

### a. Performance Comparison

Below are tables listing each NMI, ARI and modularity of each method used to cluster each network of the different benchmarks, and the overall performance comes the last.  
 For each type of the benchmarks and the overall average, the best approach that achieves the highest performance is marked by the blue border in the table.

- real-classic

real-classic	strike	karate	polblogs	polbooks	football	Average
NMI						
Louvain	0.86596	0.60214	0.37100	0.52192	0.88496	0.64920
Greedy Modularity	0.77041	0.69247	0.37711	0.53081	0.69773	0.61371
Infomap	0.88407	0.69949	0.33056	0.49345	0.92420	0.66635
Walk Trap	0.88407	0.50418	0.36954	0.54275	0.88736	0.63758
Label Propagation	0.86596	0.82552	0.38579	0.58609	0.80628	0.69393
Leading Eigenvector	0.88407	0.67709	0.37858	0.52011	0.69867	0.63170
Edge Betweenness	0.88407	0.57983	-	0.55845	0.87889	0.72531
Spinglass	0.88407	0.68726	-	0.46727	0.87909	0.72942
ARI						
Louvain	0.84863	0.51312	0.51594	0.53662	0.80347	0.64356
Greedy Modularity	0.66466	0.68026	0.52644	0.63790	0.47410	0.59667
Infomap	0.79779	0.70216	0.43774	0.53606	0.89665	0.67408
Walk Trap	0.79779	0.33313	0.51210	0.65342	0.81544	0.62238
Label Propagation	0.84863	0.80275	0.53758	0.68935	0.52025	0.67971
Leading Eigenvector	0.79779	0.51209	0.52607	0.54666	0.46405	0.56933
Edge Betweenness	0.79779	0.46862	-	0.68237	0.77810	0.68172
Spinglass	0.79779	0.54136	-	0.39882	0.80522	0.63580
Modularity						
Louvain	0.54744	0.41560	0.42668	0.52680	0.60435	0.50417
Greedy Modularity	0.55575	0.38067	0.42480	0.50197	0.54974	0.48259
Infomap	0.56198	0.40204	0.41778	0.52285	0.60052	0.50103
Walk Trap	0.56198	0.35322	0.42552	0.50697	0.60291	0.49012
Label Propagation	0.54744	0.39908	0.42605	0.49462	0.56940	0.48732
Leading Eigenvector	0.56198	0.39341	0.42433	0.46718	0.49261	0.46790
Edge Betweenness	0.56198	0.40130	-	0.51680	0.59963	0.51993
Spinglass	0.56198	0.41979	-	0.52514	0.60343	0.52759

\* Although it seems that Spinglass and Edge Betweenness beat other approaches with their higher average performance in terms of NMI and/or ARI, they are not chosen as the best performance winner. The reason for this is that the results of them on the largest network "polblogs" were not successfully reported, which turned out to be the lowest results among all the networks and should have a significant impact on the average value. They did not finish the work due to different reasons: Spinglass encounter does not work on unconnected graph and Edge Betweenness sometimes takes too much time to complete.  
 Given this, I prefer to choose a method that covered all networks as the winner.  
 Same logic adopted when comparing overall performance below.

- real-node-label

real-node-label	citeseer	cora	pubmed	Average
NMI				
Louvain	0.21061	0.20779	0.18101	0.19980
Greedy Modularity	0.21567	0.21492	0.19197	0.20752
Infomap	0.22964	0.23384	0.15427	0.20592
Walk Trap	0.23012	0.22920	0.16399	0.20777
Label Propagation	0.22793	0.22899	0.17197	0.20963
Leading Eigenvector	0.21199	0.17821	0.13942	0.17654
Edge Betweenness	0.06829	0.04742	-	0.05785
Spinglass			0.15830	0.15830
ARI				
Louvain	0.04455	0.09921	0.10219	0.08198
Greedy Modularity	0.06454	0.10174	0.16065	0.10898
Infomap	0.00876	0.01766	0.00545	0.01062
Walk Trap	0.05579	0.07482	0.07319	0.06793
Label Propagation	0.01262	0.05686	0.08415	0.05121
Leading Eigenvector	0.05606	0.07643	0.02746	0.05332
Edge Betweenness	0.01336	-0.00286	-	0.00525
Spinglass			0.09235	0.09235
Modularity				
Louvain	0.89076	0.81536	0.76688	0.82434

Greedy Modularity	0.87364	0.80687	0.72780	0.80277
Infomap	0.82130	0.71787	0.64437	0.72784
Walk Trap	0.83304	0.76457	0.71141	0.76967
Label Propagation	0.81152	0.74562	0.68233	0.74649
Leading Eigenvector	0.85412	0.73187	0.46134	0.68244
Edge Betweenness	0.34788	0.07740		0.21264
Spinglass			0.77511	0.77511

- LFR Benchmark (synthetic)

LFR synthetic	graph 1	graph 2	graph 3	graph 4	graph 5	Average
NMI						
Louvain	1.00000	0.46729	1.00000	1.00000	1.00000	0.89346
Greedy Modularity	0.89392	0.52407	0.88953	0.99166	0.96978	0.85379
Infomap	1.00000	0.00000	1.00000	1.00000	1.00000	0.80000
Walk Trap	0.99067	0.84371	1.00000	1.00000	1.00000	0.96688
Label Propagation	0.96437	0.00000	0.90739	0.98196	0.98566	0.76788
Leading Eigenvector	0.84037	0.48441	0.78695	0.81844	0.72112	0.73026
Edge Betweenness	0.99428	0.47254	1.00000	1.00000	0.97519	0.88840
Spinglass	0.98029	0.51012	0.98892	0.98346	0.98592	0.88974
ARI						
Louvain	1.00000	0.28122	1.00000	1.00000	1.00000	0.85624
Greedy Modularity	0.88004	0.38394	0.81984	0.99055	0.97986	0.81085
Infomap	1.00000	0.00000	1.00000	1.00000	1.00000	0.80000
Walk Trap	0.99455	0.91855	1.00000	1.00000	1.00000	0.98262
Label Propagation	0.96134	0.00000	0.77868	0.97301	0.99096	0.74080
Leading Eigenvector	0.83621	0.36596	0.79831	0.75164	0.75148	0.70072
Edge Betweenness	0.99713	0.58933	1.00000	1.00000	0.98905	0.91510
Spinglass	0.98285	0.33840	0.98656	0.98135	0.99100	0.85603
Modularity						
Louvain	0.56081	0.23798	0.56840	0.74779	0.52944	0.52888
Greedy Modularity	0.54394	0.22675	0.54269	0.74100	0.52430	0.51574
Infomap	0.56081	-0.00000	0.56840	0.74779	0.52944	0.48129
Walk Trap	0.55723	0.18646	0.56840	0.74779	0.52944	0.51786
Label Propagation	0.55309	-0.00000	0.52924	0.73385	0.52841	0.46892
Leading Eigenvector	0.53048	0.19263	0.46917	0.62917	0.40964	0.44622
Edge Betweenness	0.55902	0.15212	0.56840	0.74779	0.52473	0.51041
Spinglass	0.55874	0.25041	0.56745	0.74248	0.52738	0.52929

- all

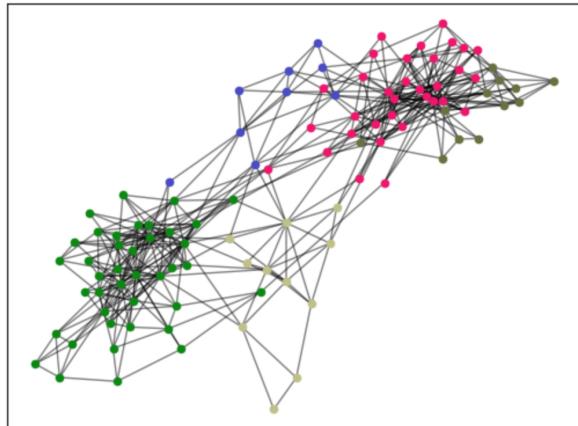
All	real-classic	real-node-label	LFR	Average
NMI				
Louvain	0.64920	0.19980	0.89346	0.63944
Greedy Modularity	0.61371	0.20752	0.85379	0.61231
Infomap	0.66635	0.20592	0.80000	0.61150
Walk Trap	0.63758	0.20777	0.96688	0.66505
Label Propagation	0.69393	0.20963	0.76788	0.61061
Leading Eigenvector	0.63170	0.17654	0.73026	0.56457
Edge Betweenness	0.72531	0.05785	0.88840	0.67809
Spinglass	0.72942	0.15830	0.88974	0.75247
ARI				
Louvain	0.64356	0.08198	0.85624	0.59576
Greedy Modularity	0.59667	0.10898	0.81085	0.56650
Infomap	0.67408	0.01062	0.80000	0.56940
Walk Trap	0.62238	0.06793	0.98262	0.63298
Label Propagation	0.67971	0.05121	0.74080	0.55817
Leading Eigenvector	0.56933	0.05332	0.70072	0.50079
Edge Betweenness	0.68172	0.00525	0.91510	0.66481
Spinglass	0.63580	0.09235	0.85603	0.69157
Modularity				
Louvain	0.50417	0.82434	0.52888	0.58756
Greedy Modularity	0.48259	0.80277	0.51574	0.56923
Infomap	0.50103	0.72784	0.48129	0.54578
Walk Trap	0.49012	0.76967	0.51786	0.56530

<b>Label Propagation</b>	0.48732	0.74649	0.46892	0.54005
<b>Leading Eigenvector</b>	0.46790	0.68244	0.44622	0.50907
<b>Edge Betweenness</b>	0.51993	0.21264	0.51041	0.45973
<b>Spinglass</b>	0.52759	0.77511	0.52929	0.55319

