Concentric Network Symmetry

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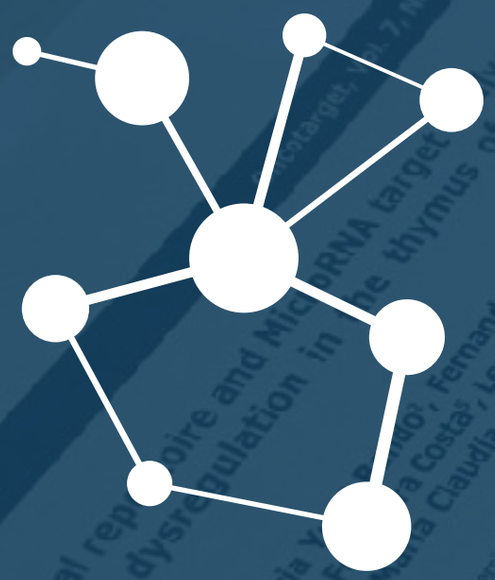
September 2017

About me

Postdoctoral fellow 2015 - now
Computational Physics
São Carlos Institute of Physics Brazil
Advisor: Prof. Luciano da F. Costa

Visiting Scholar 2017 - now
Indiana University
Advisor: Prof. Filippo Menczer

My research



Complex networks

Interactive visualization

Data analysis

My research

Science of science
Urban network analysis
Network visualization
Text analysis
Biological networks
Transistors

Representing and modeling complex systems

Connectivity

Visualization

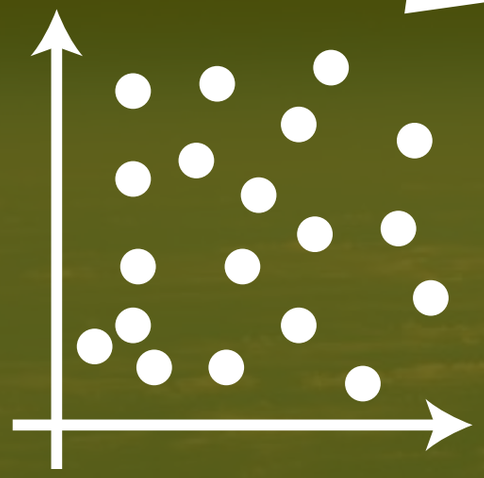
Node degree

Measurements

Clustering coefficient

Topological distance

Structural similarity



Features

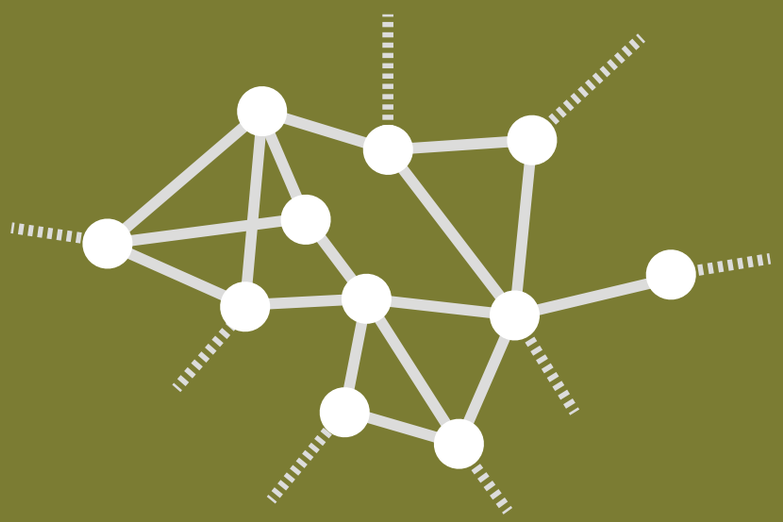
	A	B	C
A	1.0	0.8	0.5
B	0.8	1.0	0.2
C	0.5	0.2	1.0

Similarity

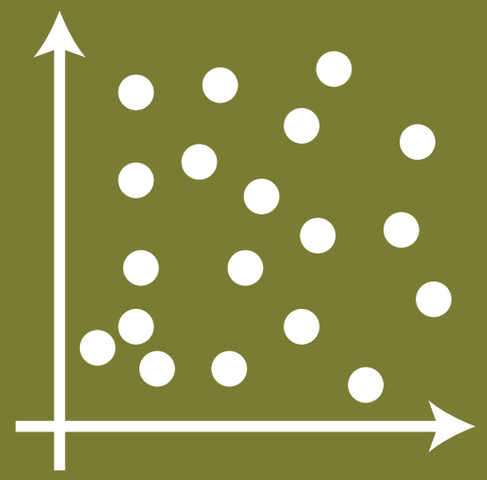
Comin, C. H.; Peron, T. K. DM.; Silva, F. N.; Amancio, D. R.; Rodrigues, F. A.; Costa, L. da F.
Complex systems: features, similarity and connectivity (https://arxiv.org/abs/1606.05400)

Representing and modeling complex systems

Informative features for nodes?



