

COMPLEX NETWORKS

EXERCISE 3

COMMUNITY DETECTION

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Introduction

In this exercise, the goal is to analyze communities in networks given as input of the exercise. Community detection of several networks (whose data are specified en .net – pajek files) will be studied in this paper.

The given networks to this exercise are:

- /toy : networks very little
- /real : networks that represent situations of the real life
- /model : networks regular or networks that follows some pattern(s)

Several of this networks are accompanied by one or more .clu files, that represents the community aggrupation of nodes inside the networks.

The aim of practice is to the 3 .clu files more, in other words, apply 3 different community detection algorithms, and then compare different aggrupation proposals.

Technological tools

Several programming languages, programs and libraries are used in this exercise. In the next list we can see main technologies:

- Python as programming language, with networkx as graph library that allows manipulate graphs, draw them...
- Radatools, developed by URV tech, is a very flexible community detection software (also includes other functionalities) that allows combine different algorithms in a different ways.

Explanation of the 3 community detection algorithms

Three different algorithms must be used in this exercise (and these 3 algorithms must belong to two different applications).

Here we list these algorithms:

- **Type 1:** Clauset-Newman-Moore greedy modularity maximization algorithm. This algorithm is supported by Python networkx library.

As networkx documentation says: “*Greedy modularity maximization begins with each node in its own community and repeatedly joins the pair of communities that lead to the largest modularity until no further increase in modularity is possible (a maximum)*”.

- **Type 2:** Combined method for little networks (proposed in Radatools documentation): We can find in Radatools docs that the use of the type 'r-s-e-11!rfr-trfr' is suggested for networks with no more than 1500 nodes. Almost all networks have less than this number of nodes. This algorithm uses different heuristic in its process:

- Reposition algorithm
- Spectral optimization
- Louvain algorithm
- Fast algorithm
- Tabu search

This sequence of algorithms executions is iterated 3 times for better calculations.

- **Type 3:** Louvain algorithm: is provided by Radatools. Also use optimization by modularity. This means evaluating how much more densely connected the nodes within a community are, compared to how connected they would be in a random network.

Distribution of project

The files delivered in submit follows this distribution, and is explained here:

└──model	: model given .net & .clu
└──radatools	
└──real	: real given .net & .clu
└──toy	: toy given .net & .clu
└──images	
└──comparison_indexes	: txt files with Compare_Partitions output
└──modularity_calculations	: txt files with Modularity_Calculation output
└──type1	: .clu files results of type1 executions
└──type2	: .clu files results of type2 executions
└──type3	: .clu files results of type3 executions
└──get_communities_type1.py	: script to get type1 .clu results
└──get_communities_type2.bat	: script to get type2 .clu results
└──get_communities_type3.bat	: script to get type3 .clu results
└──get_all_comparison_indexes.bat	
└──get_modularity_calculations.bat	
└──definitions.py	
└──plot.py	: draw all network plots

Inspecting code we can show the implementation details of each community detection executions, but main behavior is explained in previous section.

Results grouped by network

rb125

Modularity

rb125-1.clu	0.80487805
rb125-2.clu	0.60975610
rb125-3.clu	0.60000000
rb125-type1.clu	0.74634146
rb125-type2.clu	0.73658537
rb125-type3.clu	0.73658537

Indexes

Jaccard Index

	rb125-type1.clu	rb125-type2.clu	rb125-type3.clu
rb125-1.clu	0.6167	0.5833	0.5833
rb125-2.clu	0.2703	0.2857	0.2857
rb125-3.clu	0.2659	0.2811	0.2811

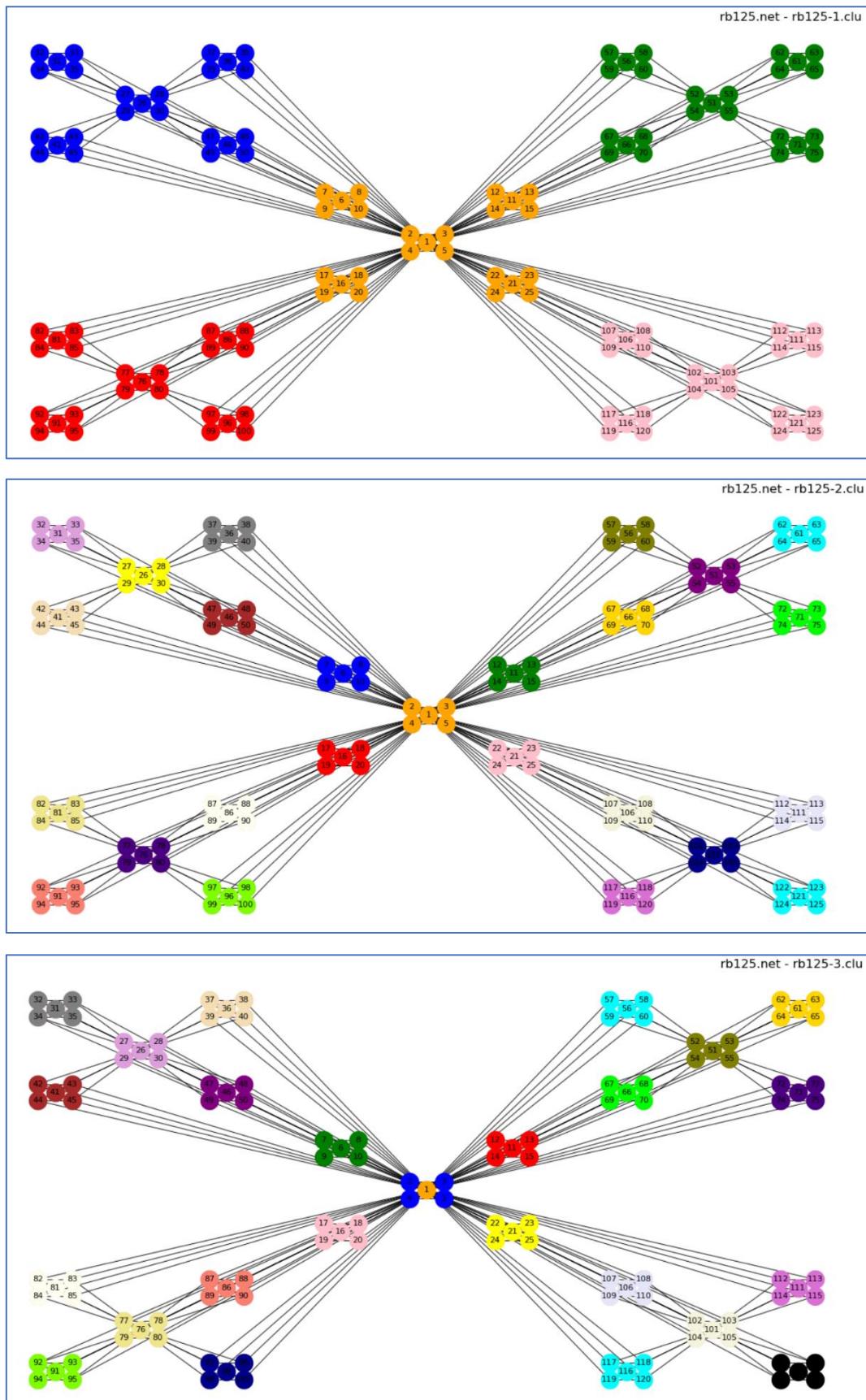
Normalized Mutual Information

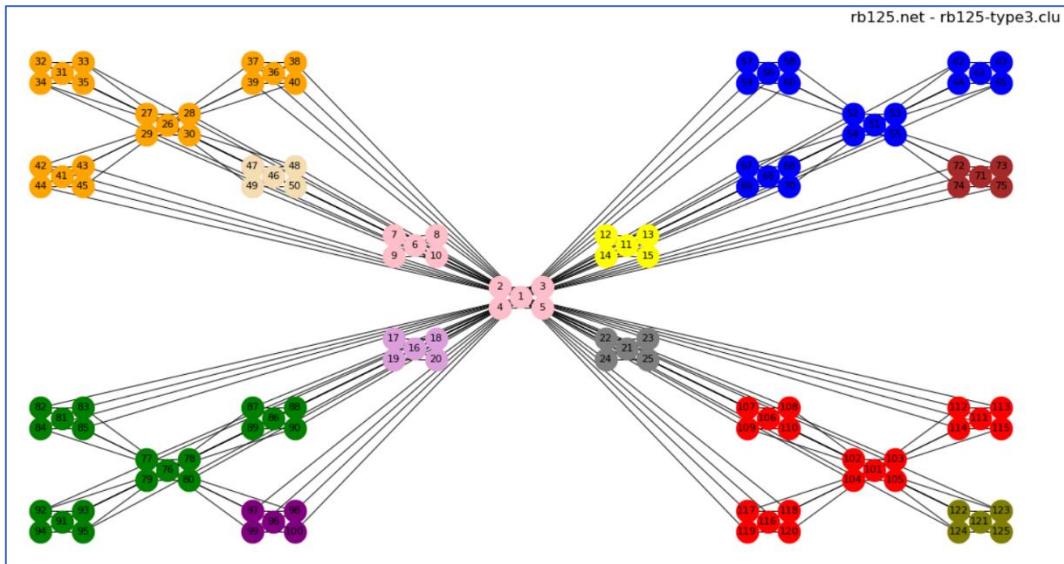
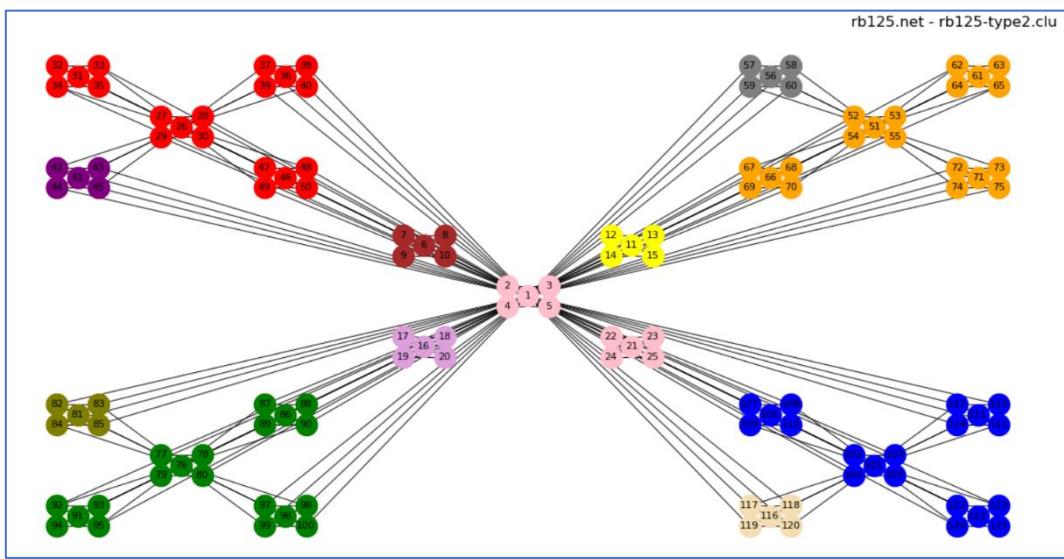
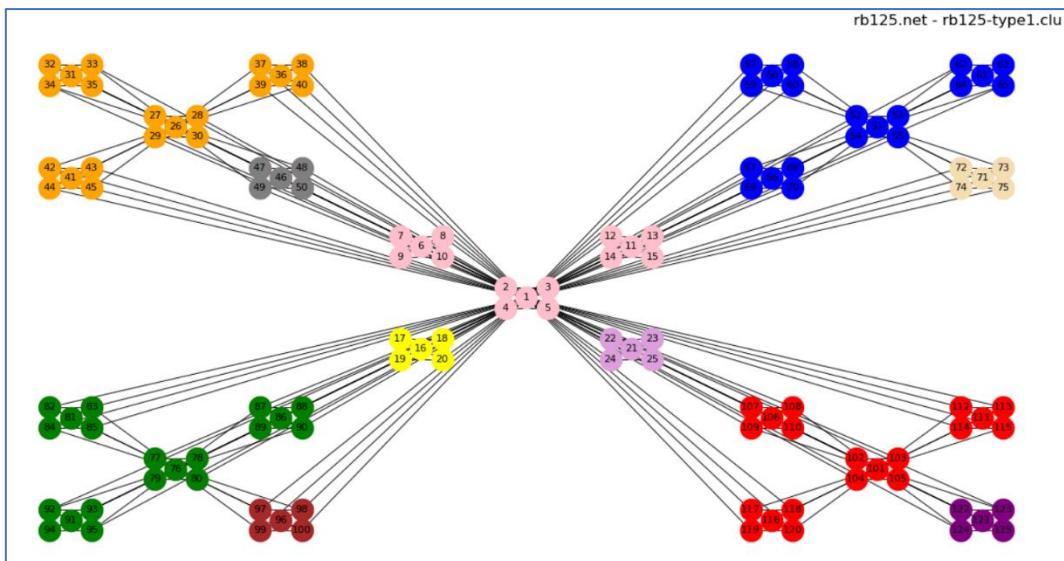
	rb125-type1.clu	rb125-type2.clu	rb125-type3.clu
rb125-1.clu	0.8450	0.8284	0.8284
rb125-2.clu	0.8119	0.8284	0.8284
rb125-3.clu	0.8089	0.8254	0.8254