## b. Cluster Plots

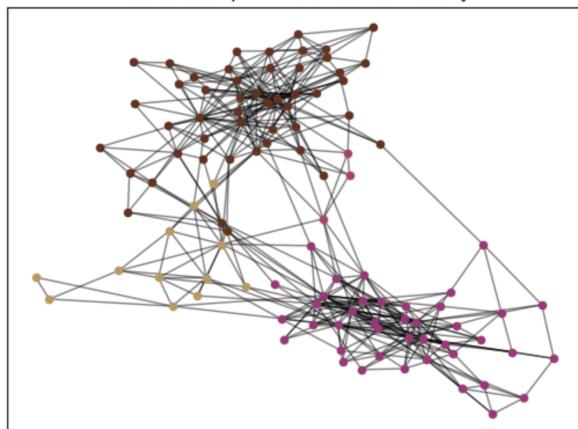
- real-classic
- polbooks
- Louvain

real-classic polbooks Louvain



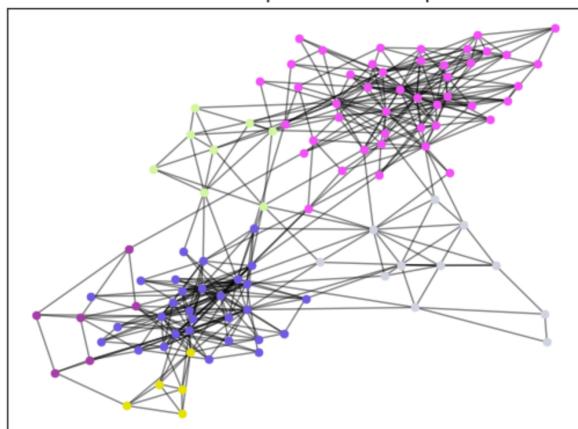
- Greedy Modularity

real-classic polbooks Fast Modularity



- Infomap

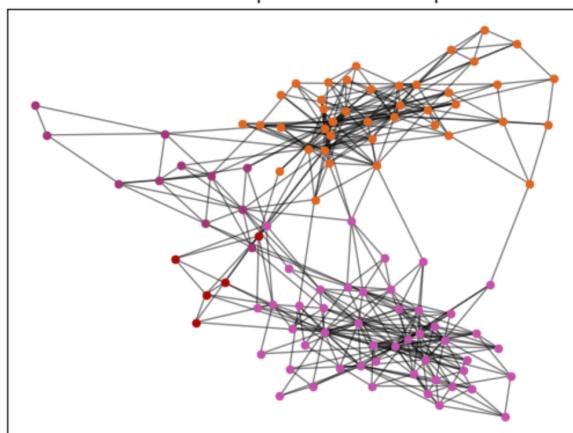
real-classic polbooks Infomap



- Walk Trap

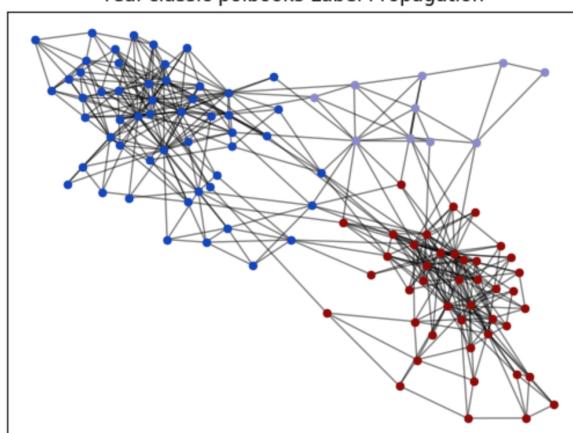
real-classic polbooks Walk Trap

real-classic polbooks Train Graph



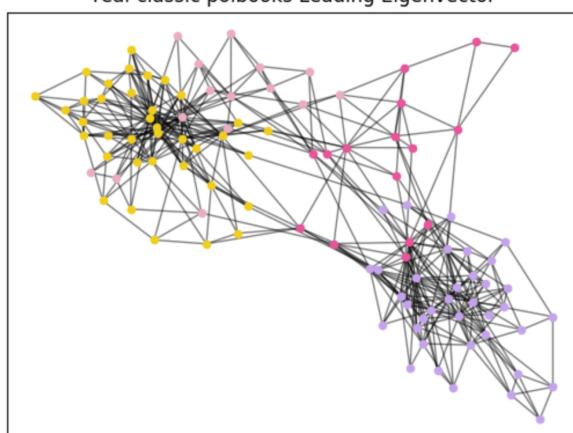
▪ Label Propagation

real-classic polbooks Label Propagation



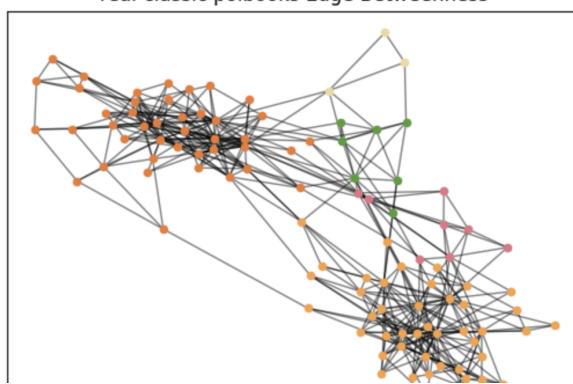
▪ Leading Eigenvector

real-classic polbooks Leading Eigenvector



▪ Edge Betweenness

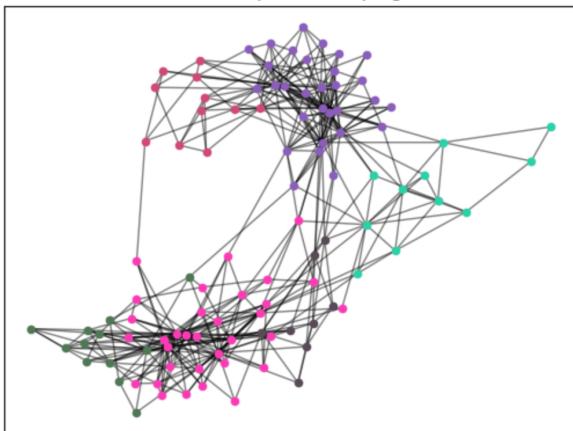
real-classic polbooks Edge Betweenness





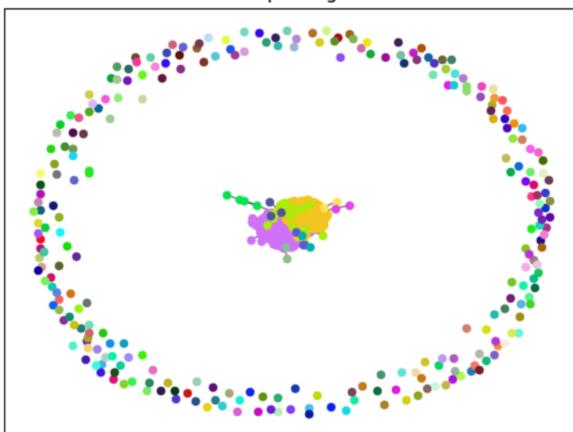
▪ Spinglass

real-classic polbooks Spinglass



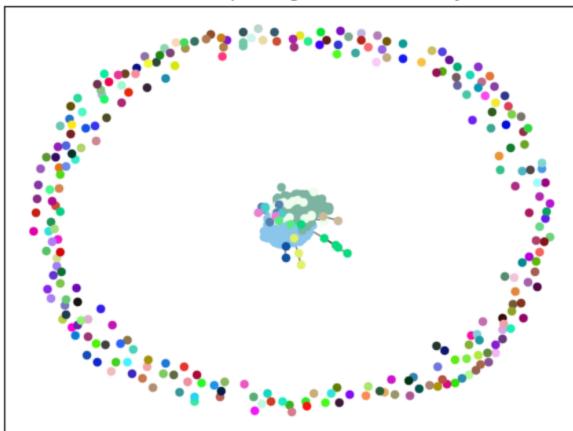
▪ polblogs  
▪ Louvain

real-classic polblogs Louvain



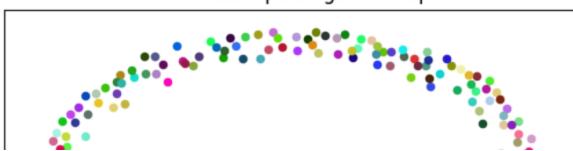
▪ Greedy Modularity

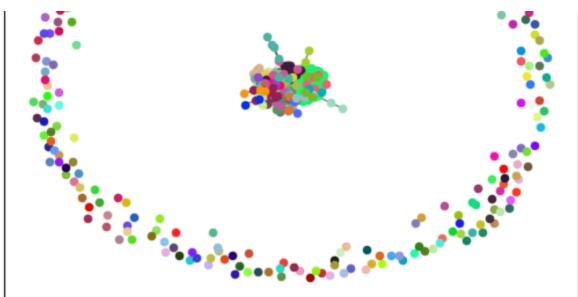
real-classic polblogs Fast Modularity



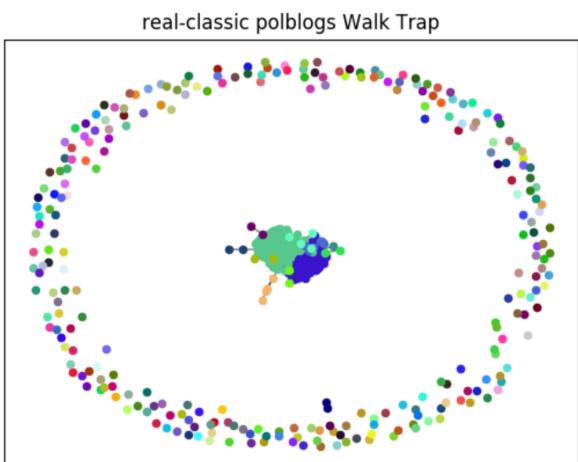
▪ Infomap

real-classic polblogs Infomap

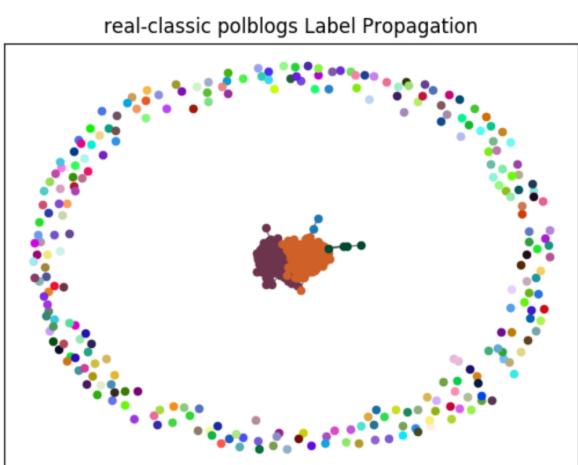




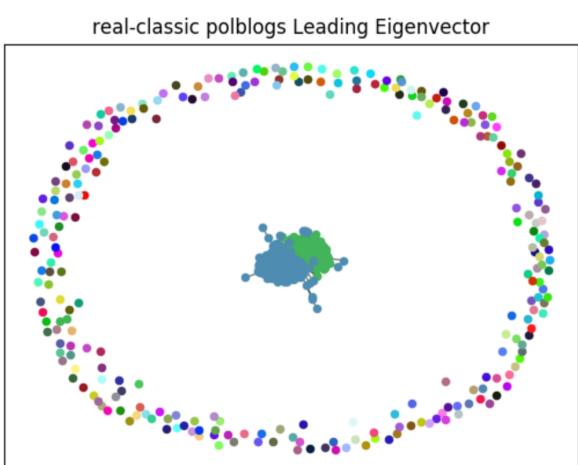
▪ Walk Trap



▪ Label Propagation



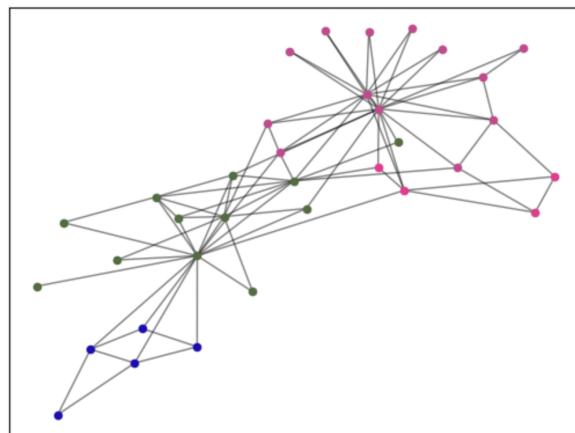
▪ Leading Eigenvector



▪ karate

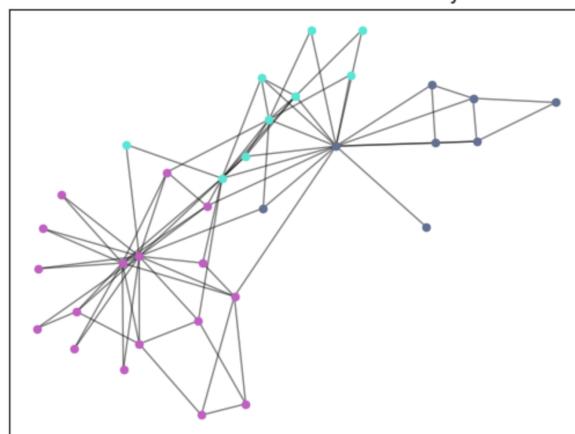
