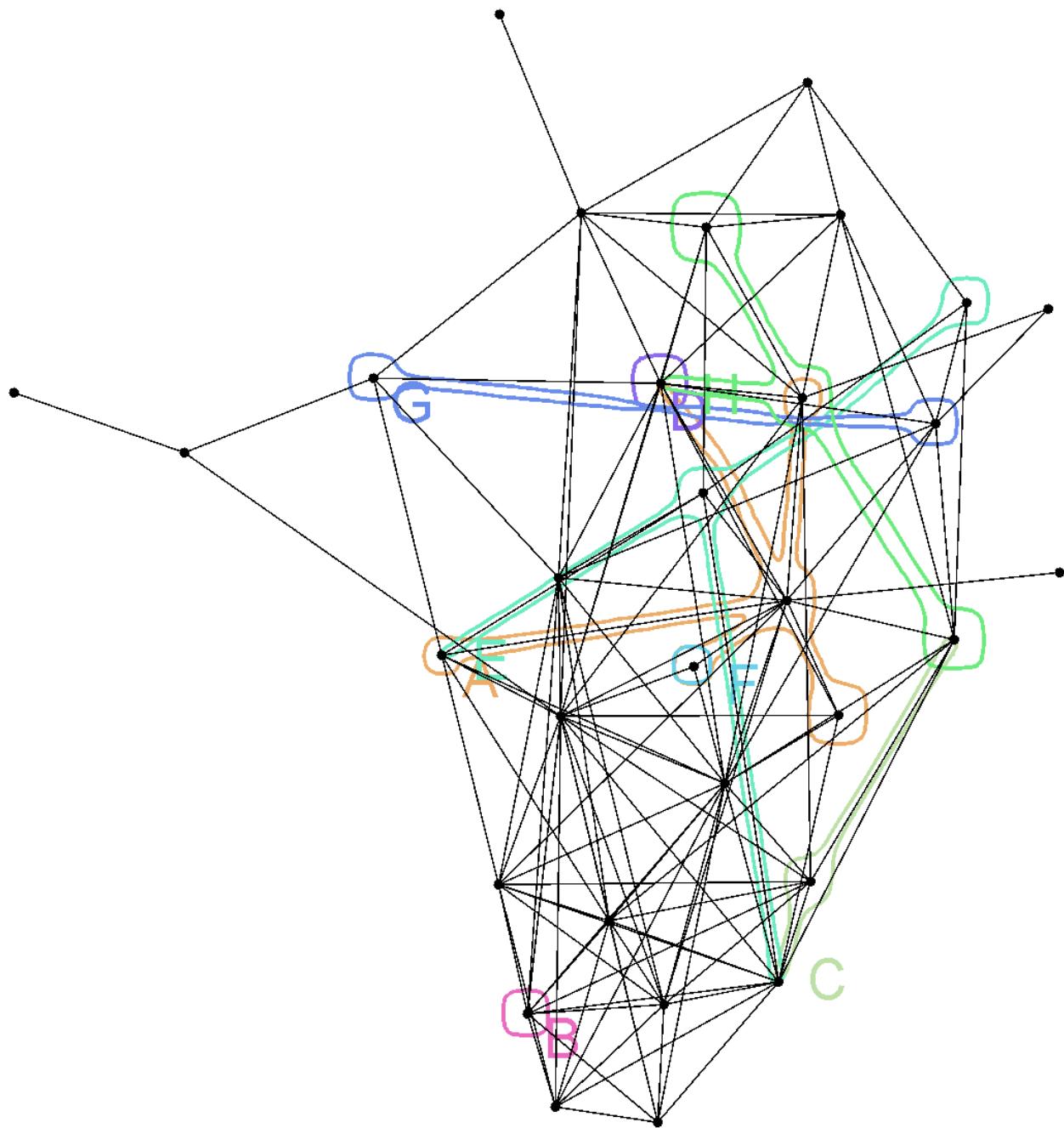
SetNet (with graph)



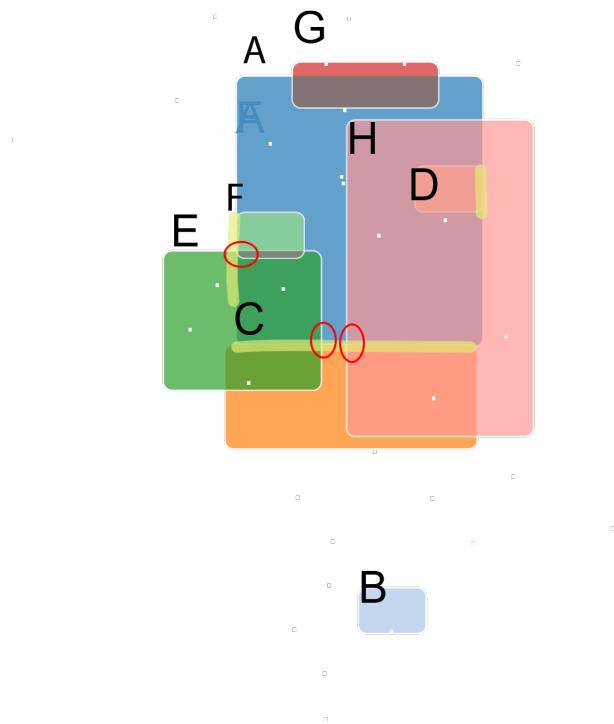
BubbleSets (without graph)