Connectivity



Features

Visualization

Classification

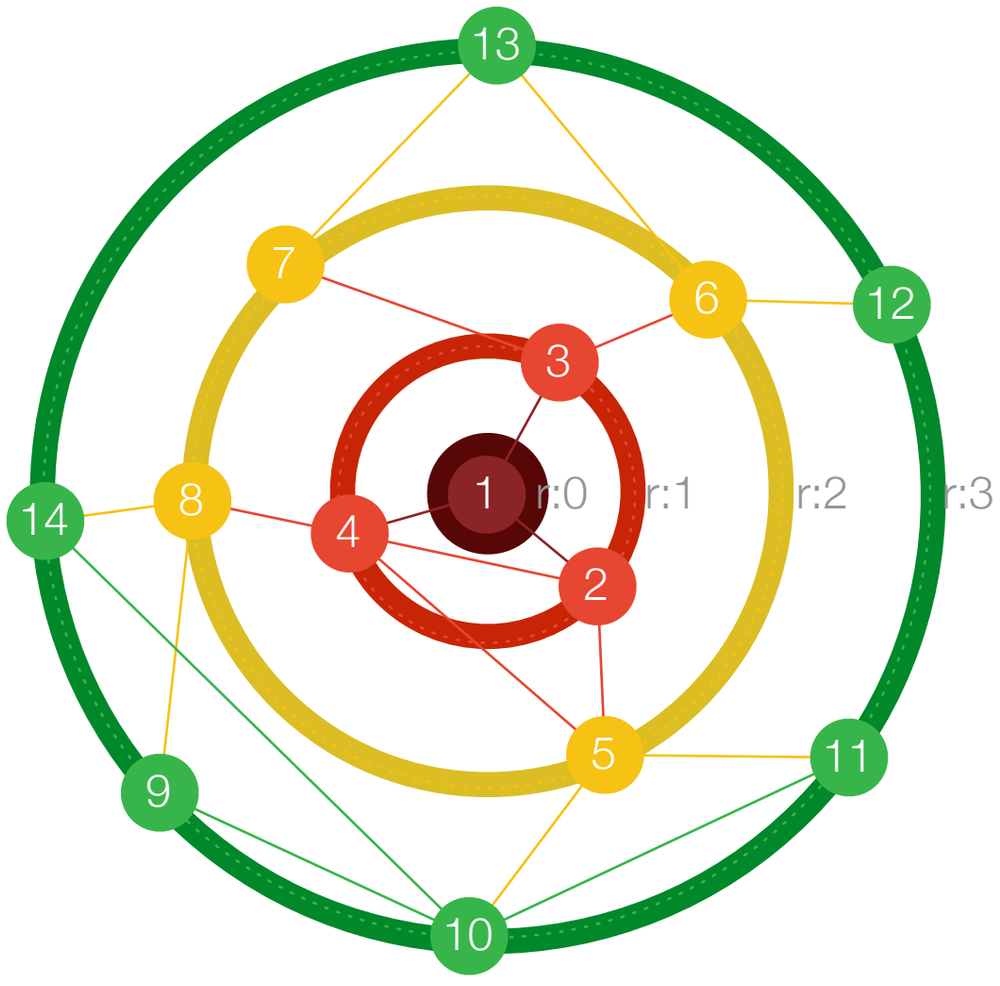
Modeling

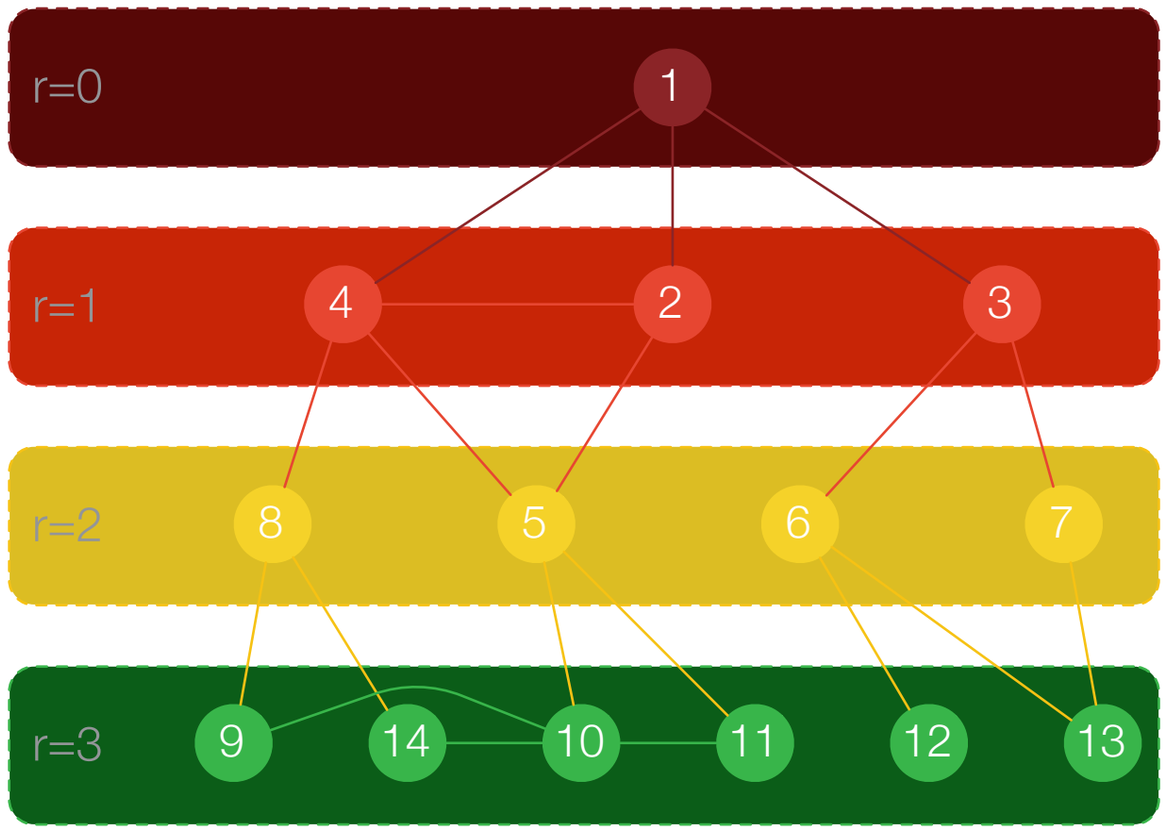
Global vs local measurements

Dependence with the size of networks is not desirable

Concentric levels and properties

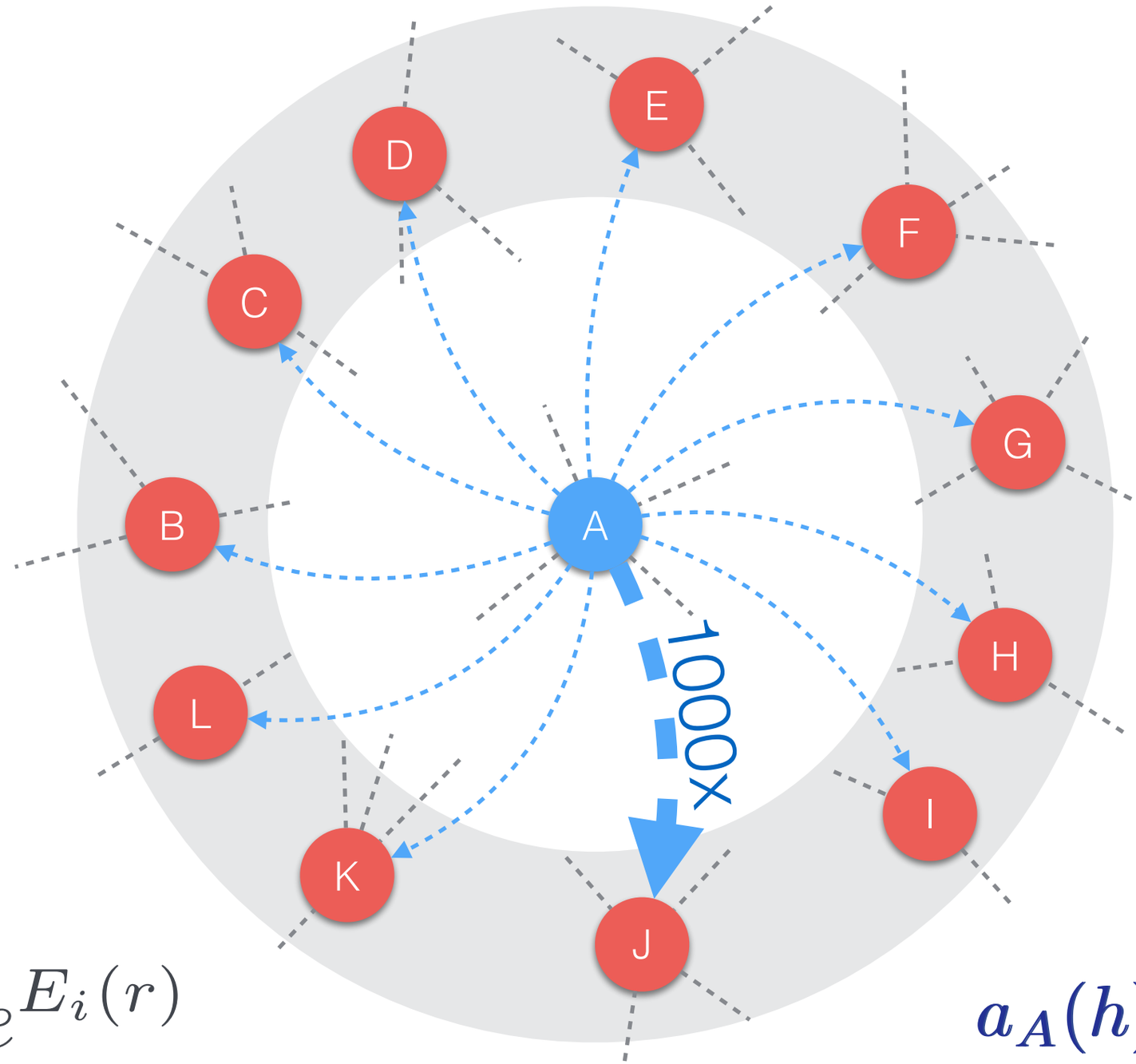
Balance between local and global measurements





COSTA, L. da F.; SILVA, F. N. Hierarchical characterization of complex networks. *Journal of Statistical Physics*, v. 125, n. 4, p. 845–876, 2006.

Accessibility

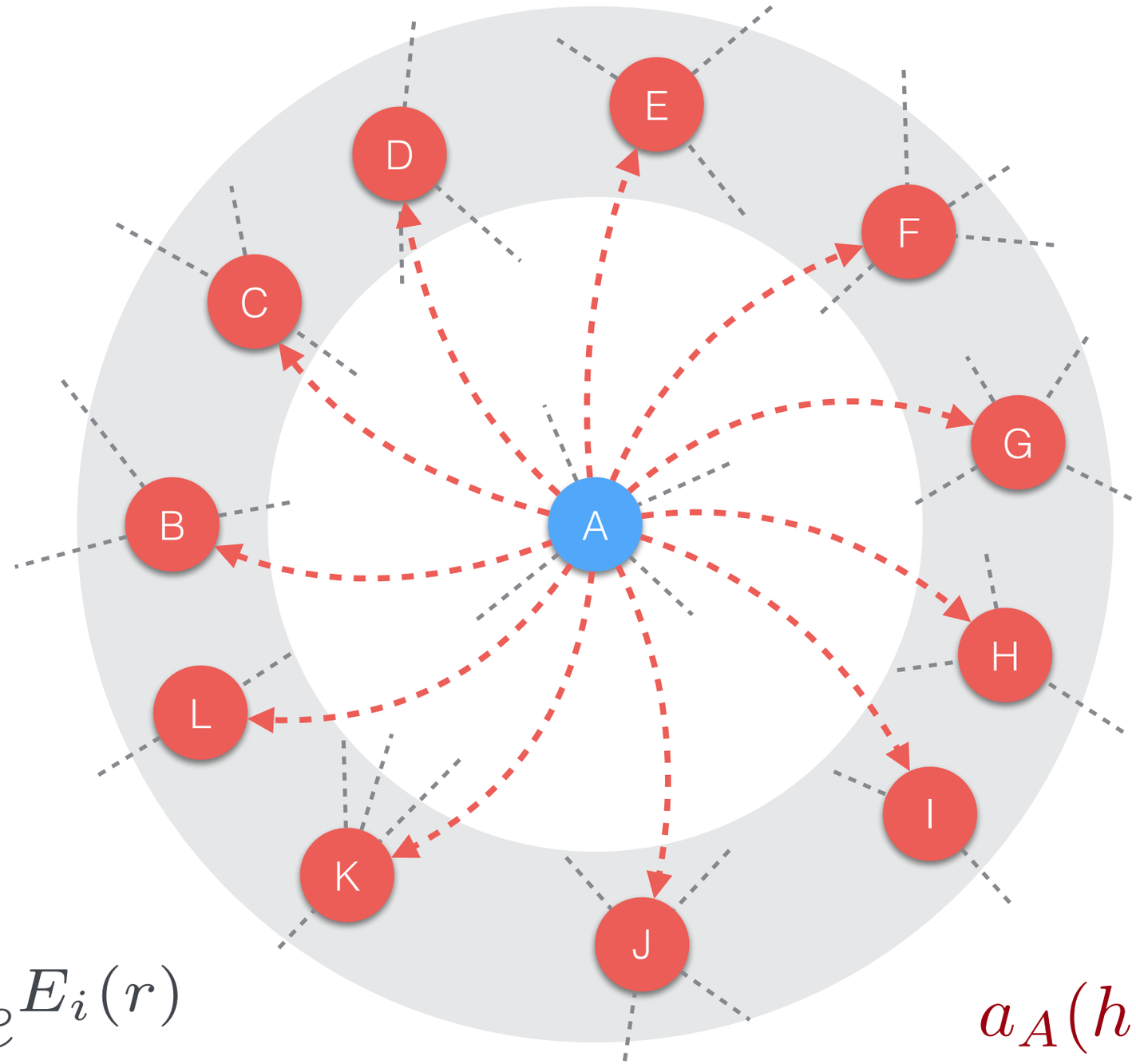


$$a_i(r) = e^{E_i(r)}$$

$$a_A(h) \approx 1.12$$

Viana, M. P.; Batista, J. a. L. B. and Costa, L. da F.
Effective number of accessed nodes in complex networks. *Phys. Rev. E*, v. 85, p. 036105, 2012.

