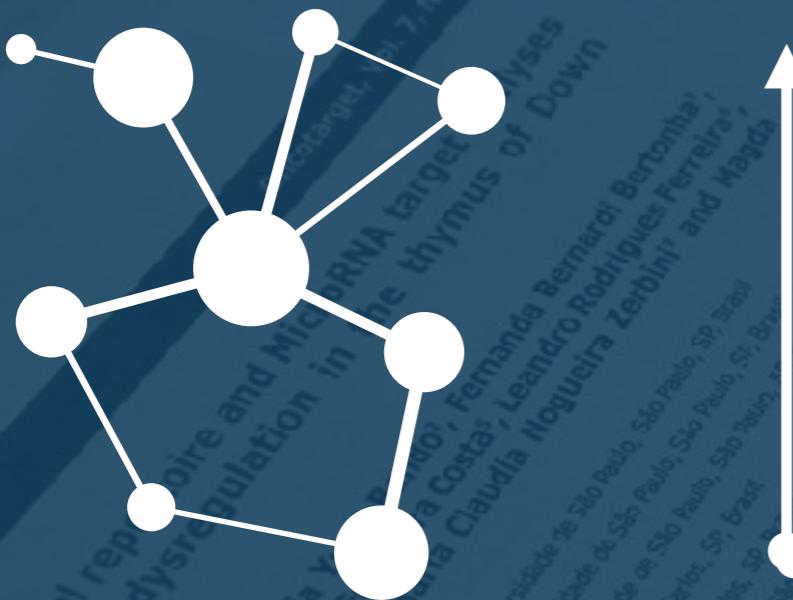


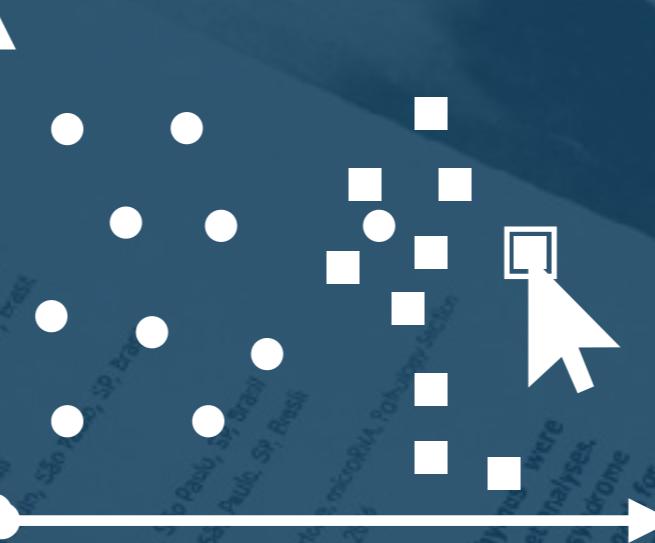
Filipi Nascimento Silva

Research Scientist at IUNI

Complex networks



Interactive visualization



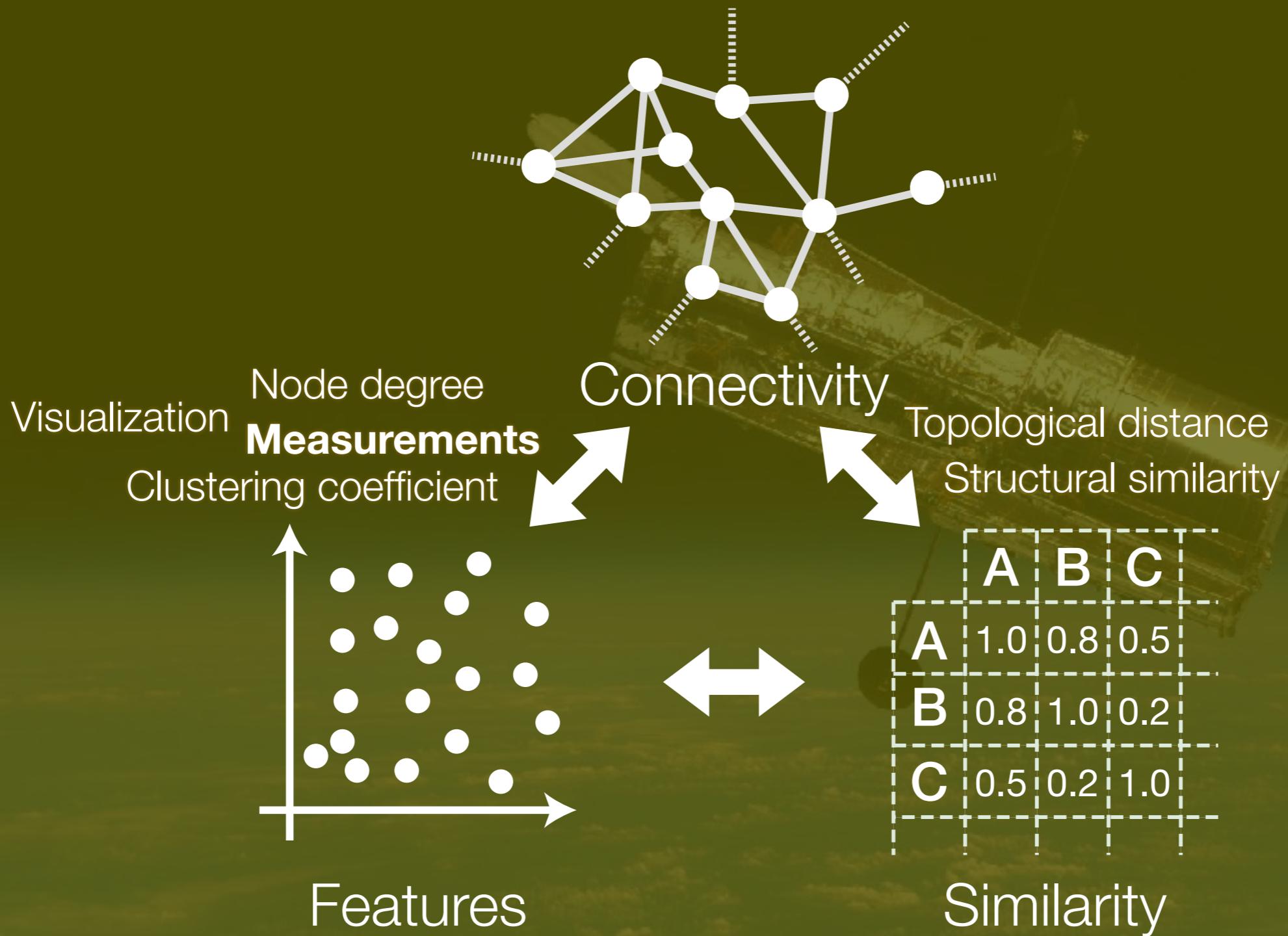
Data analysis

Research Interests

Science of science
Urban network analysis
Network visualization
Text analysis
Gene co-expression
Networks
Social

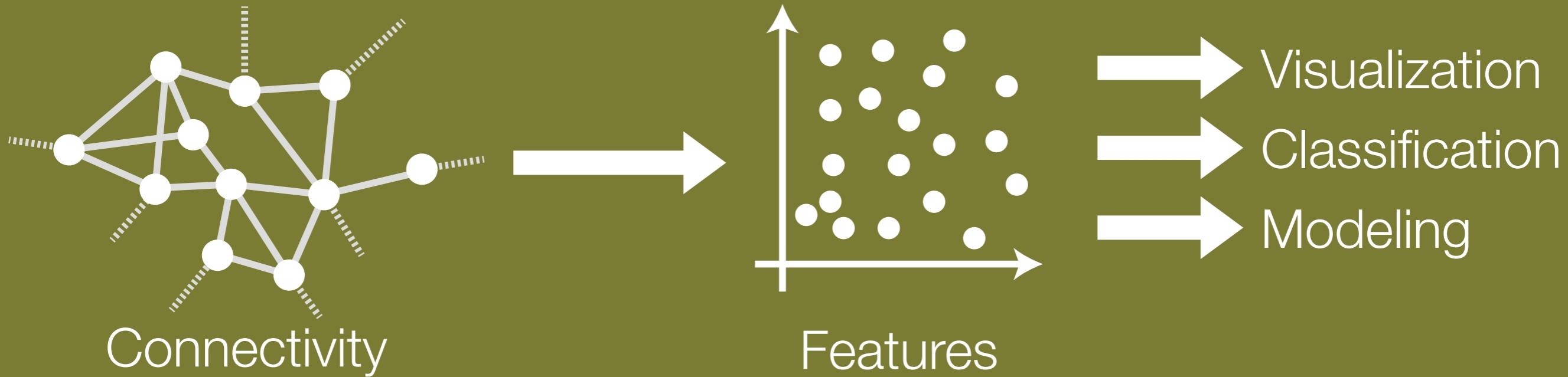


Representing and modeling complex systems



Representing and modeling complex systems

Informative features for nodes?



Global vs local measurements

Dependence with the size of networks is not desirable



Quantifying the interdisciplinarity of scientific journals and fields

Journal of Informetrics 7 (2013) 469–477



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Journal of Informetrics

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Quantifying the interdisciplinarity of scientific journals and fields



F.N. Silva^{a,*}, F.A. Rodrigues^b, O.N. Oliveira Jr^a, L. da F. Costa^a

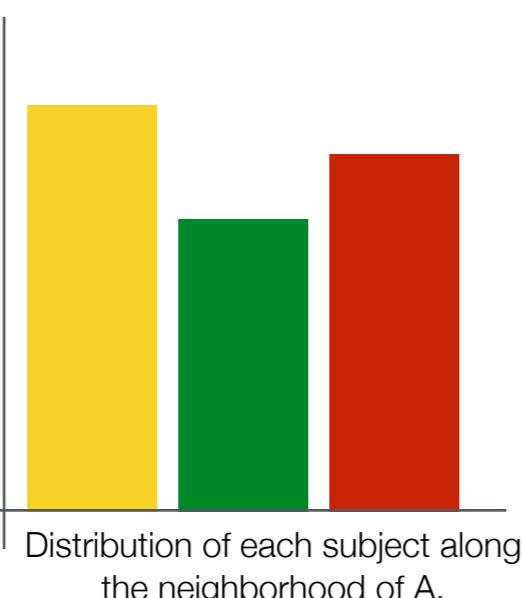
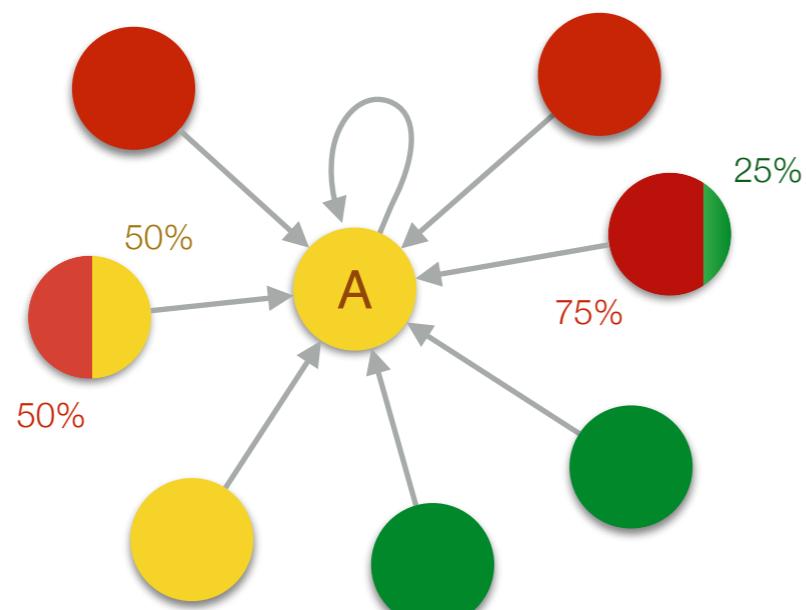
^a Institute of Physics of São Carlos, University of São Paulo, Brazil

^b Institute of Mathematics and Computer Sciences, University of São Paulo, National Institute of Science and Technology for Complex Systems, Rio de Janeiro, Brazil

Quantifying the interdisciplinarity of scientific journals and fields

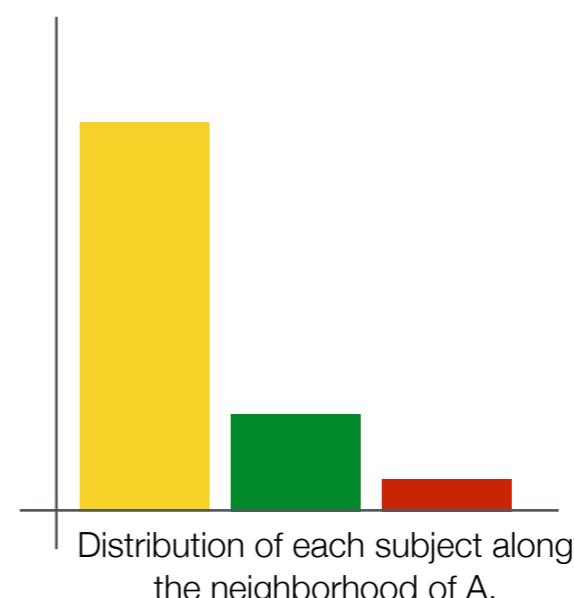
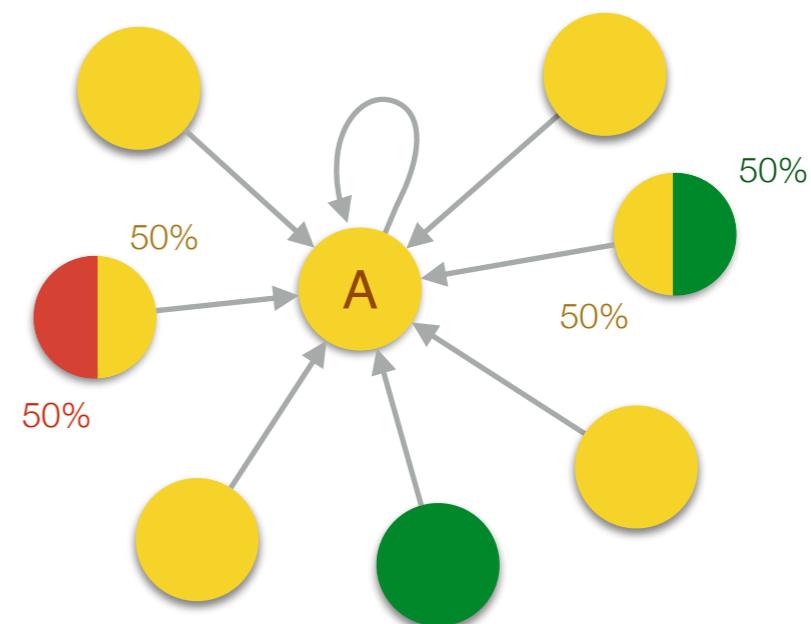
Configuration of **High** subject entropy for A.