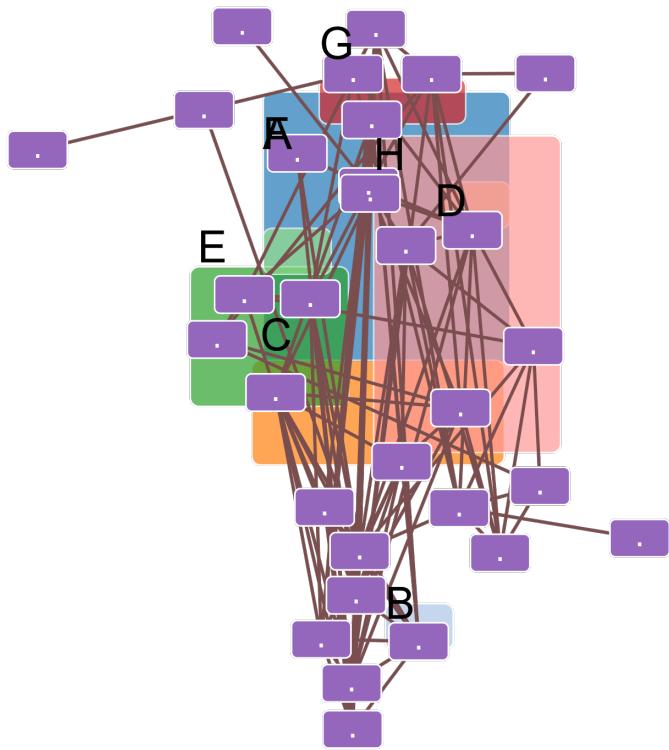
BubbleSets (with graph)



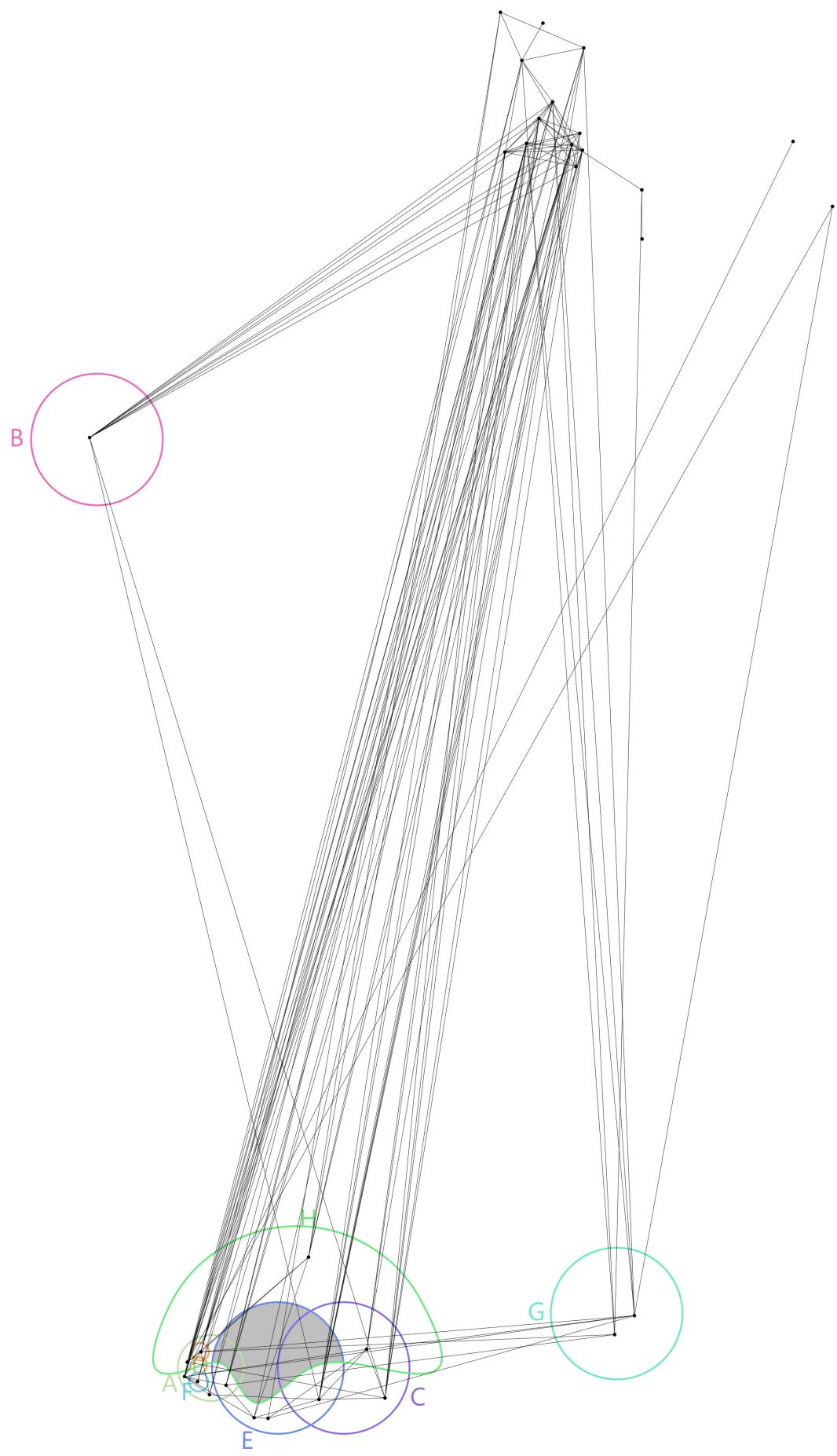
WebCola (without graph)



WebCola (with graph)