Accessibility

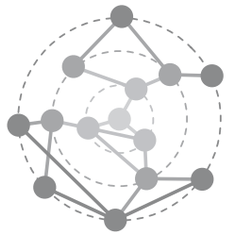


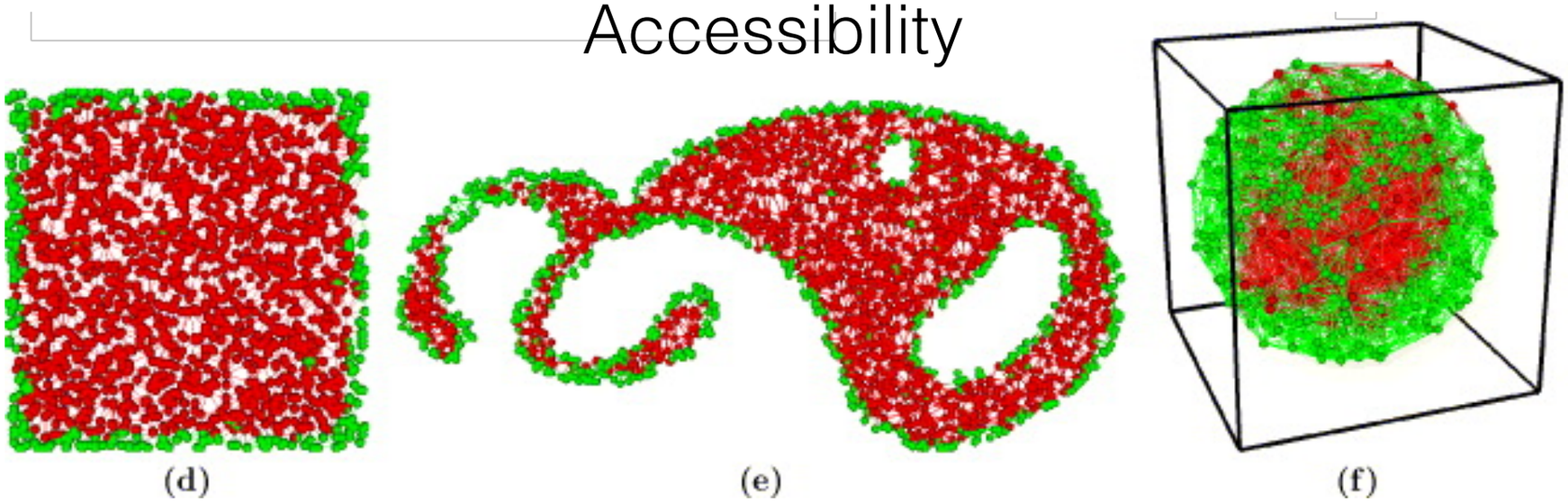
$$a_i(r) = e^{E_i(r)}$$

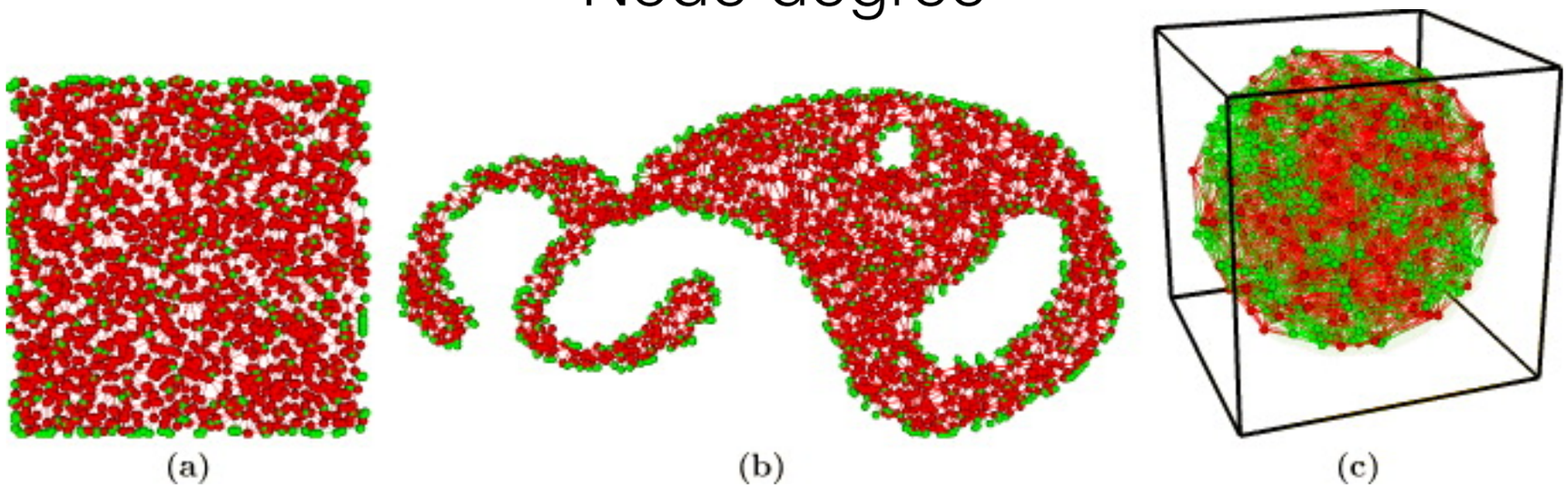
$$a_A(h) = 11$$

Viana, M. P.; Batista, J. a. L. B. and Costa, L. da F.
Effective number of accessed nodes in complex networks. *Phys. Rev. E*, v. 85, p. 036105, 2012.

Accessibility



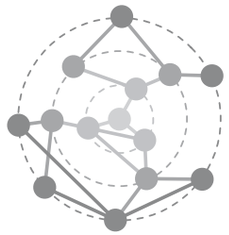




Good to detect borders on geographic networks

Figures from: Travençolo, B. A., Viana, M. P., & da Fontoura Costa, L. (2009) Border detection in complex networks. *New Journal of Physics*, *11*(6), 063019.

Accessibility



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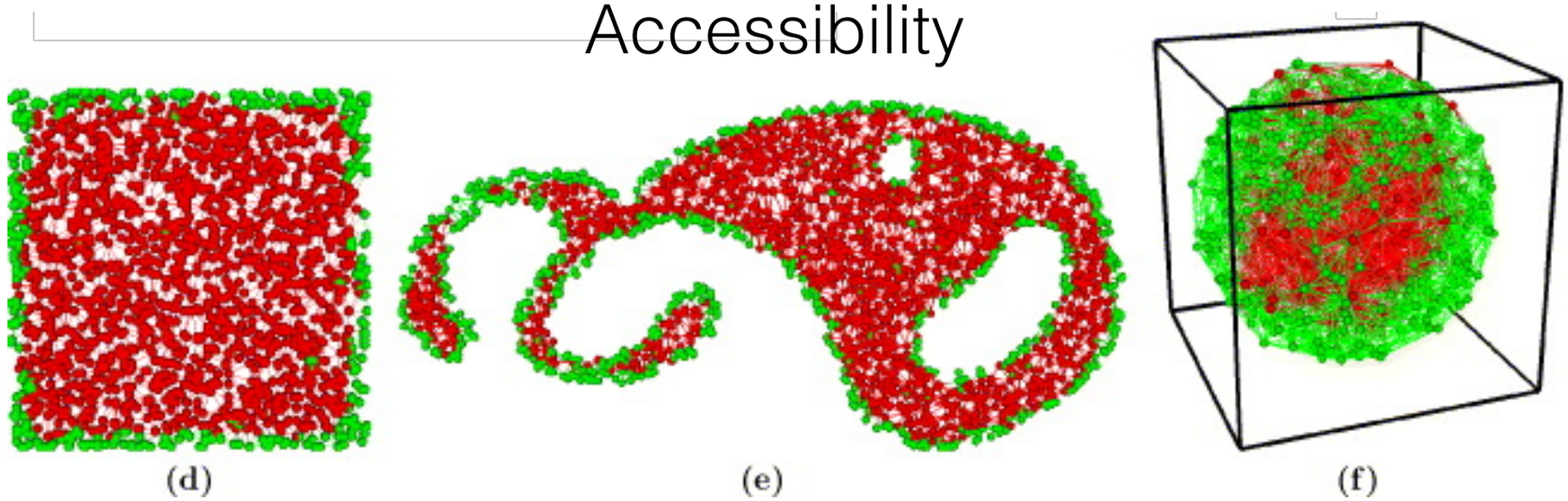
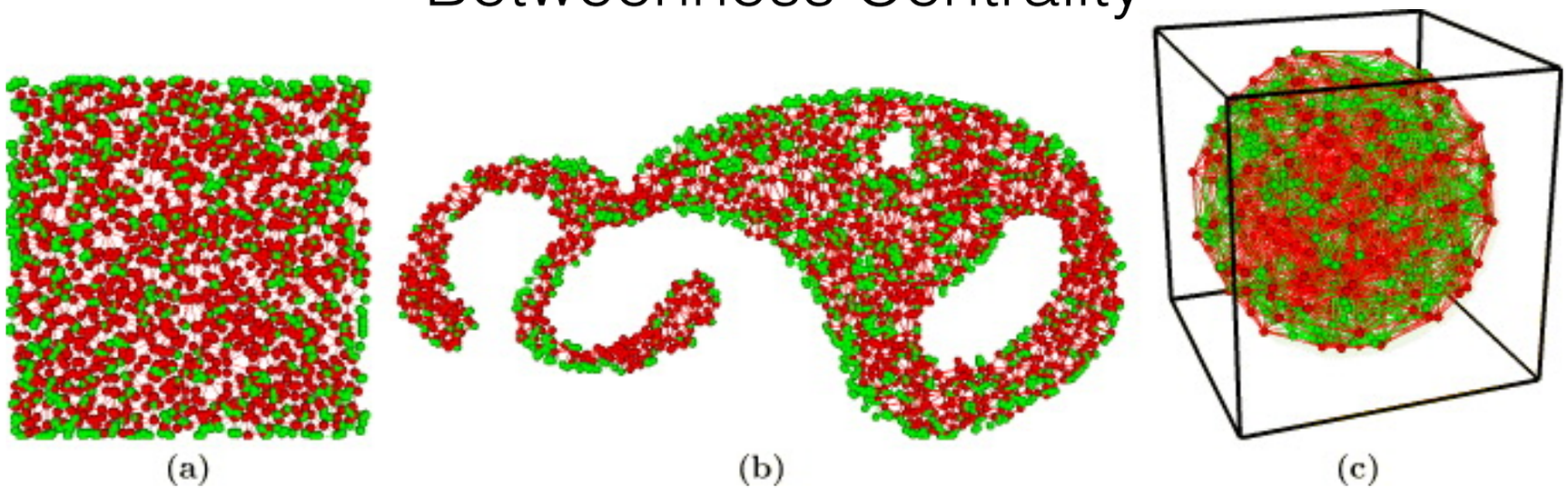


(d) (e) (f)

Betweenness Centrality



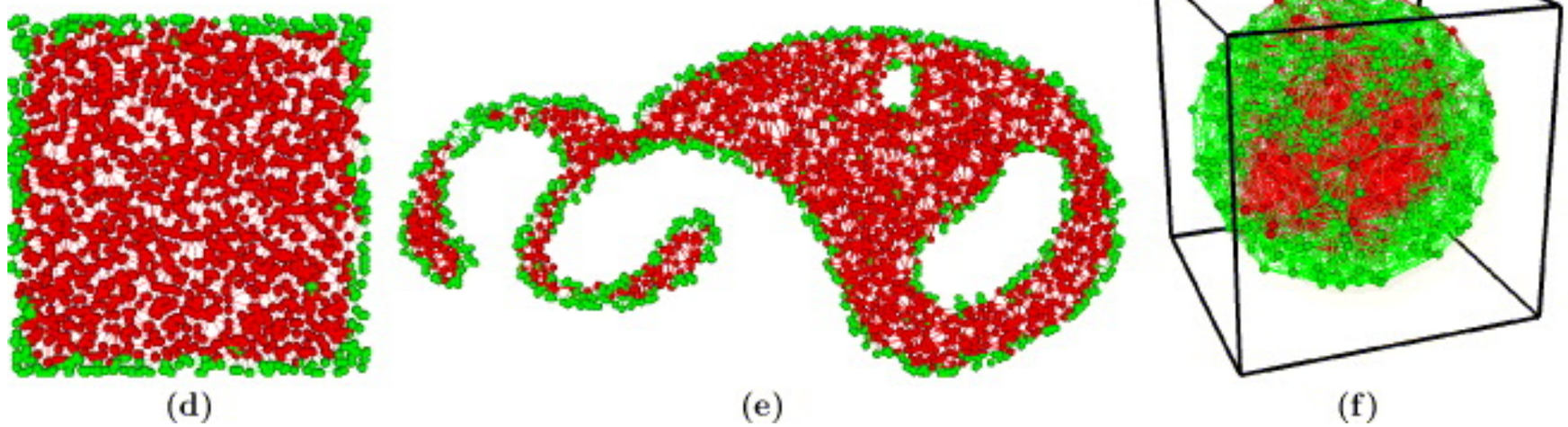
(a) (b) (c)

Good to detect borders on geographic networks

Figures from: Travençolo, B. A., Viana, M. P., & da Fontoura Costa, L. (2009) Border detection in complex networks. *New Journal of Physics*, *11*(6), 063019.