High interdisciplinarity

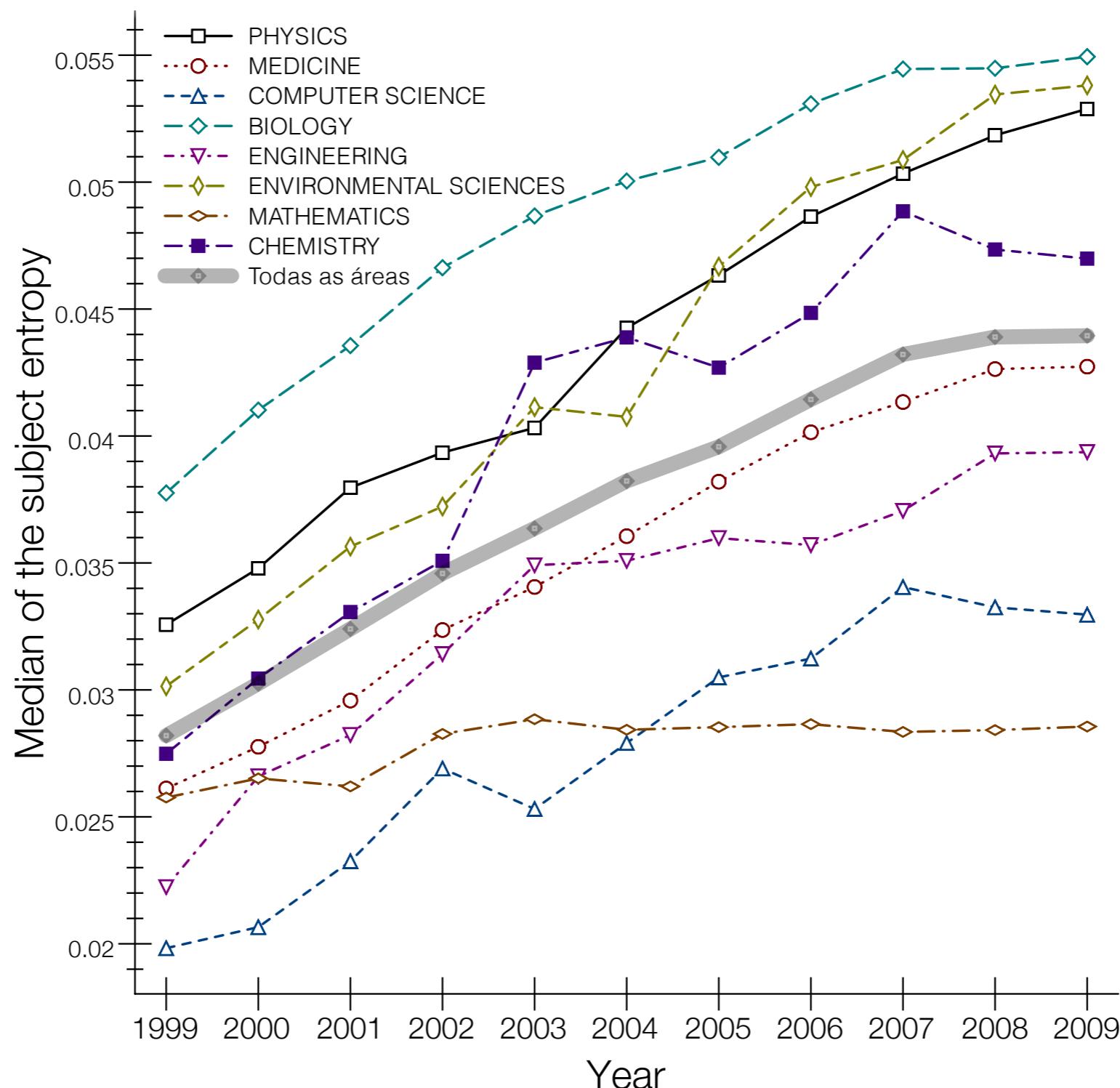


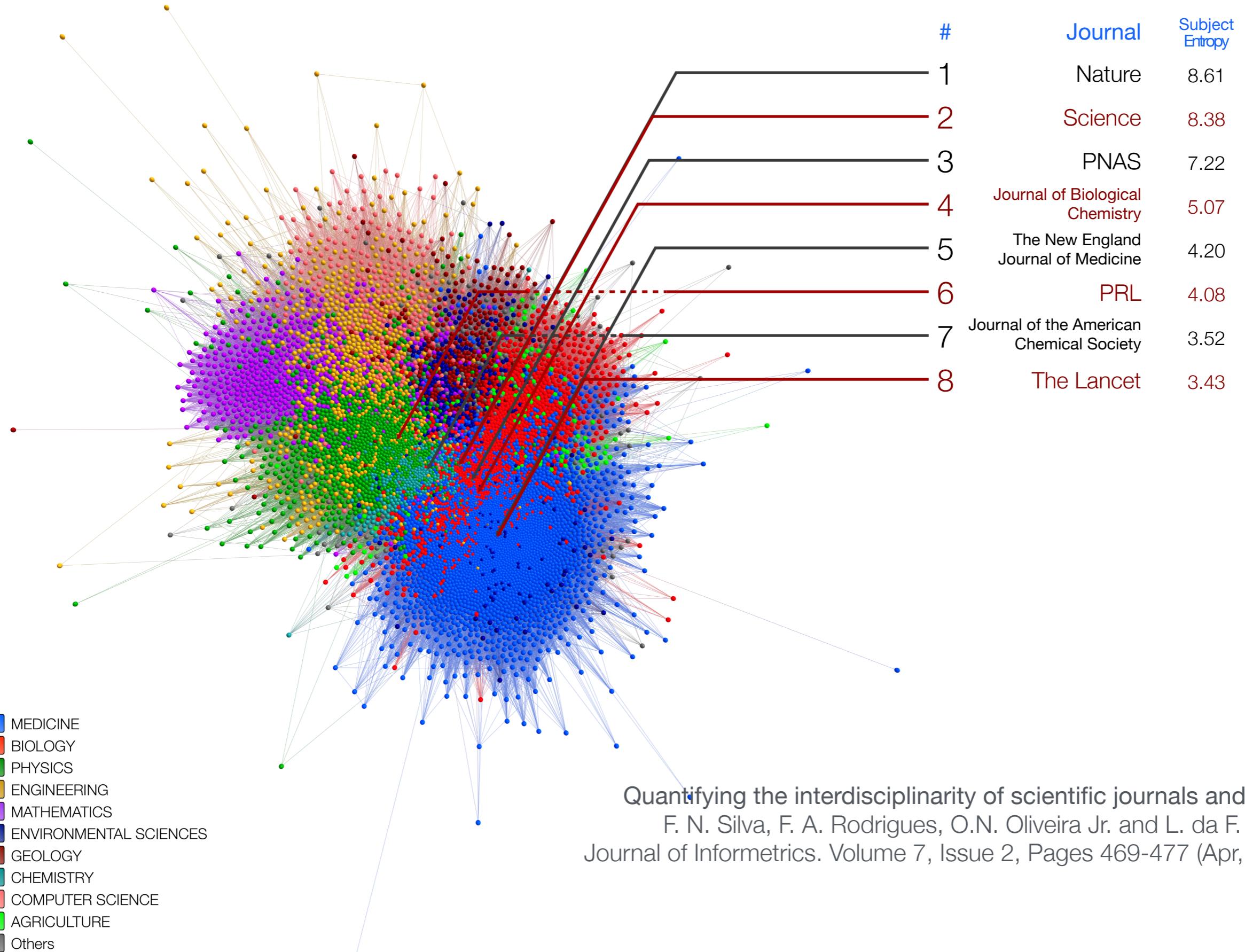
Configuration of **Low** subject entropy for A.

Low interdisciplinarity



Quantifying the interdisciplinarity of scientific journals and fields





Bibliographic summarization

Journal of Informetrics 10 (2016) 487–502



Contents lists available at [ScienceDirect](#)

Journal of Informetrics

journal homepage: www.elsevier.com/locate/joi



Using network science and text analytics to produce surveys
in a scientific topic



Filipi N. Silva^a, Diego R. Amancio^{b,*}, Maria Bardosova^c, Luciano da F. Costa^a,
Osvaldo N. Oliveira Jr.^a

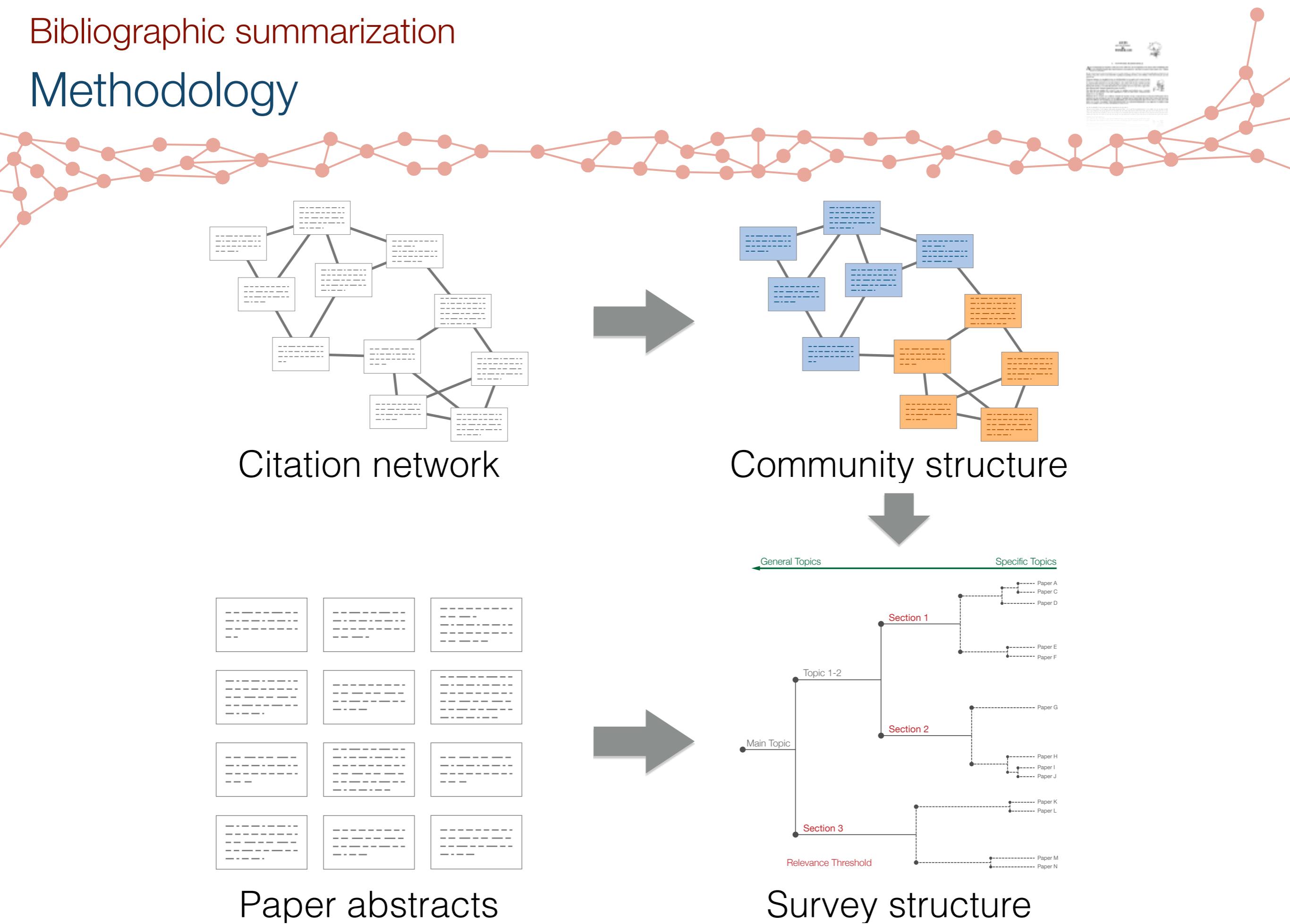
^a São Carlos Institute of Physics, University of São Paulo, São Carlos, Brazil

^b Institute of Mathematics and Computer Science, University of São Paulo, São Carlos, Brazil

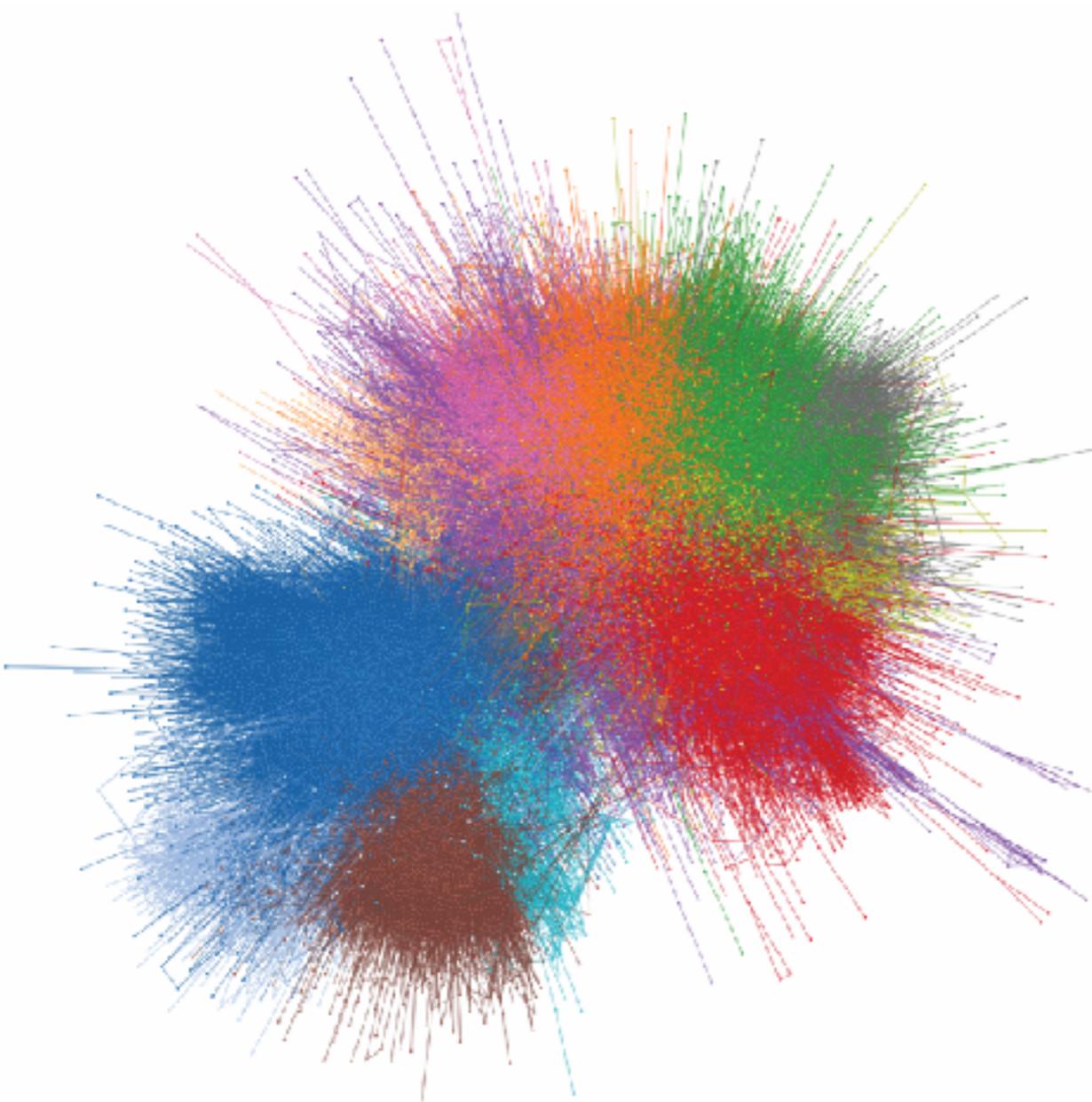
^c Tyndall National Institute, Cork City, Ireland