Normalized Variation of Information

	rb125-type1.clu	rb125-type2.clu	rb125-type3.clu
rb125-1.clu	0.1223	0.1381	0.1381
rb125-2.clu	0.2111	0.1952	0.1952
rb125-3.clu	0.2152	0.1994	0.1994

Images





256_4_4_2_15_18_p

Modularity

256_4_4_2_15_18_p.clu	0.84432718
256_4_4_2_15_18_p-type1.clu	0.84432718
256_4_4_2_15_18_p-type2.clu	0.84432718
256_4_4_2_15_18_p-type3.clu	0.84432718

Indexes

Jaccard Index

	256_4_4_2_15_18_p-type1.clu	256_4_4_2_15_18_p-type2.clu	256_4_4_2_15_18_p-type3.clu
256_4_4_2_15_18_p.clu	1.0000	1.0000	1.0000

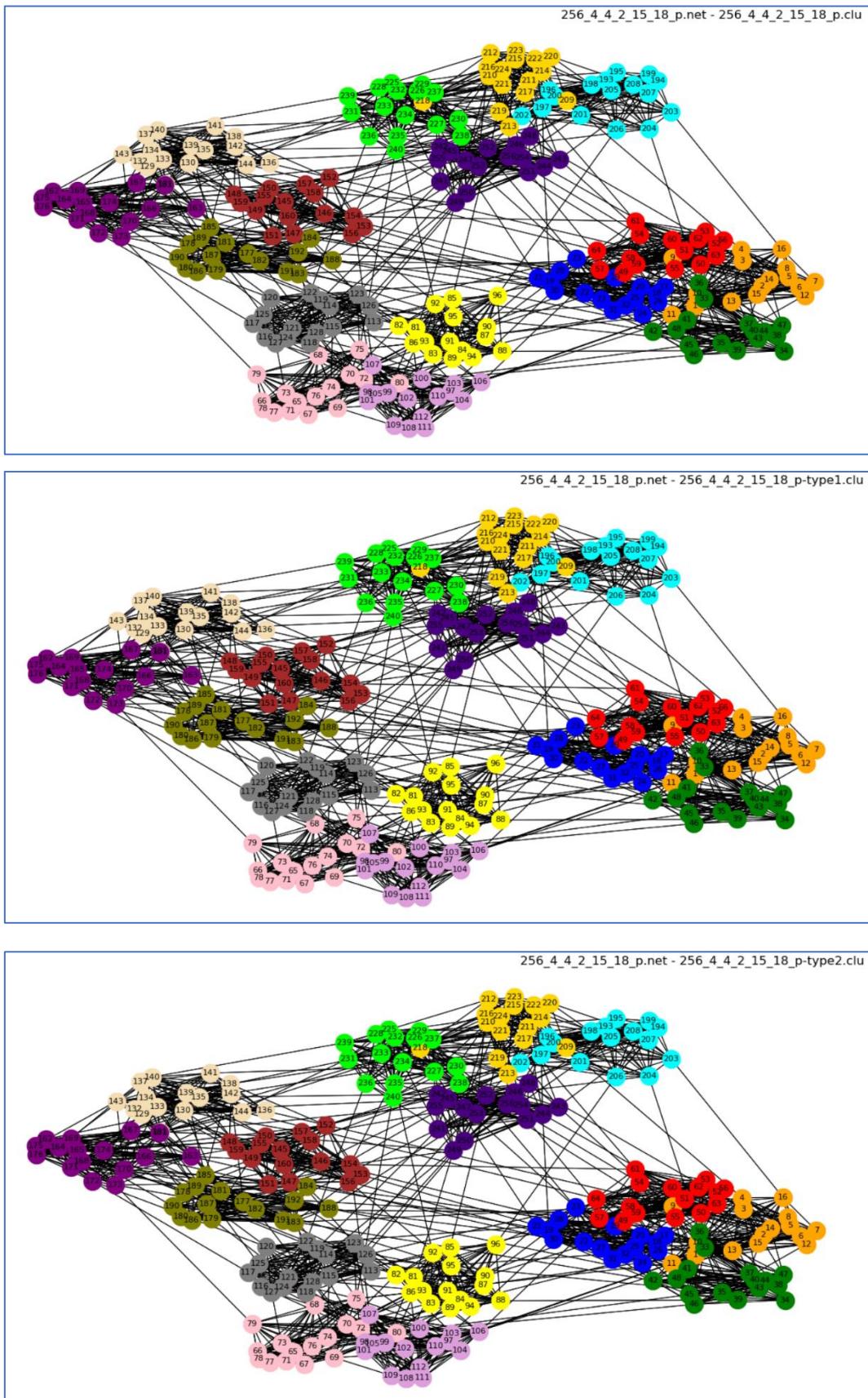
Normalized Mutual Information

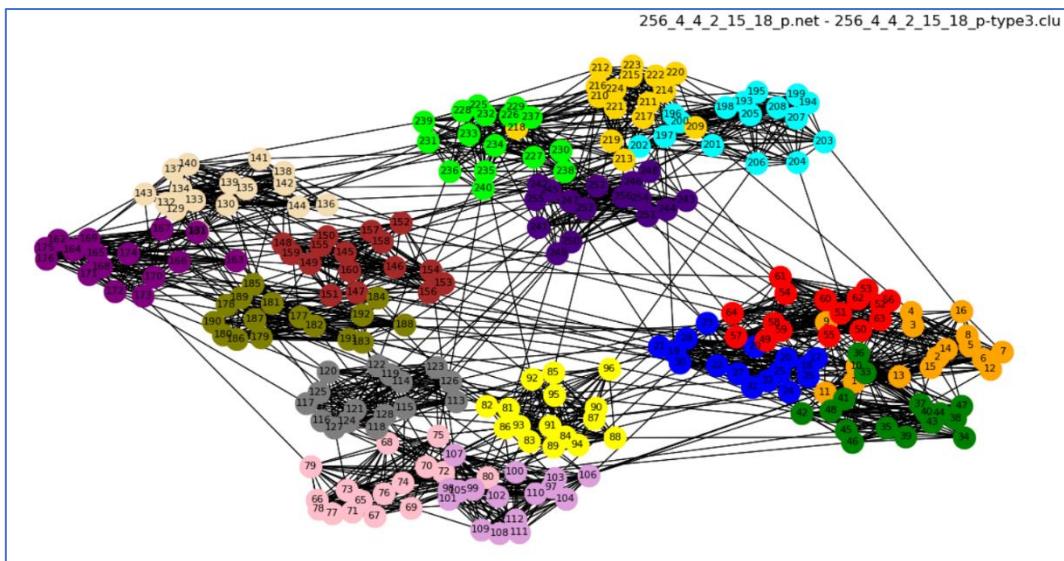
	256_4_4_2_15_18_p-type1.clu	256_4_4_2_15_18_p-type2.clu	256_4_4_2_15_18_p-type3.clu
256_4_4_2_15_18_p.clu	1.0000	1.0000	1.0000

Normalized Variation of Information

	256_4_4_2_15_18_p-type1.clu	256_4_4_2_15_18_p-type2.clu	256_4_4_2_15_18_p-type3.clu
256_4_4_2_15_18_p.clu	0.0000	0.0000	0.0000

Images





256_4_4_4_13_18_p

Modularity

256_4_4_4_13_18_p.clu	0.94693345
256_4_4_4_13_18_p-type1.clu	0.77990431
256_4_4_4_13_18_p-type2.clu	0.92431492
256_4_4_4_13_18_p-type3.clu	0.92431492

Indexes

Jaccard Index

	256_4_4_4_13_18_p-type1.clu	256_4_4_4_13_18_p-type2.clu	256_4_4_4_13_18_p-type3.clu
256_4_4_4_13_18_p.clu	0.4591	0.9048	0.9048