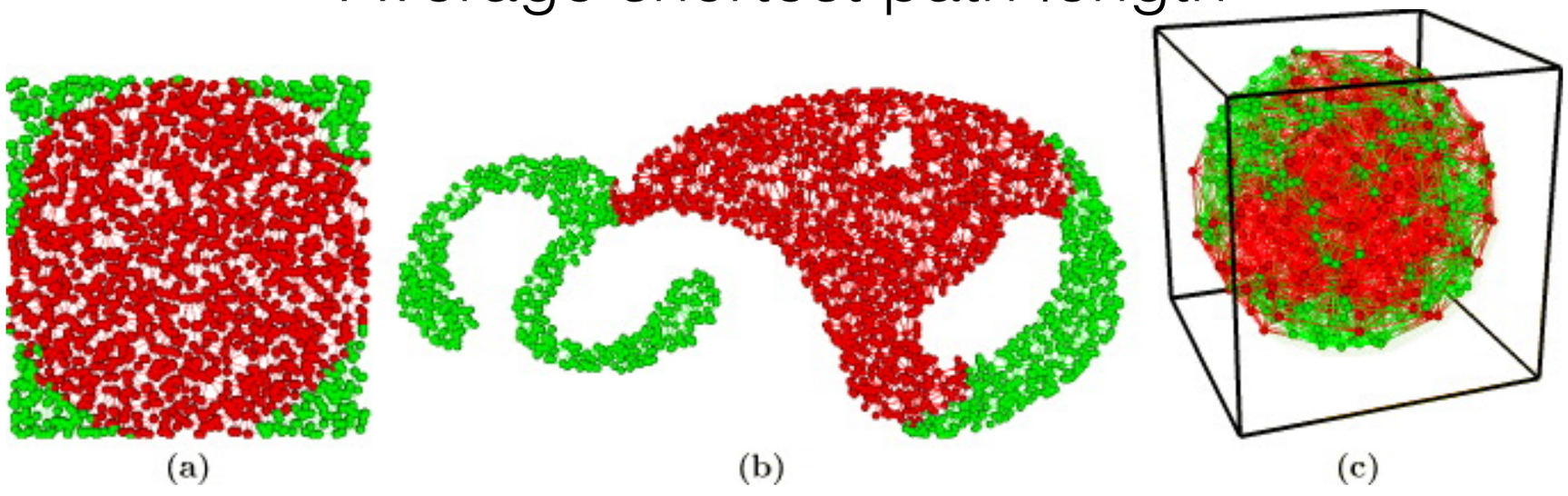
Accessibility

Accessibility



(d) (e) (f)

Average shortest path length

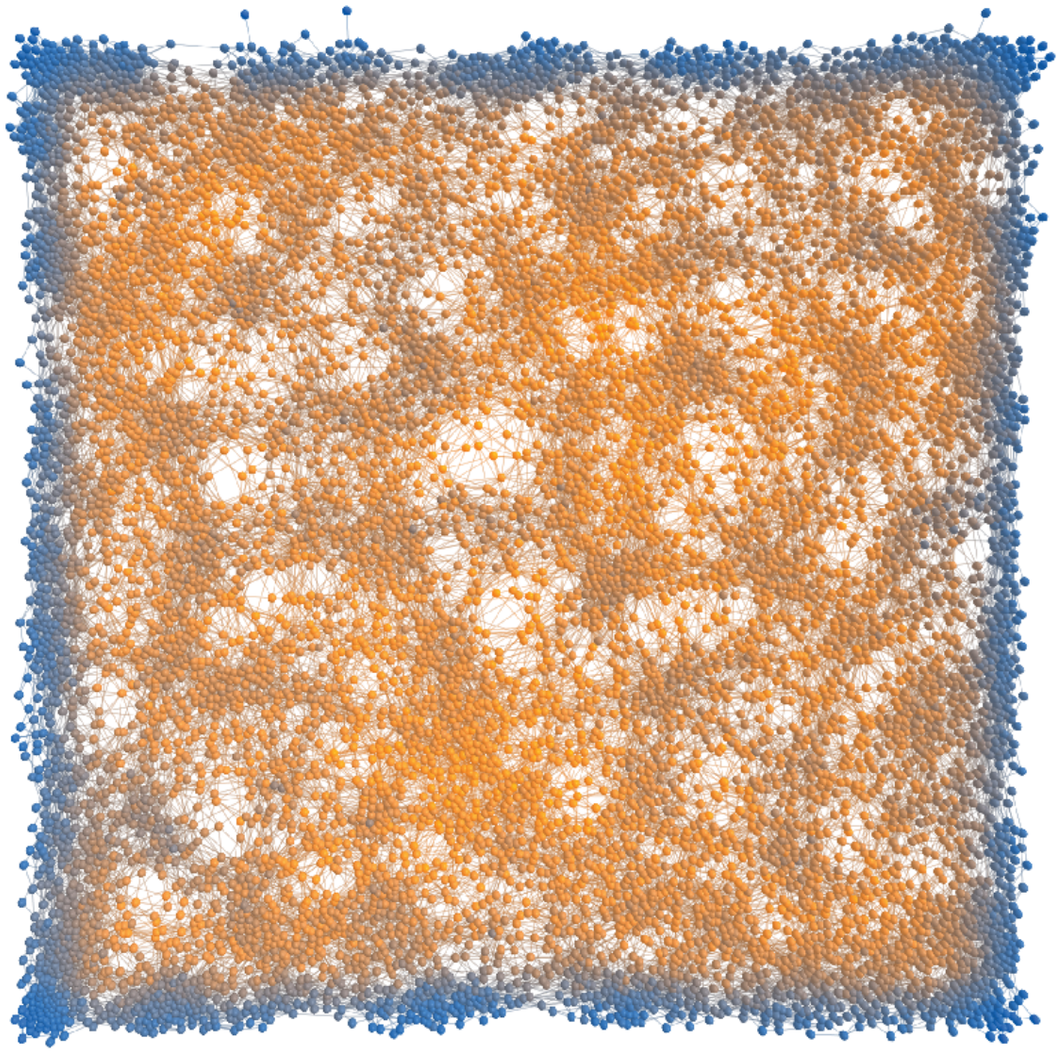


(a) (b) (c)

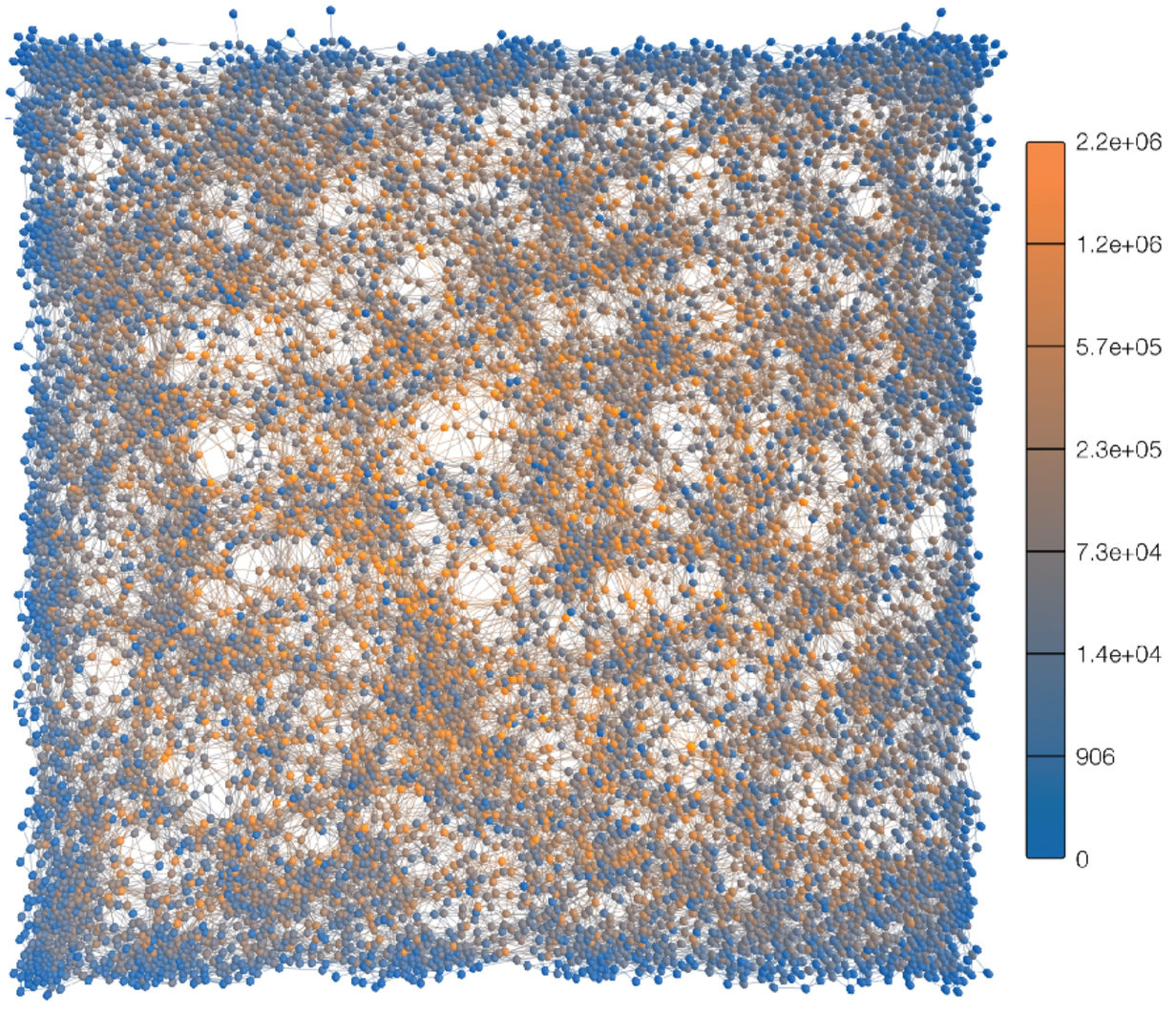
Good to detect borders on geographic networks

Figures from: Travençolo, B. A., Viana, M. P., & da Fontoura Costa, L. (2009) Border detection in complex networks. *New Journal of Physics*, *11*(6), 063019.

Accessibility



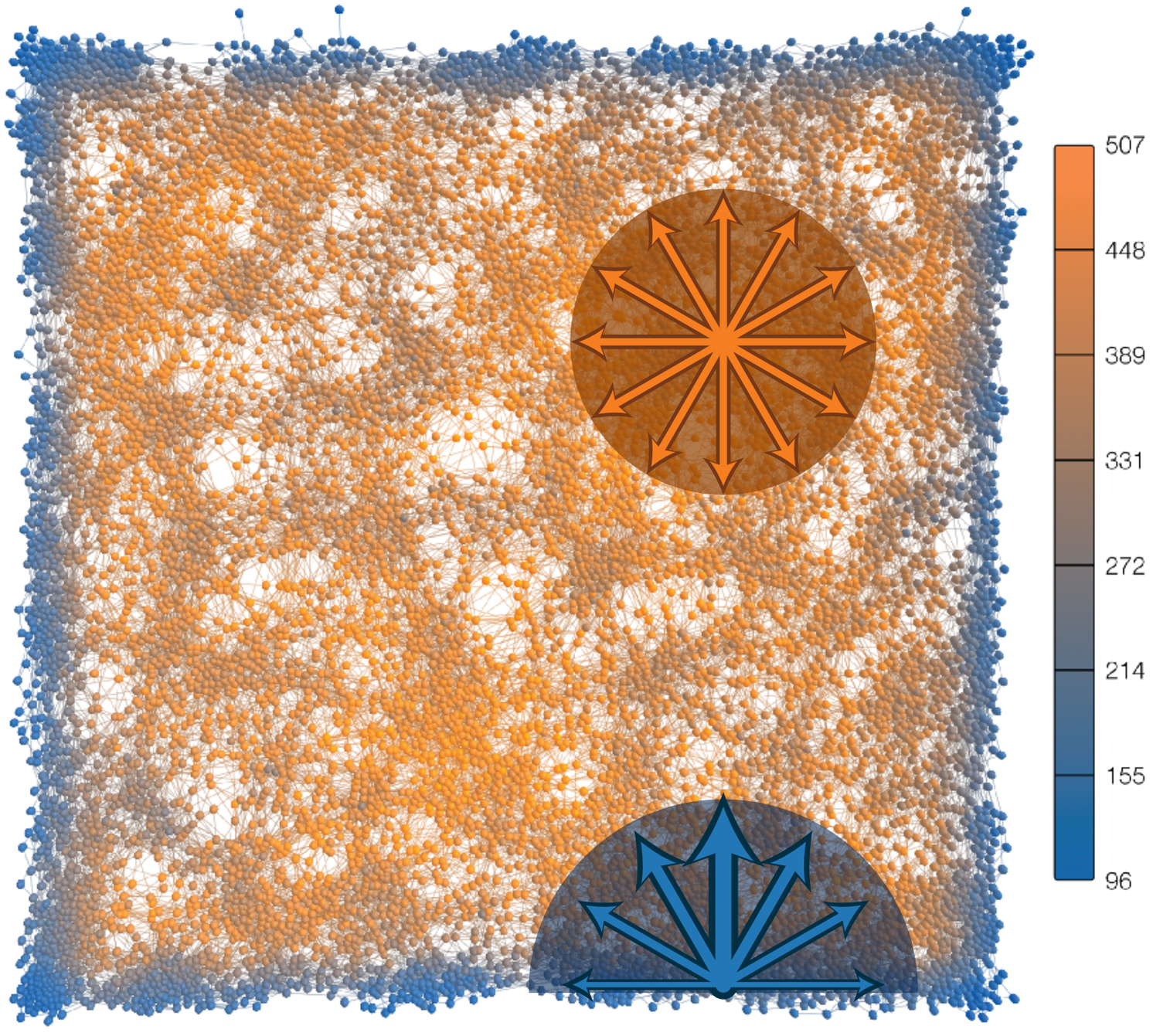
Accessibility (*r*=3)