▪ Louvain

real-classic karate Louvain



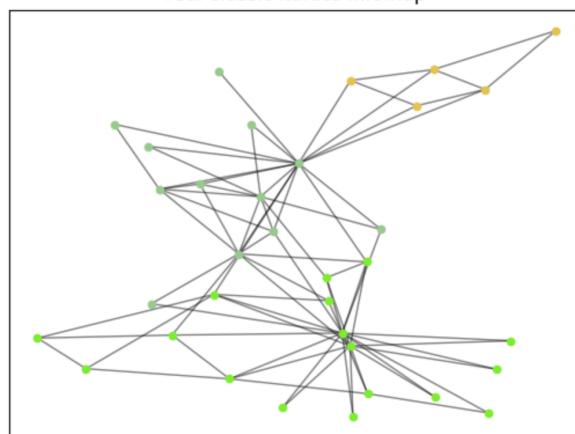
▪ Greedy Modularity

real-classic karate Fast Modularity



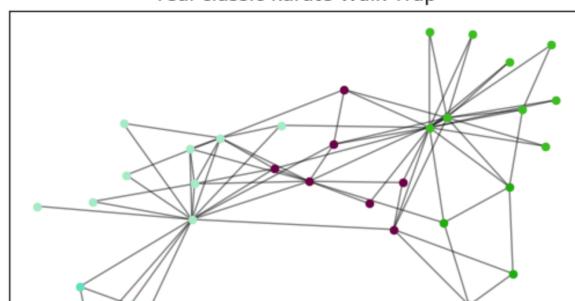
▪ Infomap

real-classic karate Infomap



▪ Walk Trap

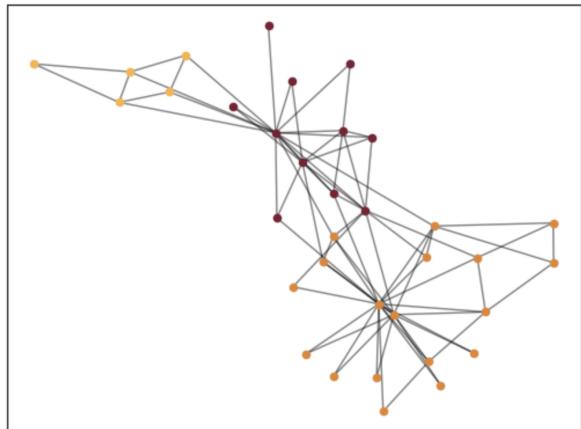
real-classic karate Walk Trap





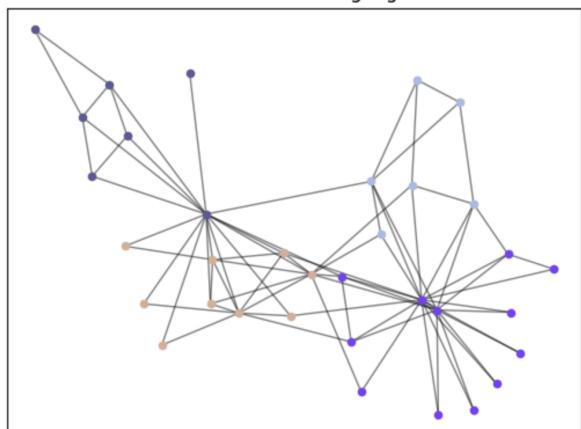
- Label Propagation

real-classic karate Label Propagation



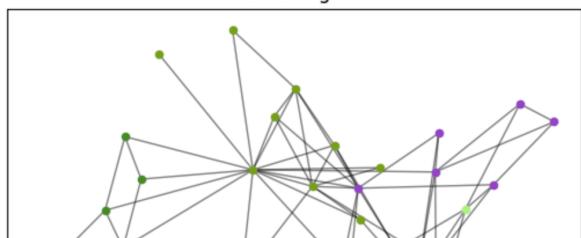
- Leading Eigenvector

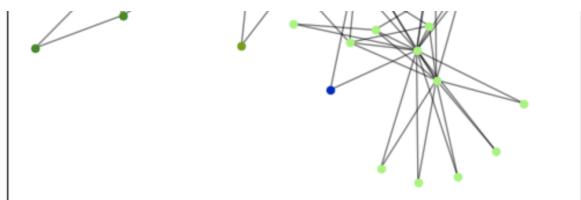
real-classic karate Leading Eigenvector



- Edge Betweenness

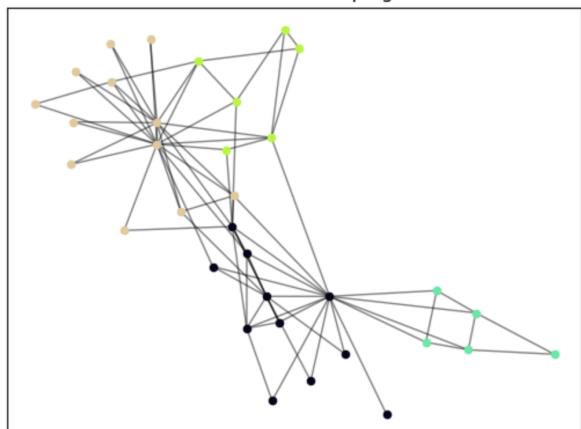
real-classic karate Edge Betweenness





▪ Spinglass

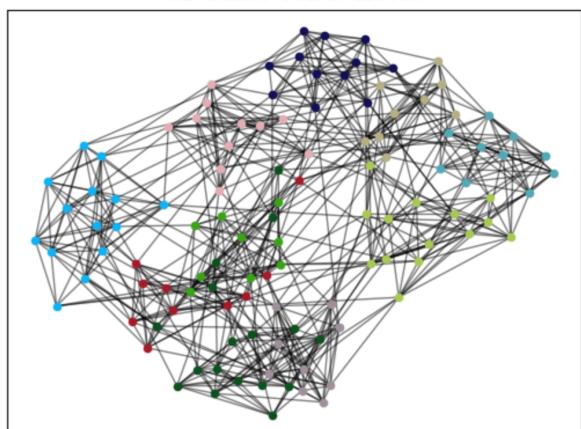
real-classic karate Spinglass



▪ football

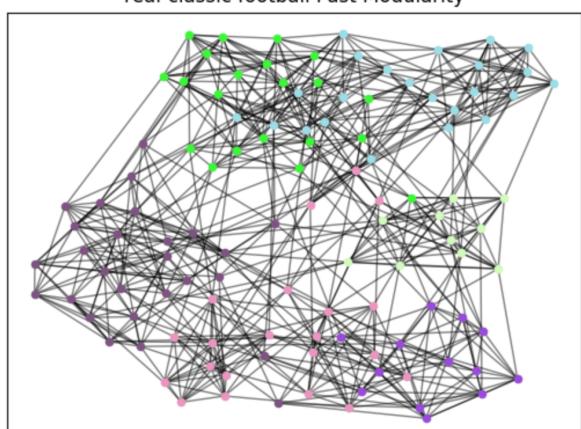
▪ Louvain

real-classic football Louvain



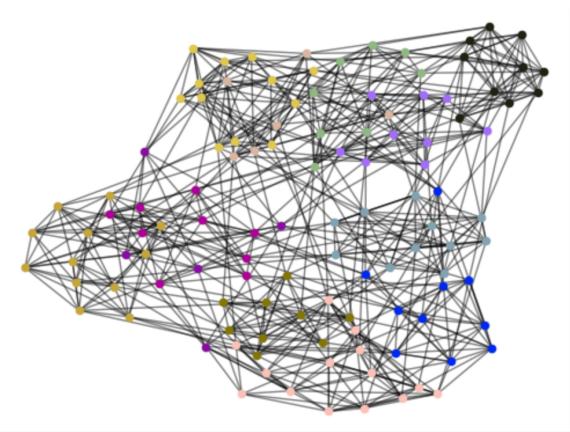
▪ Greedy Modularity

real-classic football Fast Modularity



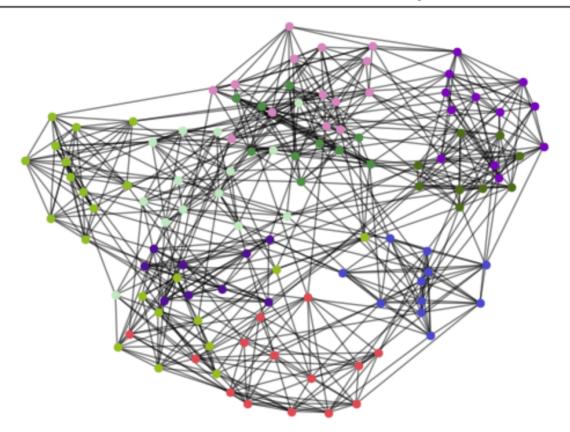
▪ Infomap

real-classic football Infomap



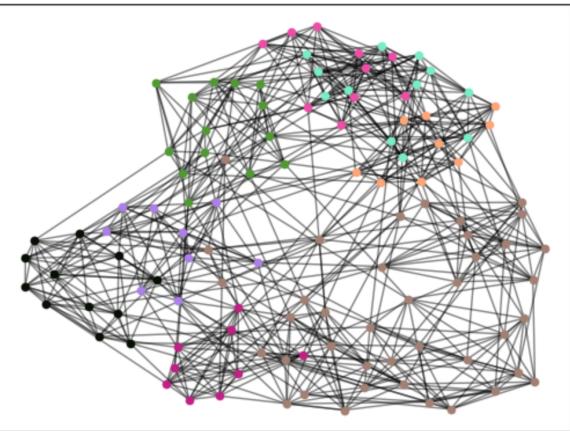
▪ Walk Trap

real-classic football Walk Trap



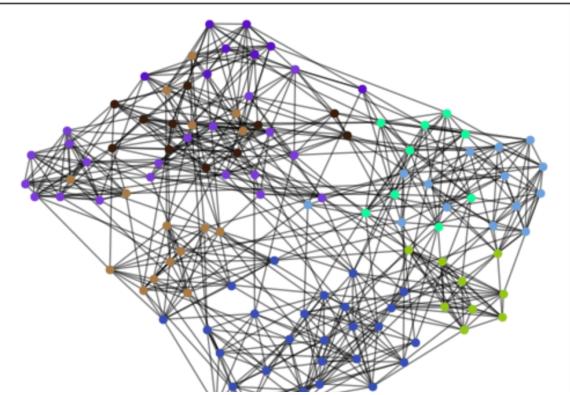
▪ Label Propagation

real-classic football Label Propagation



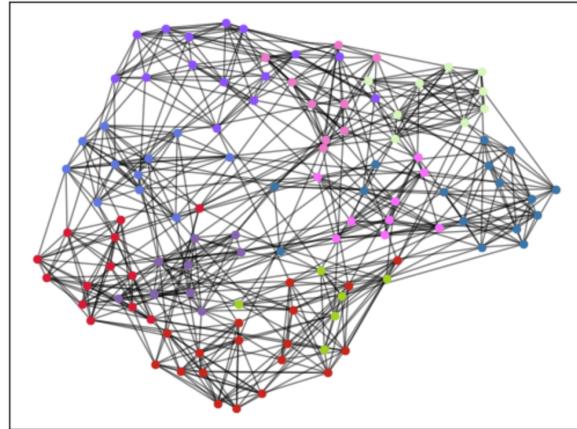
▪ Leading Eigenvector

real-classic football Leading Eigenvector



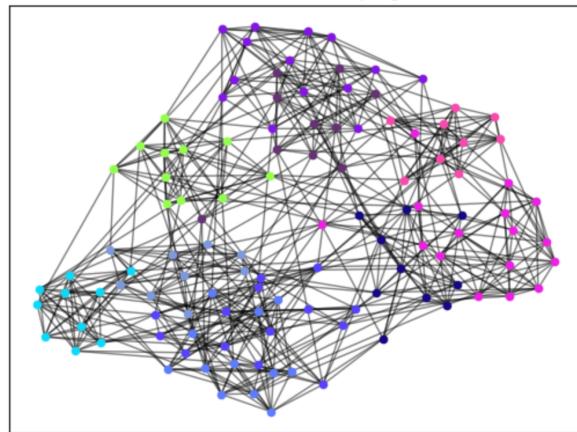
- Edge Betweenness