GroupNet

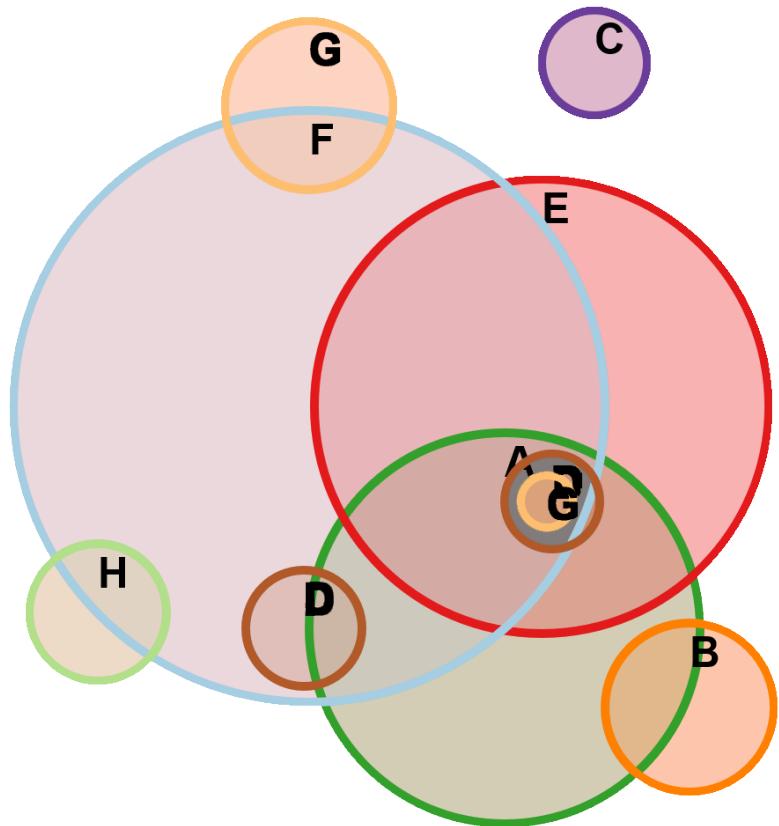


8-set data set 6 : SNAP ID: 45310286

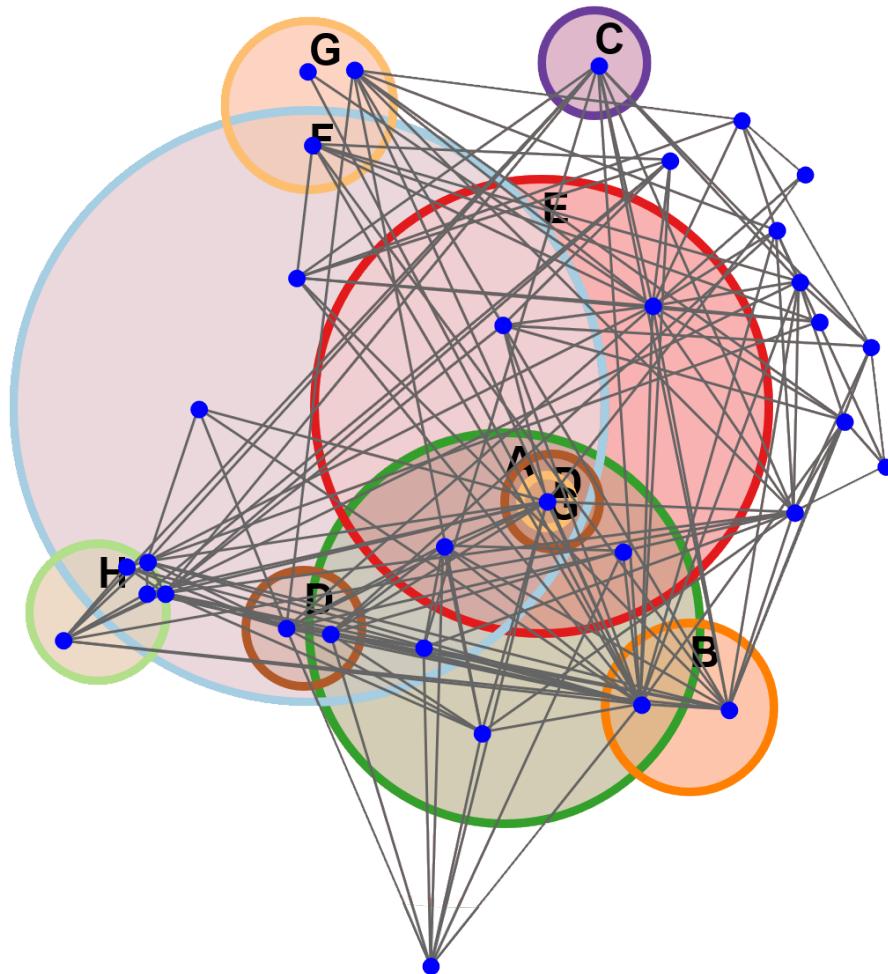
Number of Sets: 8
 Number of Zones: 19
 Number of Nodes: 33
 Number of Edges: 148
 Zones high: yes
 Nodes high: yes
 Edges high: no

	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

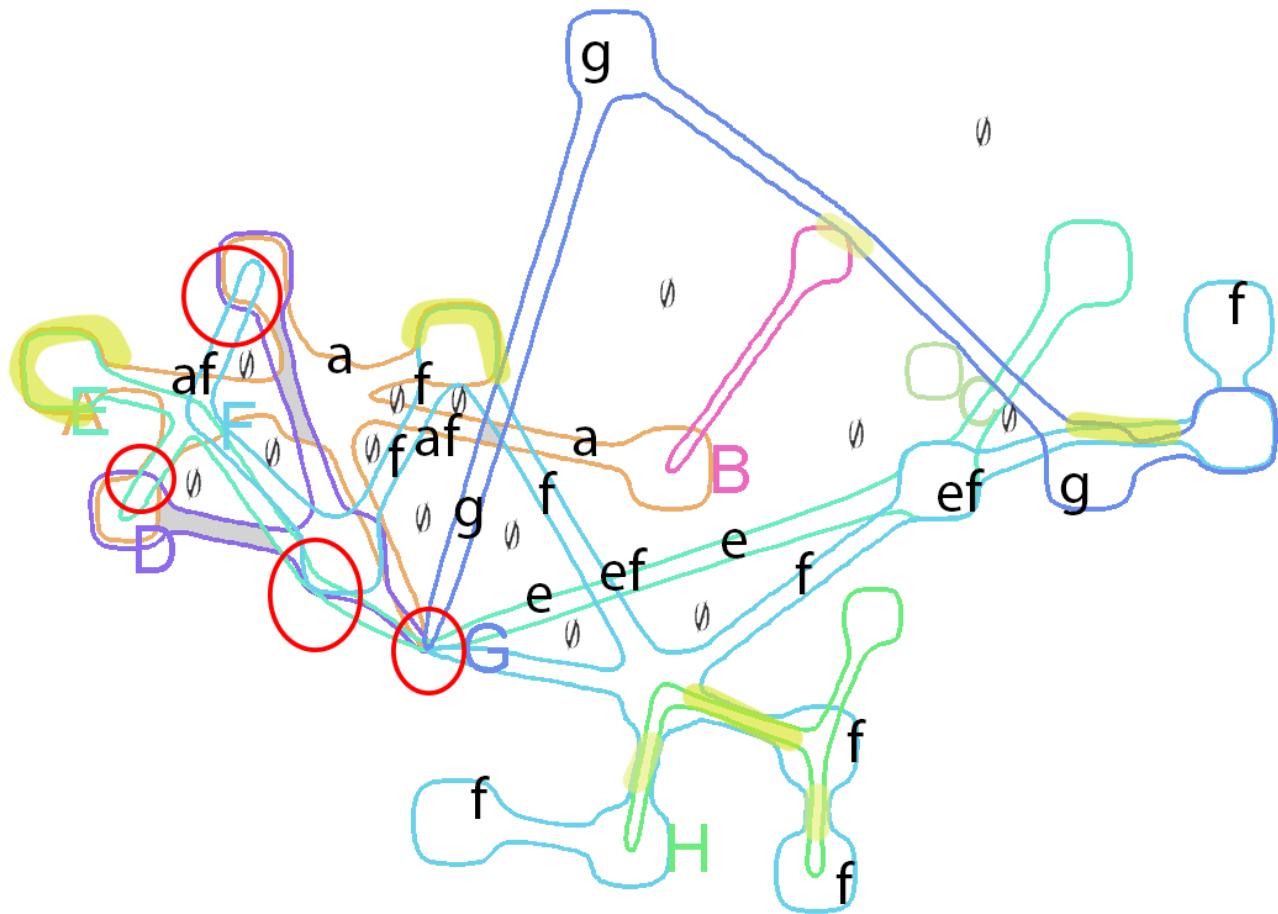
SetNet (without graph)