Bibliographic summarization

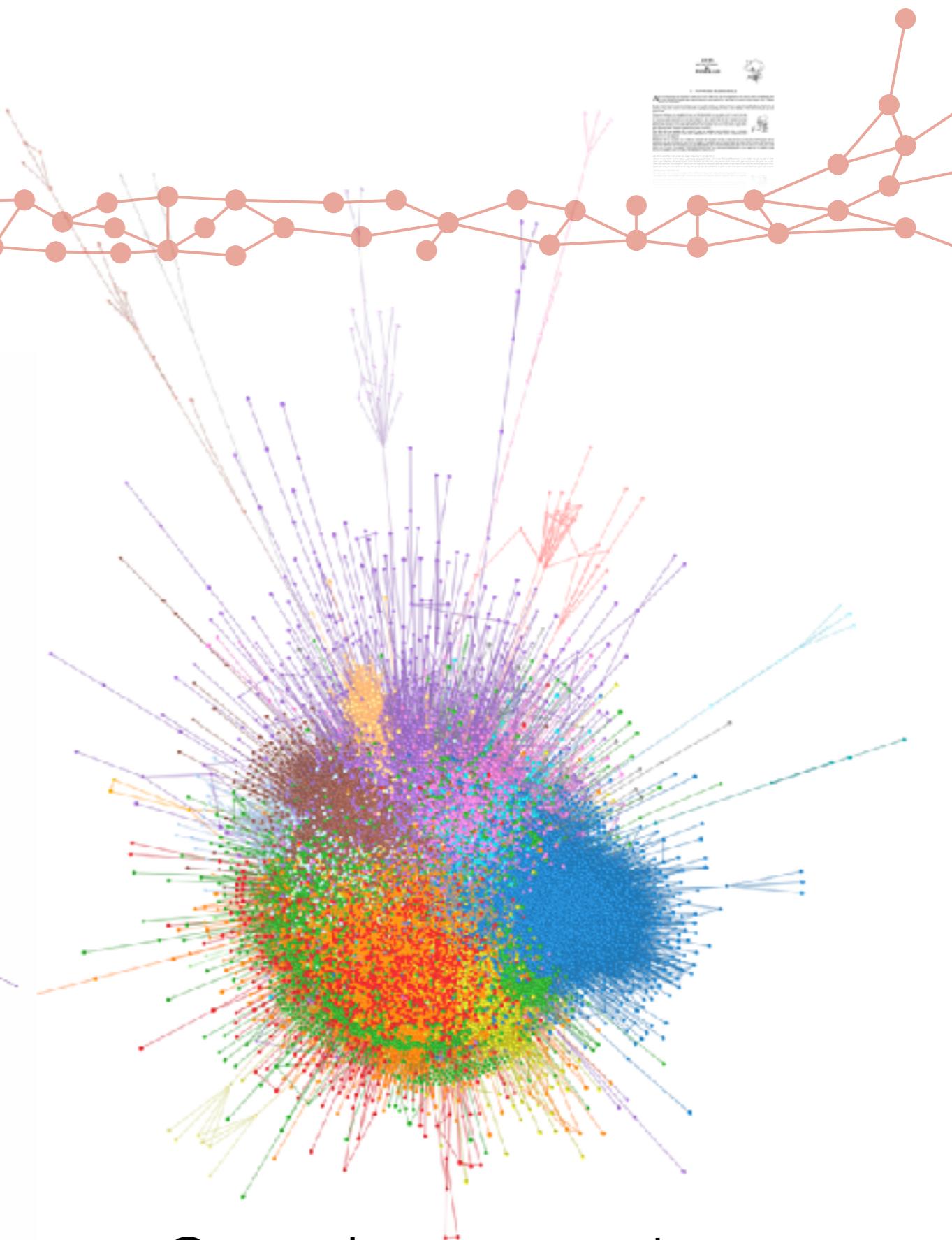
Methodology



Bibliographic summarization Applications

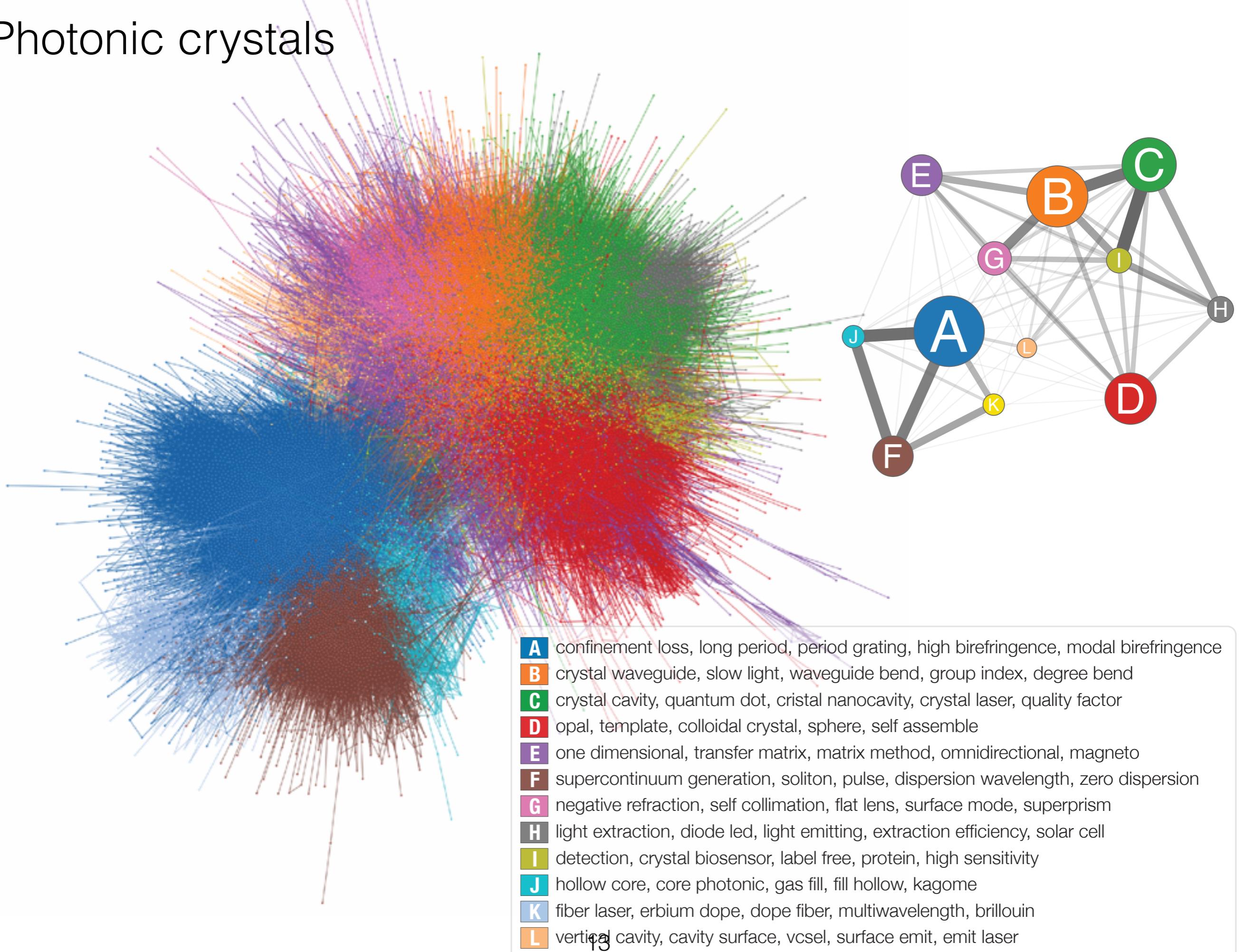


Photonic crystals

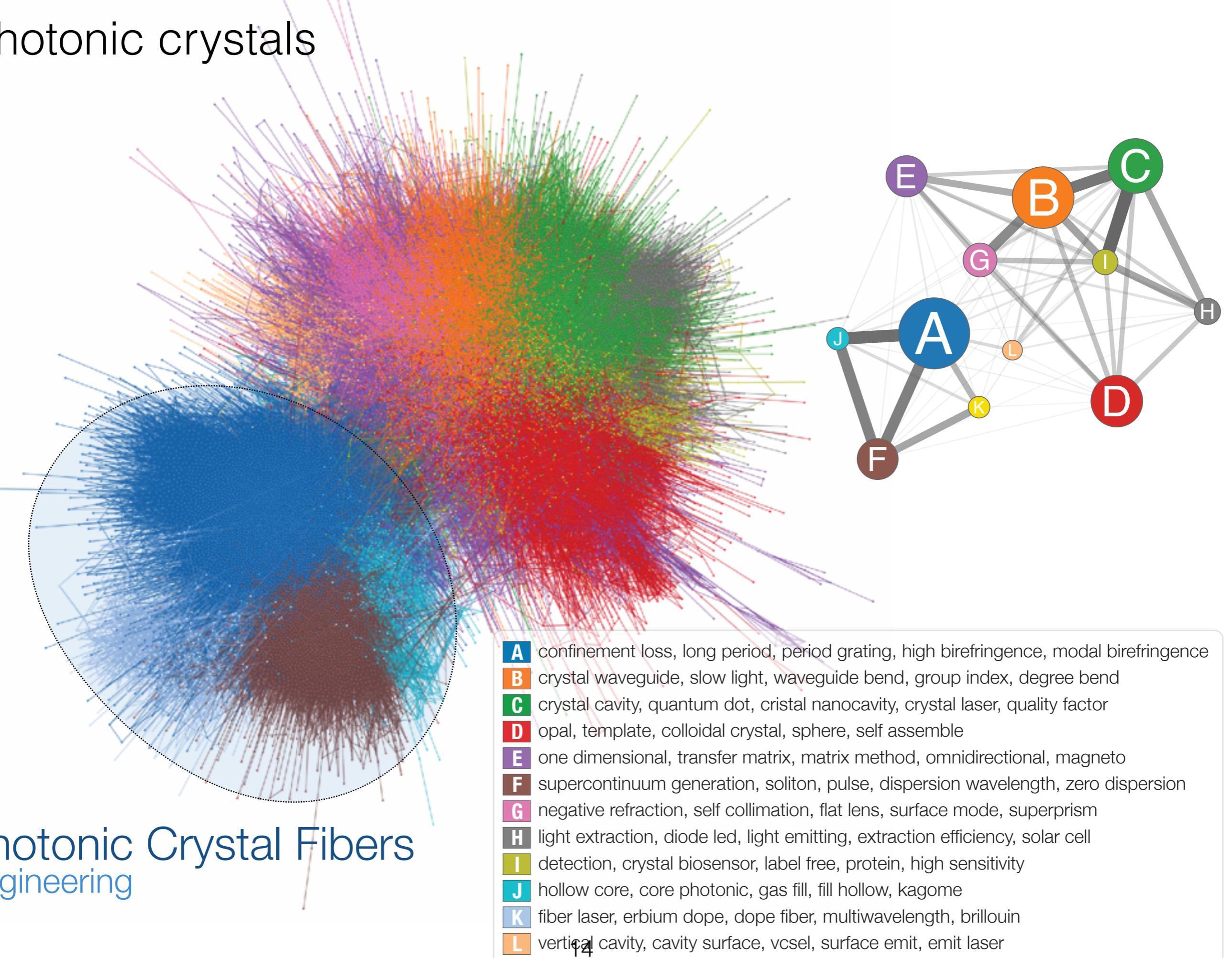


Complex networks

Photonic crystals



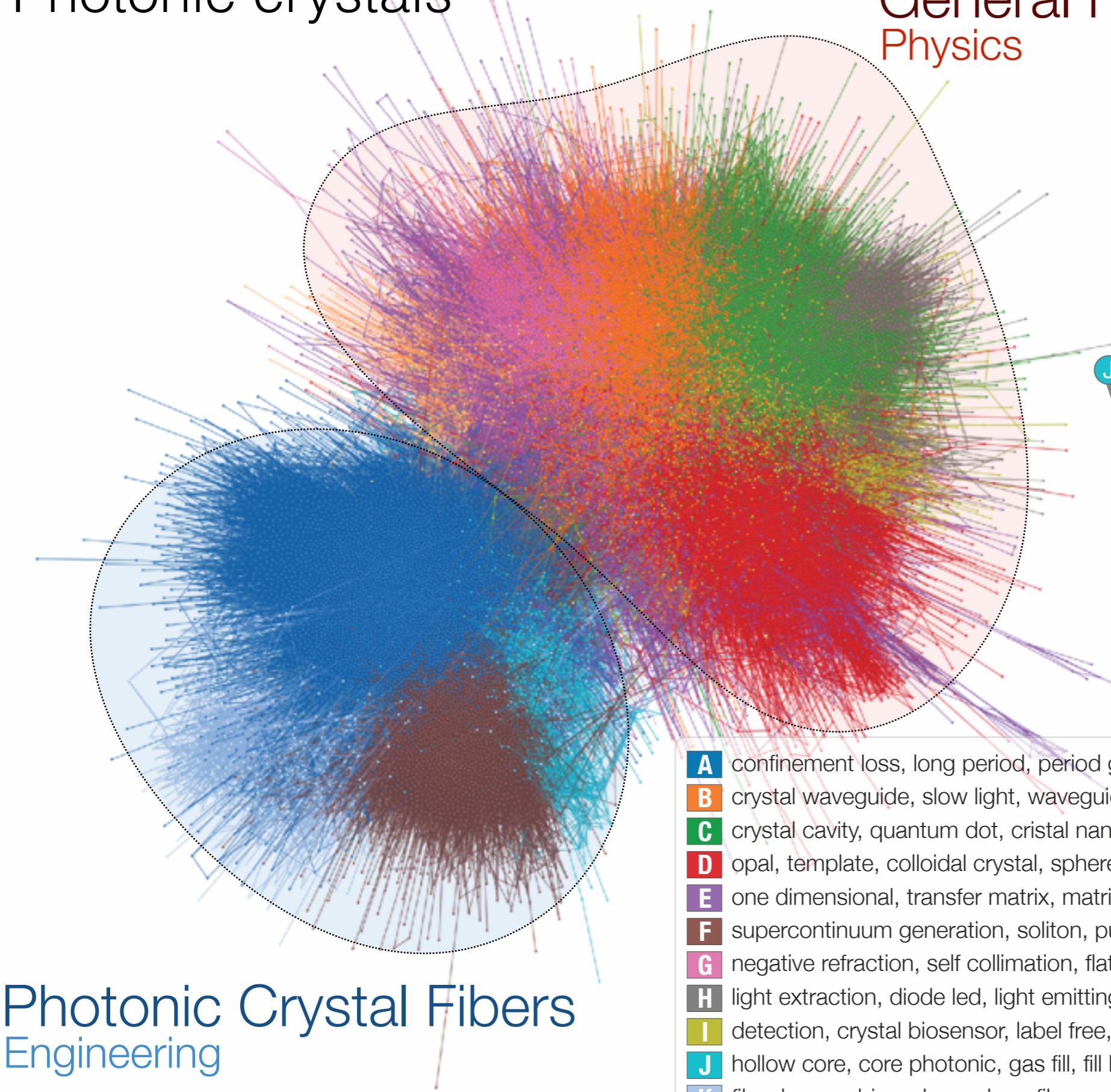
Photonic crystals



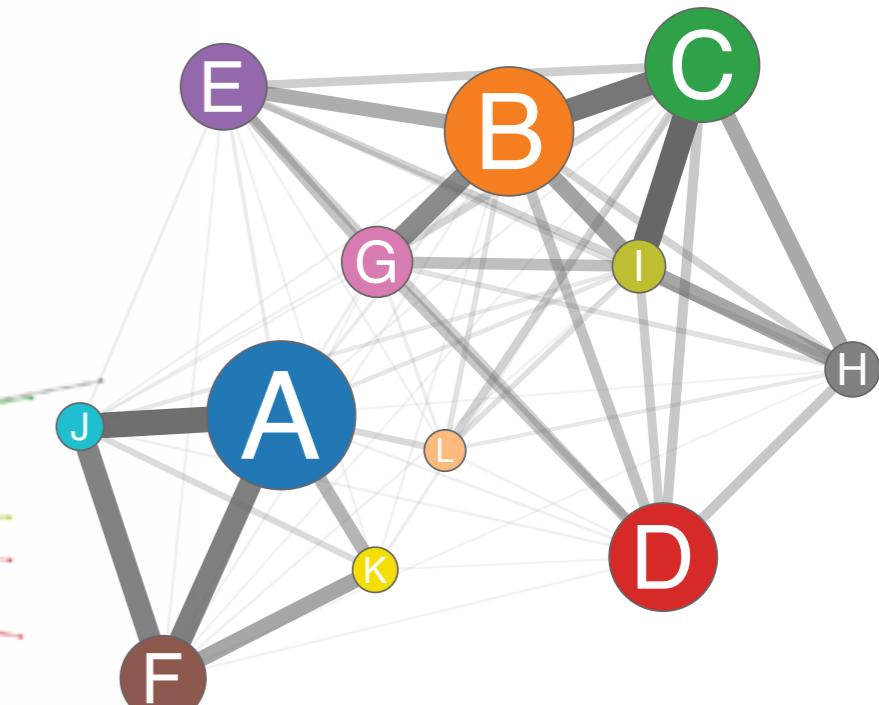
Photonic Crystal Fibers Engineering

Photonic crystals

General Photonic Crystals Physics



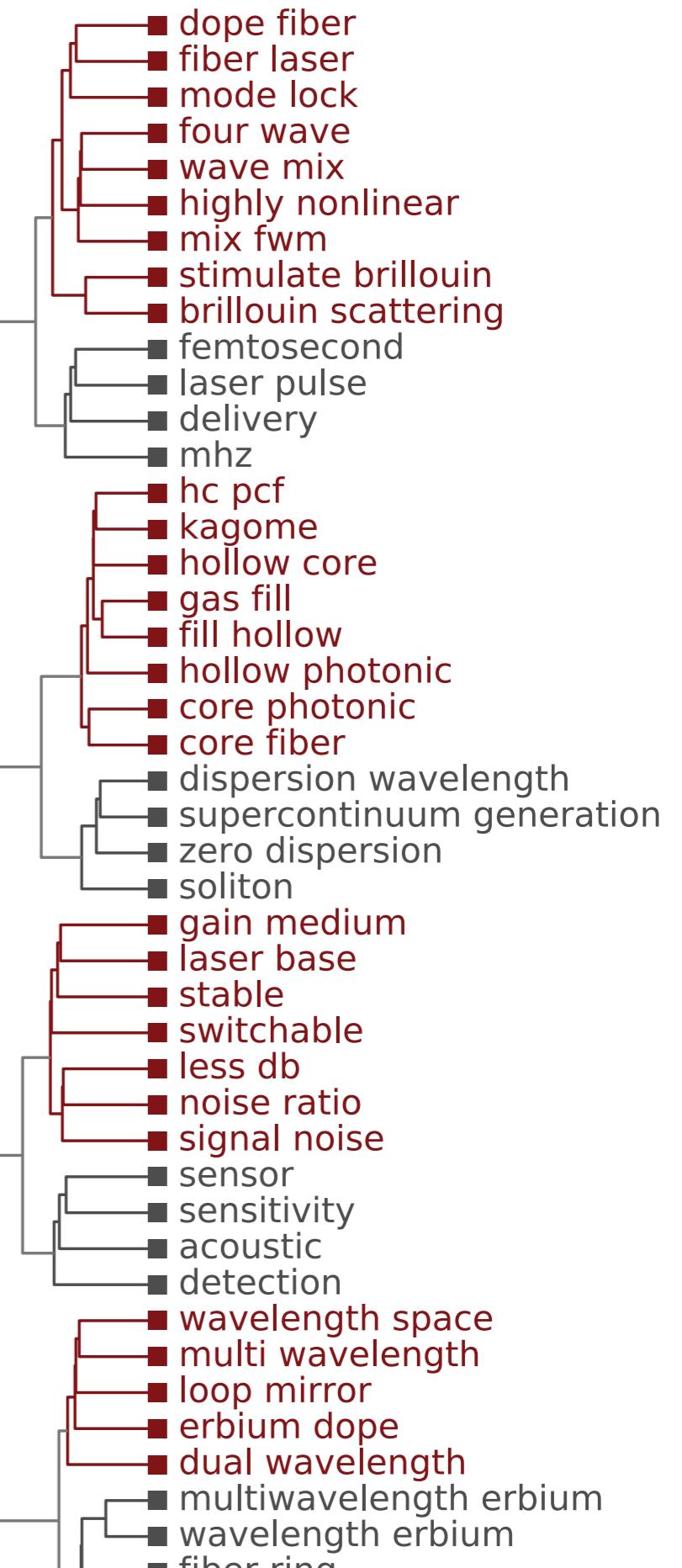
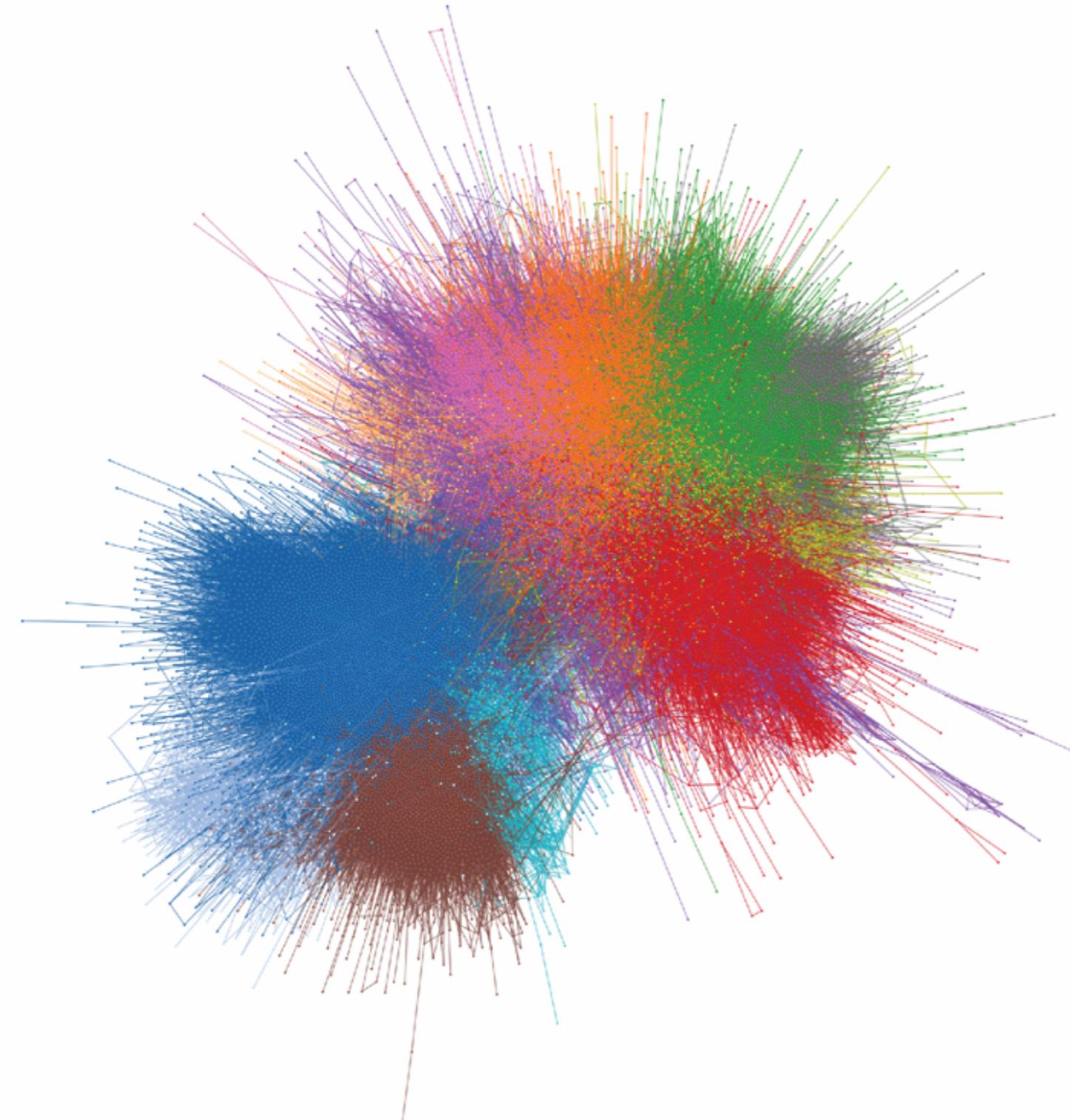
Photonic Crystal Fibers Engineering