Betweenness centrality

Good to detect borders on geographic networks

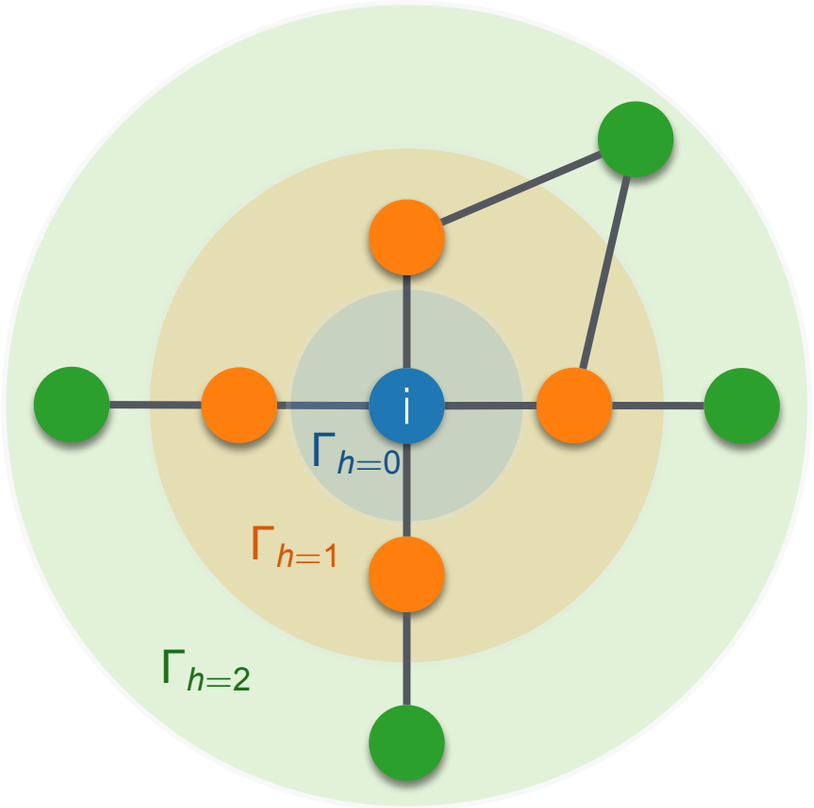
Accessibility



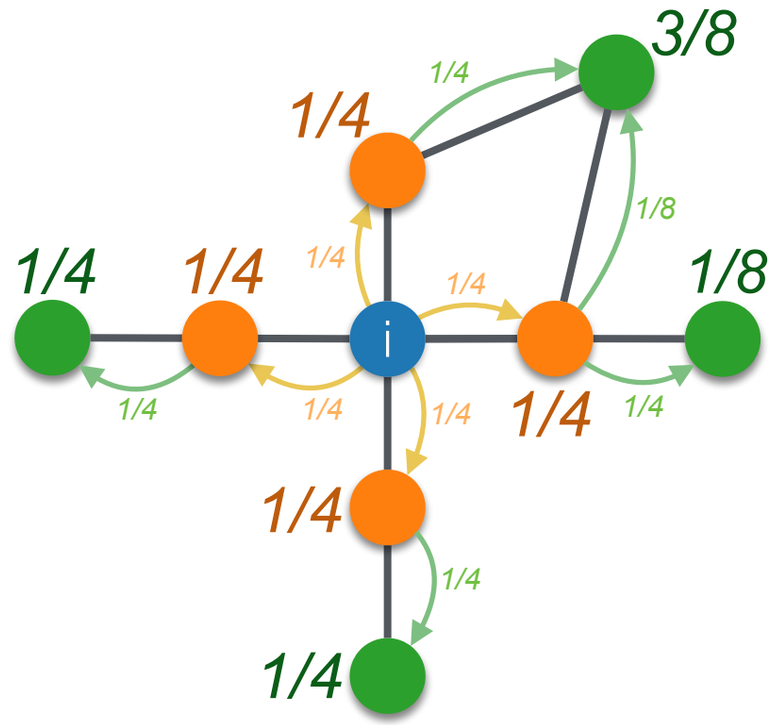
Accessibility (*r*=3)

Concentric symmetry

Original Pattern



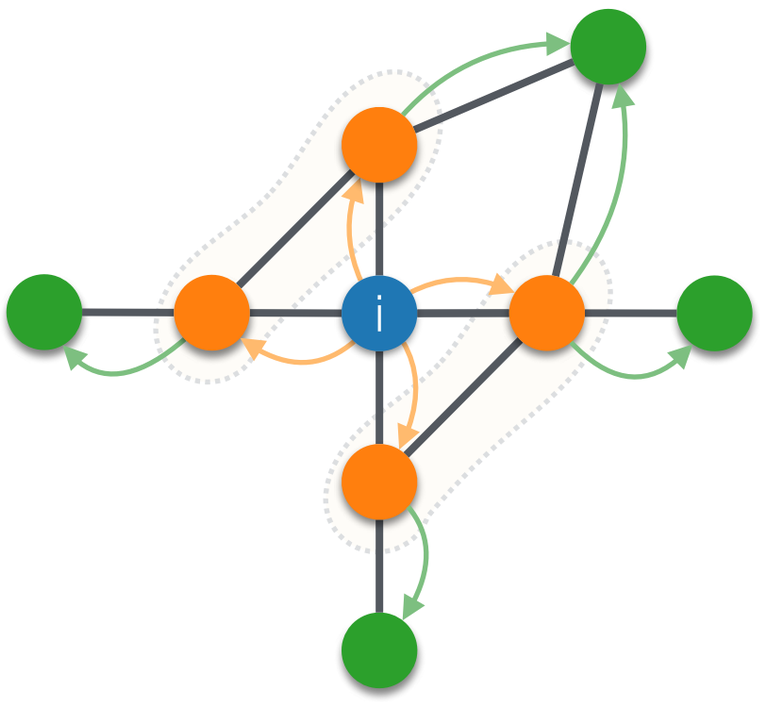
Transitions

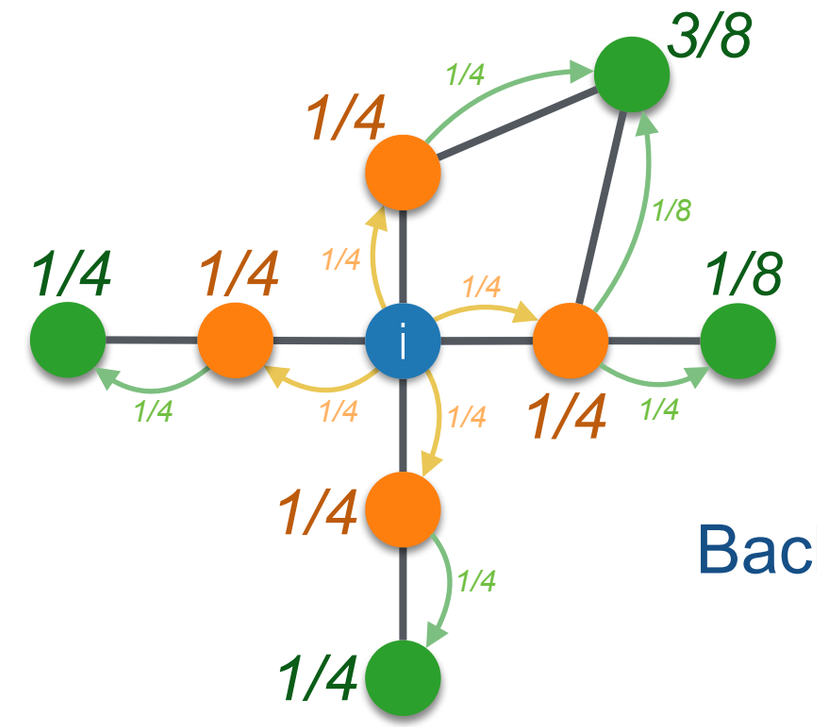


$$H_{h=3}(i) = \sum_{j \in \Gamma_{h=2}} P(i \to j) \ln(P(i \to j))$$

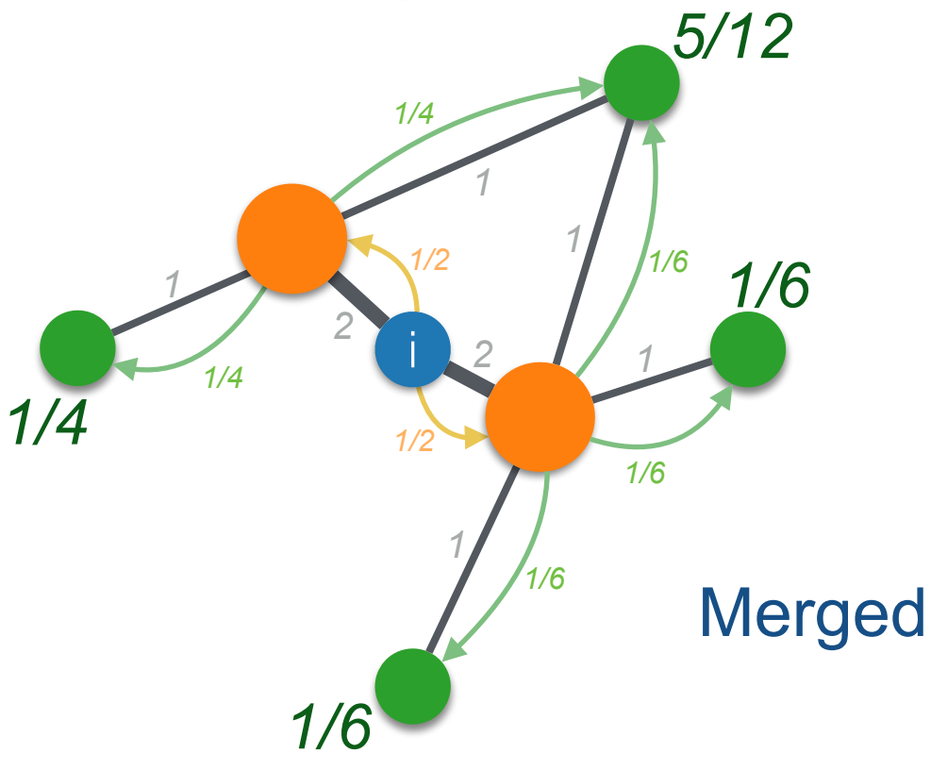
$$S_{h=3}(i) = \frac{e^{H_{h=3}(i)}}{|\Gamma_{h=2}|}$$