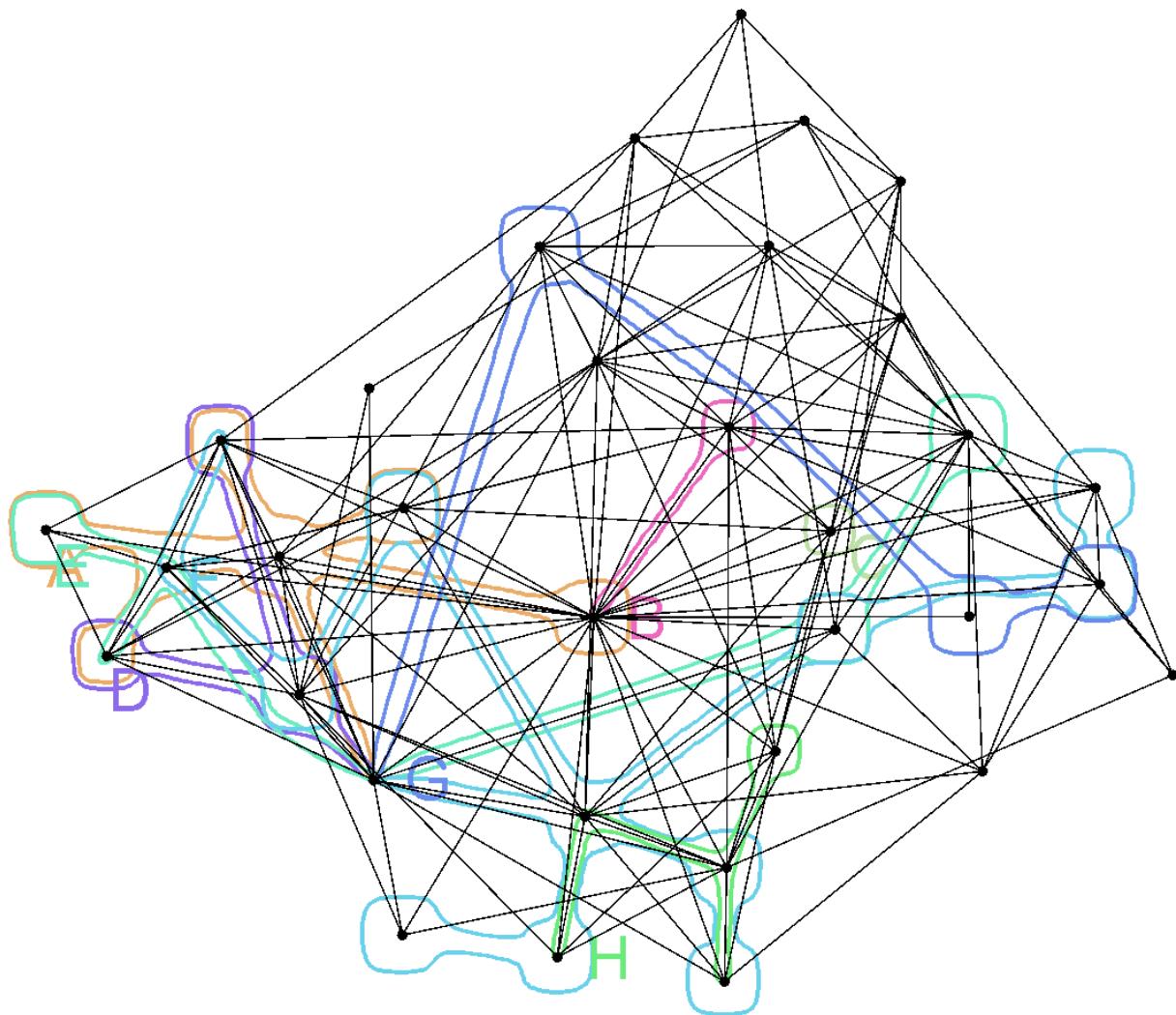
SetNet (with graph)