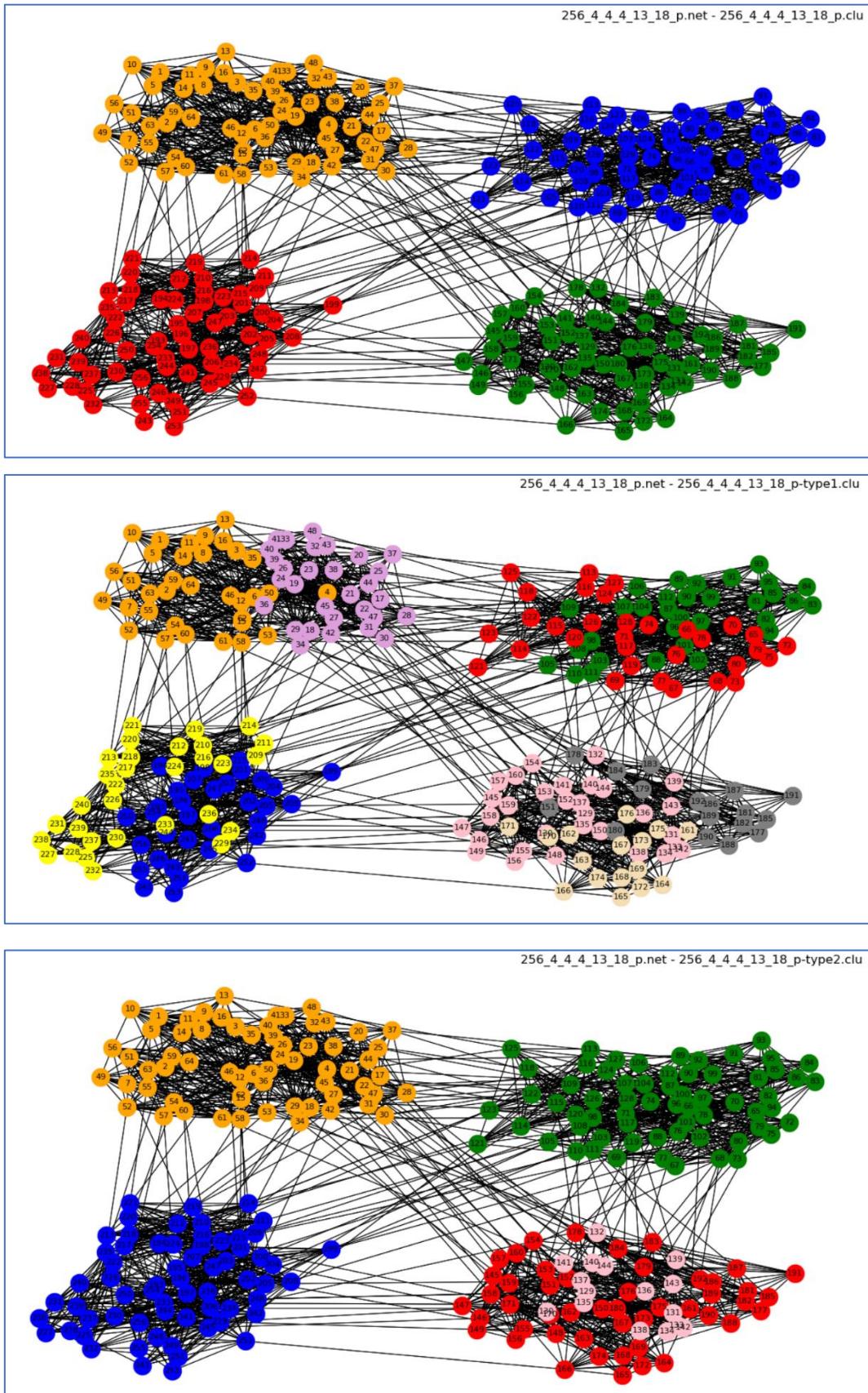
Normalized Mutual Information

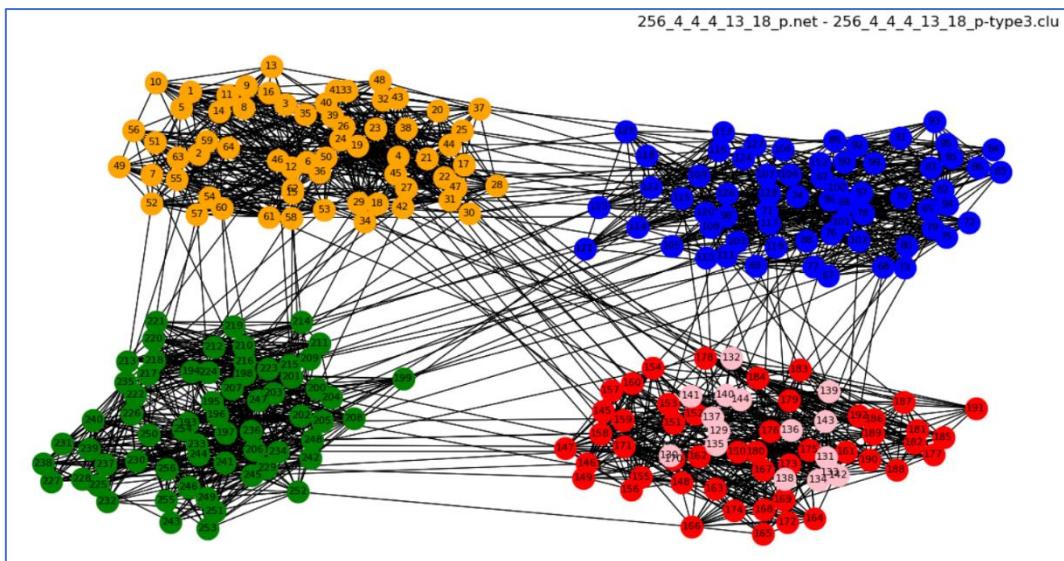
	256_4_4_4_13_18_p-type1.clu	256_4_4_4_13_18_p-type2.clu	256_4_4_4_13_18_p-type3.clu
256_4_4_4_13_18_p.clu	0.7801	0.9517	0.9517

Normalized Variation of Information

	256_4_4_4_13_18_p-type1.clu	256_4_4_4_13_18_p-type2.clu	256_4_4_4_13_18_p-type3.clu
256_4_4_4_13_18_p.clu	0.1410	0.0254	0.0254

Images





airports_UW

Modularity

airports_UW-type1.clu	1
airports_UW-type2.clu	0.86591455
airports_UW-type3.clu	0.86591455

Indexes

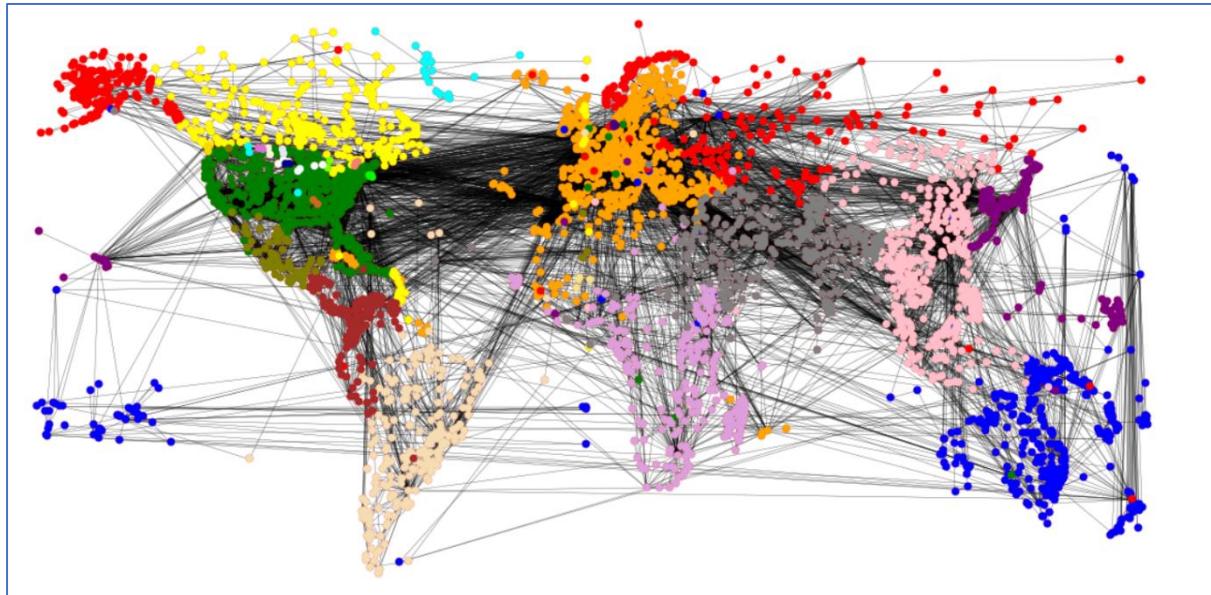
No comparisons because this network has no .clu files given as input of exercise

Images

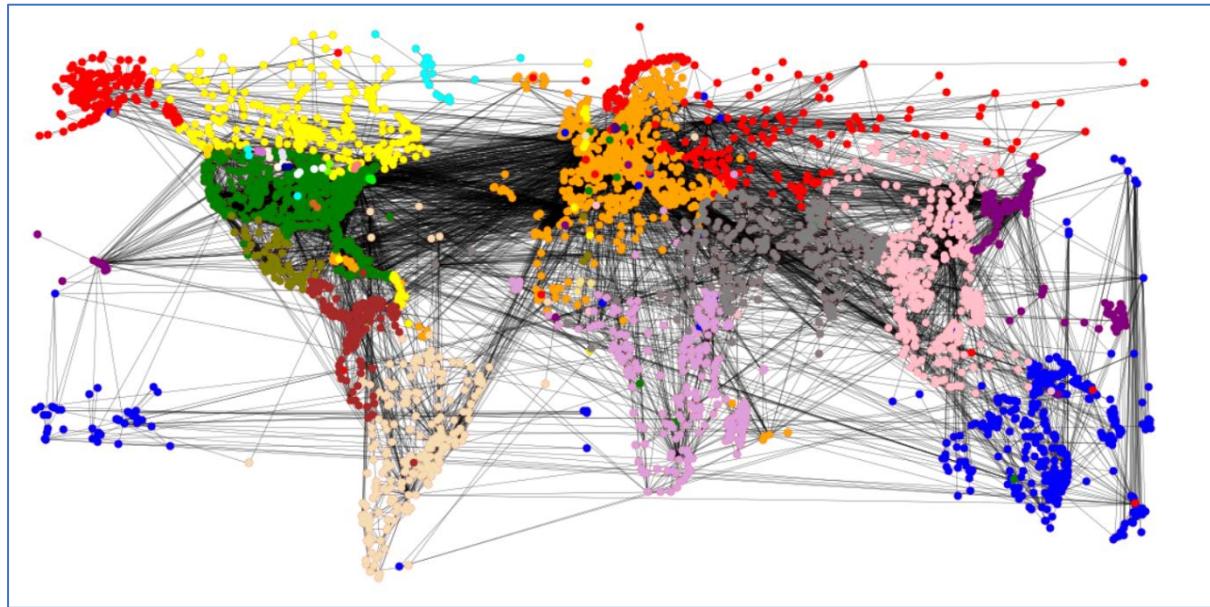
airports_UW.net - airports_UW-type1.clu



airports_UW.net - airports_UW-type2.clu



airports_UW.net - airports_UW-type3.clu



cat_cortex_sim

Modularity

cat_cortex_sim.clu	0.65371506
cat_cortex_sim-type1.clu	0.82685753
cat_cortex_sim-type2.clu	0.72119973
cat_cortex_sim-type3.clu	0.72119973

Indexes

Jaccard Index

	cat_cortex_sim-type1.clu	cat_cortex_sim-type2.clu	cat_cortex_sim-type3.clu
cat_cortex_sim.clu	0.3847	0.6711	0.6711

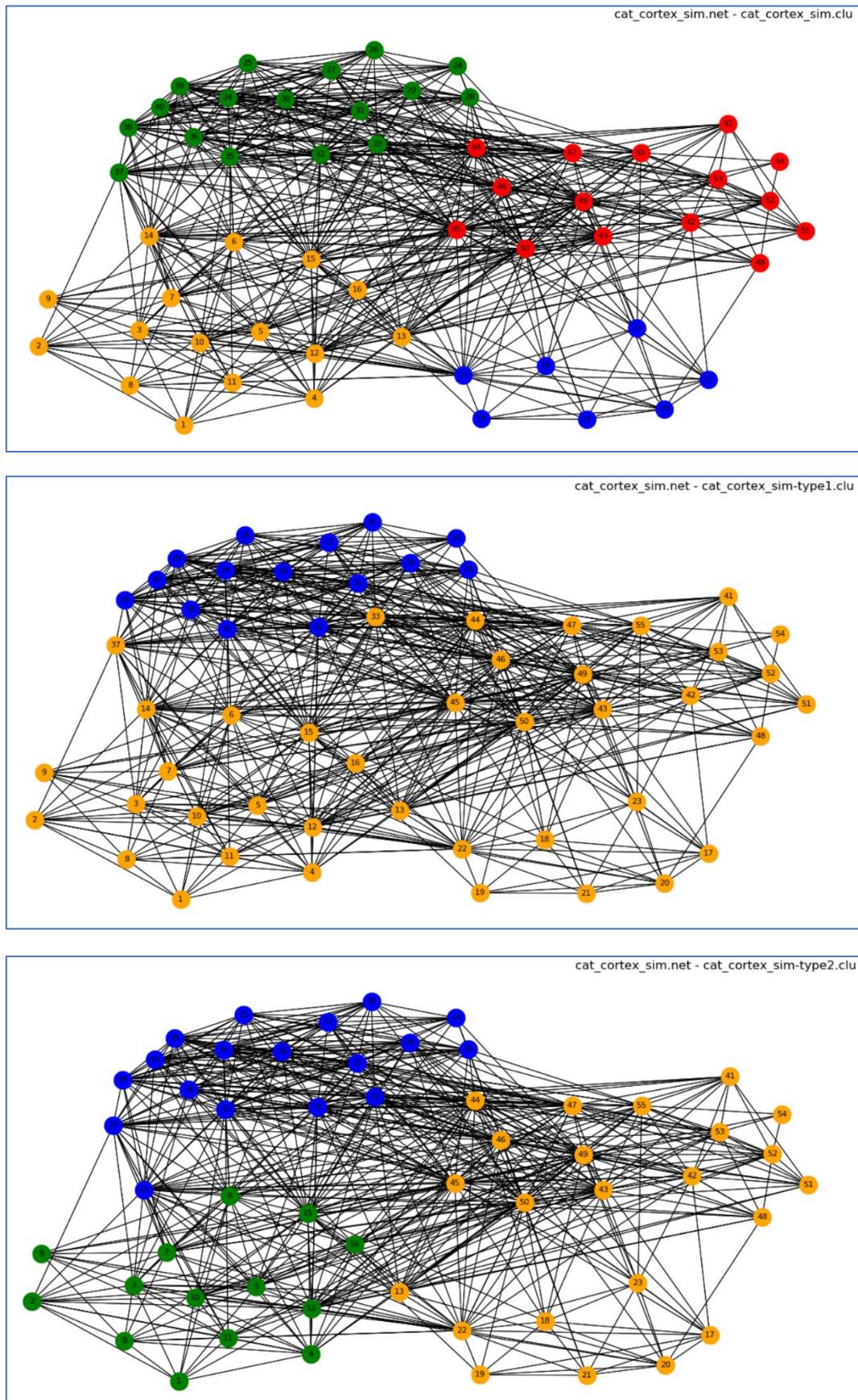
Normalized Mutual Information

	cat_cortex_sim-type1.clu	cat_cortex_sim-type2.clu	cat_cortex_sim-type3.clu
cat_cortex_sim.clu	0.4925	0.7807	0.7807