real-classic football Edge Betweenness



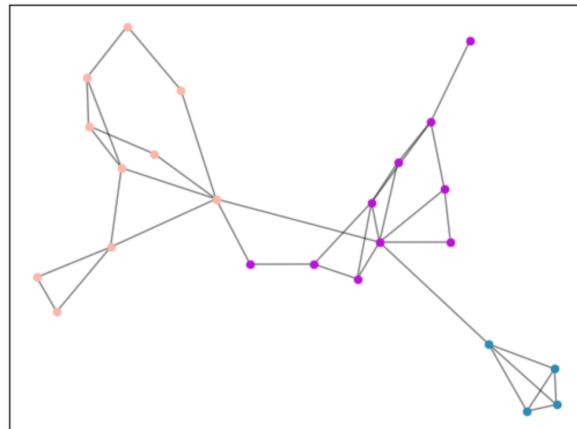
- Spinglass

real-classic football Spinglass



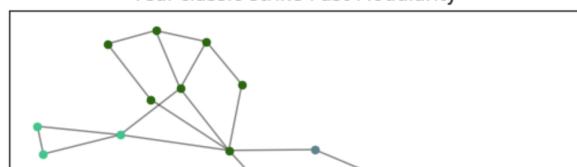
- strike
- Louvain

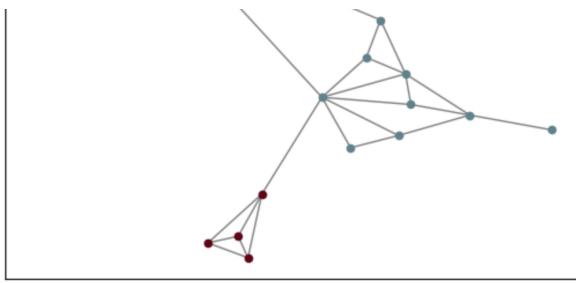
real-classic strike Louvain



- Greedy Modularity

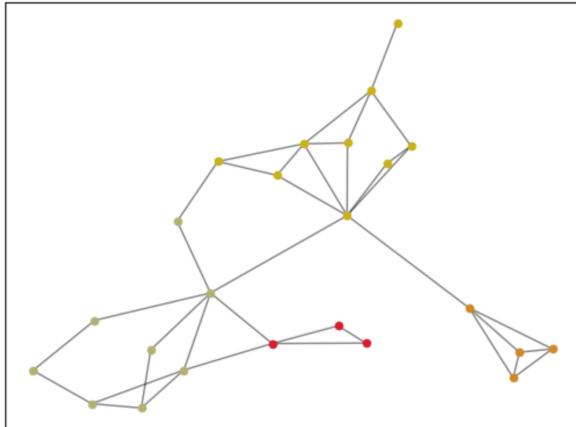
real-classic strike Fast Modularity





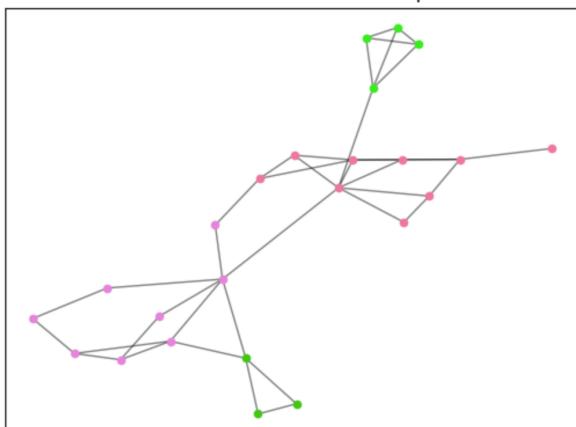
▪ Infomap

real-classic strike Infomap



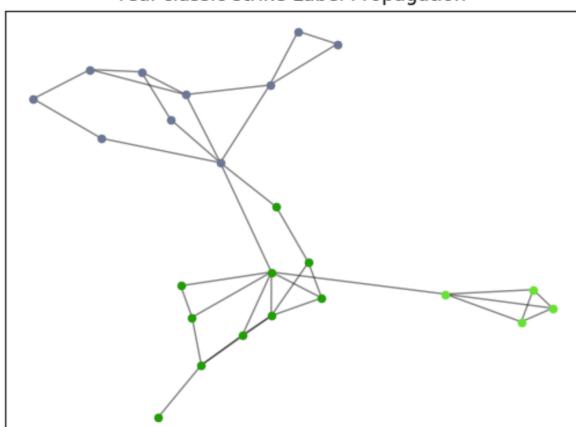
▪ Walk Trap

real-classic strike Walk Trap



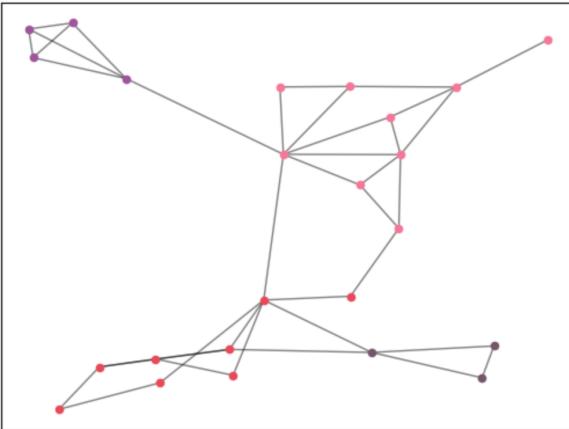
▪ Label Propagation

real-classic strike Label Propagation



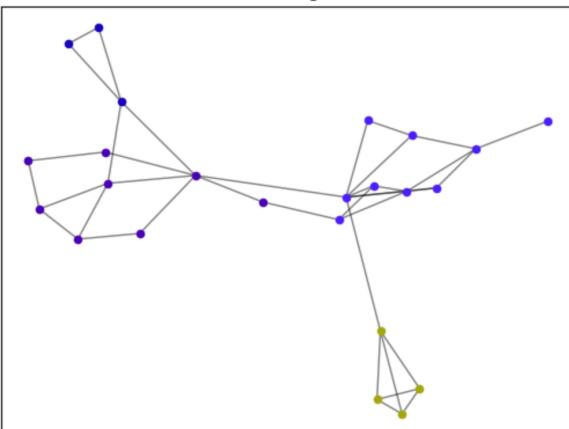
▪ Leading Eigenvector

real-classic strike Leading Eigenvector



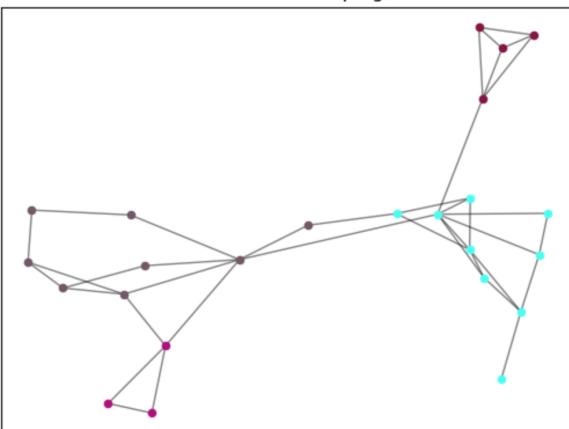
▪ Edge Betweenness

real-classic strike Edge Betweenness



▪ Spinglass

real-classic strike Spinglass

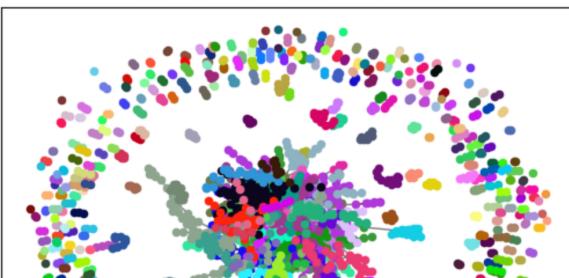


◦ real-node-label

▪ citeseer

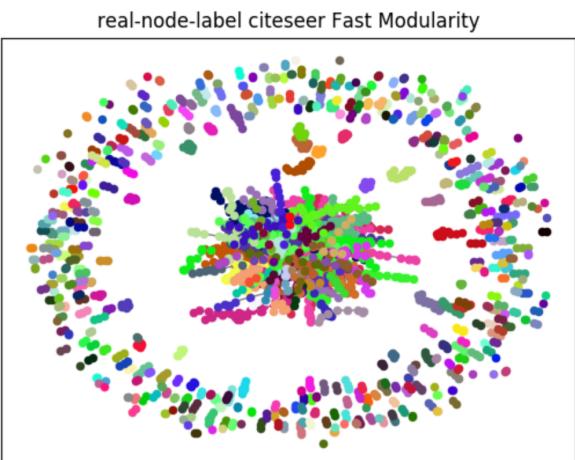
▪ Louvain

real-node-label citeseer Louvain

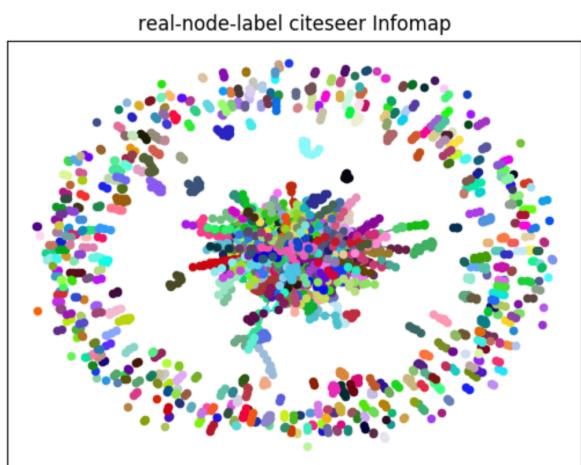




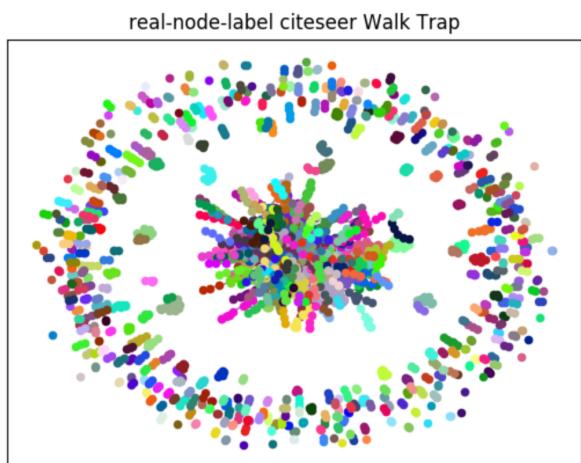
▪ Greedy Modularity



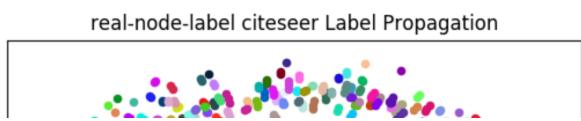
▪ Infomap

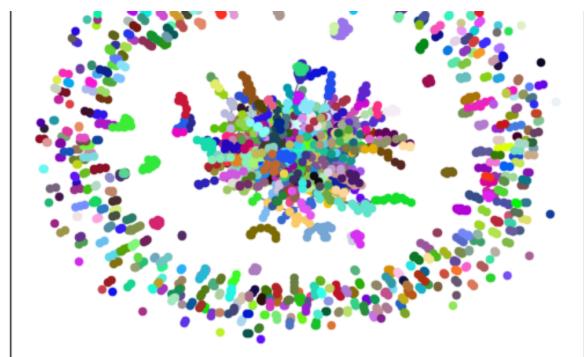


▪ Walk Trap

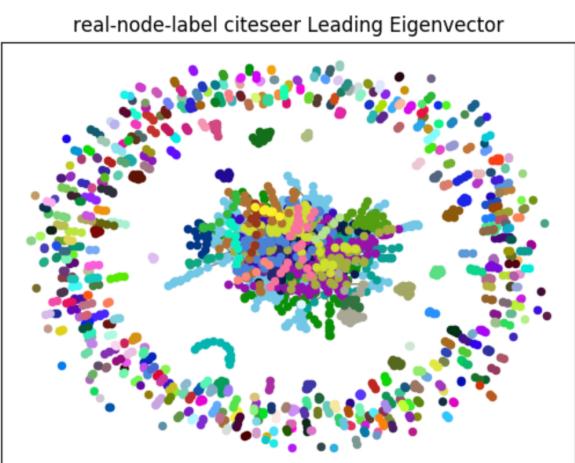


▪ Label Propagation

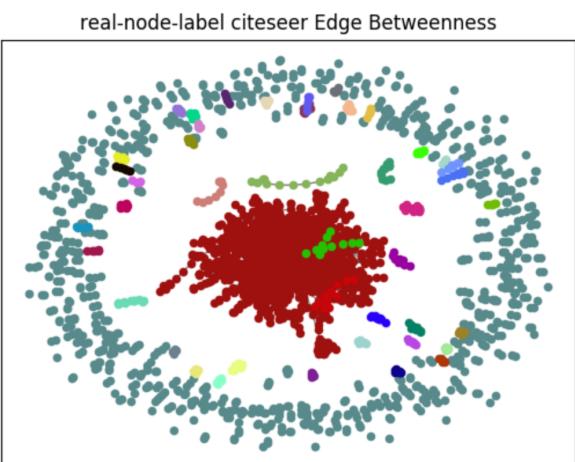




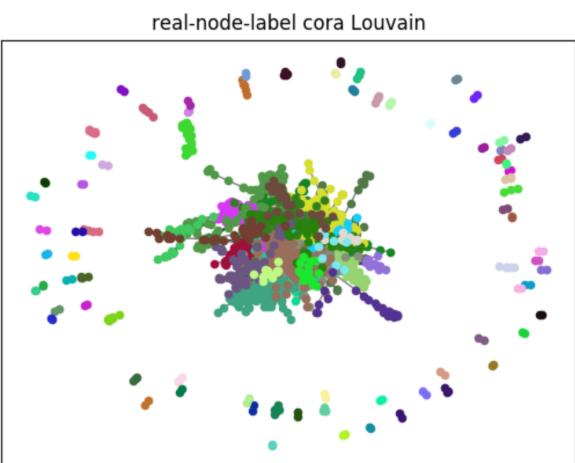