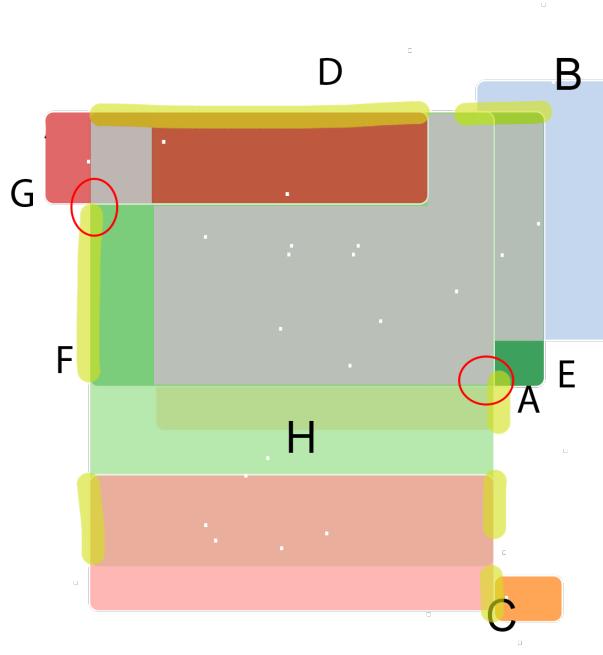
BubbleSets (without graph)



BubbleSets (with graph)

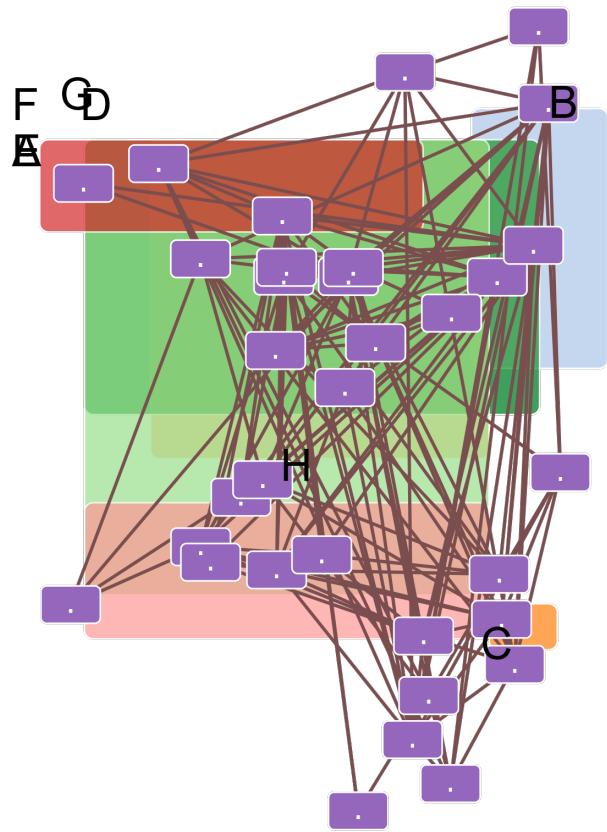


WebCola (without graph)

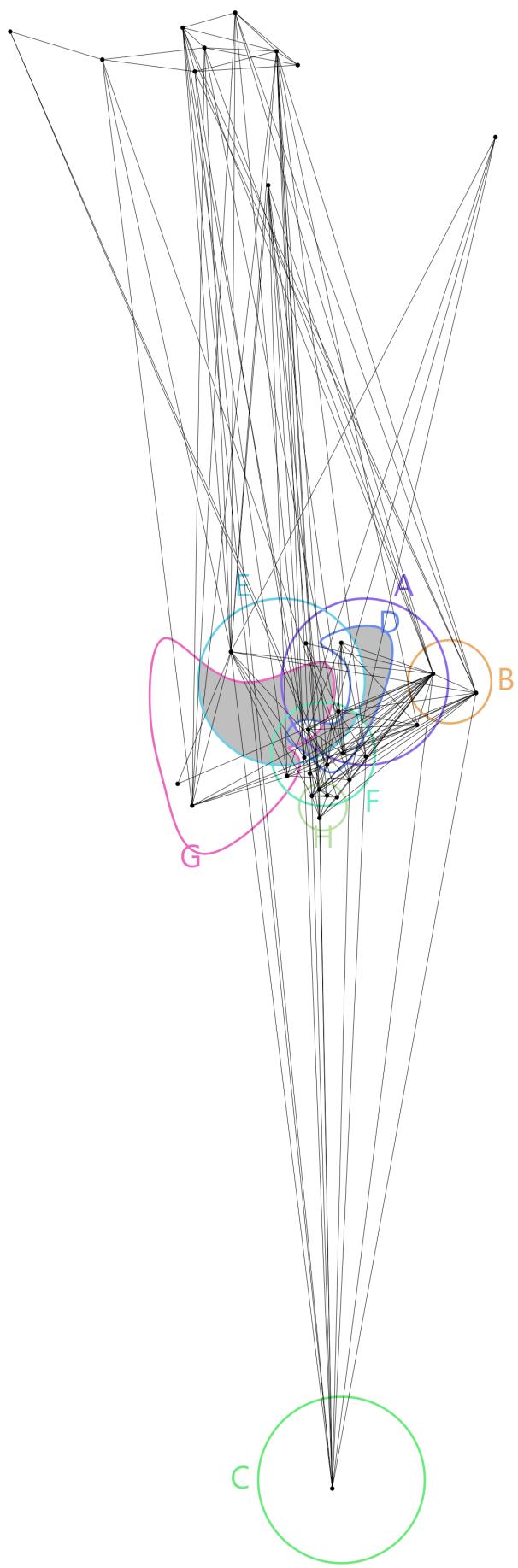


Omitted zones: A, E, AB, AF, EF, FG, ADE,
ADF

WebCola (with graph)