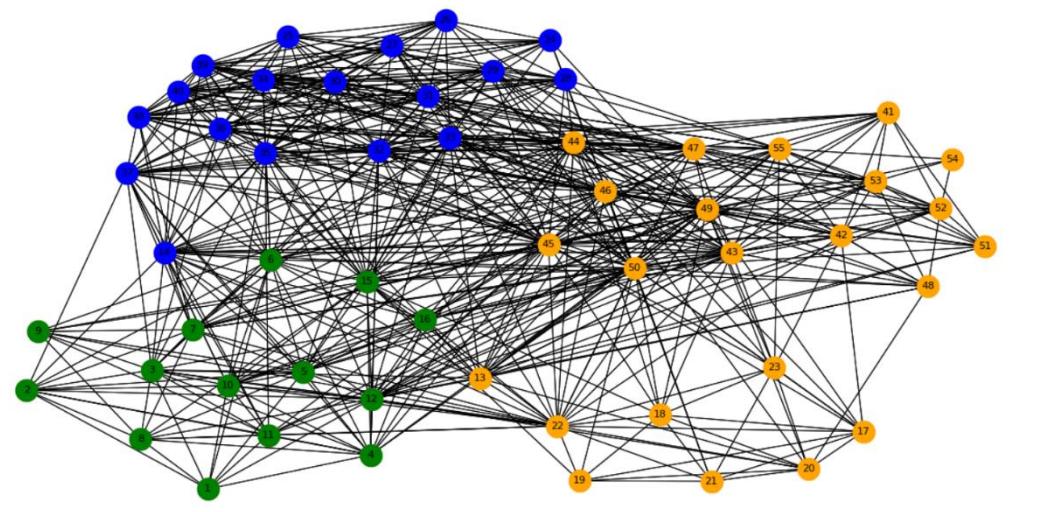
Normalized Variation of Information

	cat_cortex_sim-type1.clu	cat_cortex_sim-type2.clu	cat_cortex_sim-type3.clu
cat_cortex_sim.clu	0.2437	0.1323	0.1323

Images



cat_cortex_sim.net - cat_cortex_sim-type3.clu



football

Modularity

football-conferences.clu	0.64274062
football-type1.clu	0.73083197
football-type2.clu	0.70799347
football-type3.clu	0.70799347

Indexes

Jaccard Index

	football-type1.clu	football-type2.clu	football-type3.clu
football-conferences.clu	0.3622	0.7004	0.7004

Normalized Mutual Information

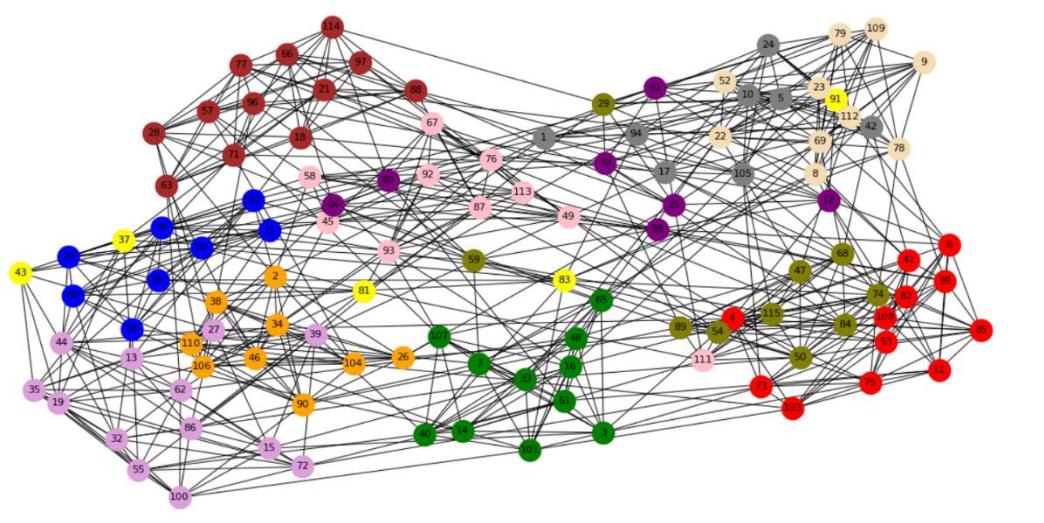
	football-type1.clu	football-type2.clu	football-type3.clu
football-conferences.clu	0.6977	0.8903	0.8903

Normalized Variation of Information

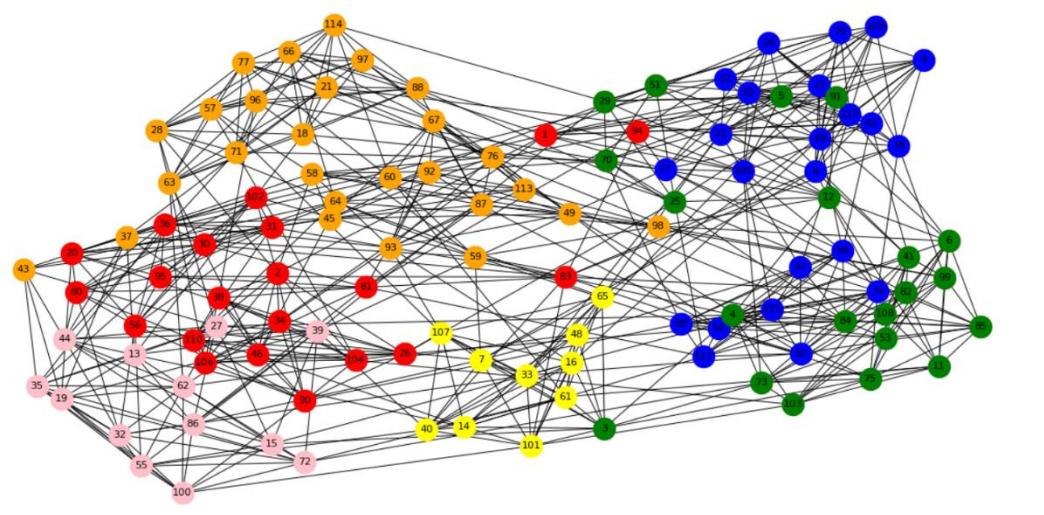
	football-type1.clu	football-type2.clu	football-type3.clu
football-conferences.clu	0.2675	0.1095	0.1095

Images

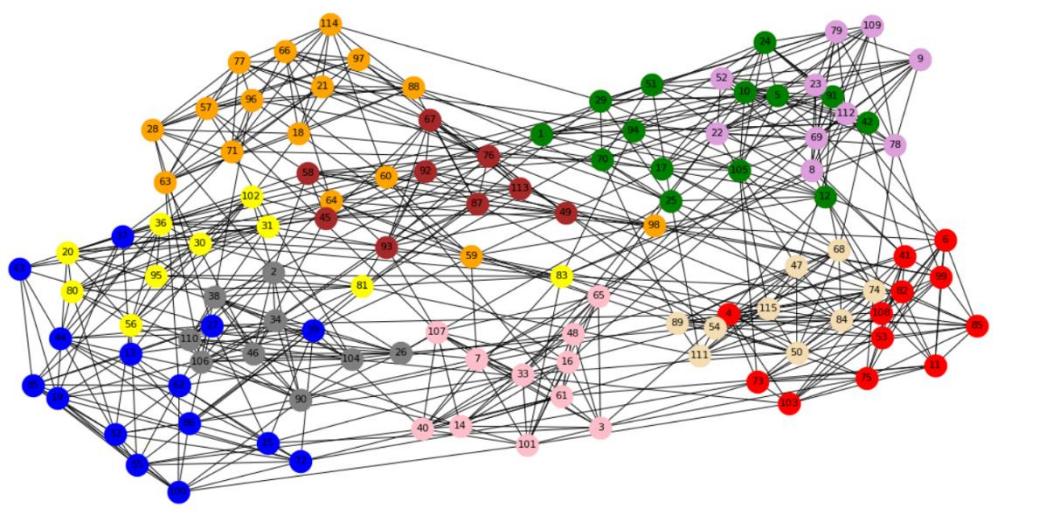
football.net - football-conferences.clu

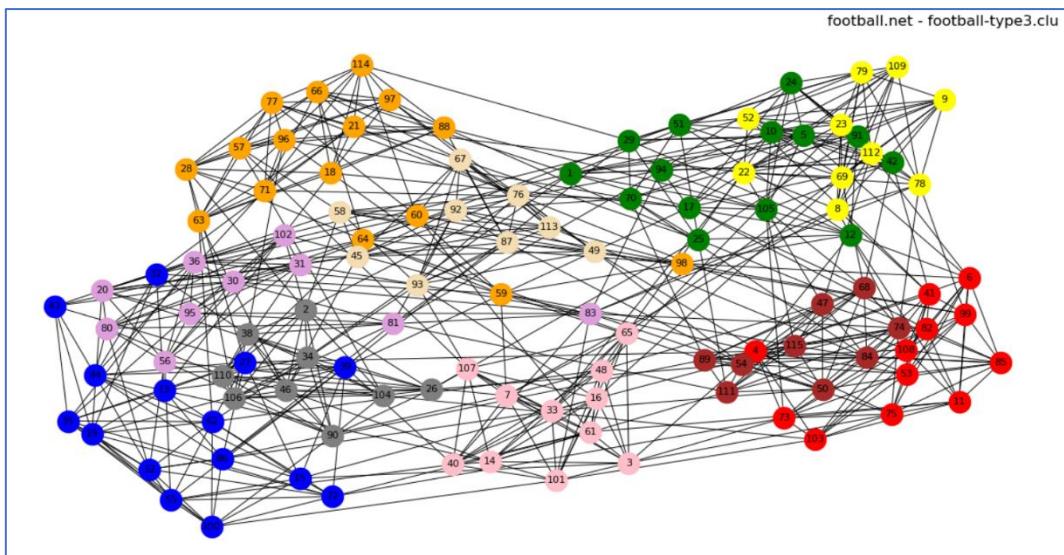


football.net - football-type1.clu



football.net - football-type2.clu





dolphins

Modularity

dolphins-real.clu	0.96226415
dolphins -type1.clu	0.82389937
dolphins -type2.clu	0.80503145
dolphins -type3.clu	0.74842767

Indexes

Jaccard Index

	dolphins-type1.clu	dolphins-type2.clu	dolphins-type3.clu
dolphins-real.clu	0.5041	0.4547	0.3688