■ Leading Eigenvector



■ Edge Betweenness

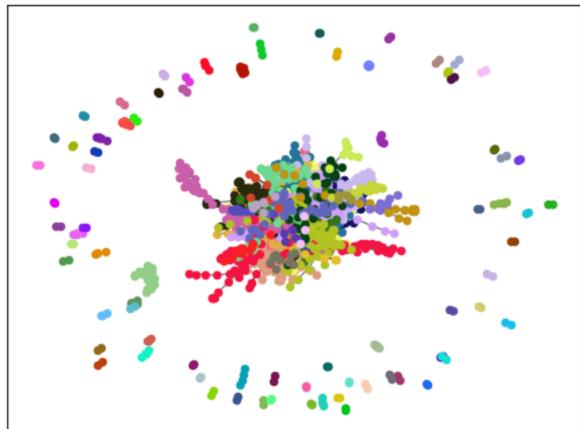


■ cora  
■ Louvain



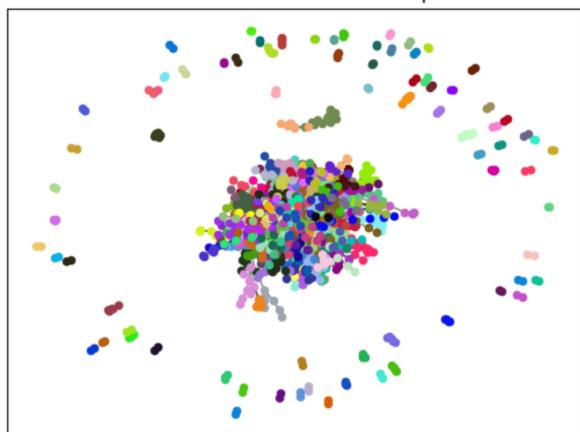
- Greedy Modularity

real-node-label cora Fast Modularity



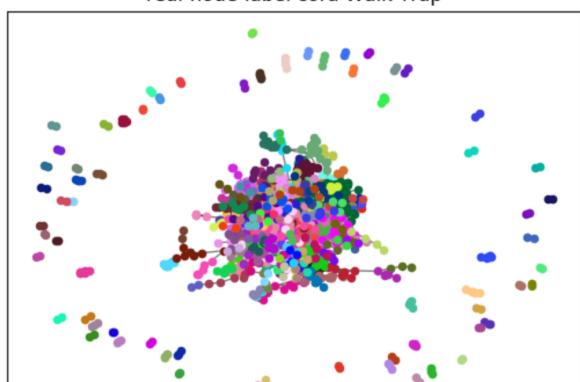
- Infomap

real-node-label cora Infomap



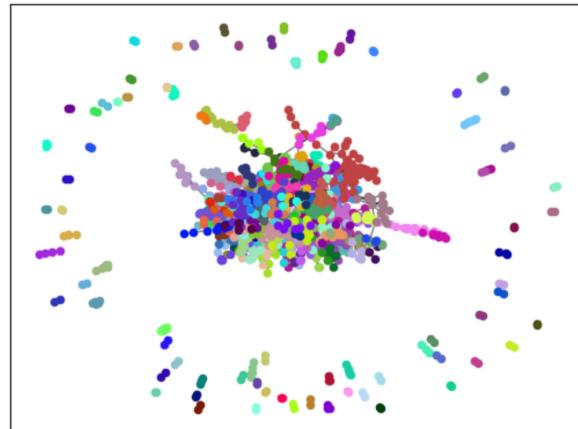
- Walk Trap

real-node-label cora Walk Trap



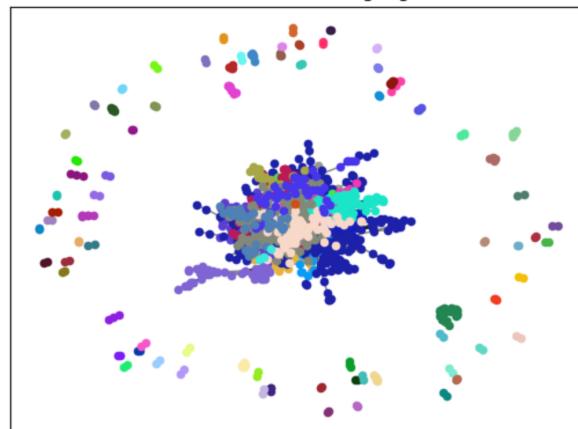
▪ Label Propagation

real-node-label cora Label Propagation



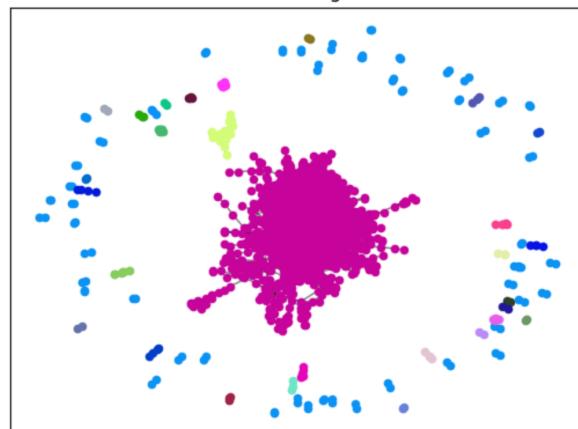
▪ Leading Eigenvector

real-node-label cora Leading Eigenvector



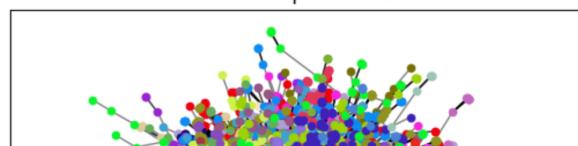
▪ Edge Betweenness

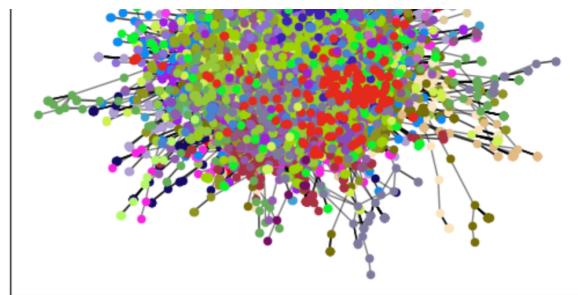
real-node-label cora Edge Betweenness



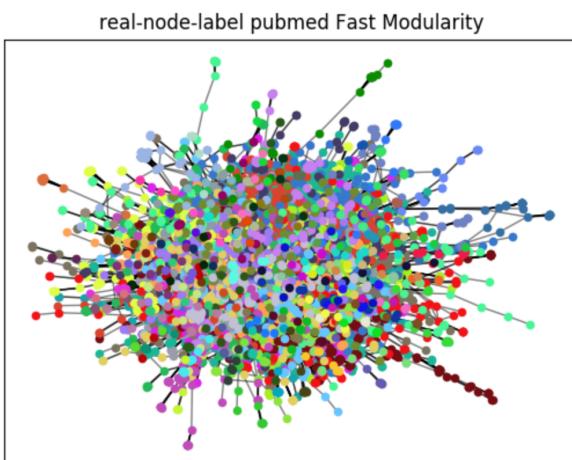
▪ pubmed  
▪ Louvain

real-node-label pubmed Louvain

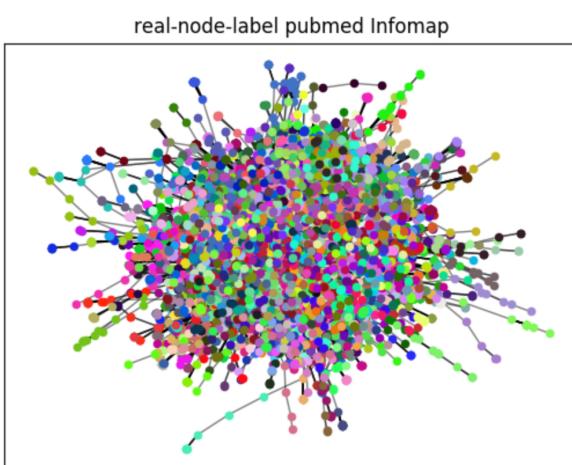




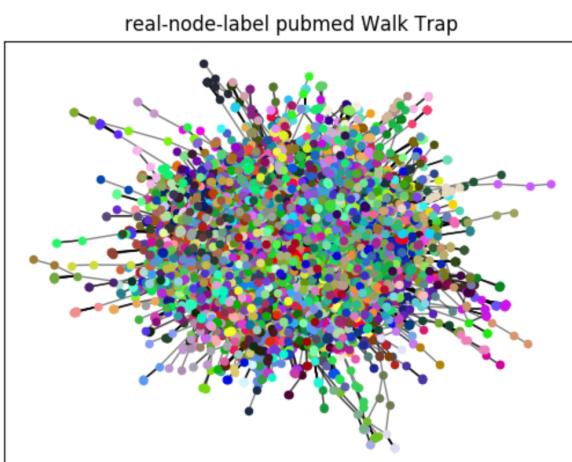
▪ Greedy Modularity



▪ Infomap

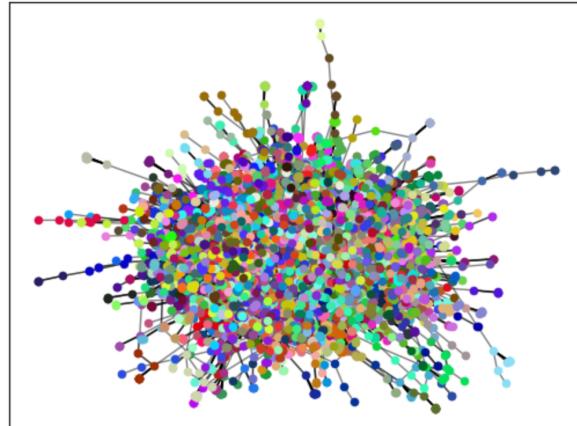


▪ Walk Trap



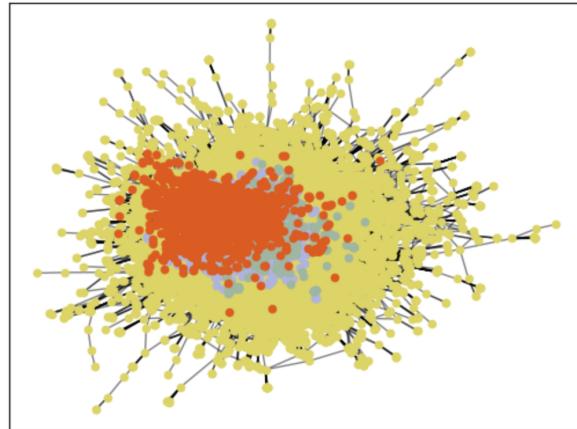
▪ Label Propagation

real-node-label pubmed Label Propagation



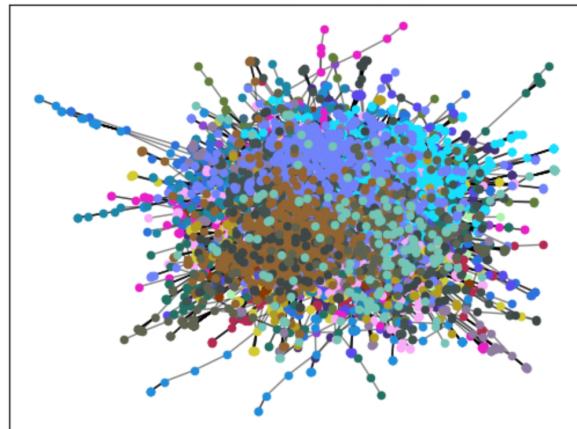
▪ Leading Eigenvector

real-node-label pubmed Leading Eigenvector



▪ Spinglass

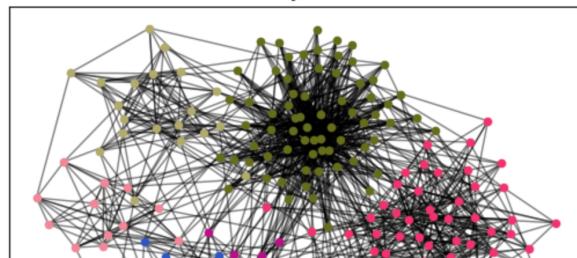
real-node-label pubmed Spinglass

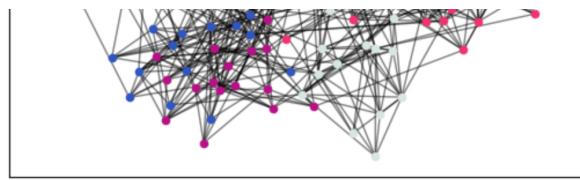


◦ LFR Benchmark (synthetic)