Concentric symmetry



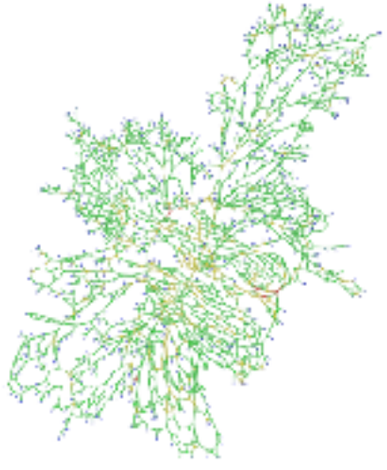


Backbone



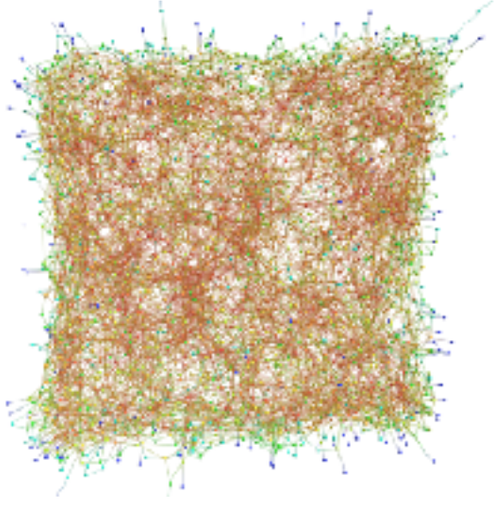
Merged

Results



Cities (Oldenburg)

ER

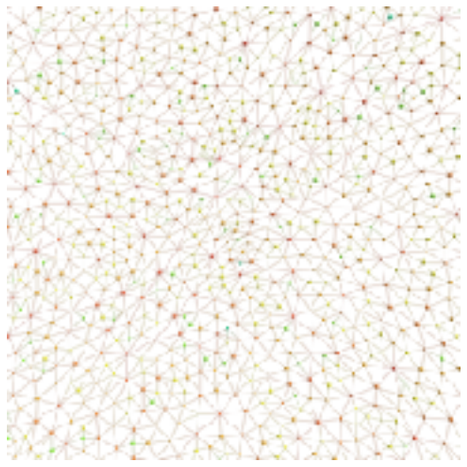


Random Geographic

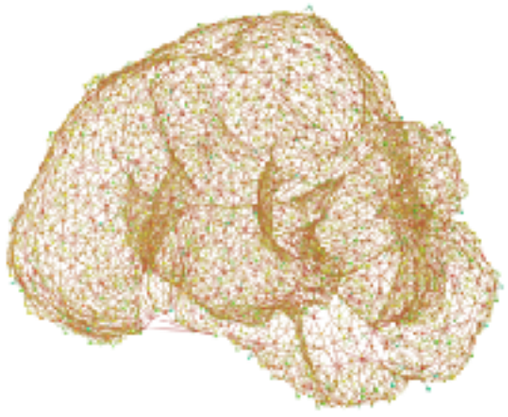
BA

Wikipedia

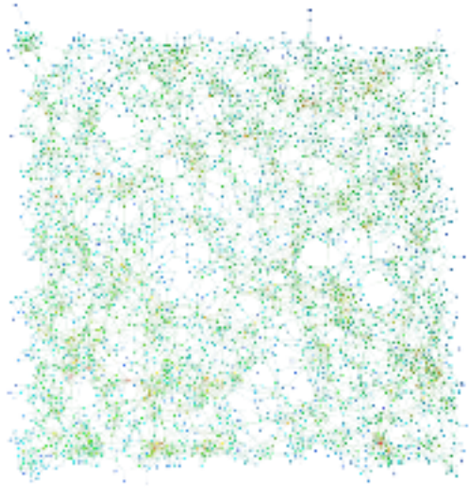
Voronoi



Rewired Voronoi



Waxman



Airports

http://cyvision.ifsc.usp.br/software/networks3d

Concentric Symmetry Results

ER (similar to BA)

	Clustering Coefficient	Node Degree	Betweenness Centrality	Merged Symmetry h=4	Backbone Symmetry h=4	Merged Symmetry h=3	Backbone Symmetry h=3	Merged Symmetry h=2
Clustering Coefficient	0.00	0.00	-0.01	-0.00	-0.00	0.02	-0.02	-0.02
Node Degree	-0.04	-0.08	-0.09	-0.32	-0.16	-0.79	0.95	
Betweenness Centrality	-0.06	-0.10	-0.12	-0.36	-0.19	-0.70		
Merged Symmetry h=4	0.12	0.16	0.17	0.37	0.25			
Backbone Symmetry h=4	0.82	0.81	0.95	0.91				
Merged Symmetry h=3	0.80	0.80	0.93					
Backbone Symmetry h=3	0.87	0.86						
Merged Symmetry h=2	0.99							

Waxman (similar to other GEO models)

	Clustering Coefficient	Node Degree	Betweenness Centrality	Merged Symmetry h=4	Backbone Symmetry h=4	Merged Symmetry h=3	Backbone Symmetry h=3	Merged Symmetry h=2
Clustering Coefficient	0.01	-0.04	-0.01	-0.05	-0.03	-0.02	0.01	0.03
Node Degree	-0.35	-0.64	-0.53	-0.36	-0.52	-0.18	0.29	
Betweenness Centrality	-0.06	-0.16	-0.12	-0.16	-0.14	-0.13		
Merged Symmetry h=4	0.07	0.21	0.12	0.35	0.13			
Backbone Symmetry h=4	0.44	0.53	0.72	0.35				
Merged Symmetry h=3	0.11	0.42	0.18					
Backbone Symmetry h=3	0.65	0.50						
Merged Symmetry h=2	0.30							

F.N. Silva, C.H. Comin, T.K.DM. Peron, F.A. Rodrigues, C.Ye, R.C. Wilson, E. Hancock, L. da F. Costa
Concentric network symmetry. *Information Sciences*, v. 333, p. 61 – 80, 2015. doi: 10.1016/j.ins.2015.11.014.

Concentric Symmetry Results

San Joaquin (matrix similar to Oldenburg)

	Node Degree	Betweenness Centrality	Merged Symmetry h=4	Backbone Symmetry h=4	Merged Symmetry h=3	Backbone Symmetry h=3	Merged Symmetry h=2	Backbone Symmetry h=2
Clustering Coefficient	0.01	0.02	0.00	0.01	-0.00	-0.02	0.10	0.03
Node Degree	-0.35	-0.40	-0.40	-0.41	-0.38	-0.35	0.24	
Betweenness Centrality	0.08	0.07	0.07	0.06	0.04	0.02		
Merged Symmetry h=4	0.30	0.32	0.60	0.62	0.92			
Backbone Symmetry h=4	0.29	0.31	0.63	0.64				
Merged Symmetry h=3	0.53	0.54	0.95					
Backbone Symmetry h=3	0.54	0.55						
Merged Symmetry h=2	0.96							

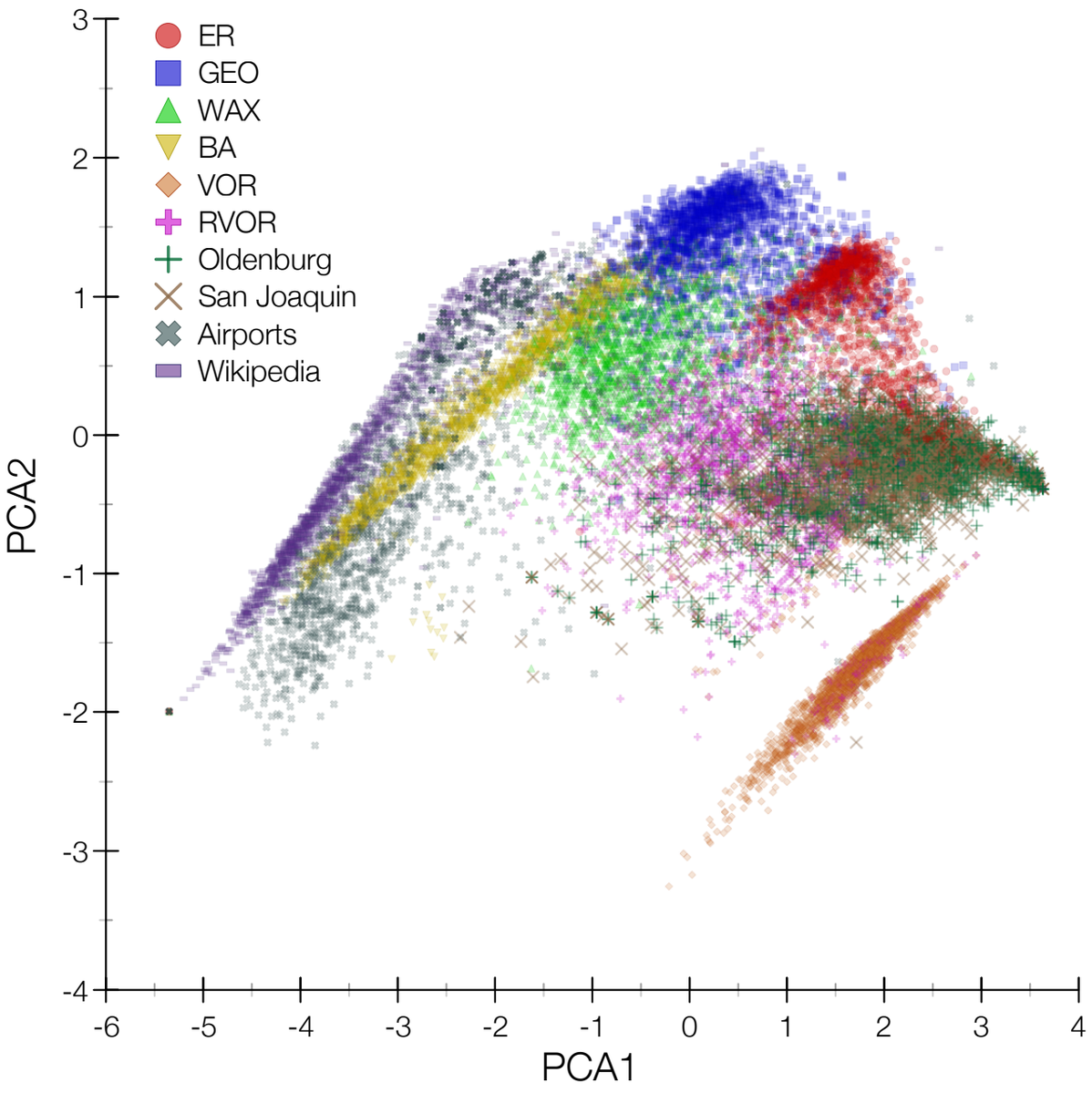
Wikipedia (matrix similar to airport)