Normalized Mutual Information

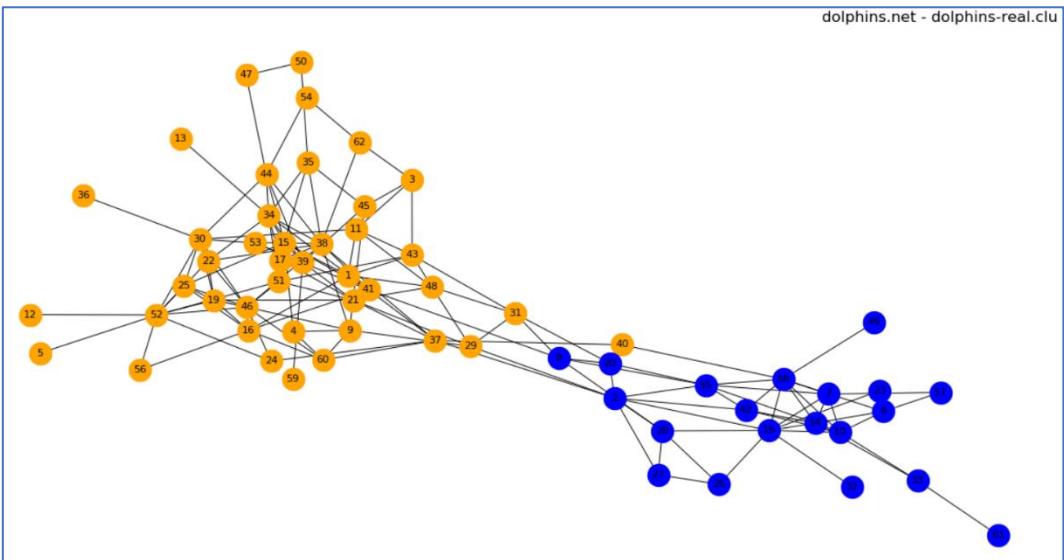
	dolphins-type1.clu	dolphins-type2.clu	dolphins-type3.clu
dolphins-real.clu	0.5727	0.5792	0.5124

Normalized Variation of Information

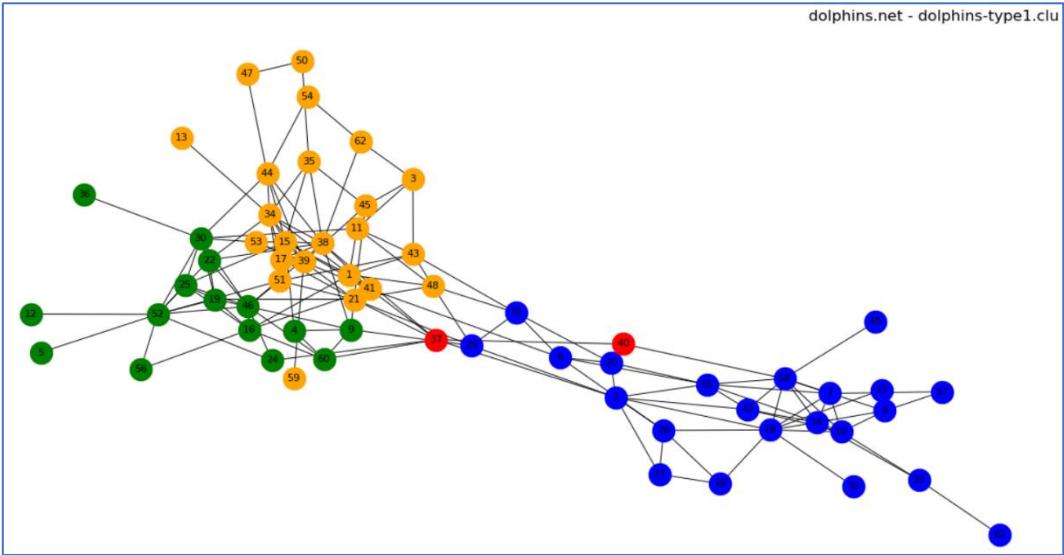
	dolphins-type1.clu	dolphins-type2.clu	dolphins-type3.clu
dolphins-real.clu	0.1883	0.1986	0.2565

Images

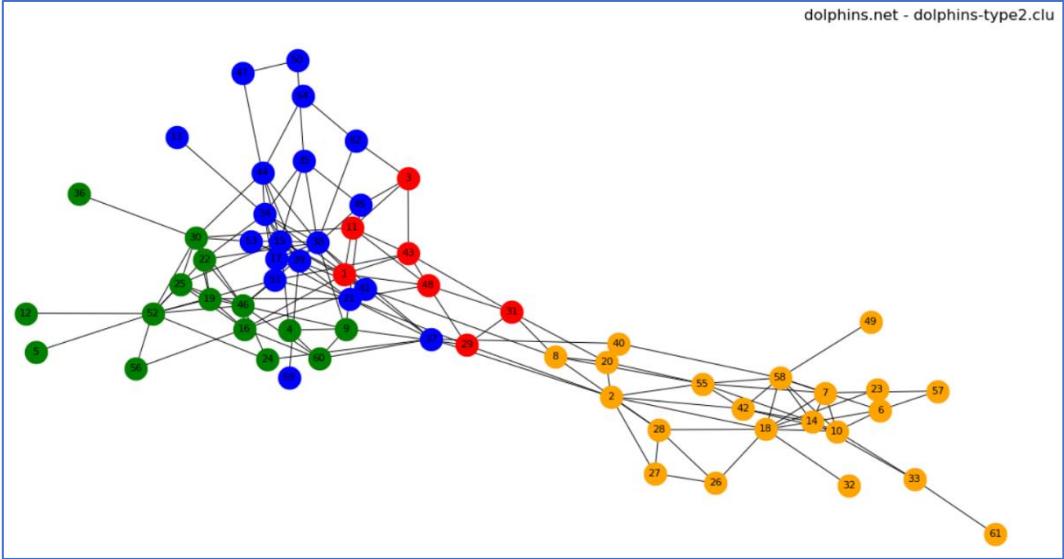
dolphins.net - dolphins-real.clu

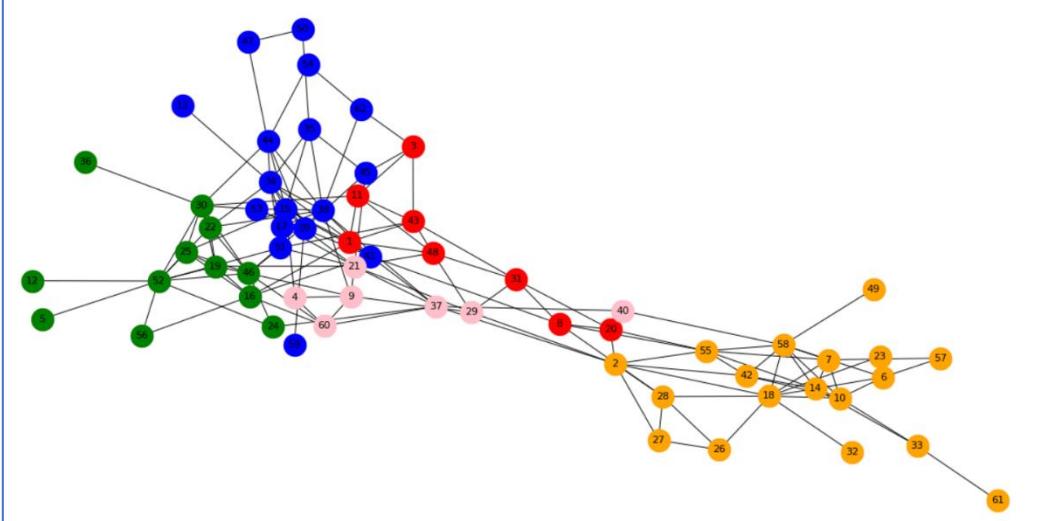


dolphins.net - dolphins-type1.clu



dolphins.net - dolphins-type2.clu





zachary_unwh

Modularity

zachary_unwh-real.clu	0.87179487
zachary_unwh-type1.clu	0.75641026
zachary_unwh-type2.clu	0.73076923
zachary_unwh-type3.clu	0.73076923

Indexes

Jaccard Index

	zachary_unwh-type1.clu	zachary_unwh-type2.clu	zachary_unwh-type3.clu
zachary_unwh-real.clu	0.6833	0.5348	0.5348