GroupNet

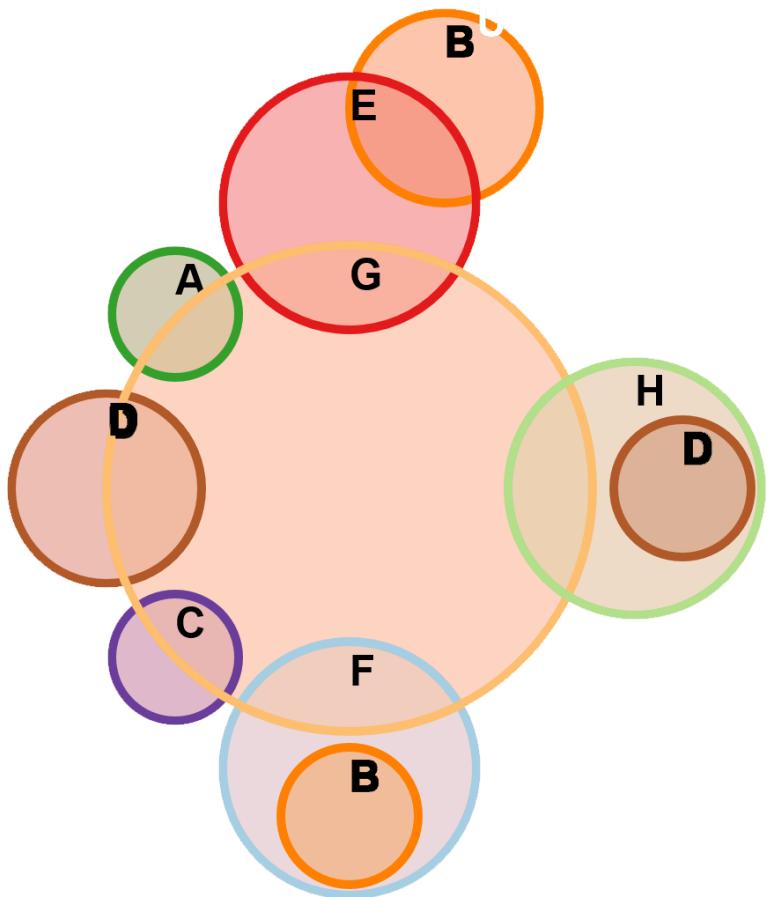


8-set data set 7 : SNAP ID: 16809036

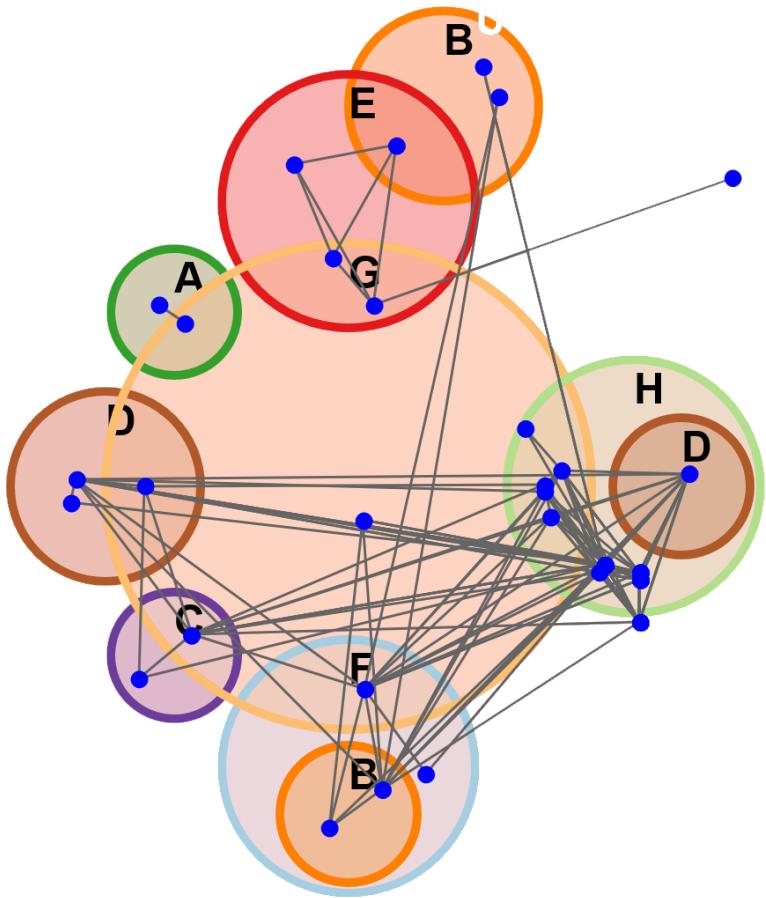
Number of Sets: 8
 Number of Zones: 18
 Number of Nodes: 41
 Number of Edges: 161
 Zones high: yes
 Nodes high: yes
 Edges high: yes

	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

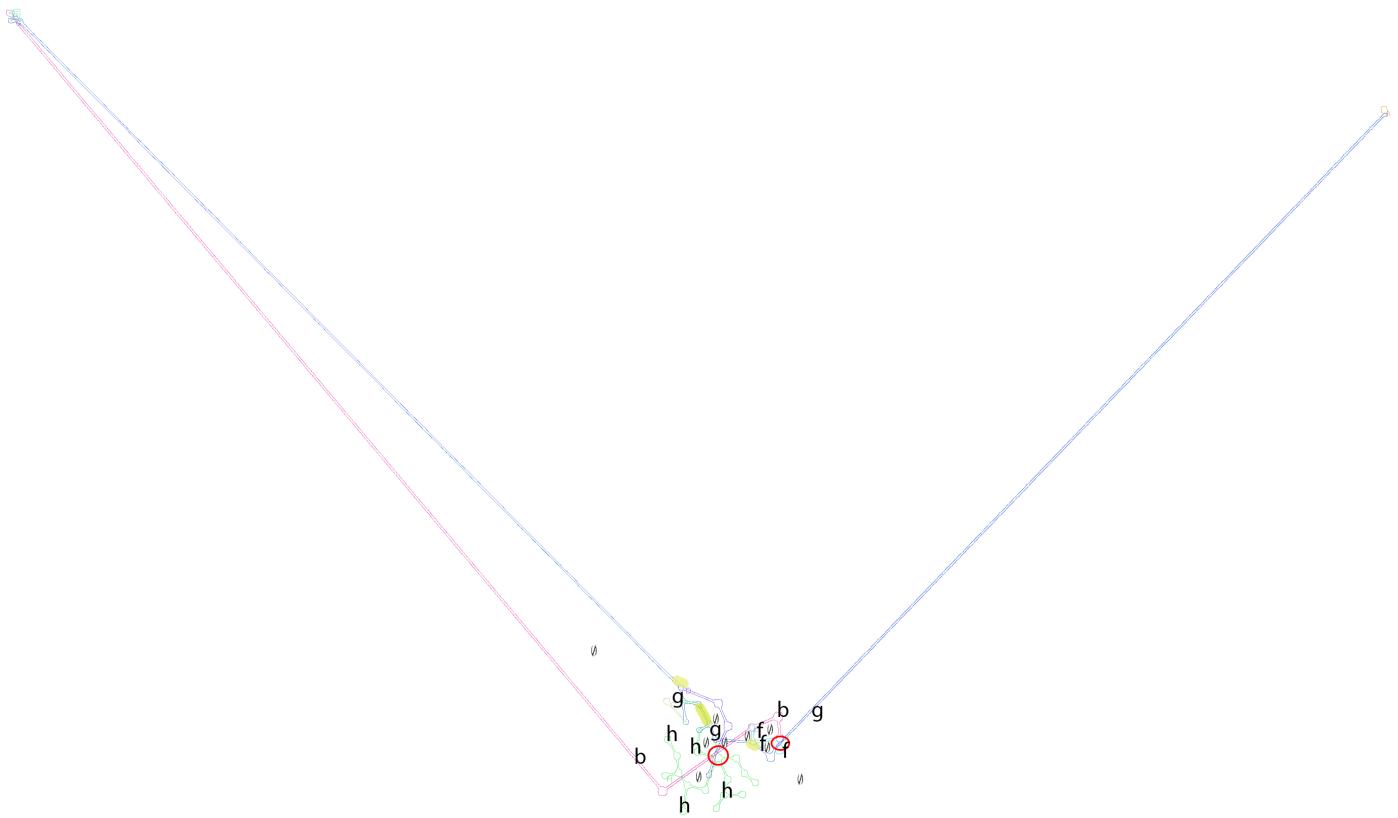
SetNet (without graph)