	Node Degree	Betweenness Centrality	Merged Symmetry h=4	Backbone Symmetry h=4	Merged Symmetry h=3	Backbone Symmetry h=3	Merged Symmetry h=2	Backbone Symmetry h=2
Clustering Coefficient	-0.05	-0.10	-0.05	-0.05	-0.00	-0.02	0.00	0.02
Node Degree	-0.31	-0.27	-0.16	-0.11	-0.12	0.06	0.78	
Betweenness Centrality	-0.11	-0.09	-0.05	-0.03	-0.04	0.10		
Merged Symmetry h=4	0.10	0.21	0.29	0.57	0.46			
Backbone Symmetry h=4	0.46	0.31	0.72	0.51				
Merged Symmetry h=3	0.30	0.57	0.63					
Backbone Symmetry h=3	0.65	0.63						
Merged Symmetry h=2	0.63							

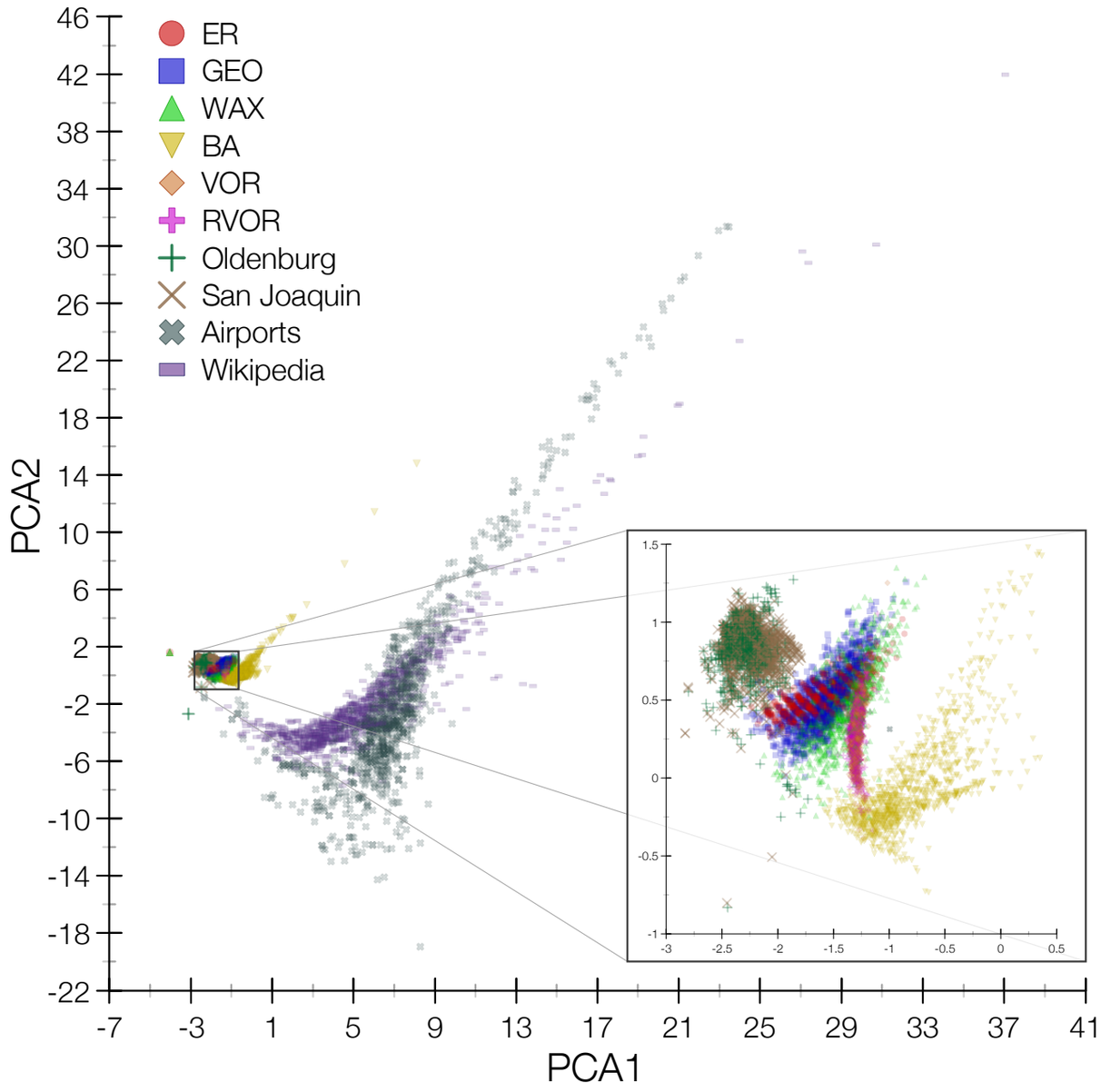
F.N. Silva, C.H. Comin, T.K.DM. Peron, F.A. Rodrigues, C.Ye, R.C. Wilson, E. Hancock, L. da F. Costa
Concentric network symmetry. *Information Sciences*, v. 333, p. 61 – 80, 2015. doi: 10.1016/j.ins.2015.11.014.

Concentric Symmetry Results

Concentric symmetry



Traditional measurements



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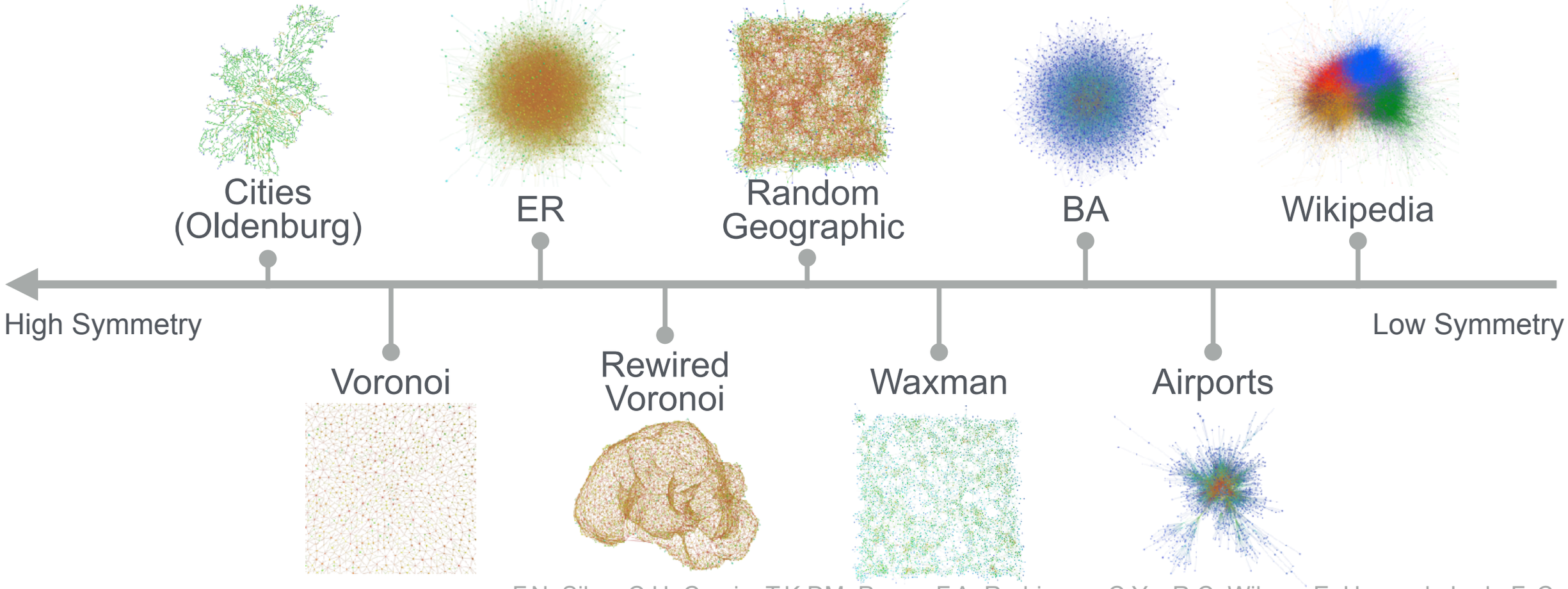
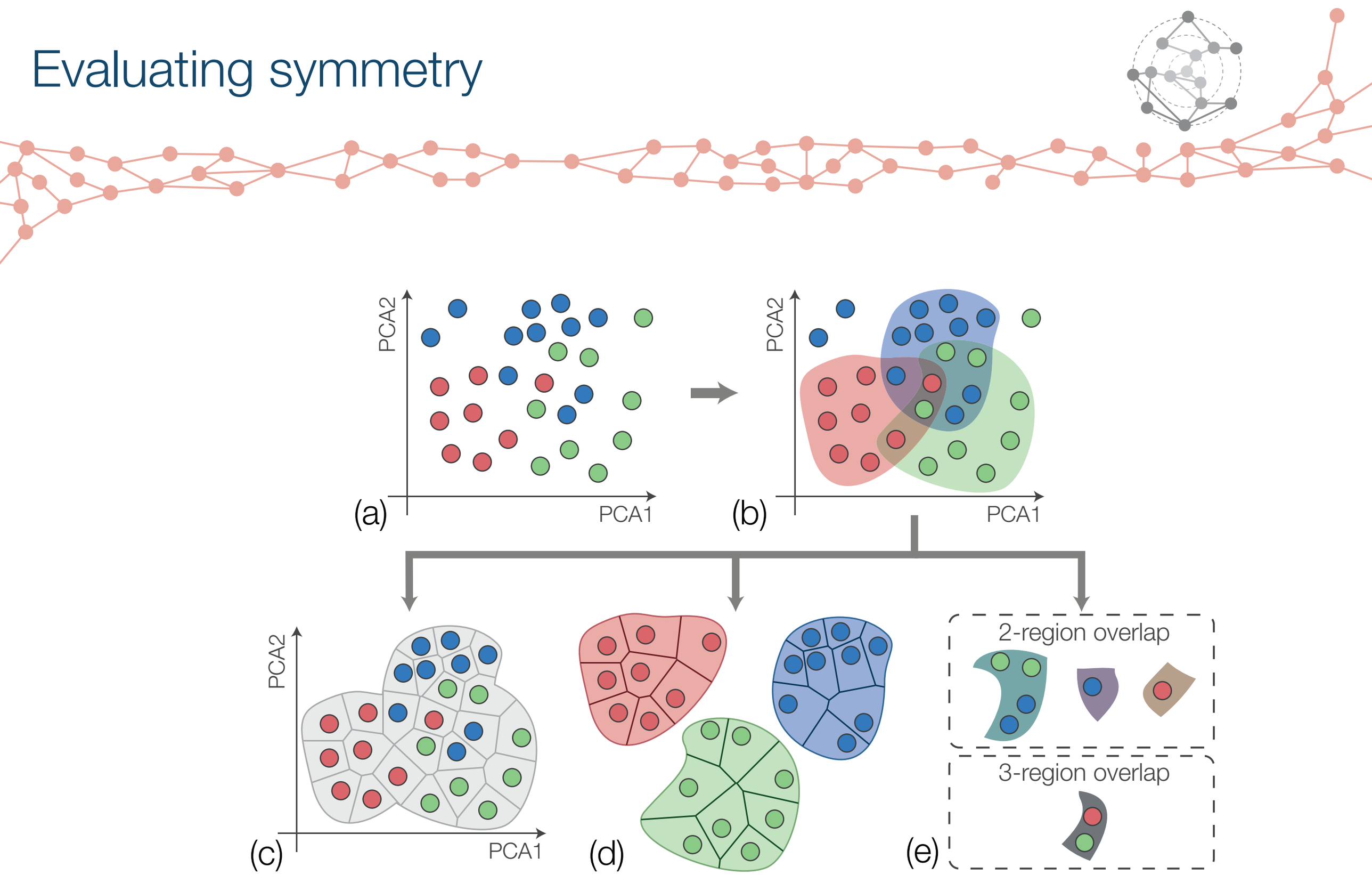
Concentric Symmetry Results

- Concentric symmetries
  - Do not correlate with traditional network measurements.
  - Discriminate between a diverse range of models and real networks.
  - Can be used to rank networks by their "average" symmetry.