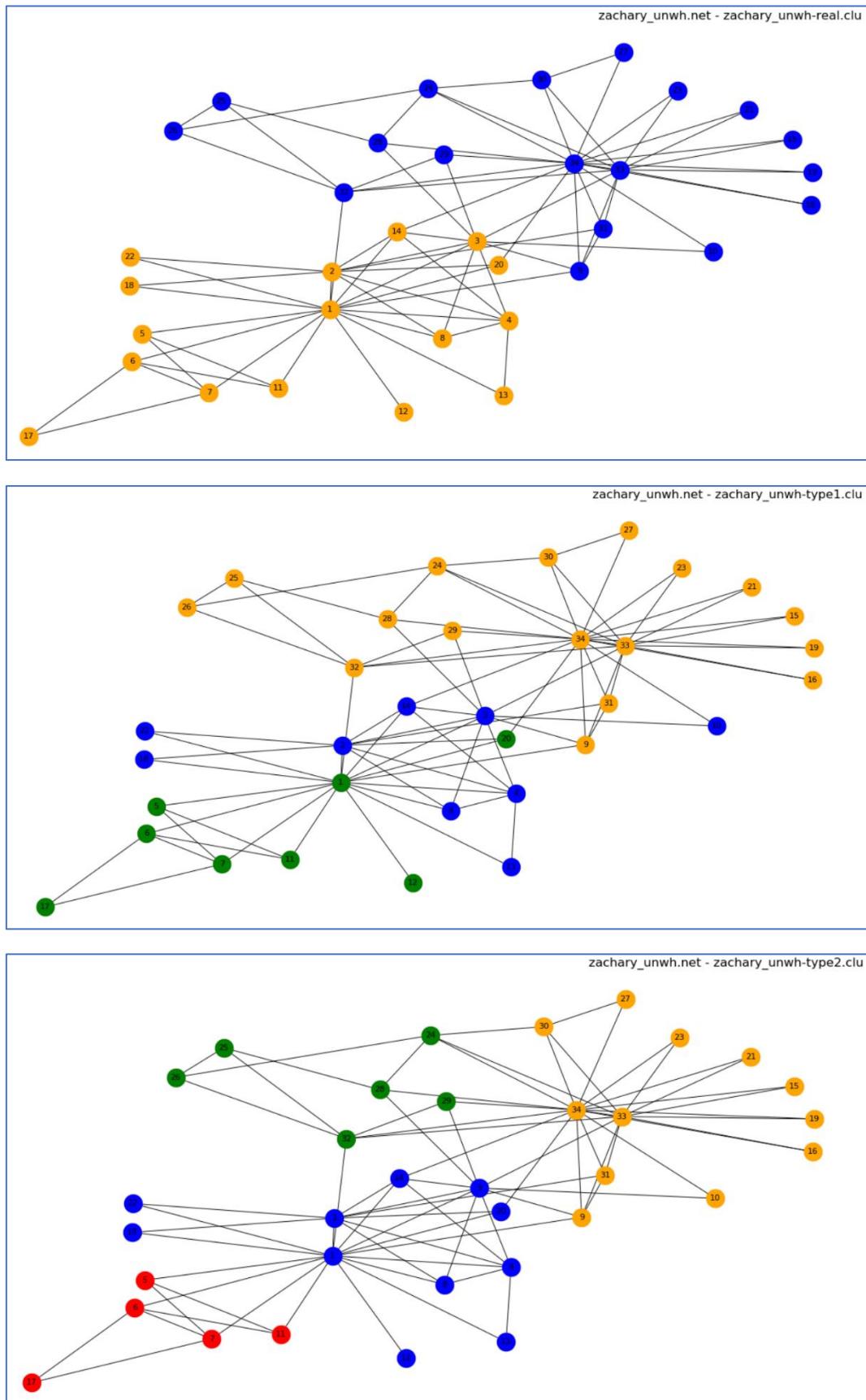
Normalized Mutual Information

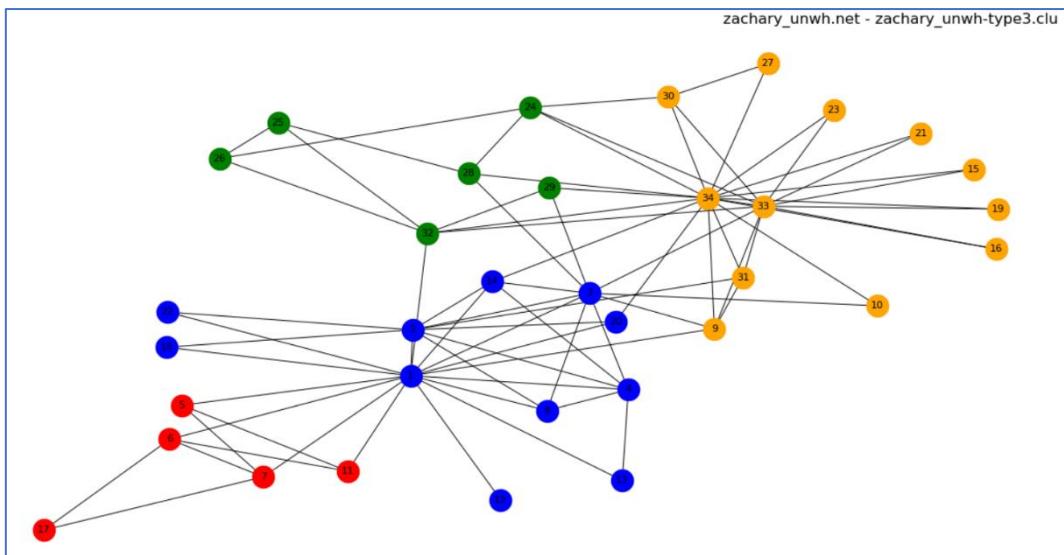
	zachary_unwh-type1.clu	zachary_unwh-type2.clu	zachary_unwh-type3.clu
zachary_unwh-real.clu	0.6925	0.6873	0.6873

Normalized Variation of Information

	zachary_unwh-type1.clu	zachary_unwh-type2.clu	zachary_unwh-type3.clu
zachary_unwh-real.clu	0.1509	0.1784	0.1784

Images





20x2+5x2

Modularity

20x2+5x2.clu	0.99009901
20x2+5x2-type1.clu	0.99257426
20x2+5x2-type2.clu	0.99257426
20x2+5x2-type3.clu	0.99257426

Indexes

Jaccard Index

	20x2+5x2-type1.clu	20x2+5x2-type2.clu	20x2+5x2-type3.clu
20x2+5x2.clu	0.9412	0.9412	0.9412

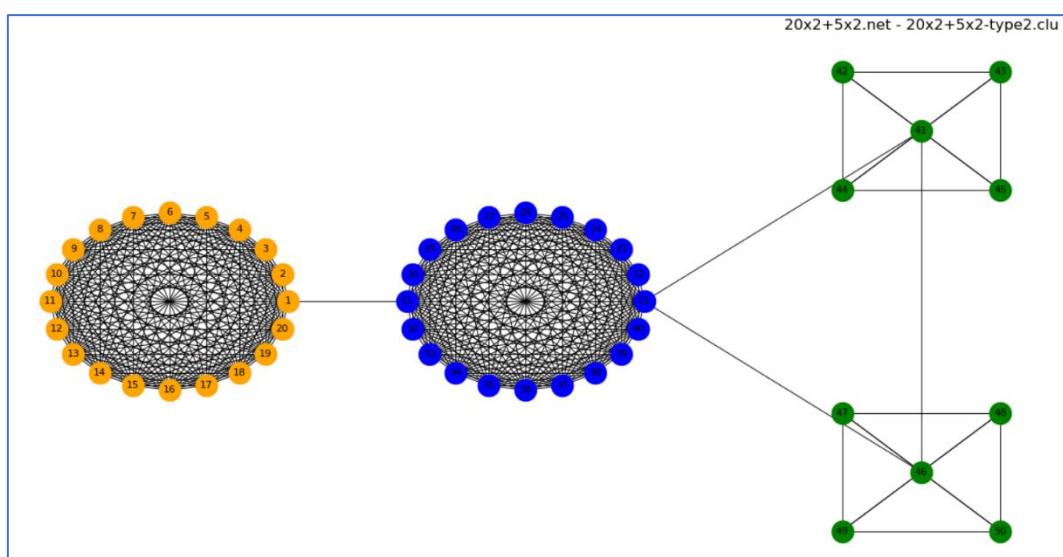
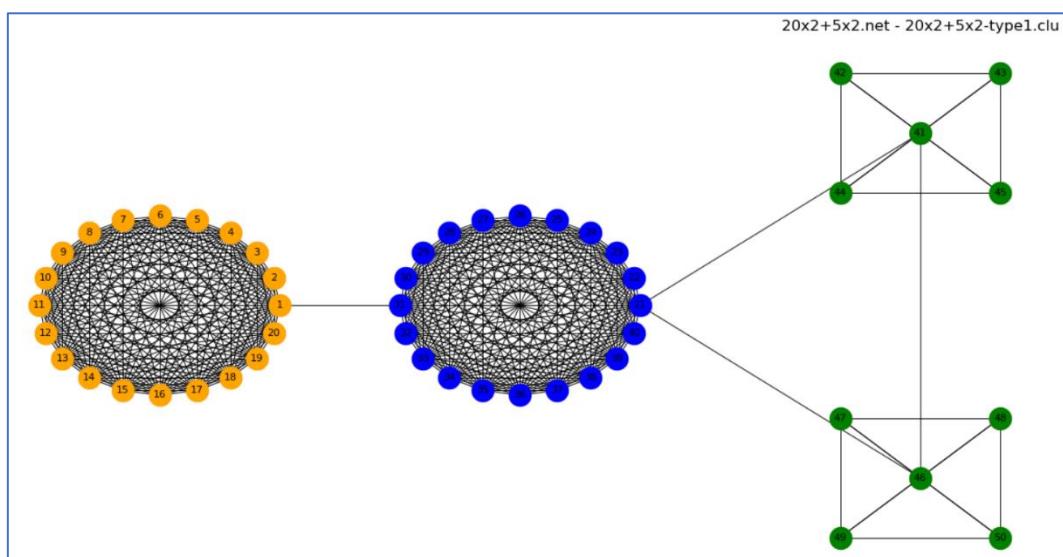
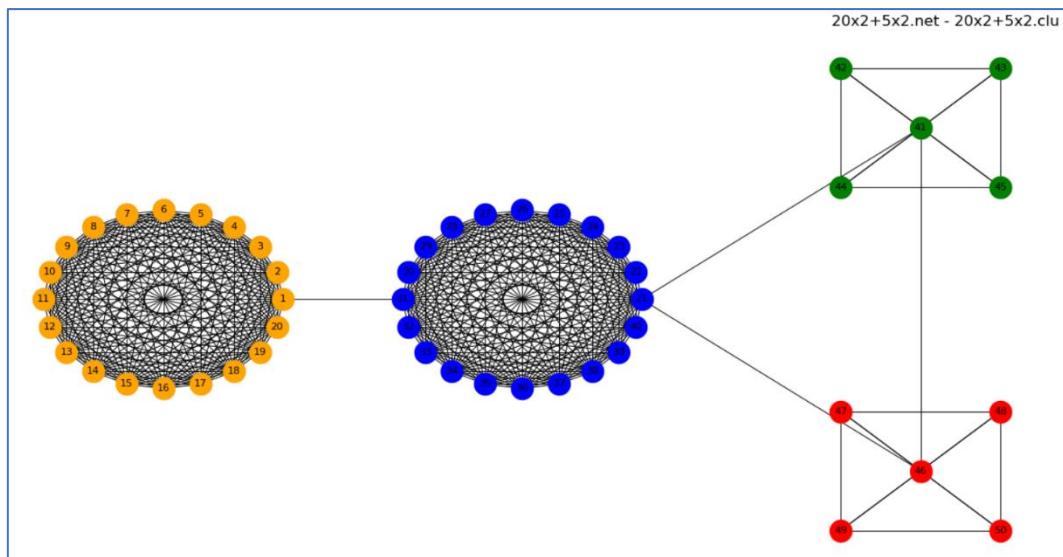
Normalized Mutual Information

	20x2+5x2-type1.clu	20x2+5x2-type2.clu	20x2+5x2-type3.clu
20x2+5x2.clu	0.9383	0.9383	0.9383

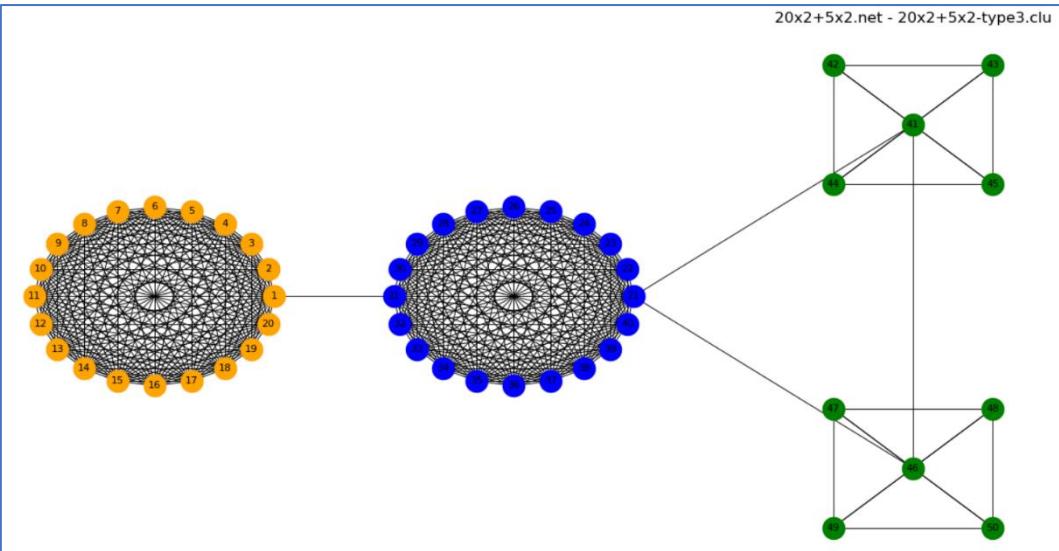
Normalized Variation of Information

	20x2+5x2-type1.clu	20x2+5x2-type2.clu	20x2+5x2-type3.clu
20x2+5x2.clu	0.0354	0.0354	0.0354

Images



20x2+5x2.net - 20x2+5x2-type3.clu



graph4+4

Modularity

graph4+4.clu	0.94285714
graph4+4-type1.clu	0.94285714
graph4+4-type2.clu	0.94285714
graph4+4-type3.clu	0.82857143

Indexes

Jaccard Index

	graph4+4-type1.clu	graph4+4-type2.clu	graph4+4-type3.clu
graph4+4.clu	1.0000	1.0000	0.4615