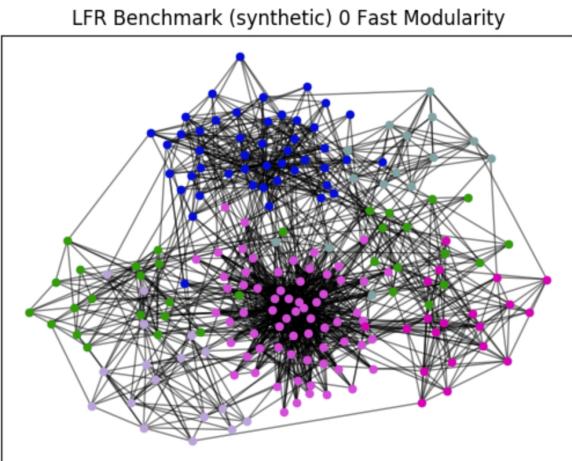
- LFR ( $n = 200$ ,  $\tau_{\text{al}} = 2.5$ ,  $\tau_{\text{al2}} = 1.5$ ,  $\mu = 0.1$ ,  $\text{mindegree} = 5$ ,  $\text{seed} = 10$ )
  - Louvain

LFR Benchmark (synthetic) 0 Louvain

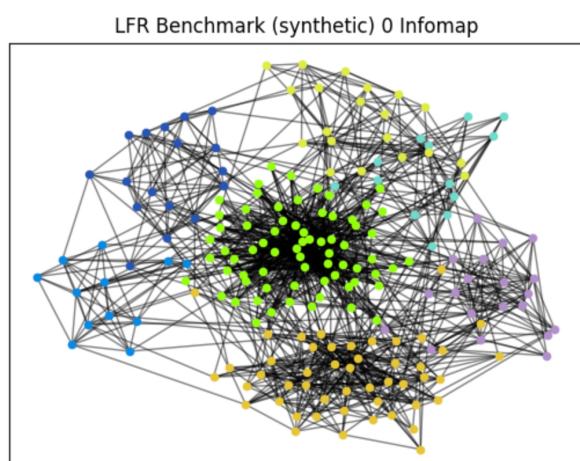




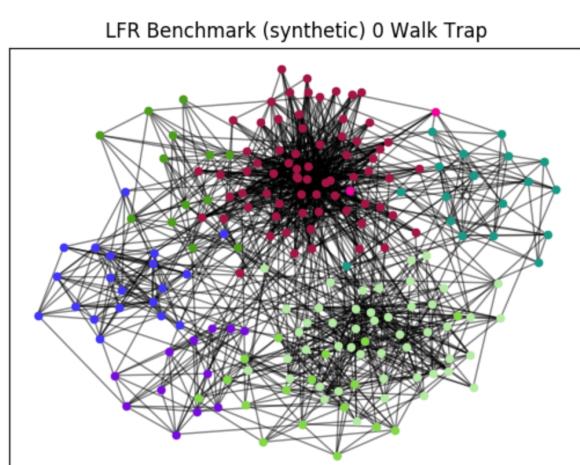
▪ Greedy Modularity



▪ Infomap

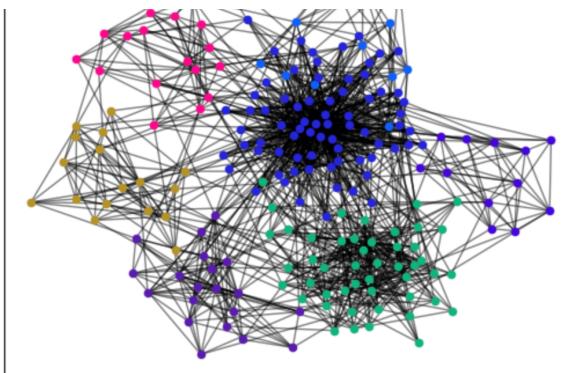


▪ Walk Trap

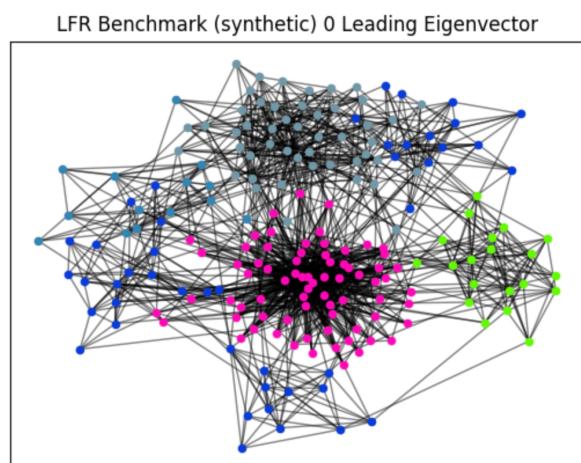


▪ Label Propagation

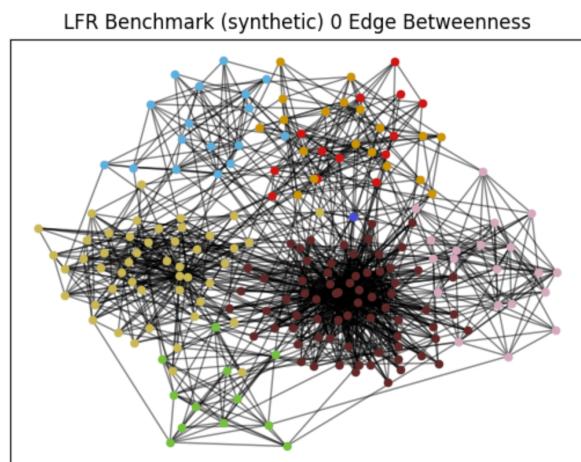




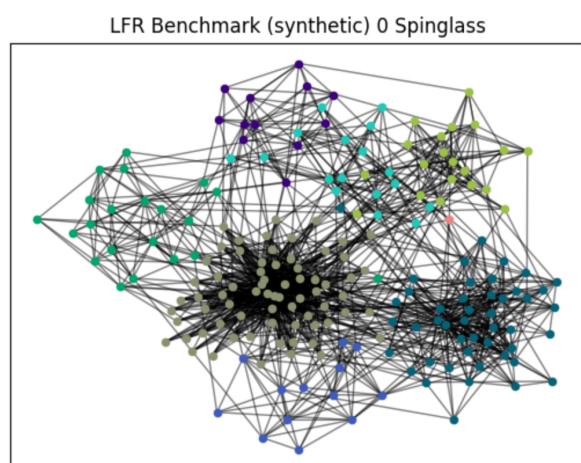
▪ Leading Eigenvector



▪ Edge Betweenness

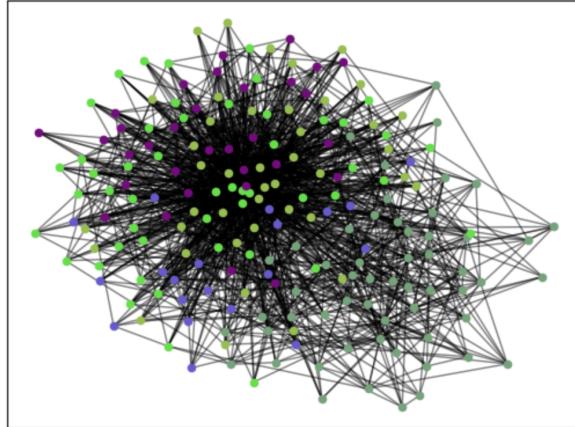


▪ Spinglass



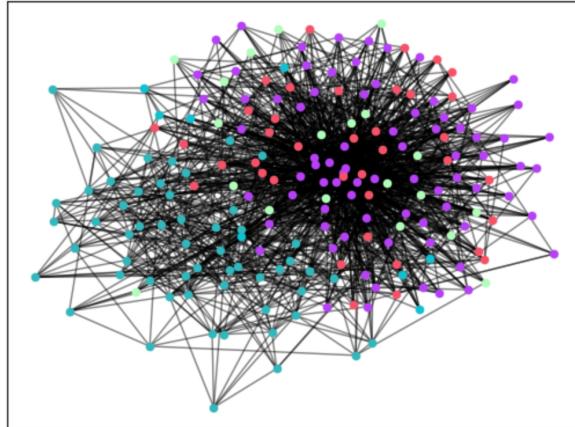
- LFR ( $n = 200$ ,  $\tau_{\text{al}} = 2.5$ ,  $\tau_{\text{a2}} = 1.5$ ,  $\mu = 0.1$ , mindegree = 5, seed = 11)
  - Louvain