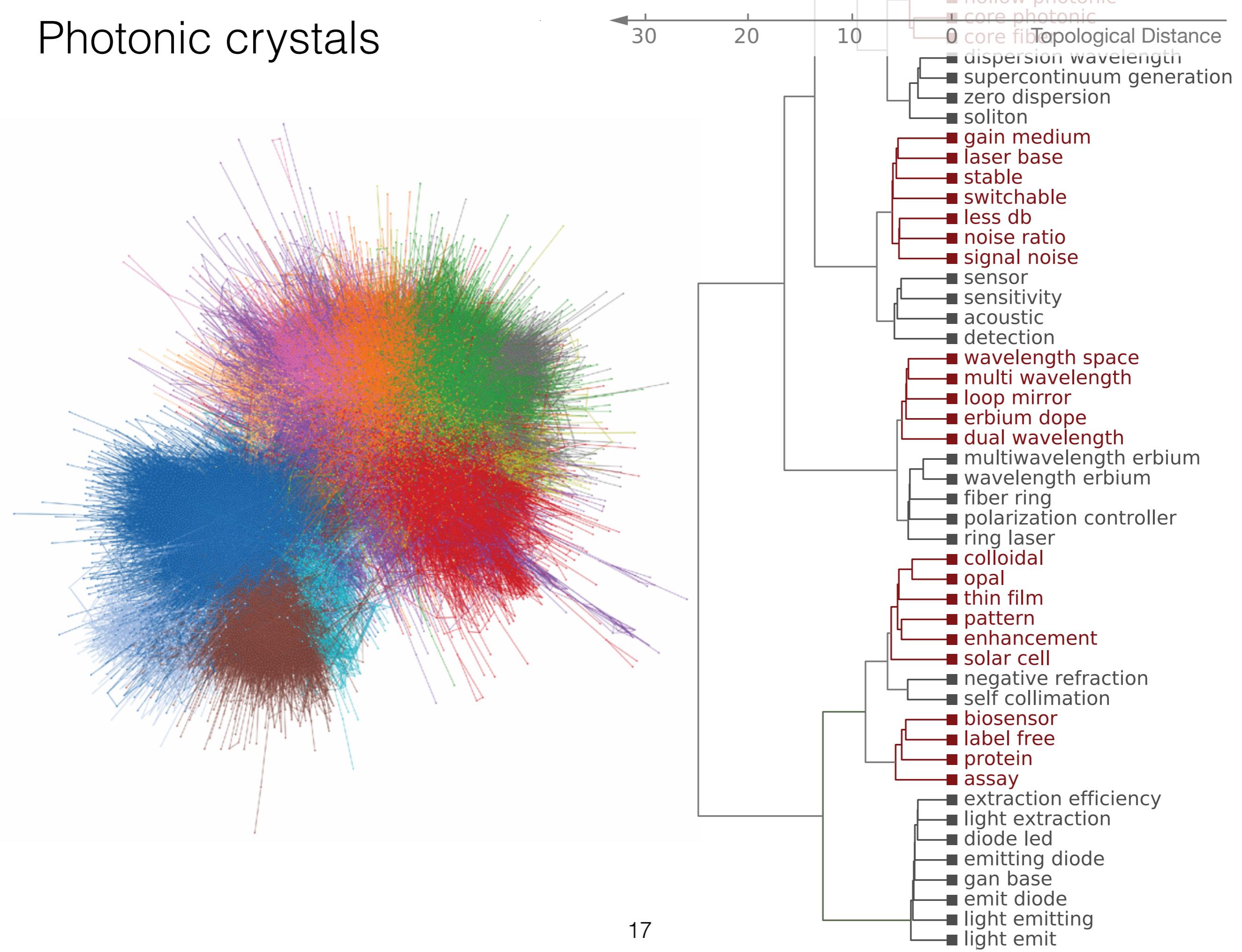
- A** confinement loss, long period, period grating, high birefringence, modal birefringence
- B** crystal waveguide, slow light, waveguide bend, group index, degree bend
- C** crystal cavity, quantum dot, cristal nanocavity, crystal laser, quality factor
- D** opal, template, colloidal crystal, sphere, self assemble
- E** one dimensional, transfer matrix, matrix method, omnidirectional, magneto
- F** supercontinuum generation, soliton, pulse, dispersion wavelength, zero dispersion
- G** negative refraction, self collimation, flat lens, surface mode, superprism
- H** light extraction, diode led, light emitting, extraction efficiency, solar cell
- I** detection, crystal biosensor, label free, protein, high sensitivity
- J** hollow core, core photonic, gas fill, fill hollow, kagome
- K** fiber laser, erbium dope, dope fiber, multiwavelength, brillouin
- L** vertical cavity, cavity surface, vcsel, surface emit, emit laser