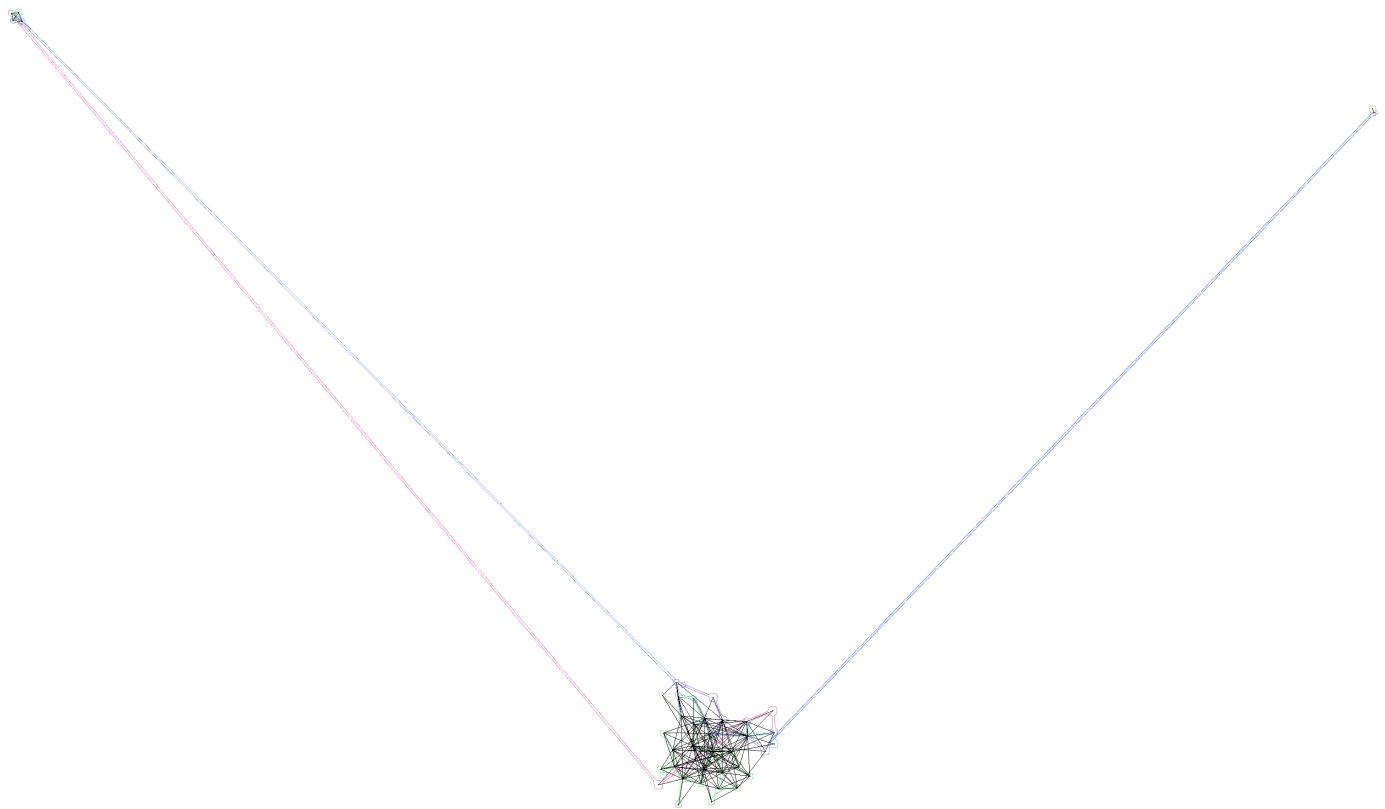
SetNet (with graph)