LFR Benchmark (synthetic) 1 Louvain



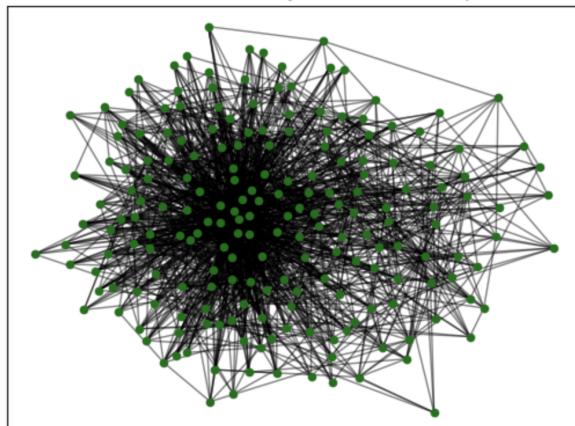
- Greedy Modularity

LFR Benchmark (synthetic) 1 Fast Modularity



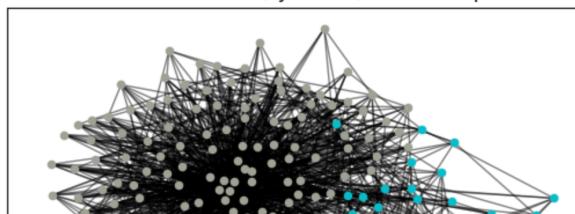
- Infomap

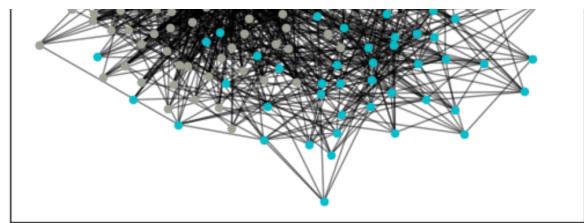
LFR Benchmark (synthetic) 1 Infomap



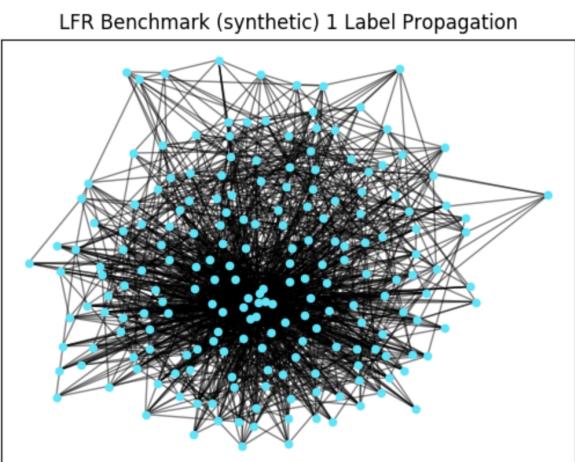
- Walk Trap

LFR Benchmark (synthetic) 1 Walk Trap

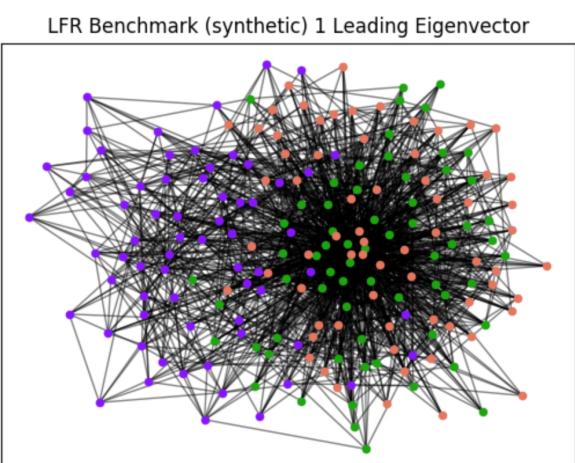




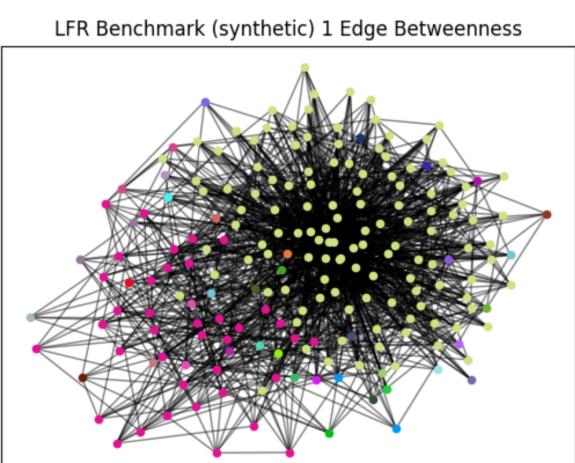
▪ Label Propagation



▪ Leading Eigenvector

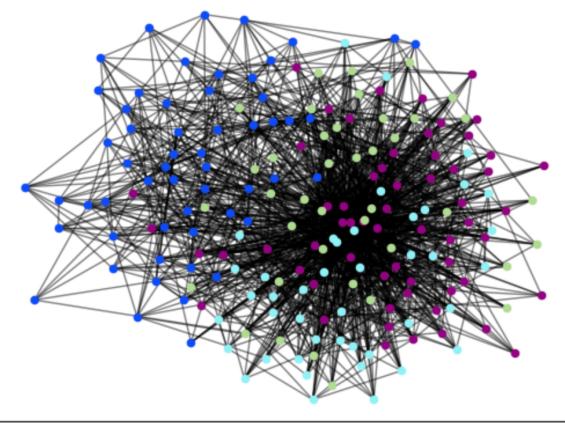


▪ Edge Betweenness



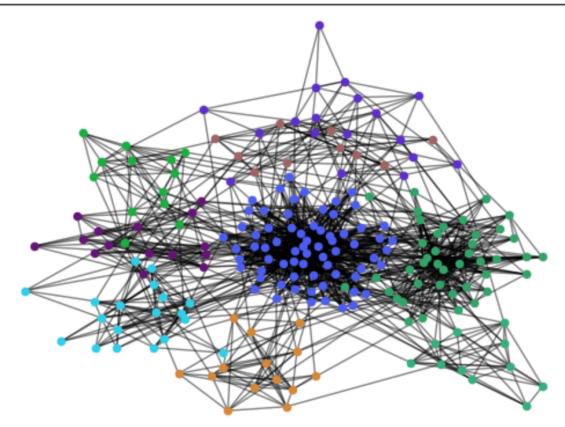
▪ Spinglass

LFR Benchmark (synthetic) 1 Spinglass



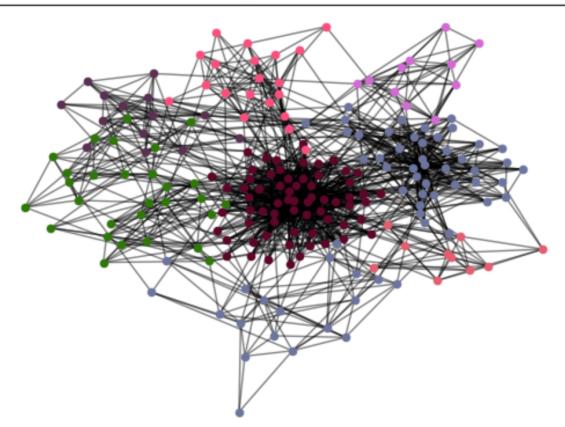
- LFR ( $n = 211$ ,  $\tau_{\text{al}} = 2.5$ ,  $\tau_{\text{a2}} = 1.5$ ,  $\mu = 0.1$ ,  $\text{mindegree} = 5$ , seed = 10)
- Louvain

LFR Benchmark (synthetic) 2 Louvain



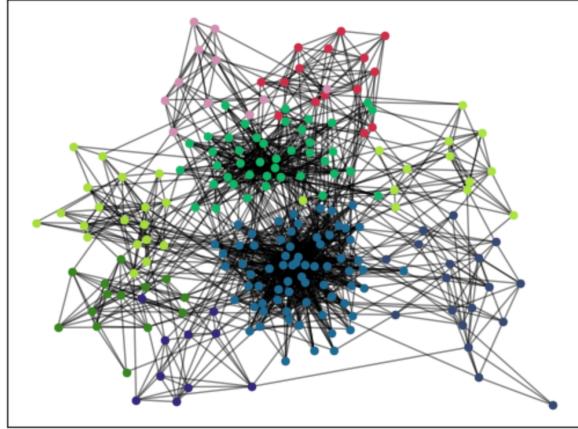
- Greedy Modularity

LFR Benchmark (synthetic) 2 Fast Modularity



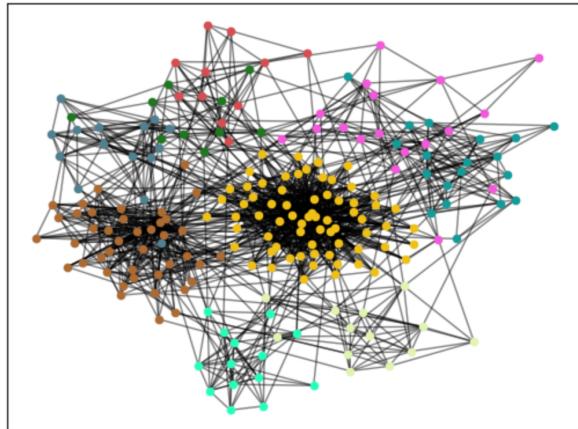
- Infomap

LFR Benchmark (synthetic) 2 Infomap



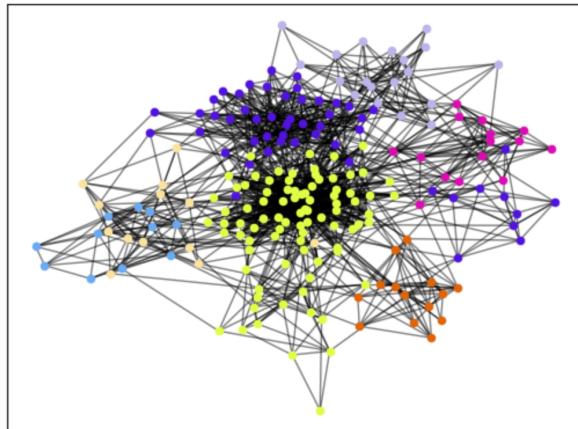
▪ Walk Trap

LFR Benchmark (synthetic) 2 Walk Trap



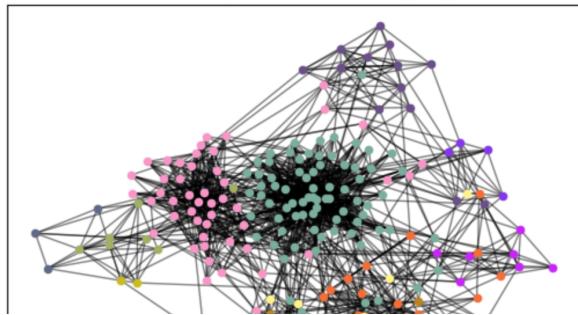
▪ Label Propagation

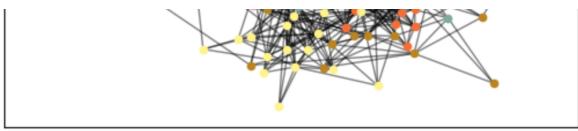
LFR Benchmark (synthetic) 2 Label Propagation



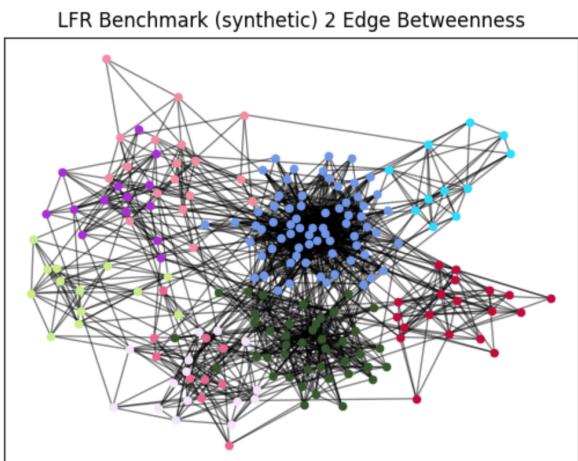
▪ Leading Eigenvector

LFR Benchmark (synthetic) 2 Leading Eigenvector

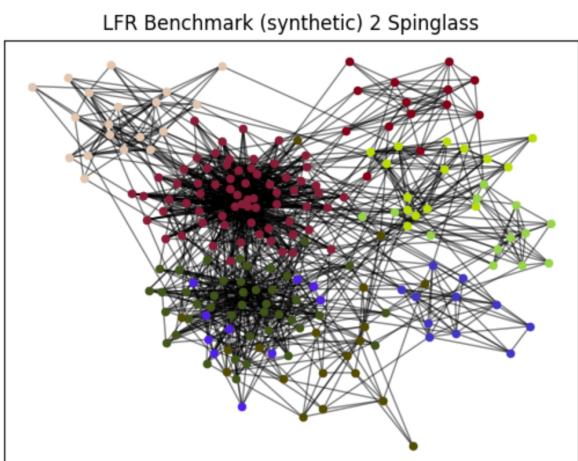




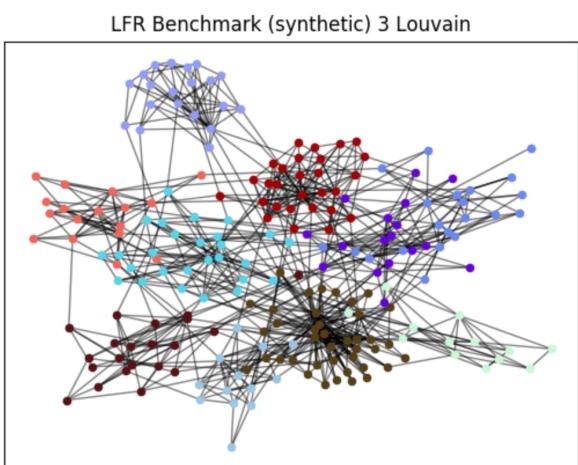
- Edge Betweenness



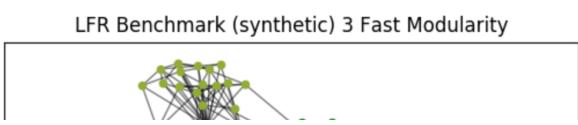
- Spinglass

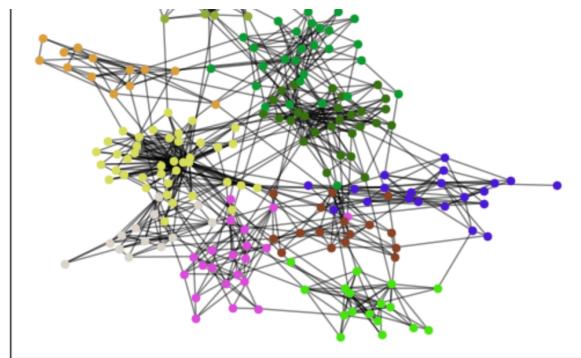


- LFR ( $n = 217$ ,  $\tau_{\text{al}} = 2.5$ ,  $\tau_{\text{l2}} = 1.5$ ,  $\mu = 0.1$ ,  $\text{mindegree} = 3$ ,  $\text{seed} = 11$ )
  - Louvain