Photonic crystals

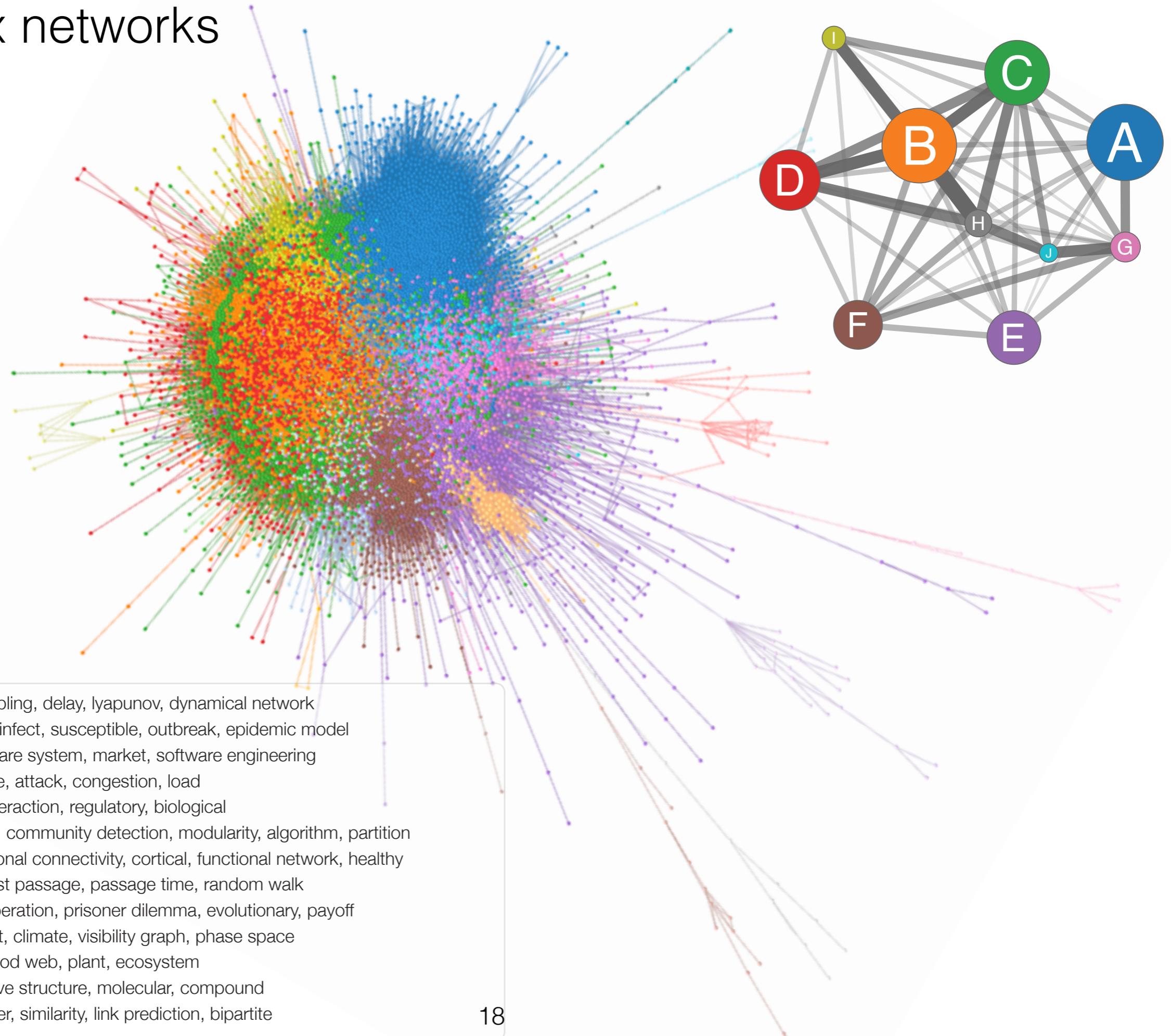
30 20 10 0 Topological Distance



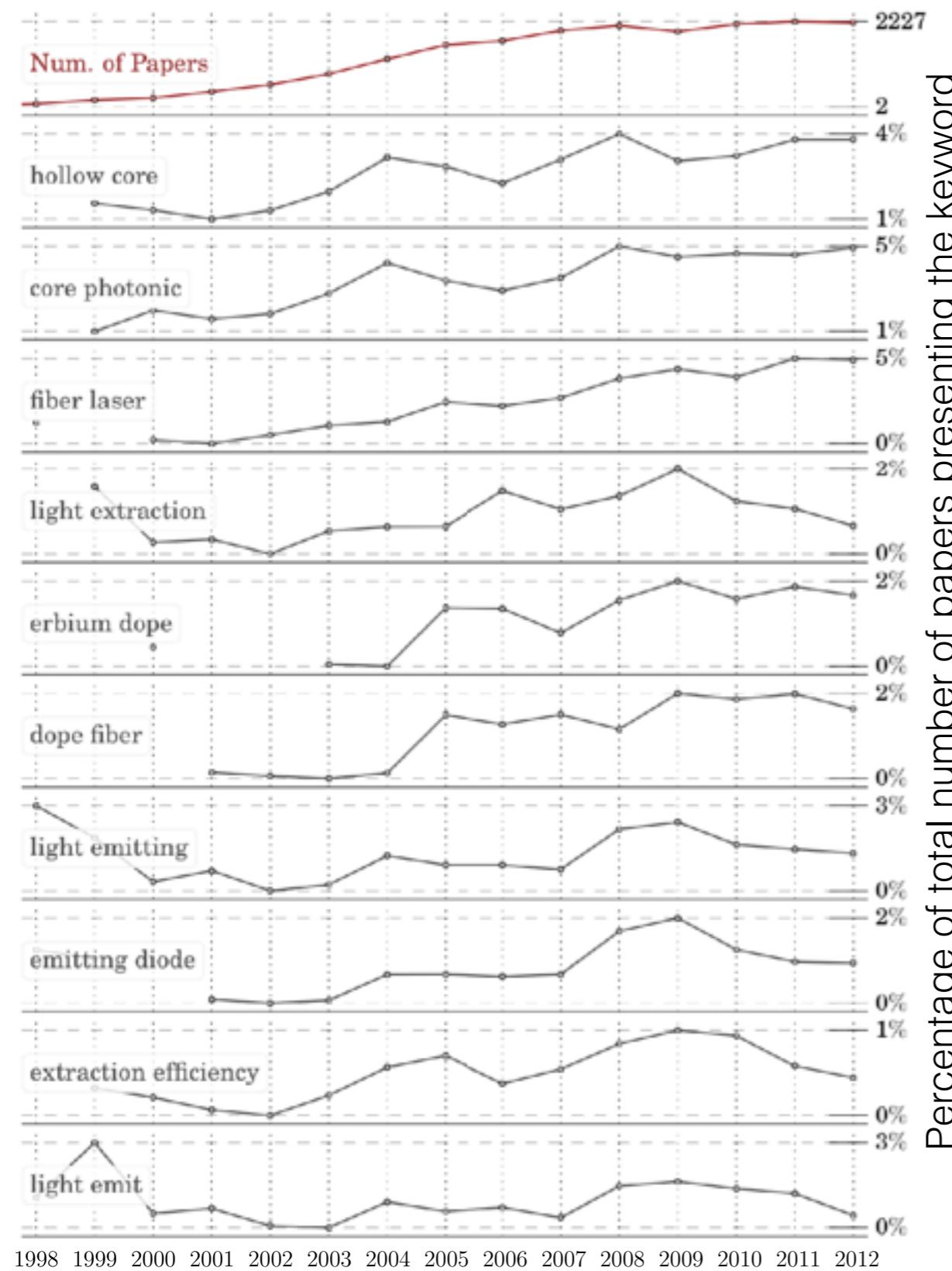
Photonic crystals



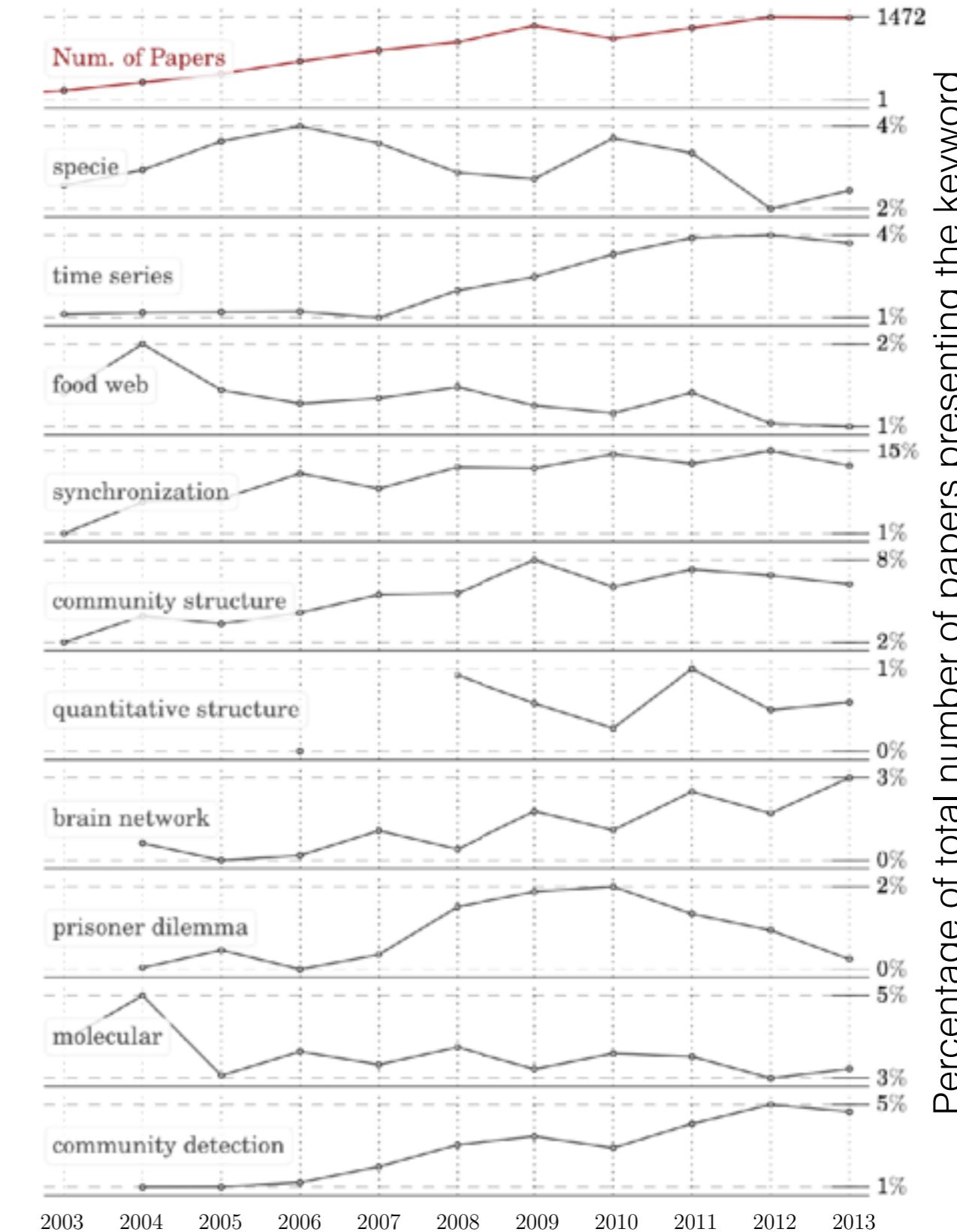
Complex networks



Chronological evolution of keywords

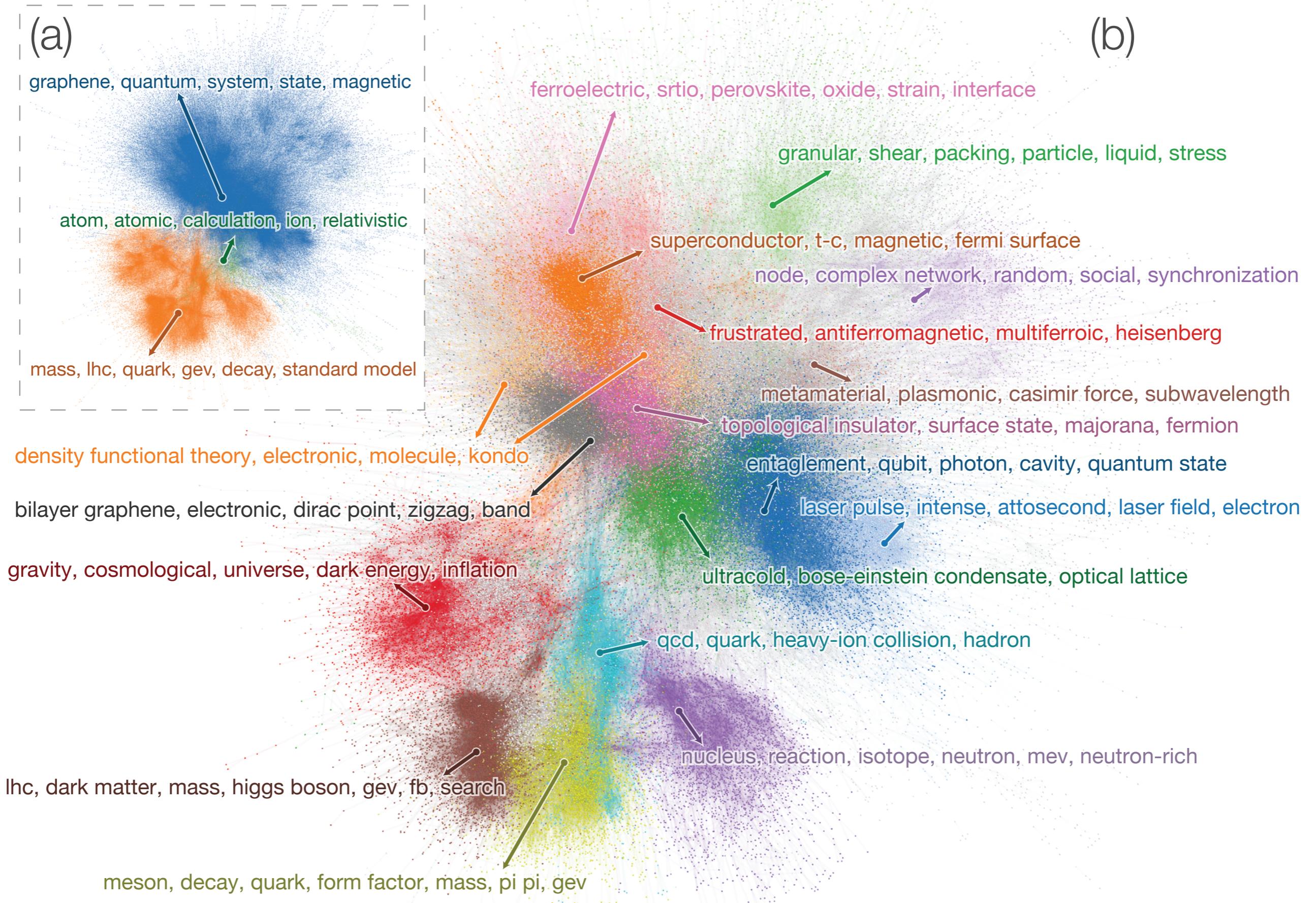


Photonic Crystals

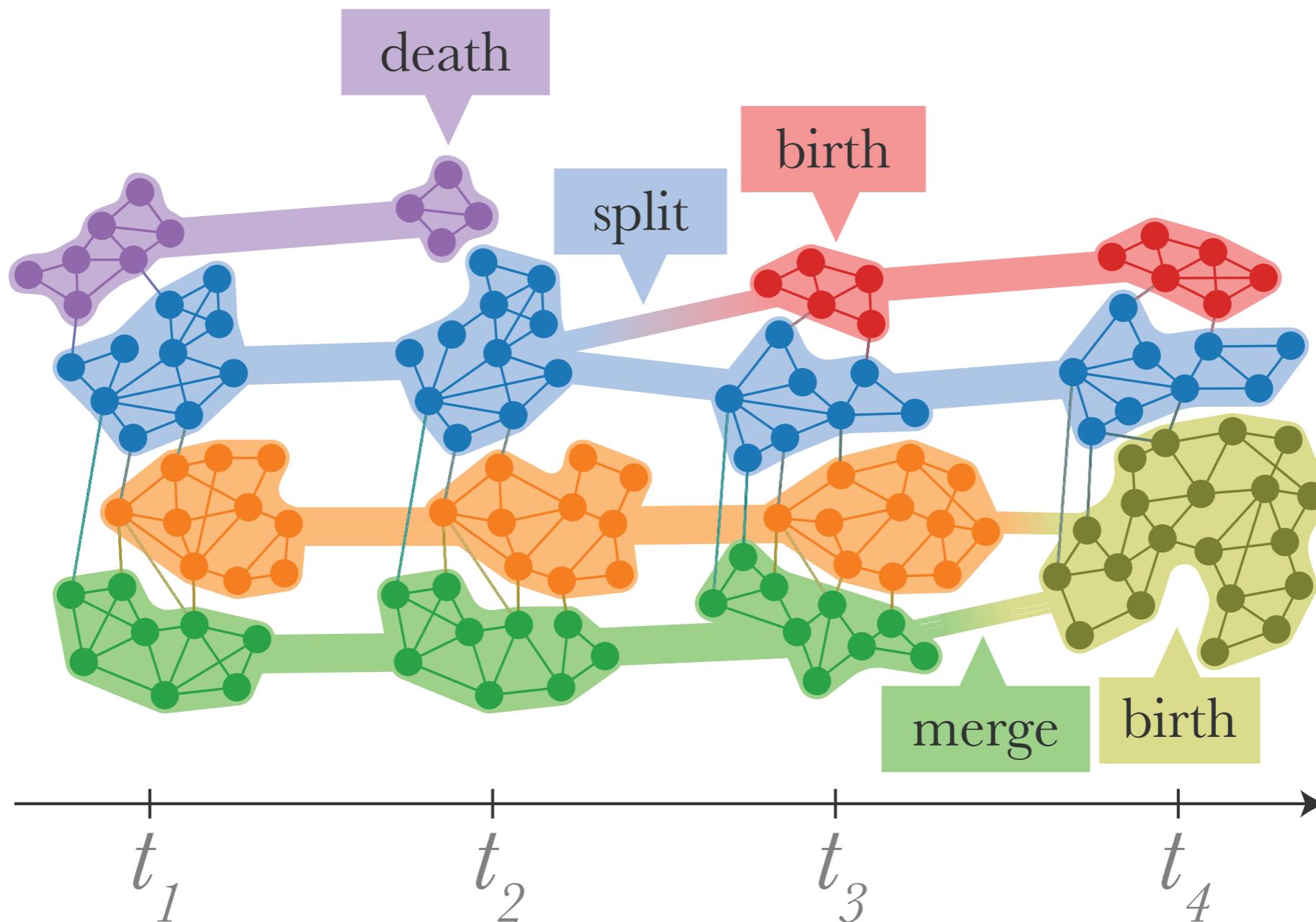


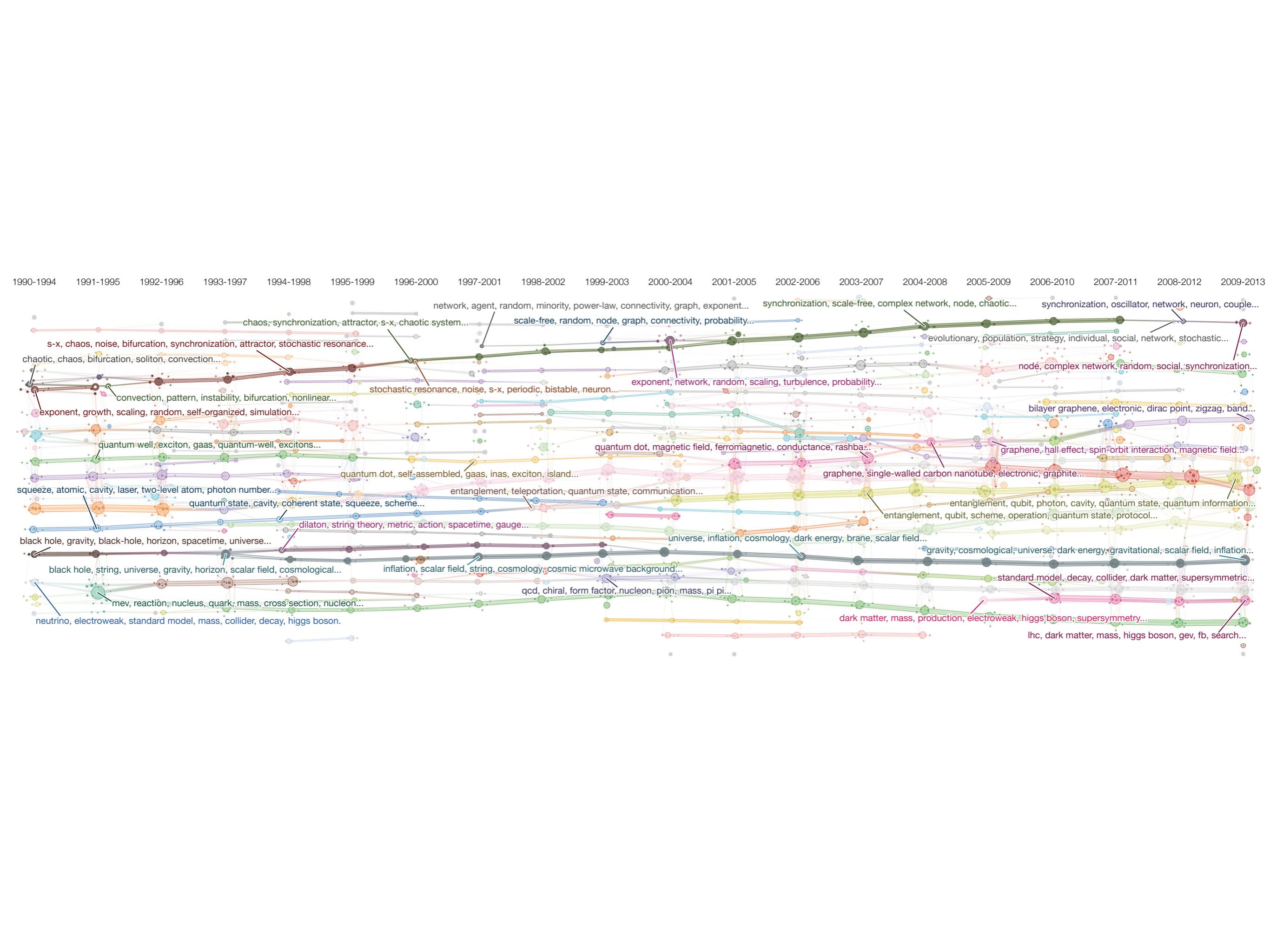
Complex Networks

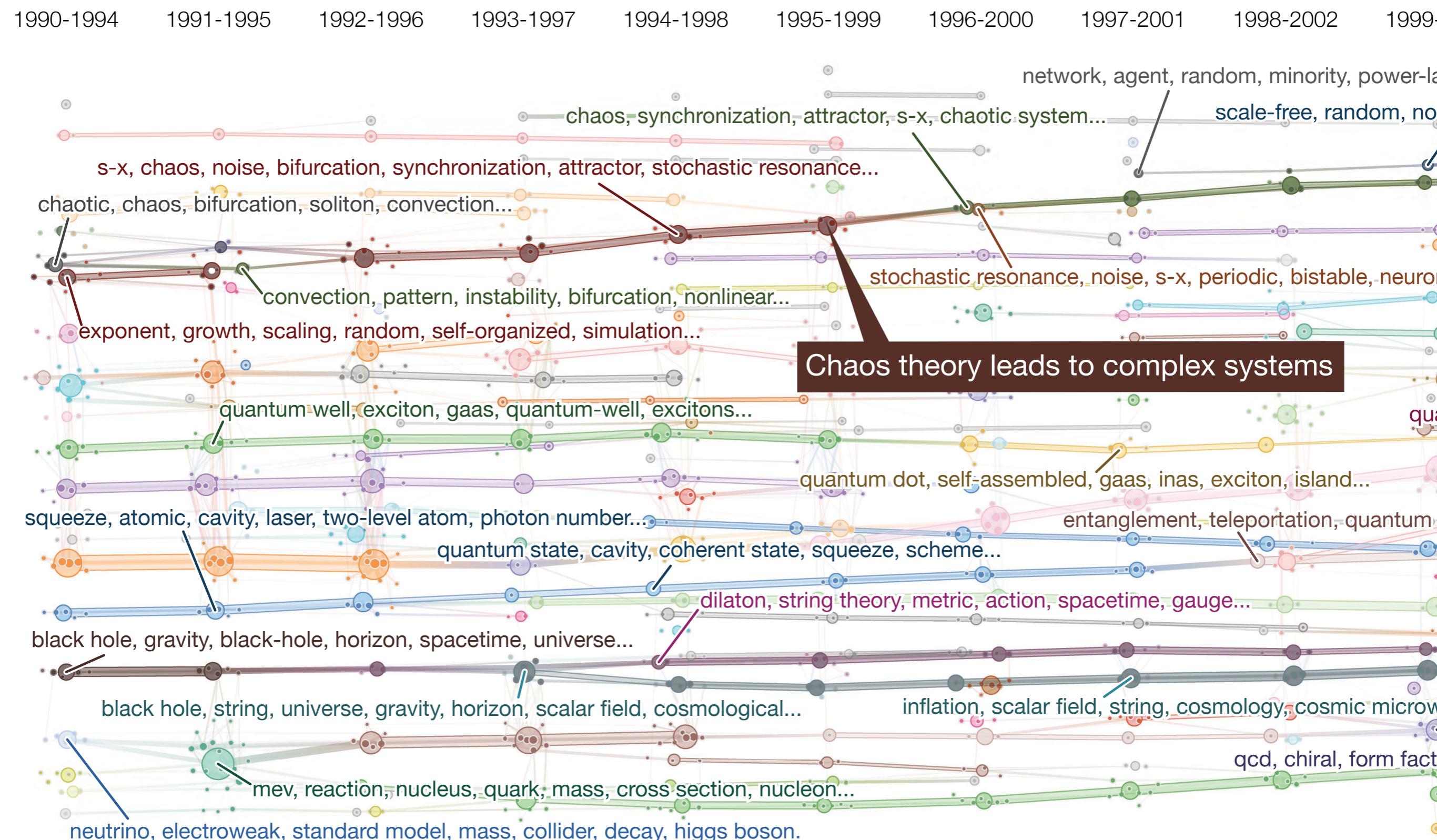
Dynamics of scientific disciplines

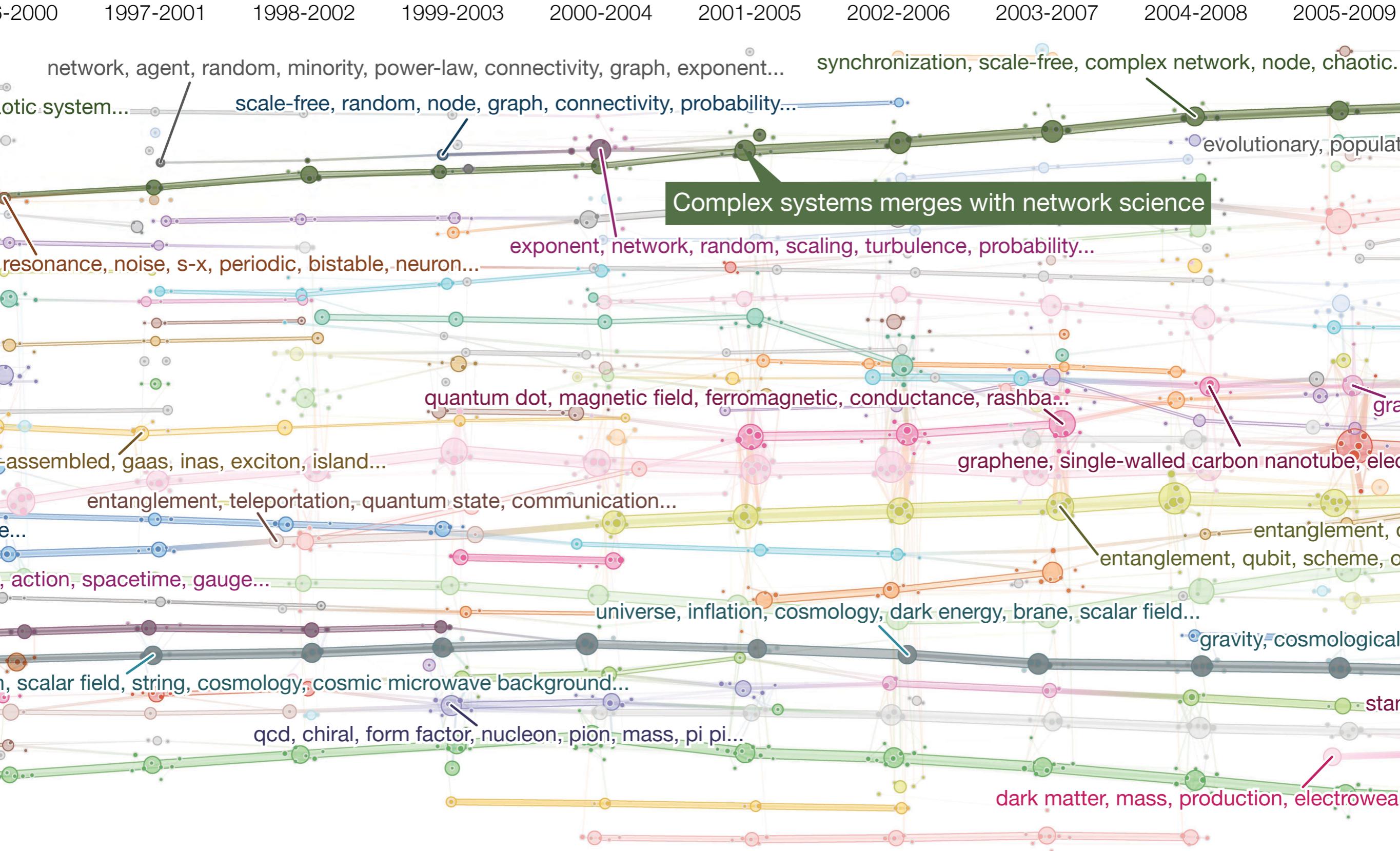


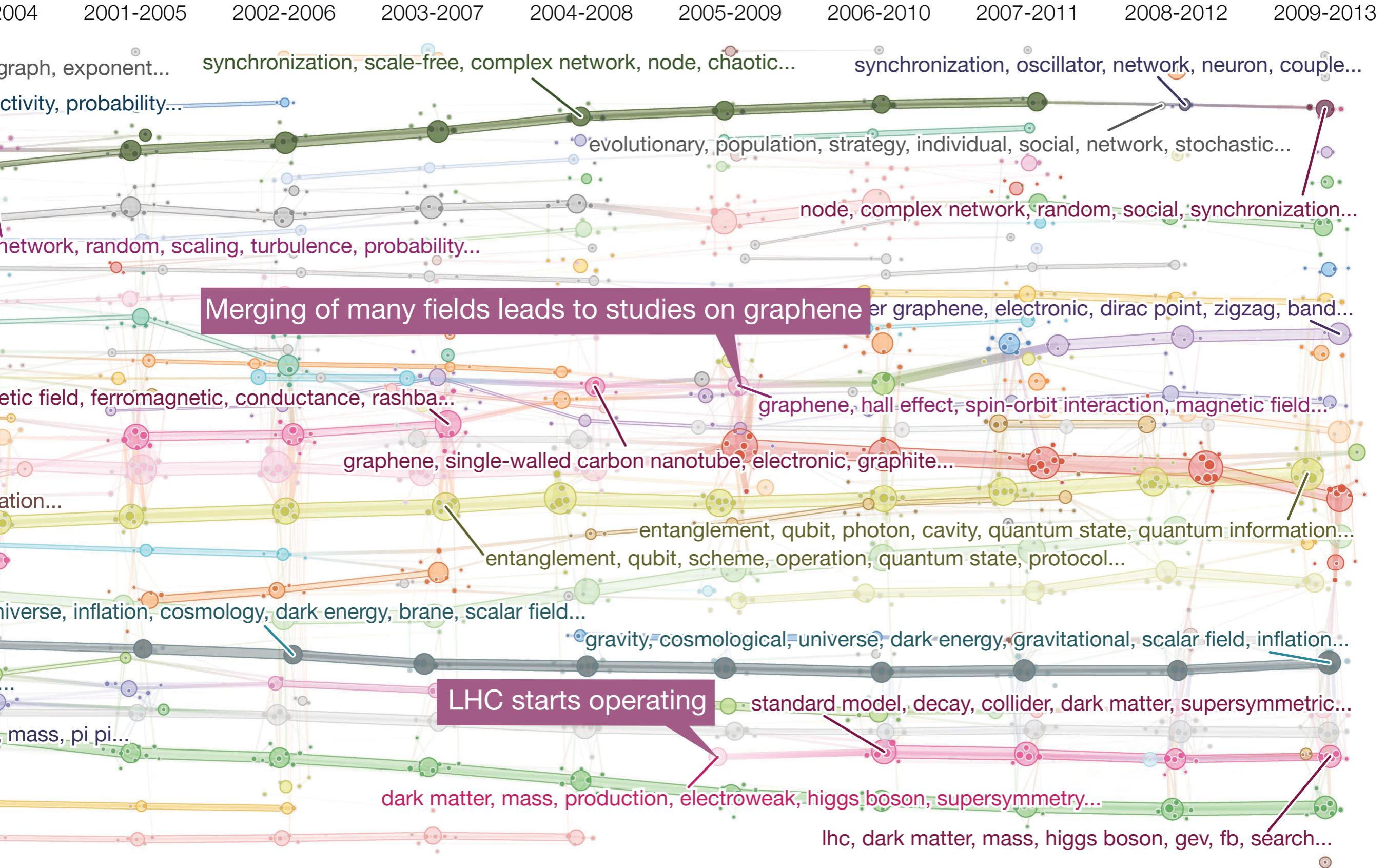