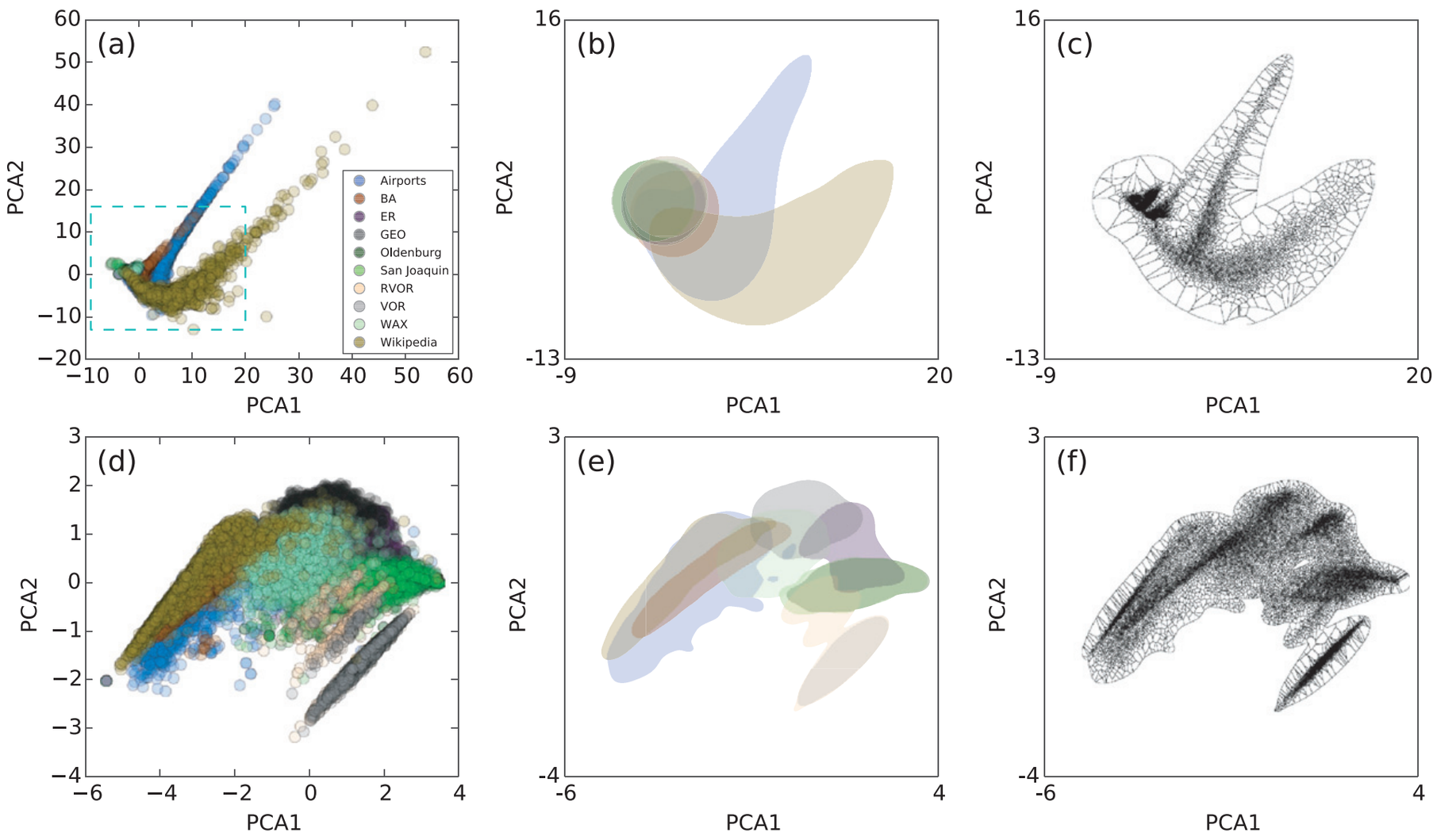
F.N. Silva, C.H. Comin, T.K.DM. Peron, F.A. Rodrigues, C.Ye, R.C. Wilson, E. Hancock, L. da F. Costa
Concentric network symmetry. *Information Sciences*, v. 333, p. 61 – 80, 2015. doi: 10.1016/j.ins.2015.11.014.

Evaluating symmetry



Comin, C. H., Silva, F. N., & Costa, L. D. F. (2015). A framework for evaluating complex networks measurements. *EPL (Europhysics Letters)*, *110*(6), 68002.

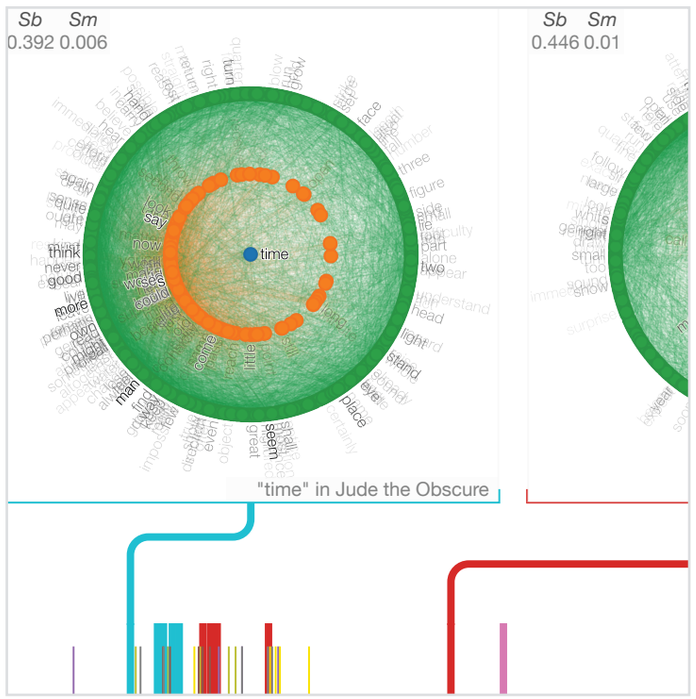
Evaluating symmetry



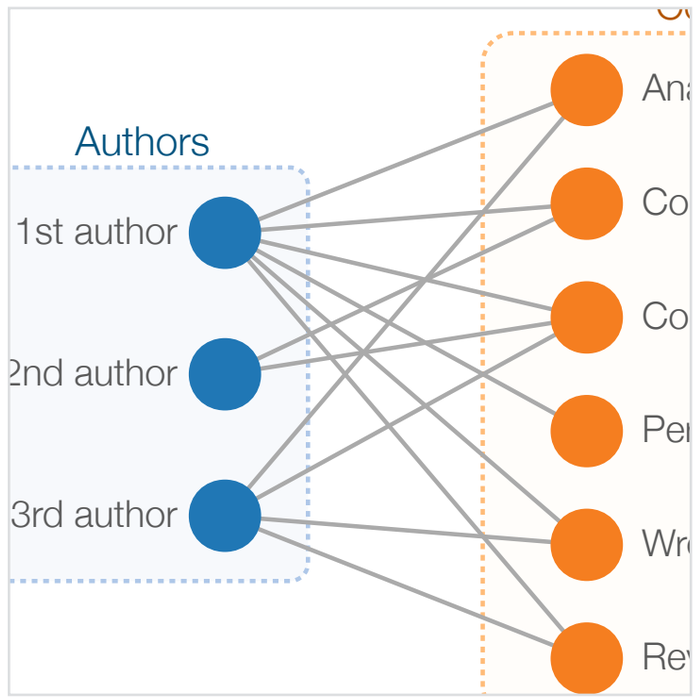
	Traditional	Symmetry
Exclusion	0.24 ± 0.05	0.848 ± 0.002
Global evenness	0.05 ± 0.01	0.387 ± 0.005
Average evenness	0.05 ± 0.01	0.447 ± 0.003

Comin, C. H., Silva, F. N., & Costa, L. D. F. (2015). A framework for evaluating complex networks measurements. *EPL (Europhysics Letters)*, *110*(6), 68002.

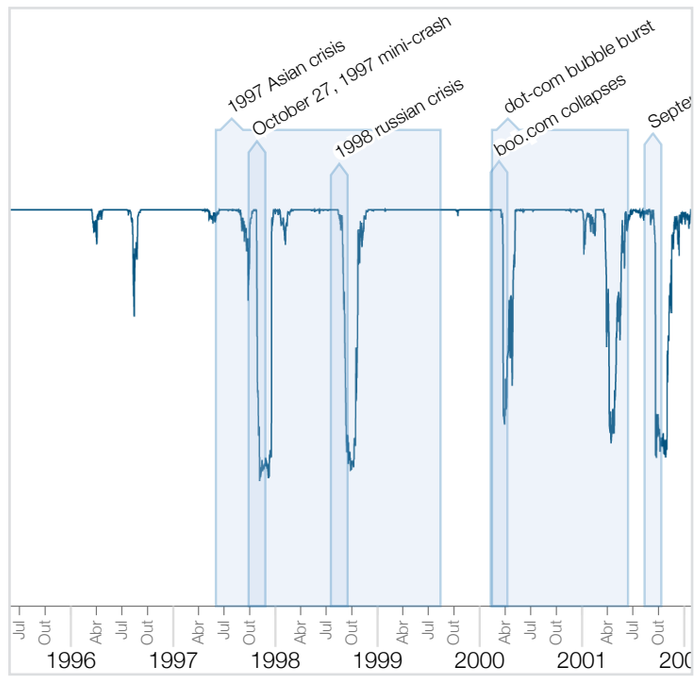
Applications



Authorship detection of books



Characterizing authors contributions



Detecting anomalies in networks generated from time series

Other uses of concentric symmetry performed by collaborators

Amancio DR (2015) A Complex Network Approach to Stylometry.
PLOS ONE 10(8): e0136076. https://doi.org/10.1371/journal.pone.0136076

Arruda, H. F., Costa, L.da F. and Amancio, D.R., (2016)
Using complex networks for text classification: Discriminating informative and imaginative documents.
EPL (Europhysics Letters), 113(2), p.28007. https://doi.org/10.1209/0295-5075/113/28007

Current interests

References

COSTA, L. da F. et al.
Analyzing and modeling real-world phenomena with complex networks: a survey of applications
Advances in Physics, v. 60, n. 3, p. 329--412, 2011.

COSTA, L. da F.; SILVA, F. N.
Hierarchical characterization of complex networks
Journal of Statistical Physics, v. 125, n. 4, p. 845–876, 2006.

COSTA, L. da F.; TOGNETTI, M. A. R.; SILVA, F. N.
Concentric characterization and classification of complex network nodes: Application to an institutional collaboration network
Physica A, v. 387, n. 24, p. 6201--6214, 2008.

SILVA, F.N.; COMIN, C.H.; PERON, T.K.DM.; RODRIGUES, F.A.; Ye, C.; WILSON, R.C.; HANCOCK, E.; COSTA, L. da F.
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Thanks!

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