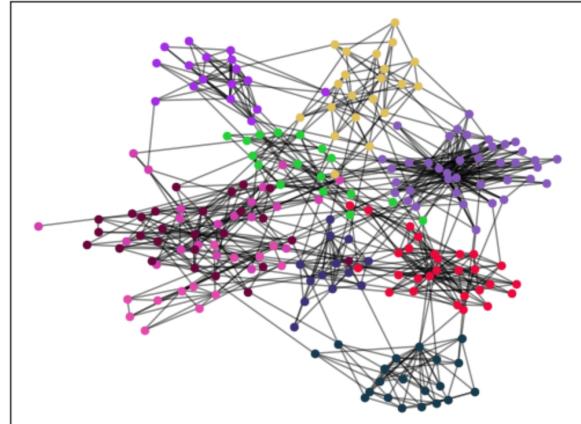
- Greedy Modularity





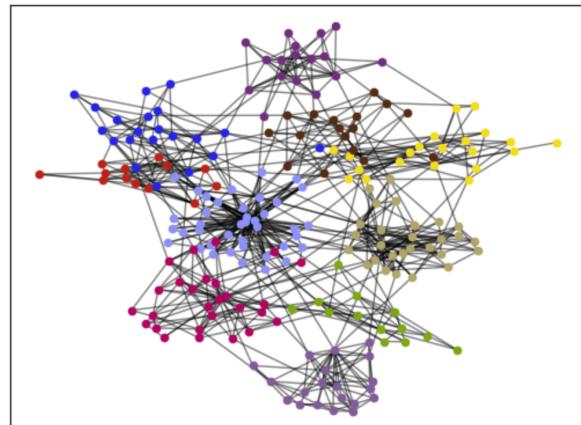
▪ Infomap

LFR Benchmark (synthetic) 3 Infomap



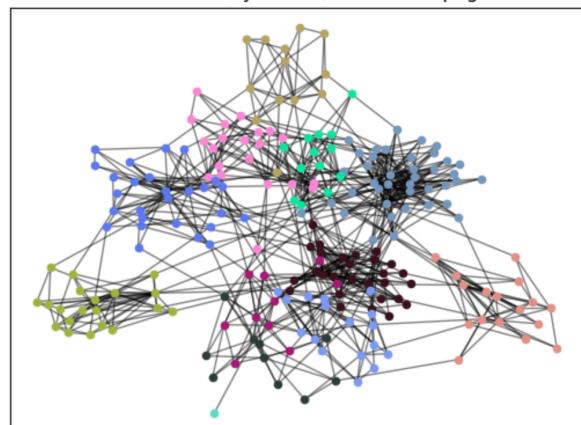
▪ Walk Trap

LFR Benchmark (synthetic) 3 Walk Trap



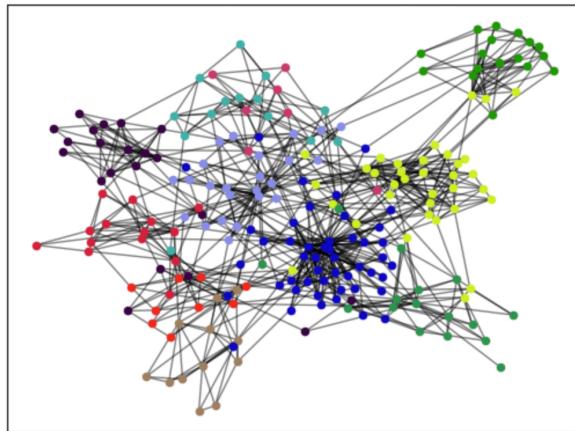
▪ Label Propagation

LFR Benchmark (synthetic) 3 Label Propagation



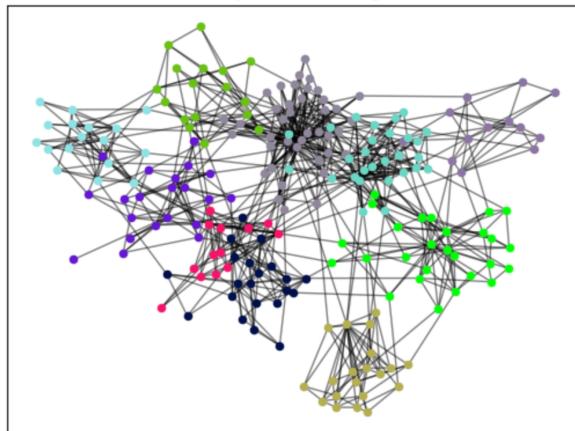
▪ Leading Eigenvector

LFR Benchmark (synthetic) 3 Leading Eigenvector



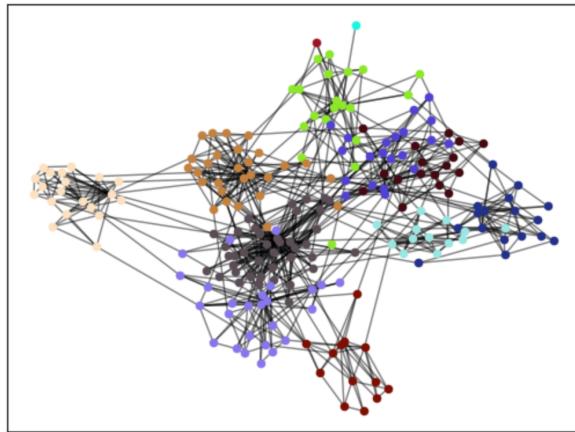
▪ Edge Betweenness

LFR Benchmark (synthetic) 3 Edge Betweenness



▪ Spinglass

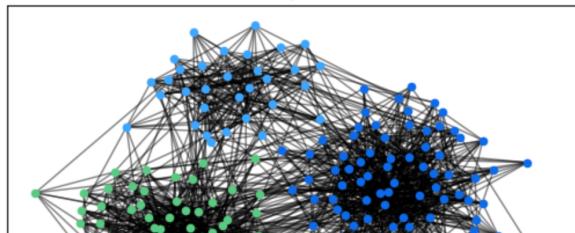
LFR Benchmark (synthetic) 3 Spinglass

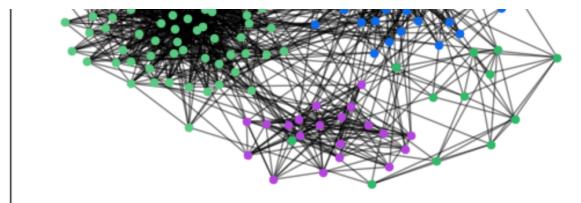


▪ LFR ( $n = 222$ ,  $\tau_{\text{al}} = 2.5$ ,  $\tau_{\text{a2}} = 1.5$ ,  $\mu = 0.1$ ,  $\text{mindegree} = 6$ ,  $\text{seed} = 10$ )

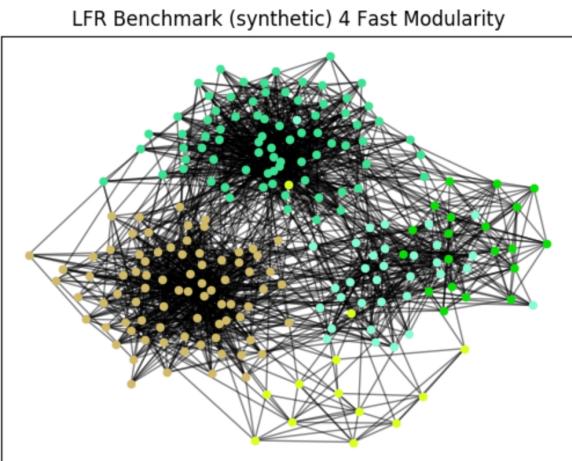
▪ Louvain

LFR Benchmark (synthetic) 4 Louvain

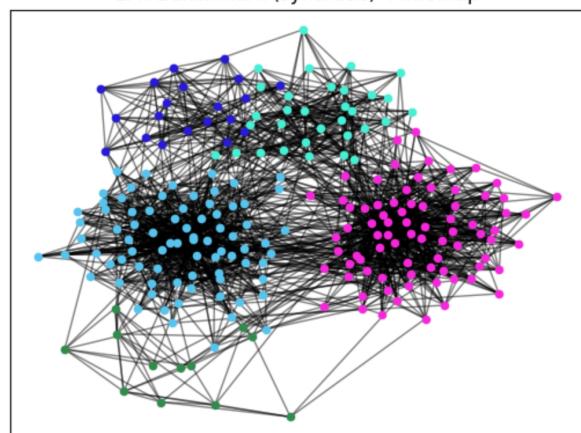




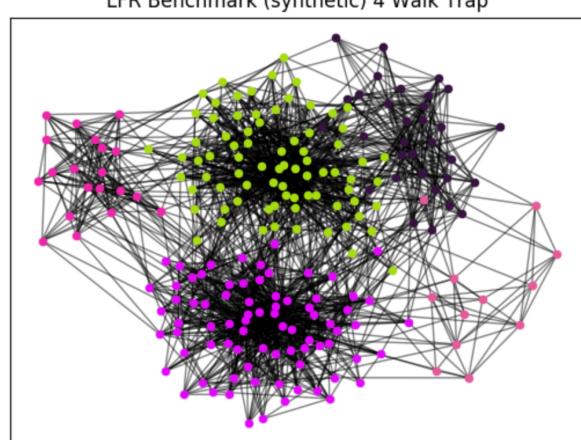
▪ Greedy Modularity



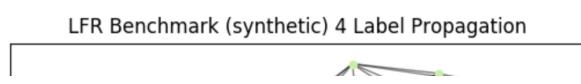
▪ Infomap

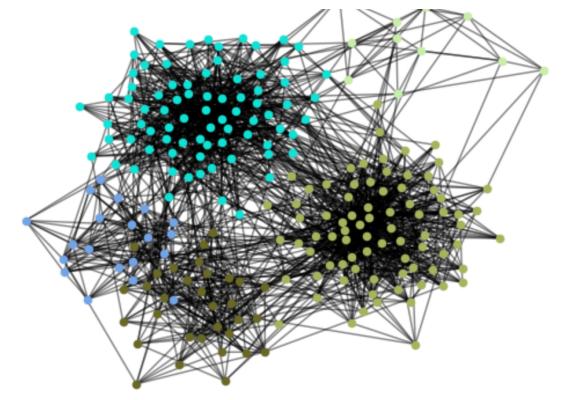


▪ Walk Trap

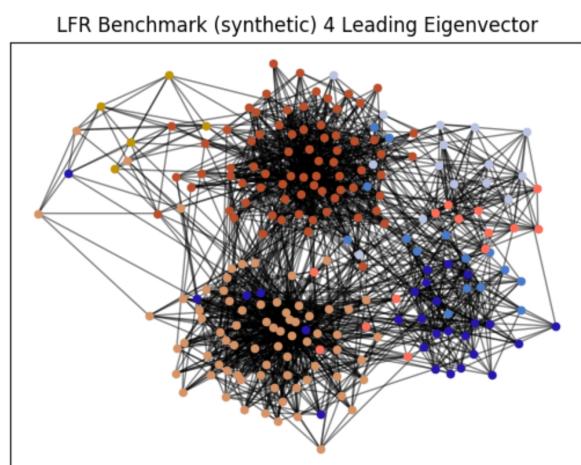


▪ Label Propagation

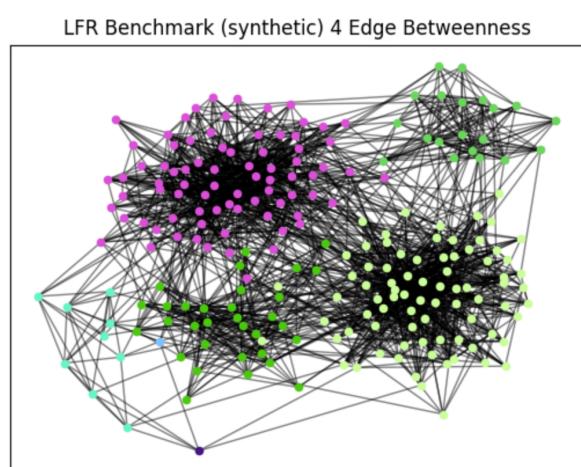




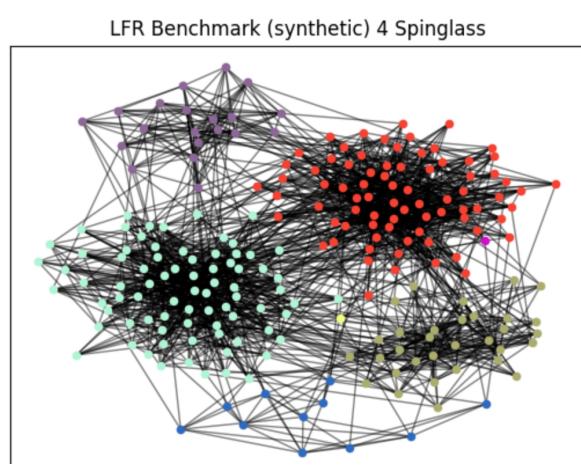
▪ Leading Eigenvector



▪ Edge Betweenness



▪ Spinglass



[REDACTED]