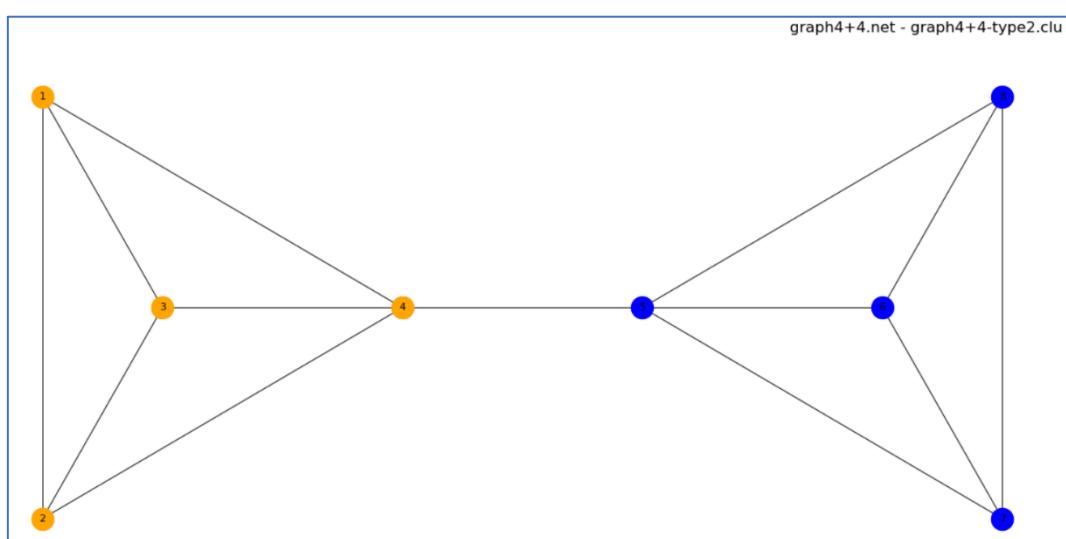
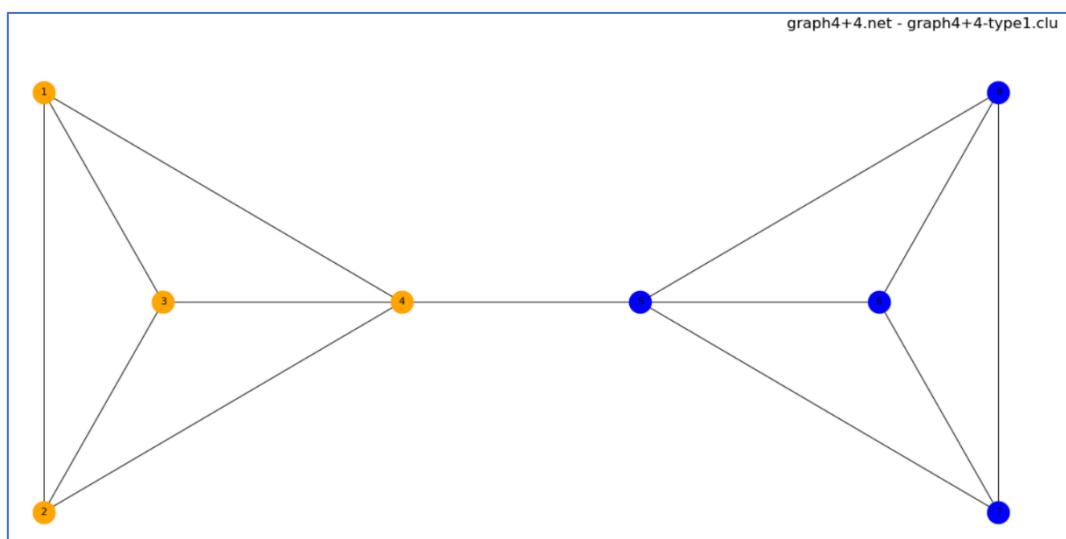
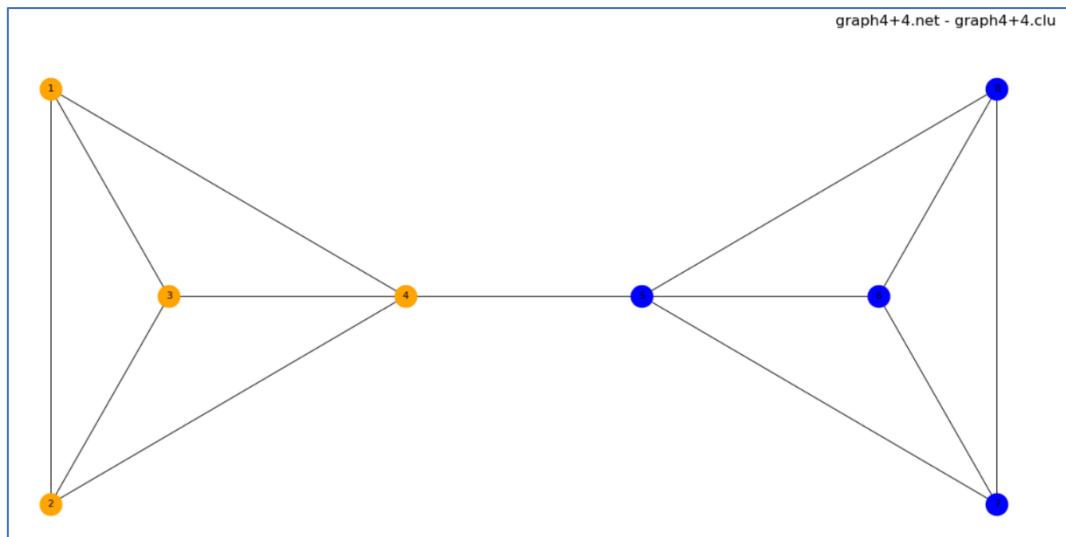
Normalized Mutual Information

	graph4+4-type1.clu	graph4+4-type2.clu	graph4+4-type3.clu
graph4+4.clu	1.0000	1.0000	0.5856

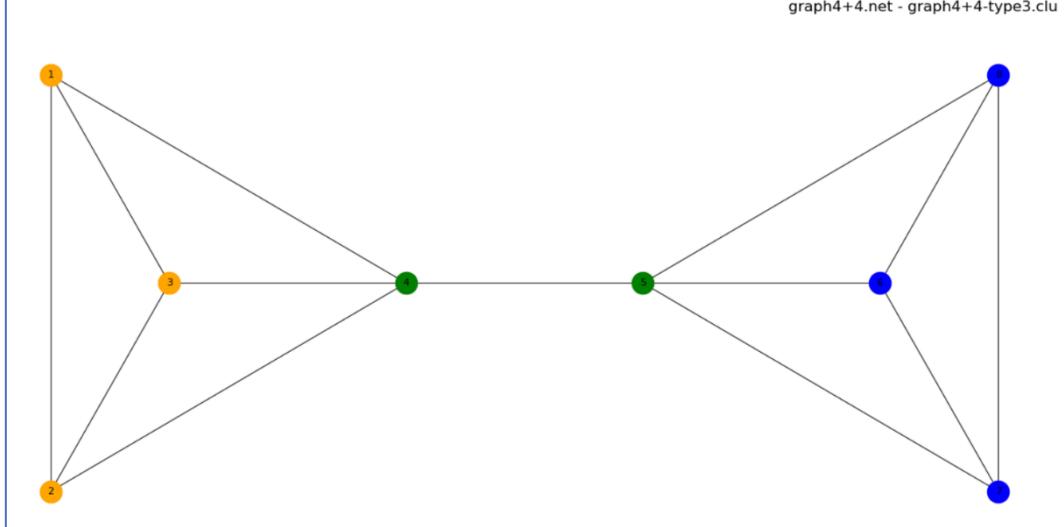
Normalized Variation of Information

	graph4+4-type1.clu	graph4+4-type2.clu	graph4+4-type3.clu
graph4+4.clu	0.0000	0.0000	0.3538

Images



graph4+4.net - graph4+4-type3.clu



graph3+1+3

Modularity

graph3+1+3.clu	0.75000000
graph3+1+3-type1.clu	0.87500000
graph3+1+3-type2.clu	0.87500000
graph3+1+3-type3.clu	0.87500000

Indexes

Jaccard Index

	graph3+1+3-type1.clu	graph3+1+3-type2.clu	graph3+1+3-type3.clu
graph3+1+3.clu	0.6667	0.6667	0.6667

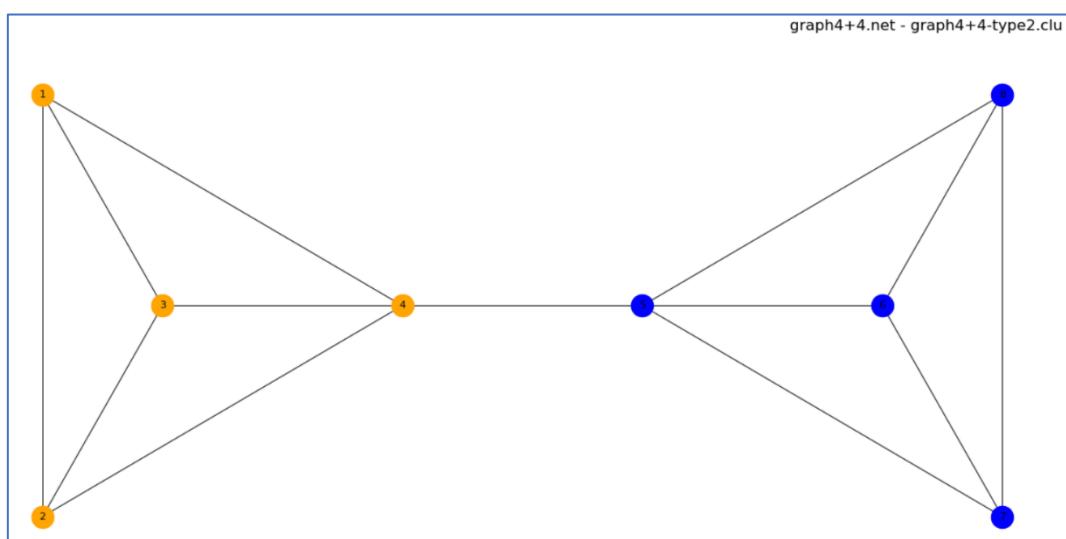
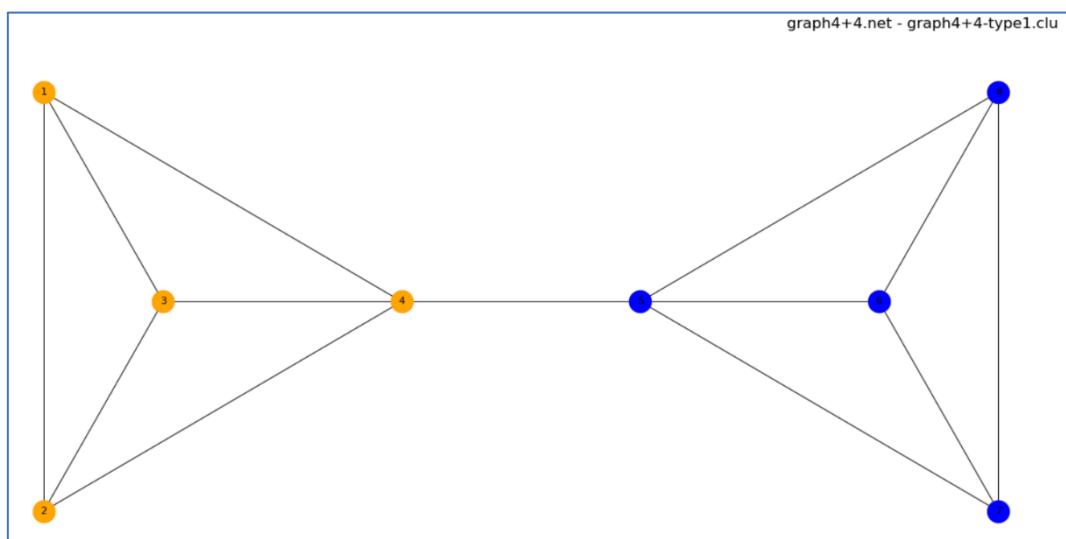
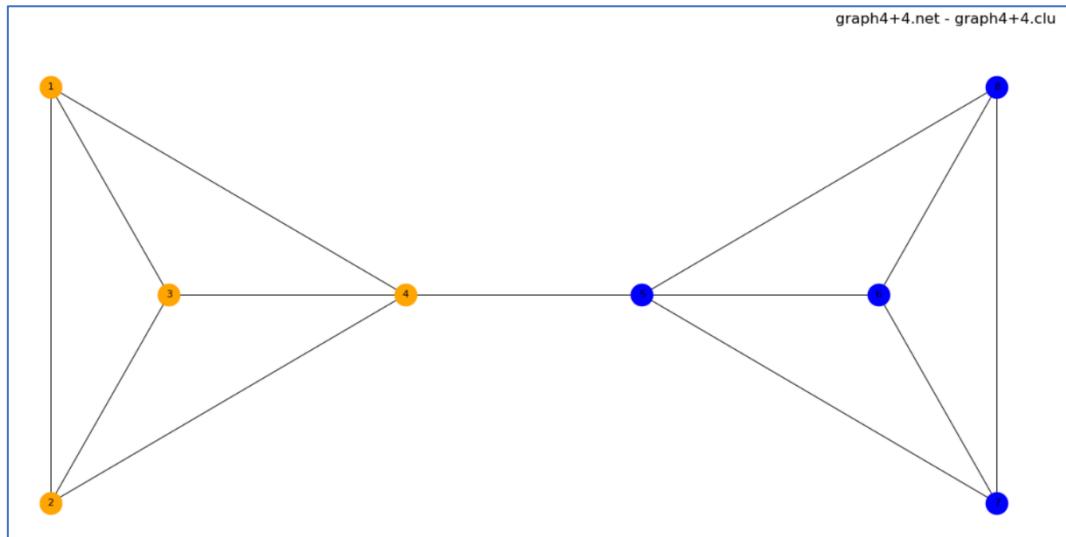
Normalized Mutual Information

	graph3+1+3-type1.clu	graph3+1+3-type2.clu	graph3+1+3-type3.clu
graph3+1+3.clu	0.8095	0.8095	0.8095