Dynamics of scientific disciplines



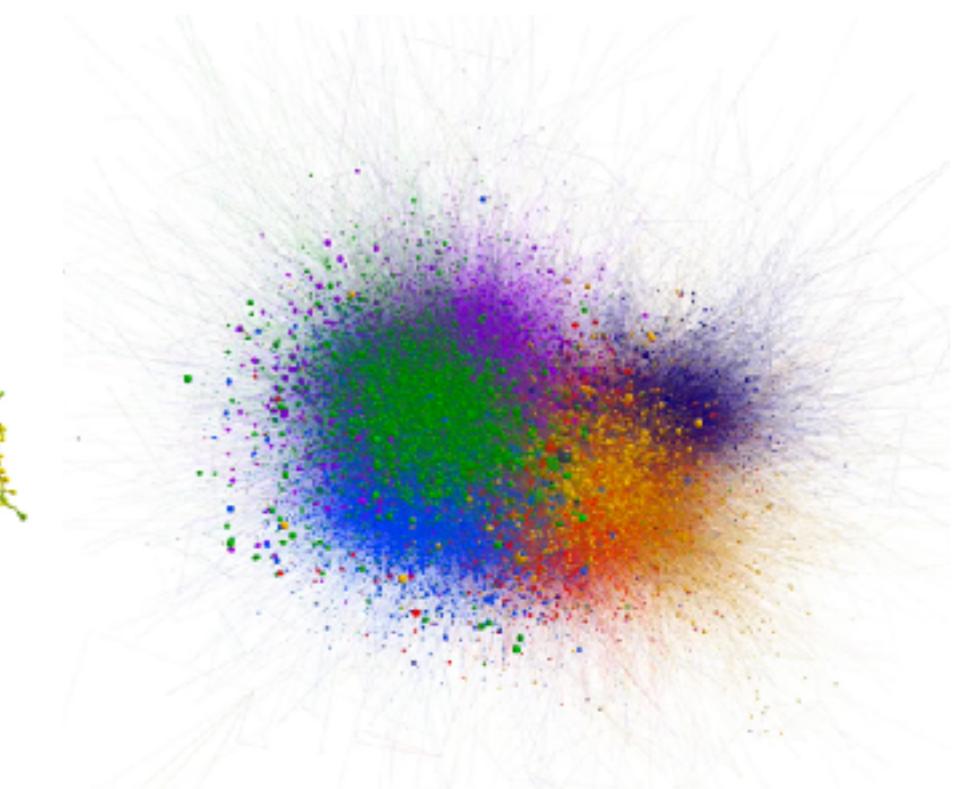
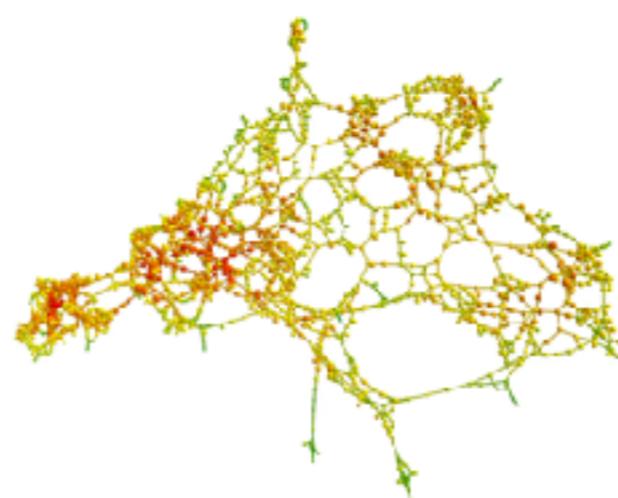
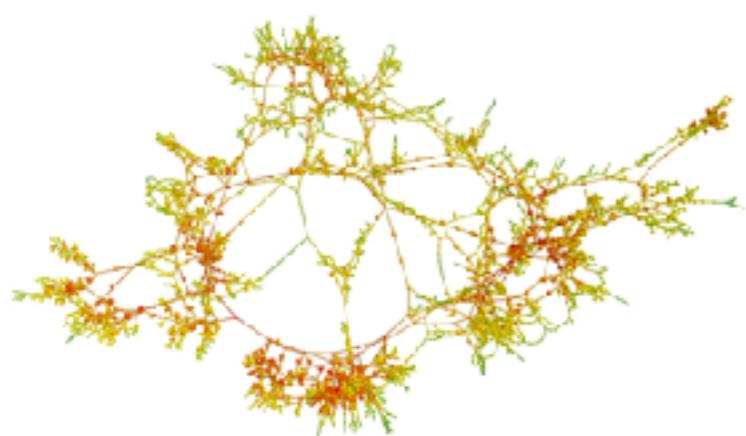
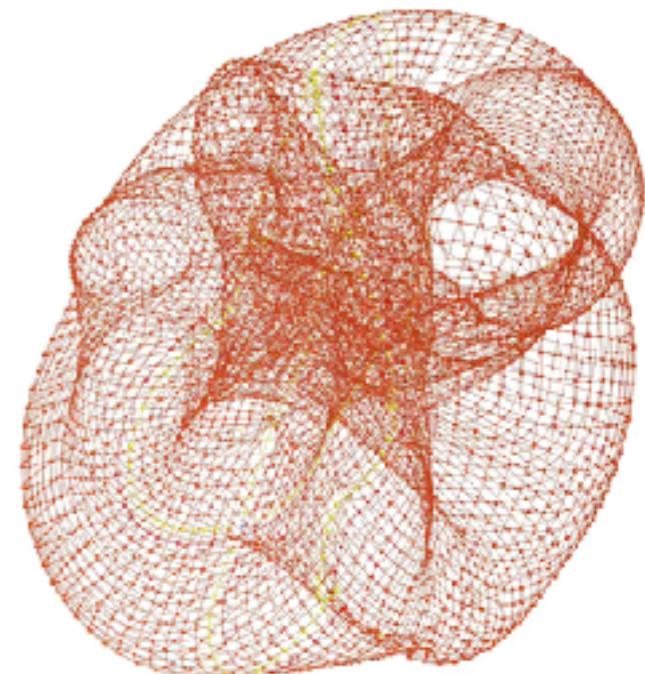
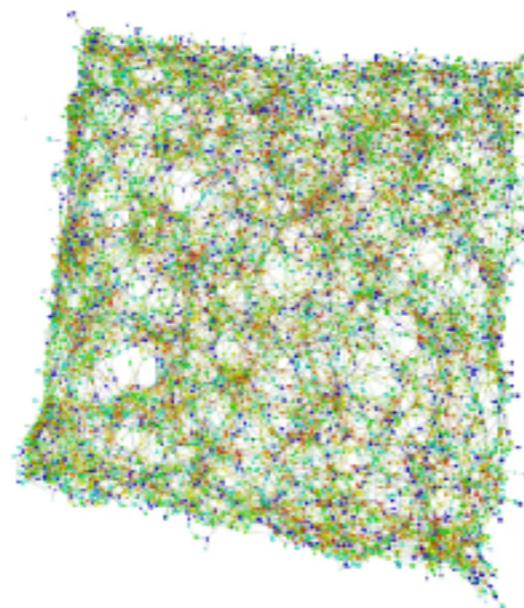
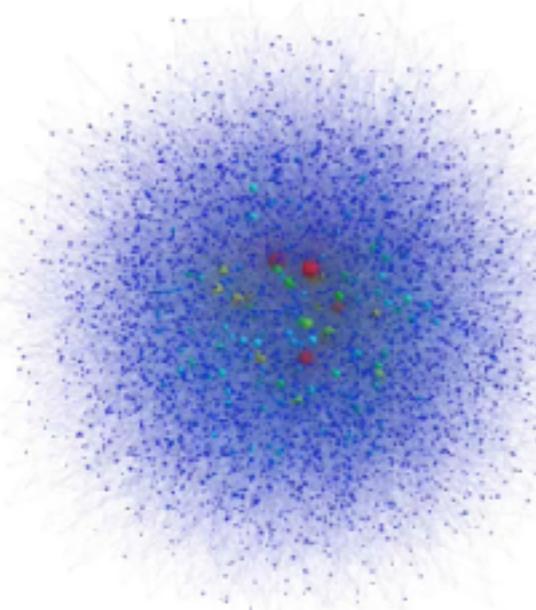




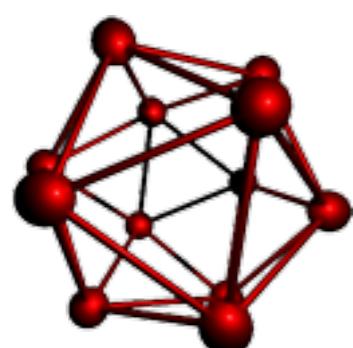
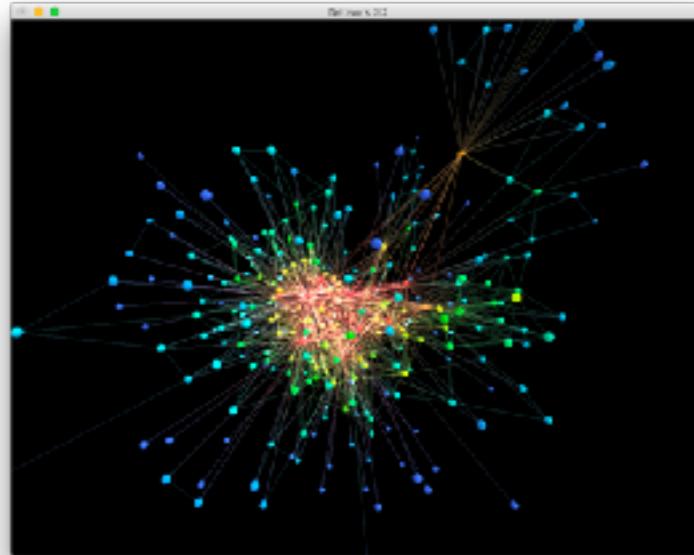
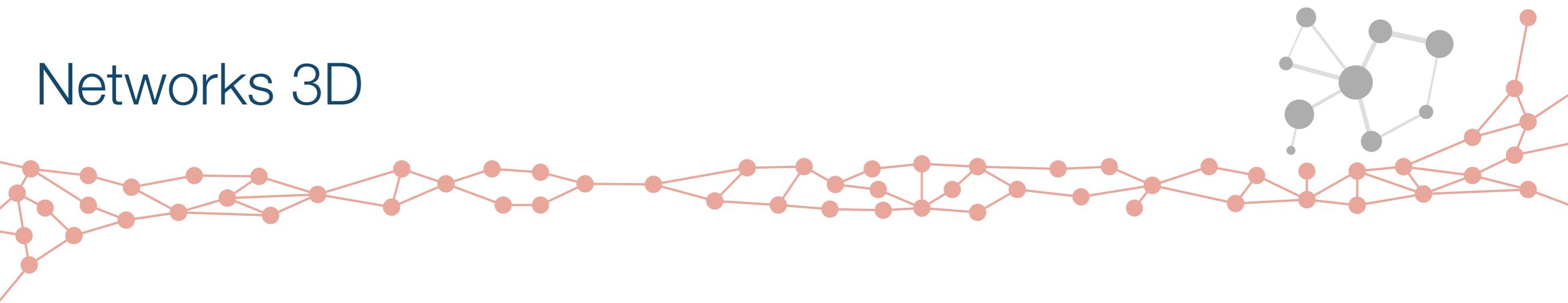




Complex networks + visualization

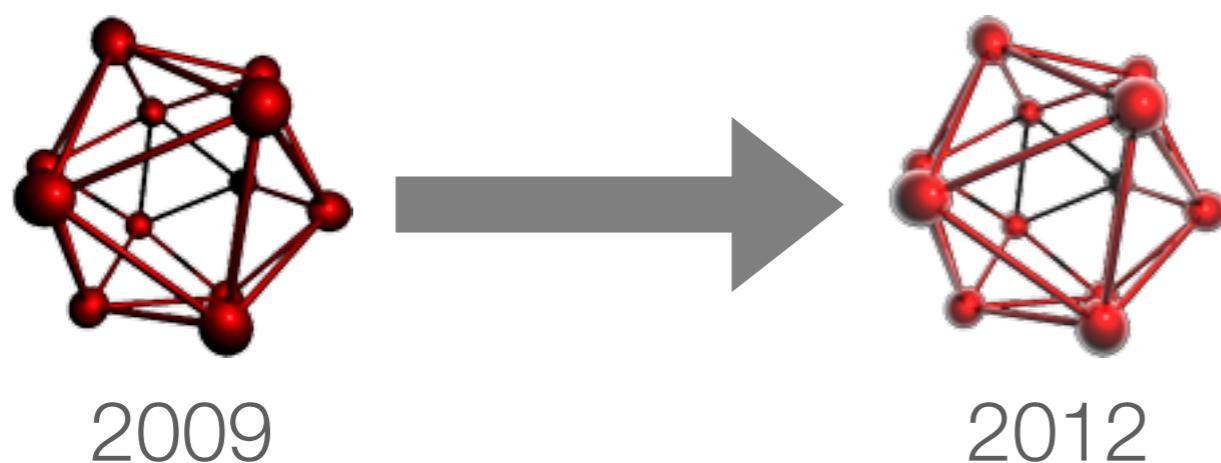
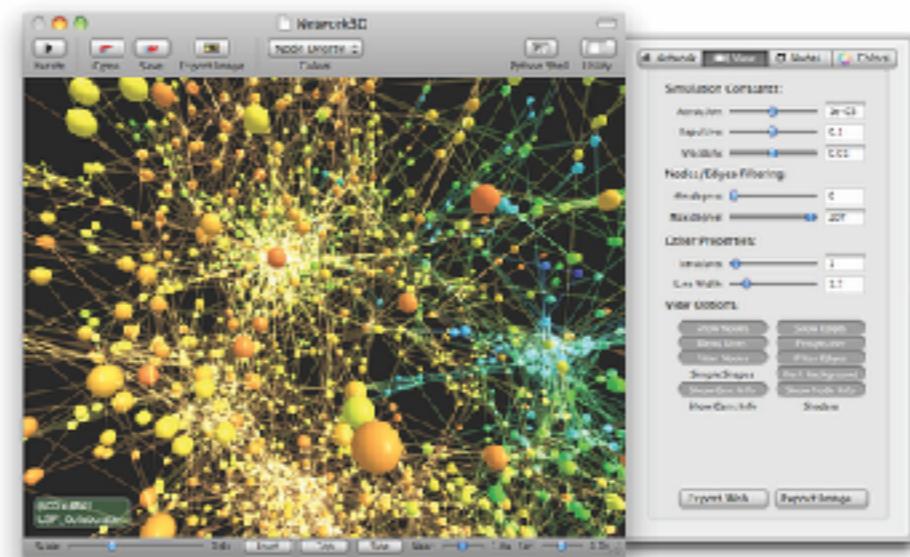
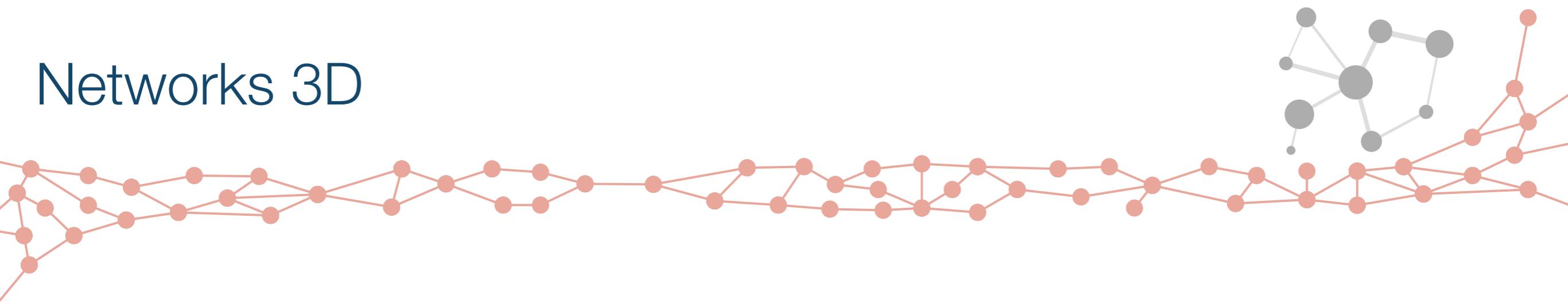