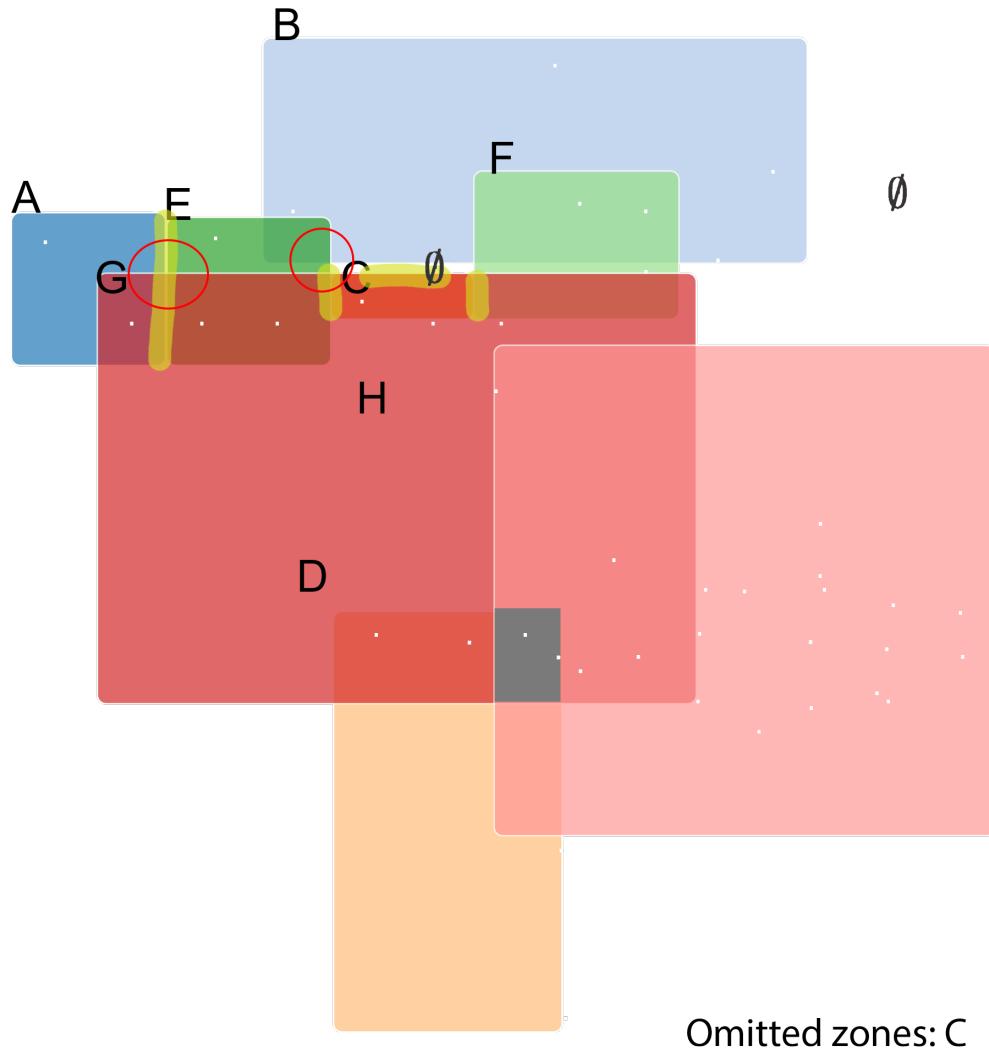
BubbleSets (without graph)



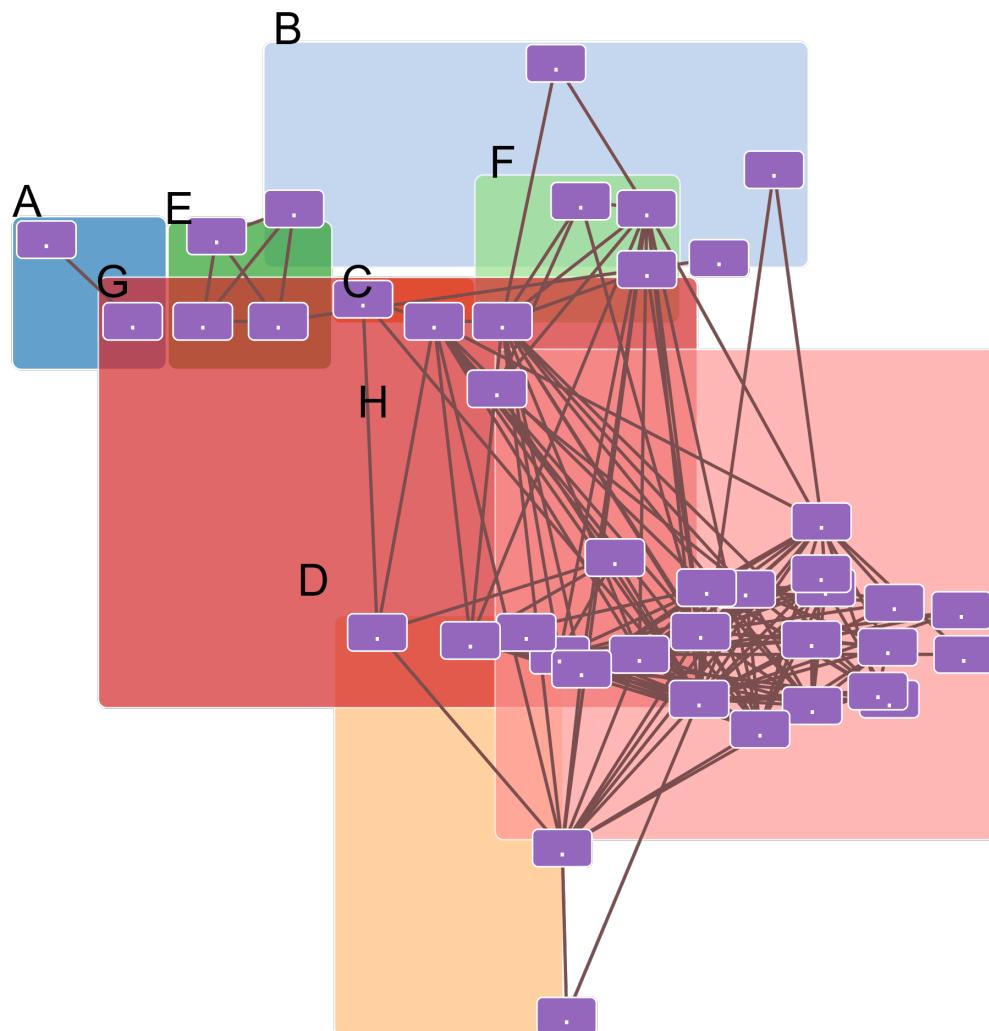
BubbleSets (with graph)



WebCola (without graph)



WebCola (with graph)



GroupNet