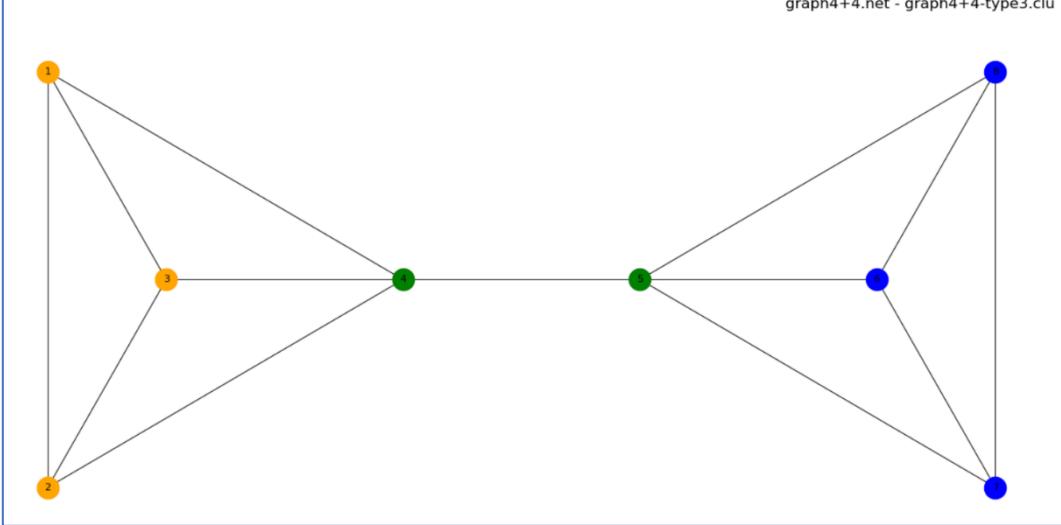
Normalized Variation of Information

	graph3+1+3-type1.clu	graph3+1+3-type2.clu	graph3+1+3-type3.clu
graph3+1+3.clu	0.1651	0.1651	0.1651

Images



graph4+4.net - graph4+4-type3.clu



grid-p-6x6

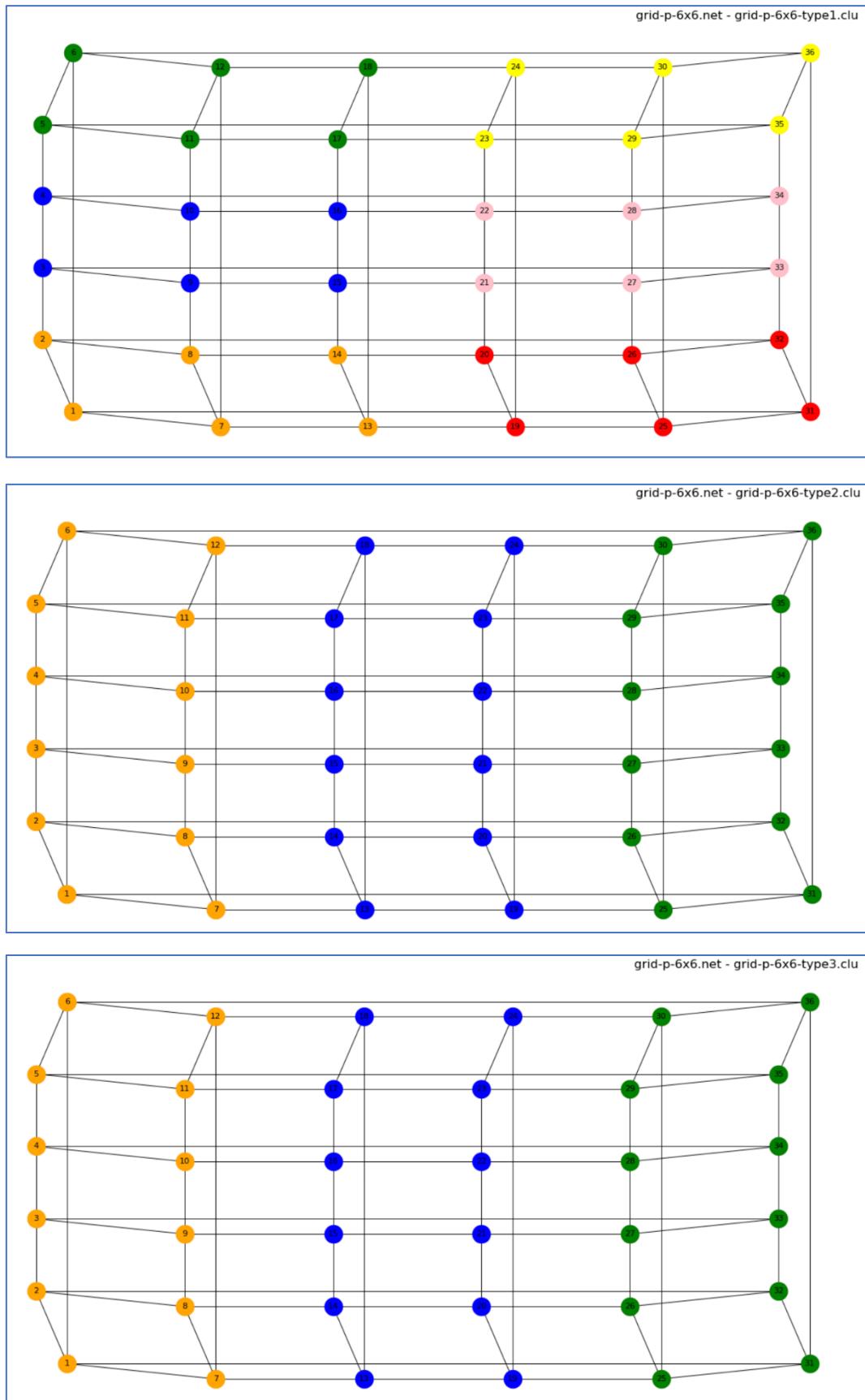
Modularity

grid-p-6x6-type1.clu	0.58333333
grid-p-6x6-type2.clu	0.75000000
grid-p-6x6-type3.clu	0.75000000

Indexes

No comparisons because this network has no .clu files given as input of exercise

Images



star

Modularity

star.clu	1.00000000
star-type1.clu	1.00000000
star-type2.clu	1.00000000
star-type3.clu	1.00000000

Indexes

Jaccard Index

	star-type1.clu	star-type2.clu	star-type3.clu
star.clu	1.0000	1.0000	1.0000

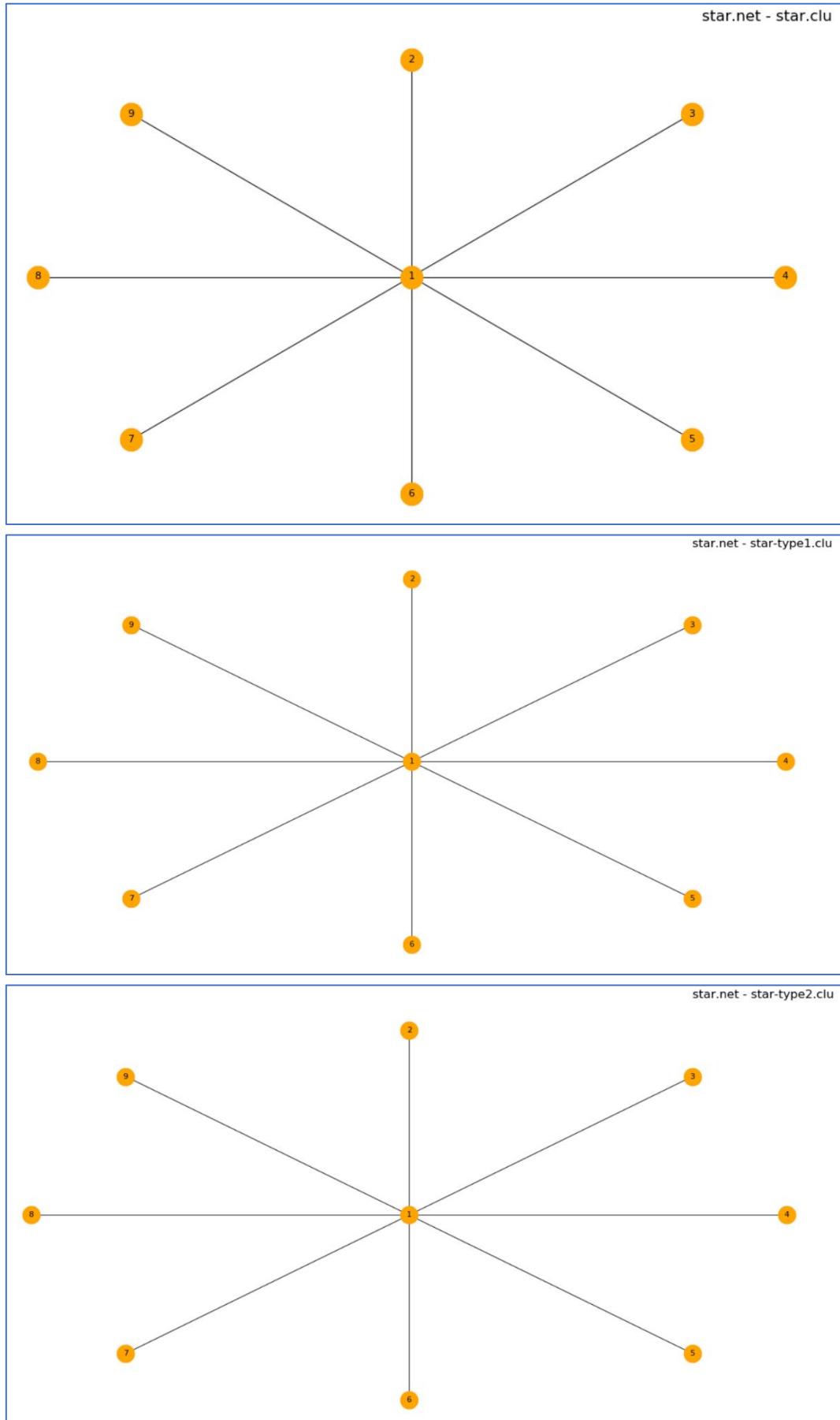
Normalized Mutual Information

	star-type1.clu	star-type2.clu	star-type3.clu
star.clu	1.0000	1.0000	1.0000

Normalized Variation of Information

	star-type1.clu	star-type2.clu	star-type3.clu
star.clu	0.0000	0.0000	0.0000

Images



star.net - star-type3.clu