Networks 3D

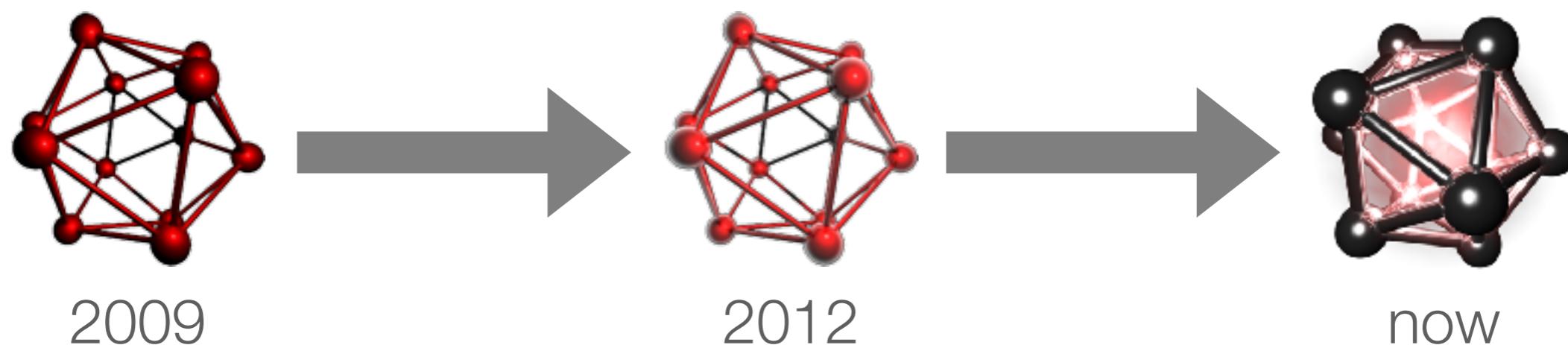
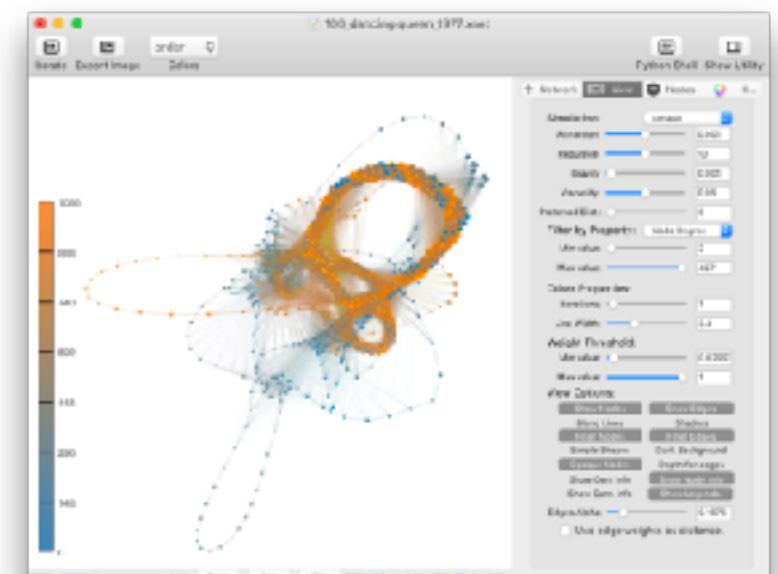
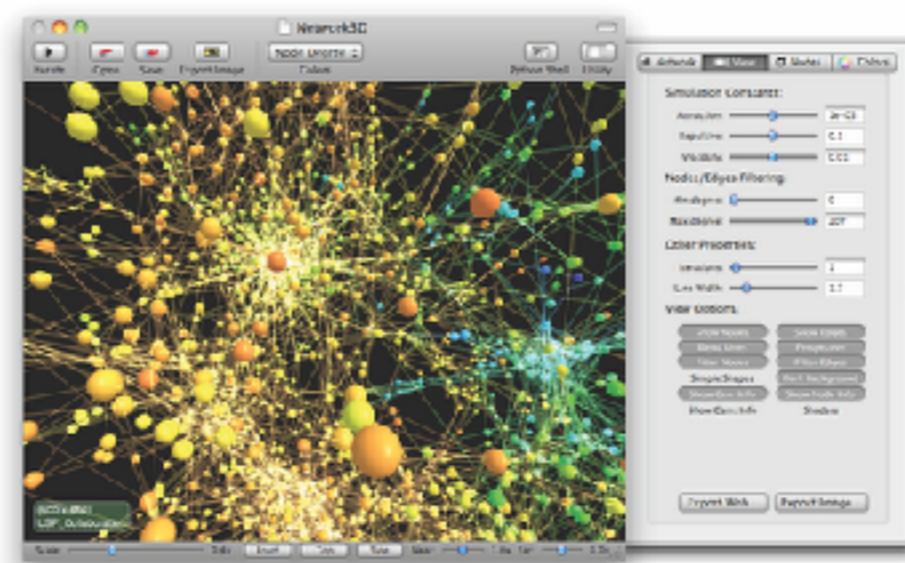
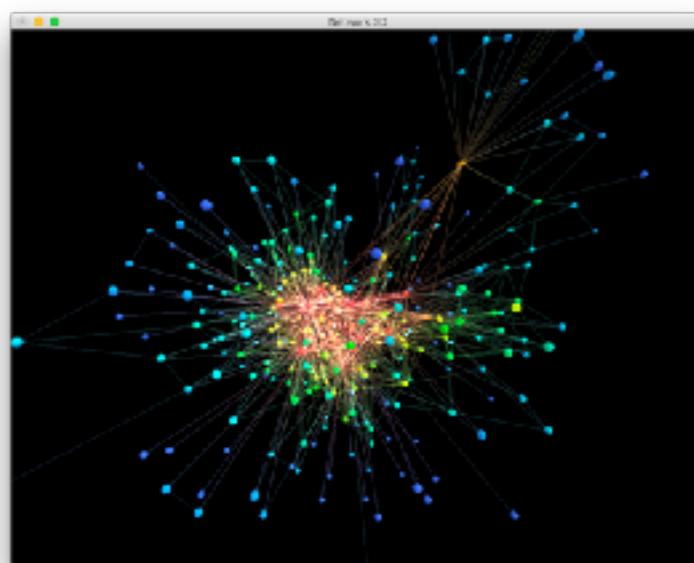
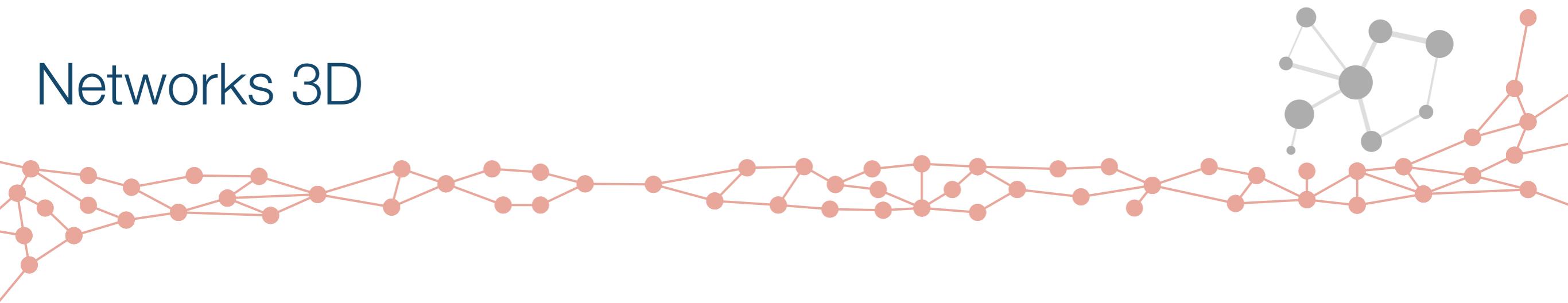


2009

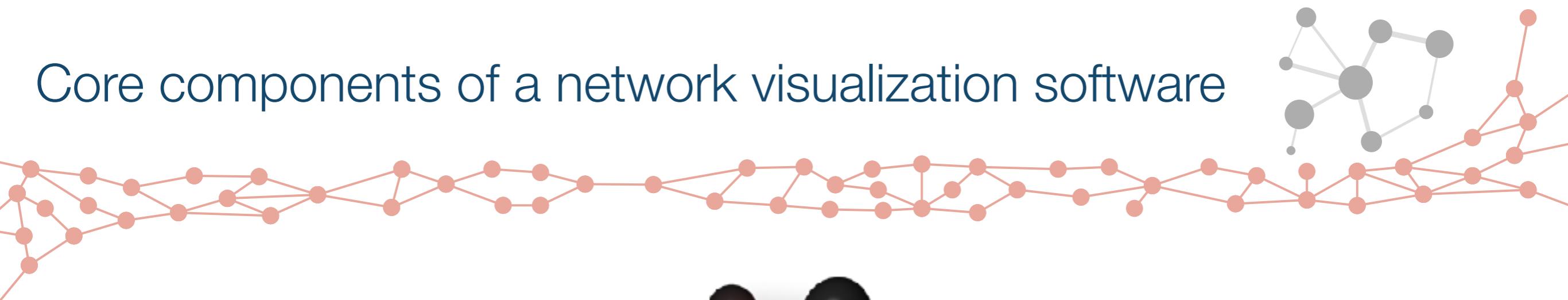
Networks 3D



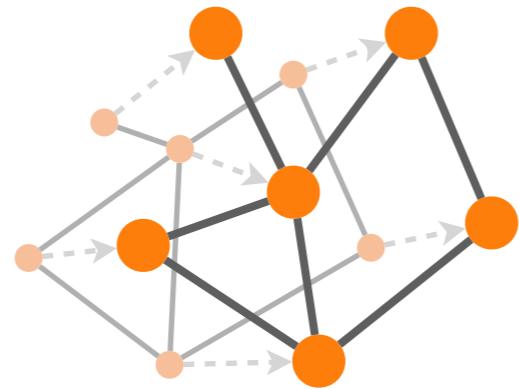
Networks 3D



Core components of a network visualization software



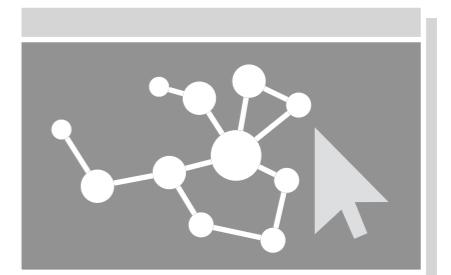
Graph Library



Layout

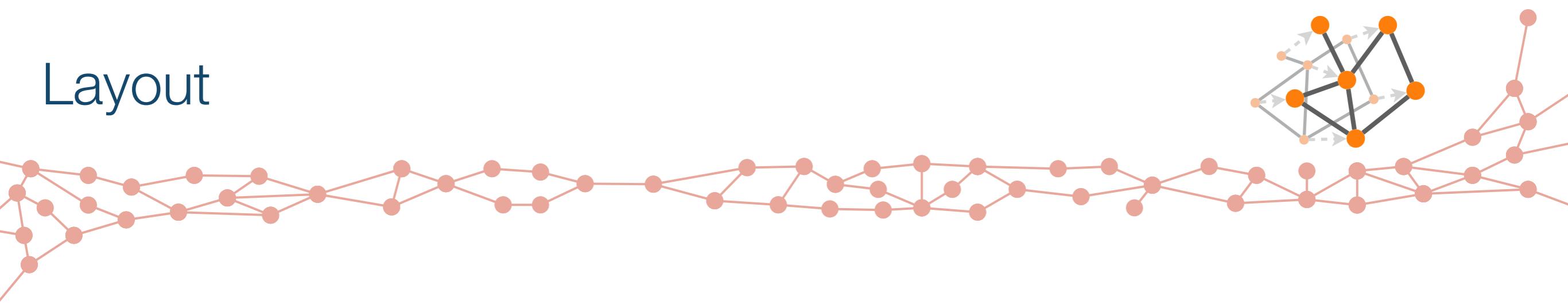


Rendering

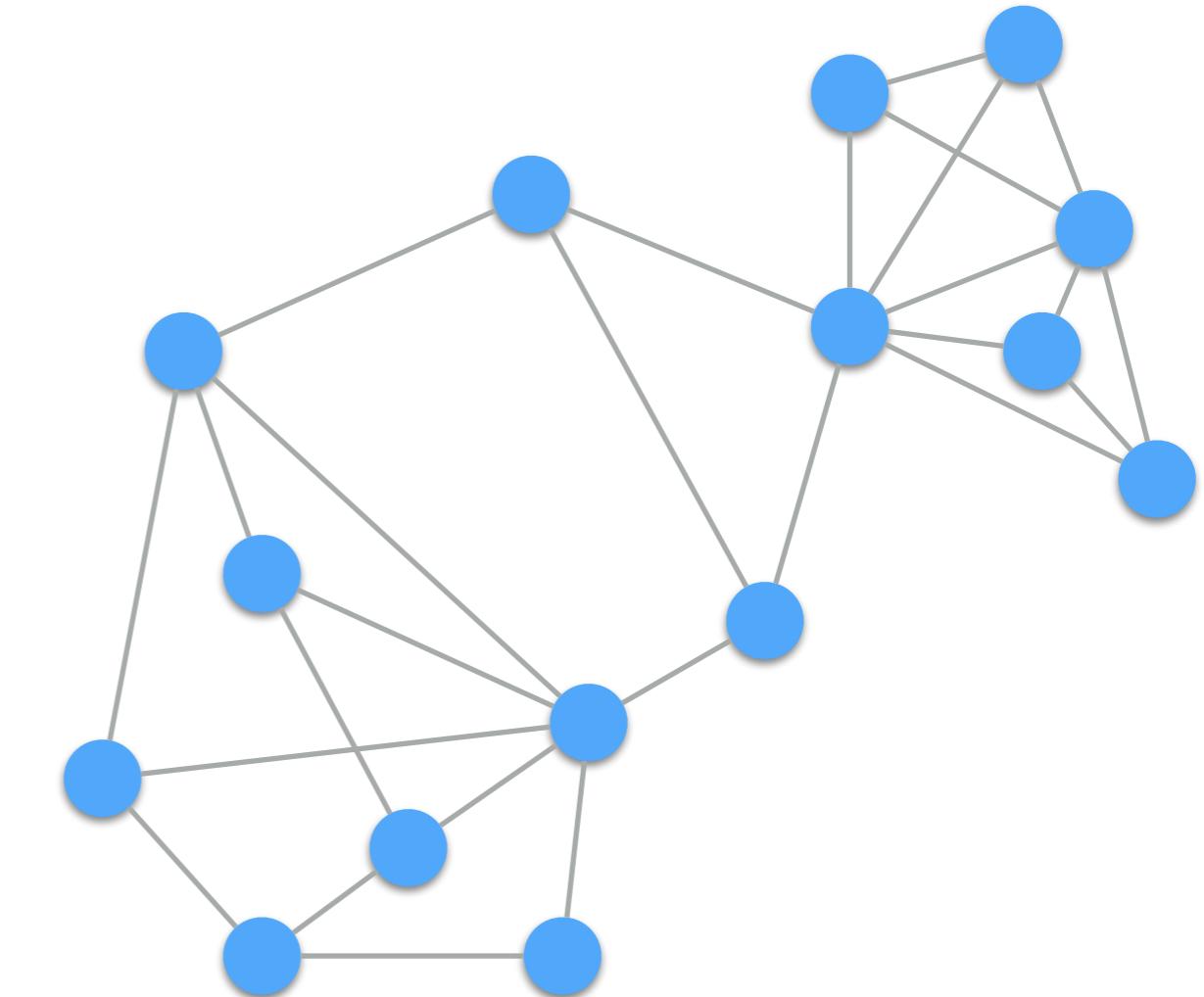


Interface

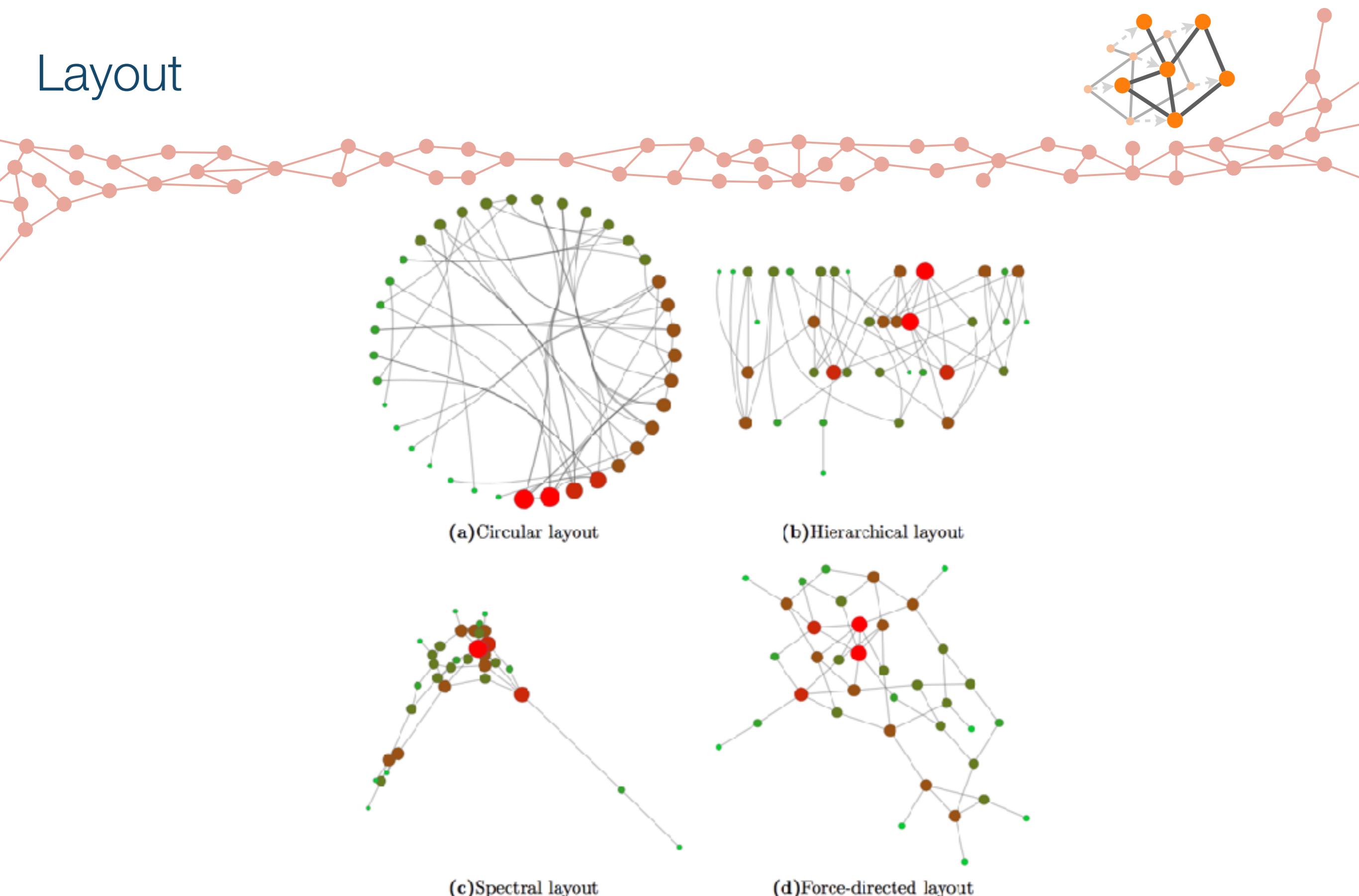
Layout



	0	1	1	
	0	1	1	...
1	0	1	1	
1	1	0	1	
1	1	1	0	...
				⋮
				⋮⋮



Layout

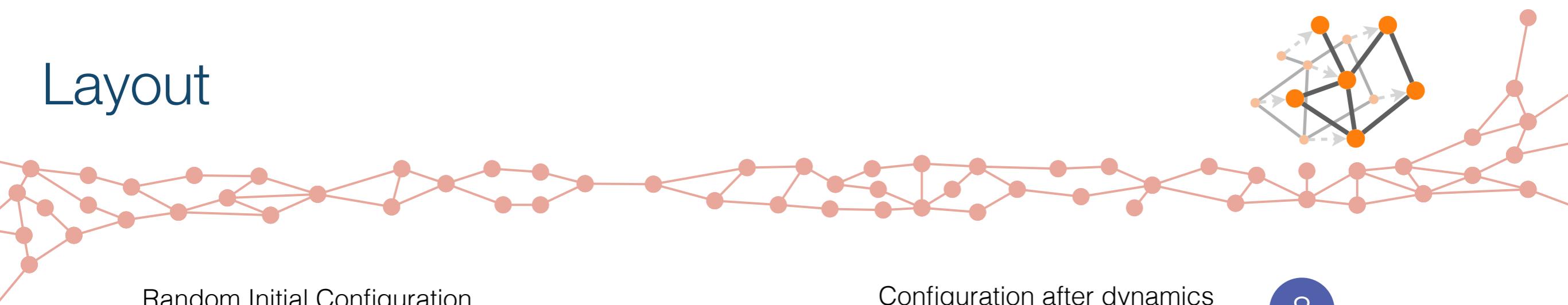


Complex systems: features, similarity and connectivity

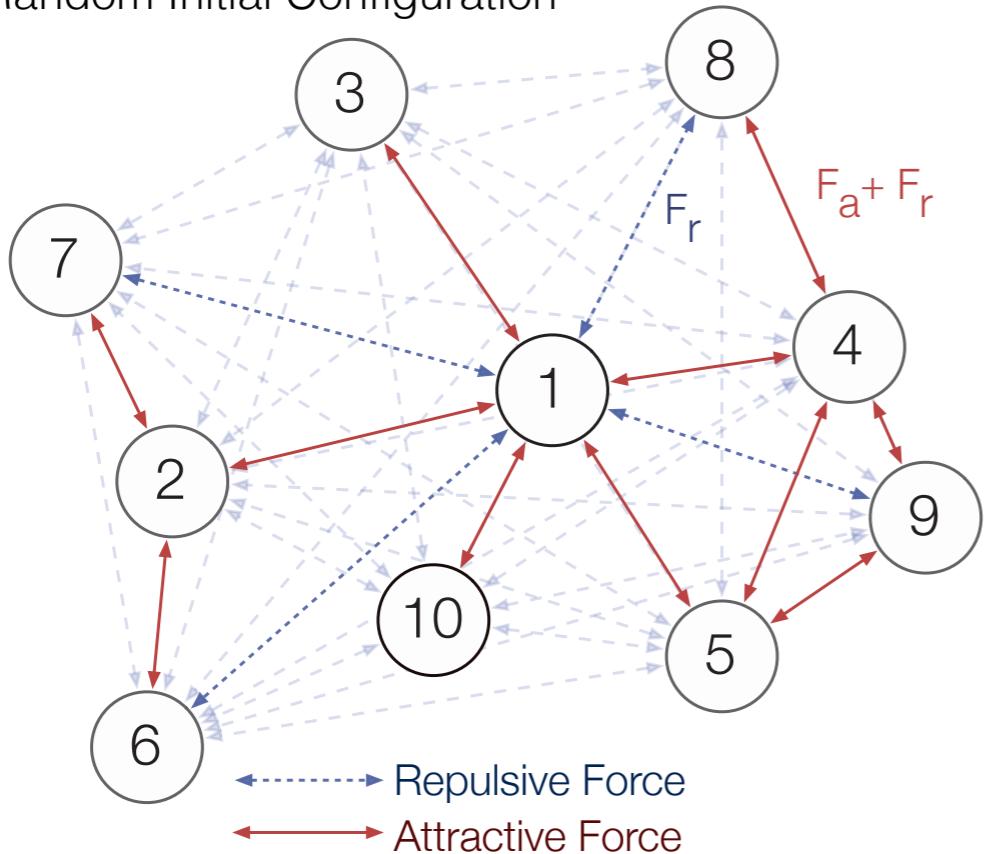
C. H. Comin, T. K. DM. Peron, F. N. Silva, D. R. Amancio, F. A. Rodrigues, L. da F. Costa

<https://arxiv.org/abs/1606.05400>

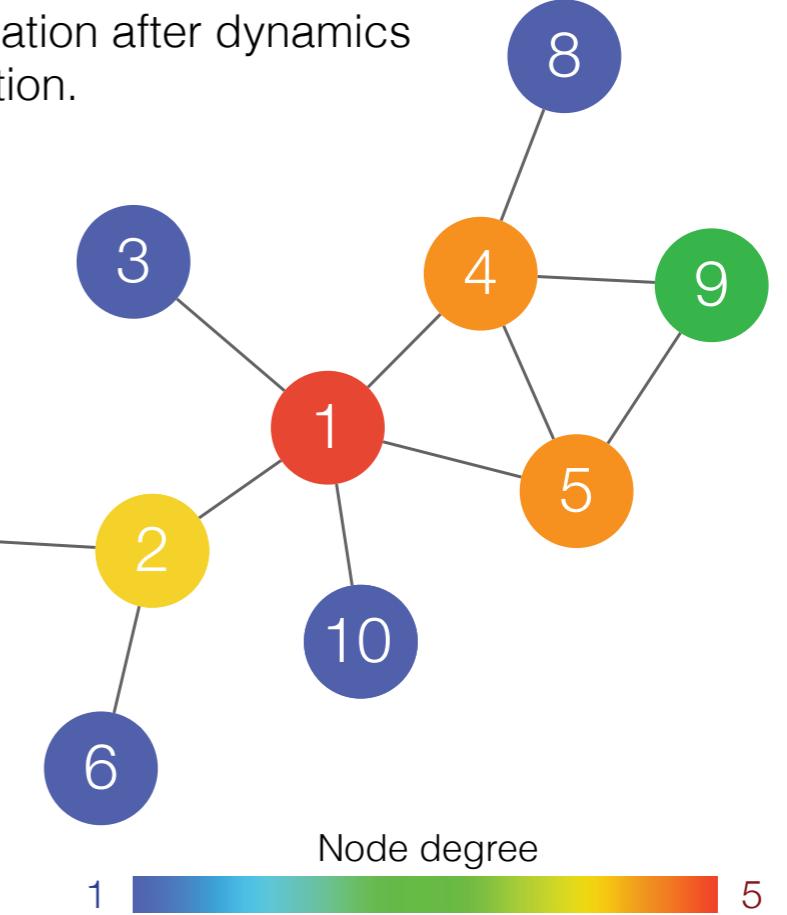
Layout



Random Initial Configuration



Configuration after dynamics stabilization.



Attractive Force

$$\vec{F}_{(a)j} = \sum_{(i,j) \in \mathcal{E}} a_{ij} (\vec{R}_i - \vec{R}_j)^2 \hat{r}_{ij}$$

Repulsive Force

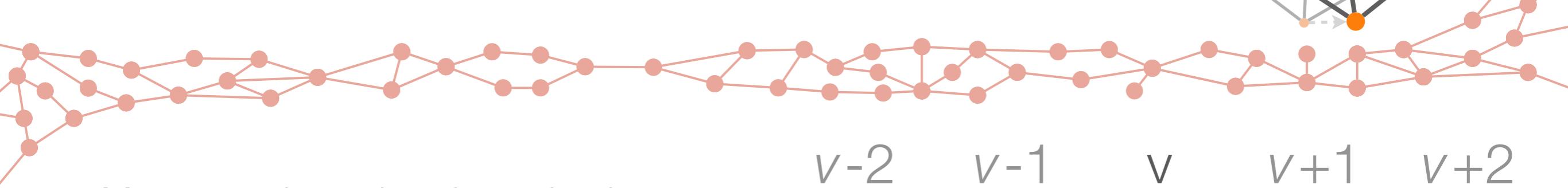
$$\vec{F}_{(r)j} = \sum_{i \in \mathcal{V}} \frac{-b}{(\vec{R}_i - \vec{R}_j)^2} \hat{r}_{ij}$$

Viscosity can be used to cool down the system

$$\frac{d^2 \vec{R}_j}{d^2 t} = \vec{F}_{(a)i} + \vec{F}_{(r)j} - \mu \frac{d \vec{R}_j}{dt}$$

Runge-Kutta or Verlet can be used

Layout

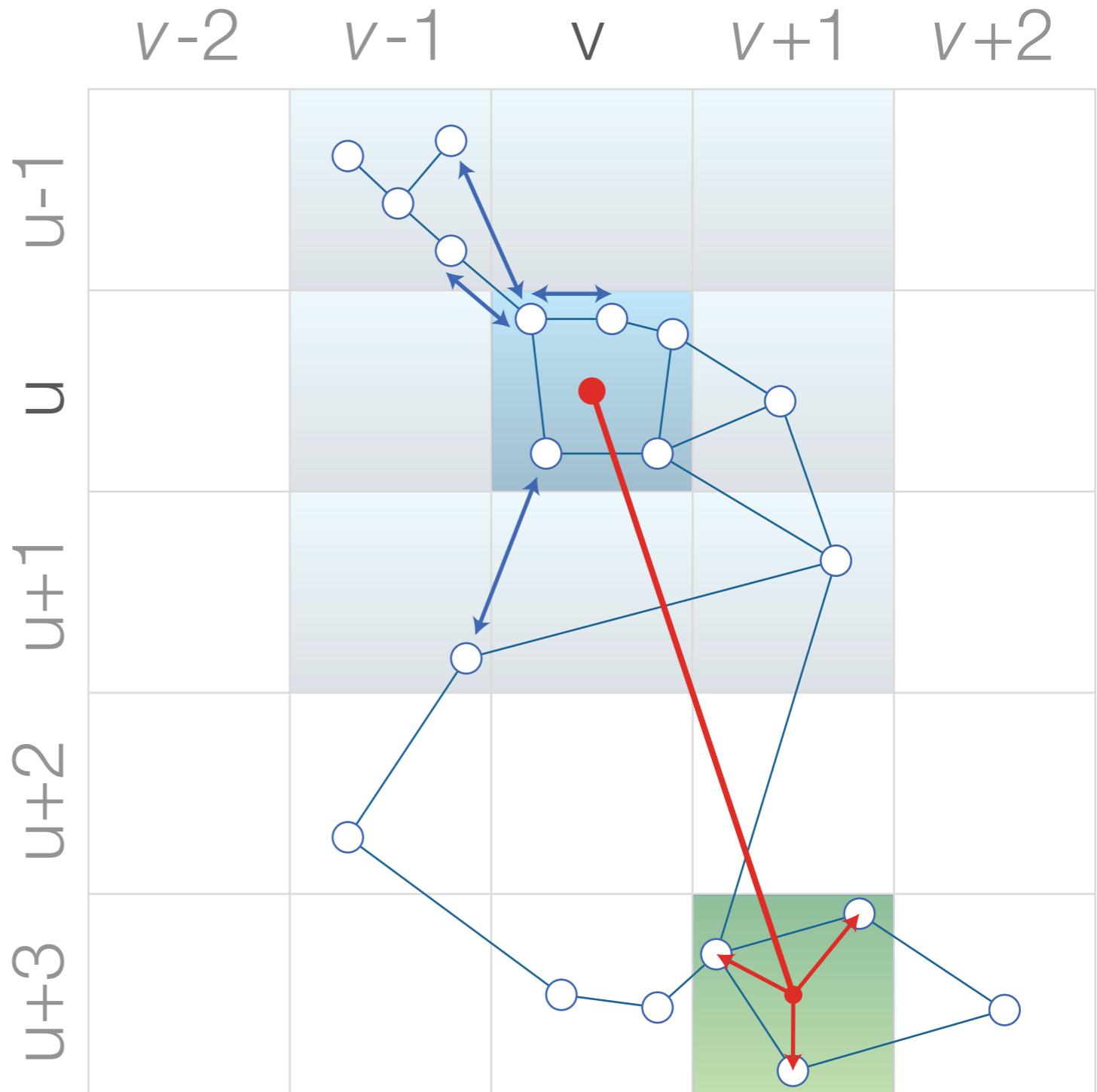


- Molecular dynamics simulation is $O(N^2)$.
- We can use multipole expansion:

$$\sum_{i \in \mathcal{V}} \frac{\hat{r}_{ij}}{(\vec{R}_i - \vec{R}_j)^2} = -\vec{\nabla} \sum_{i \in \mathcal{V}} \frac{1}{|\vec{R}_i - \vec{R}_j|} = -\vec{\nabla} \phi(\vec{R}_j)$$

$$\phi(\vec{R}_j) \propto \frac{N_{u,v}}{|\vec{R}_j|} + \frac{\vec{p}_{u,v} \cdot \vec{R}_j}{|\vec{R}_j|^3} + \frac{1}{2} \sum_m^3 \sum_n^3 \frac{(Q_{u,v})_{mn} (R_j)_m (R_j)_n}{|\vec{R}_j|^5} + \dots$$

- Where $N_{u,v}$, $\vec{p}_{u,v}$ e $Q_{u,v}$ are the monopole, dipole and quadrupole moments on box (u,v) .
- Quadrupole is OK for most of networks.



Visualizing Complex Networks (CDT-5)
Silva, F. N. and Costa, L. da F.

<http://dx.doi.org/10.13140/RG.2.2.21310.74567/1>

Waxman model



Visualizing Complex Networks (CDT-5)
Silva, F. N. and Costa, L. da F.
<http://dx.doi.org/10.13140/RG.2.2.21310.74567/1>

European Powergrid



Visualizing Complex Networks (CDT-5)
Silva, F. N. and Costa, L. da F.
<http://dx.doi.org/10.13140/RG.2.2.21310.74567/1>

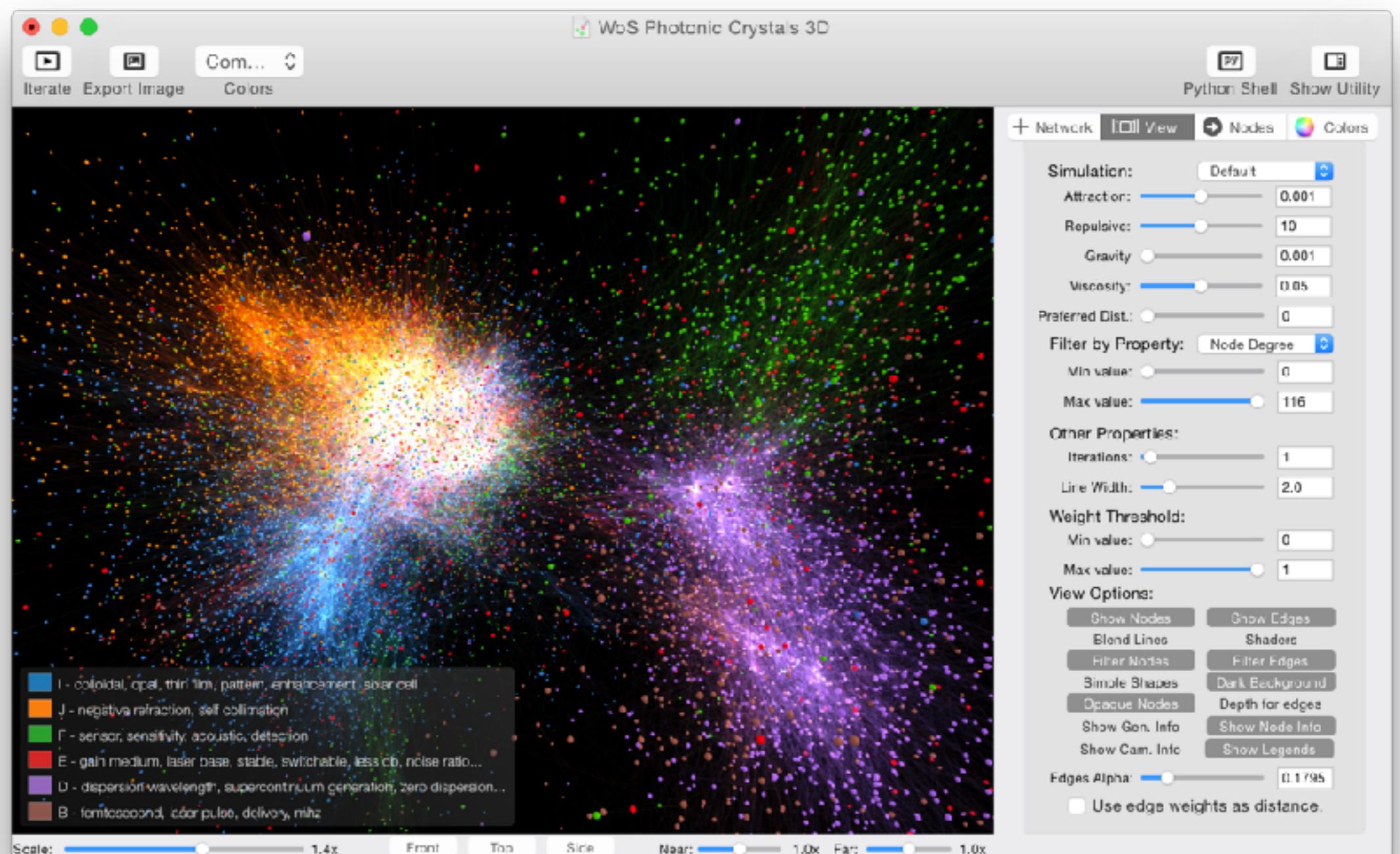
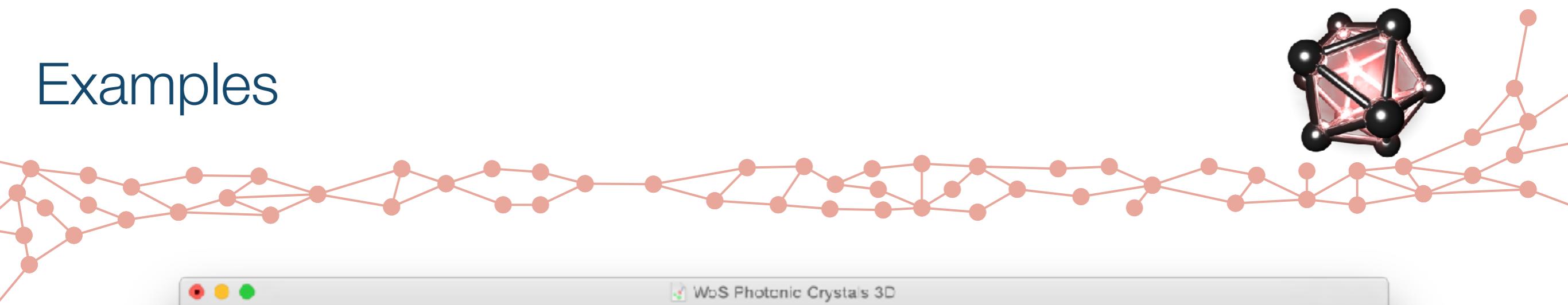
Airport network of direct flights



Visualizing Complex Networks (CDT-5)
Silva, F. N. and Costa, L. da F.

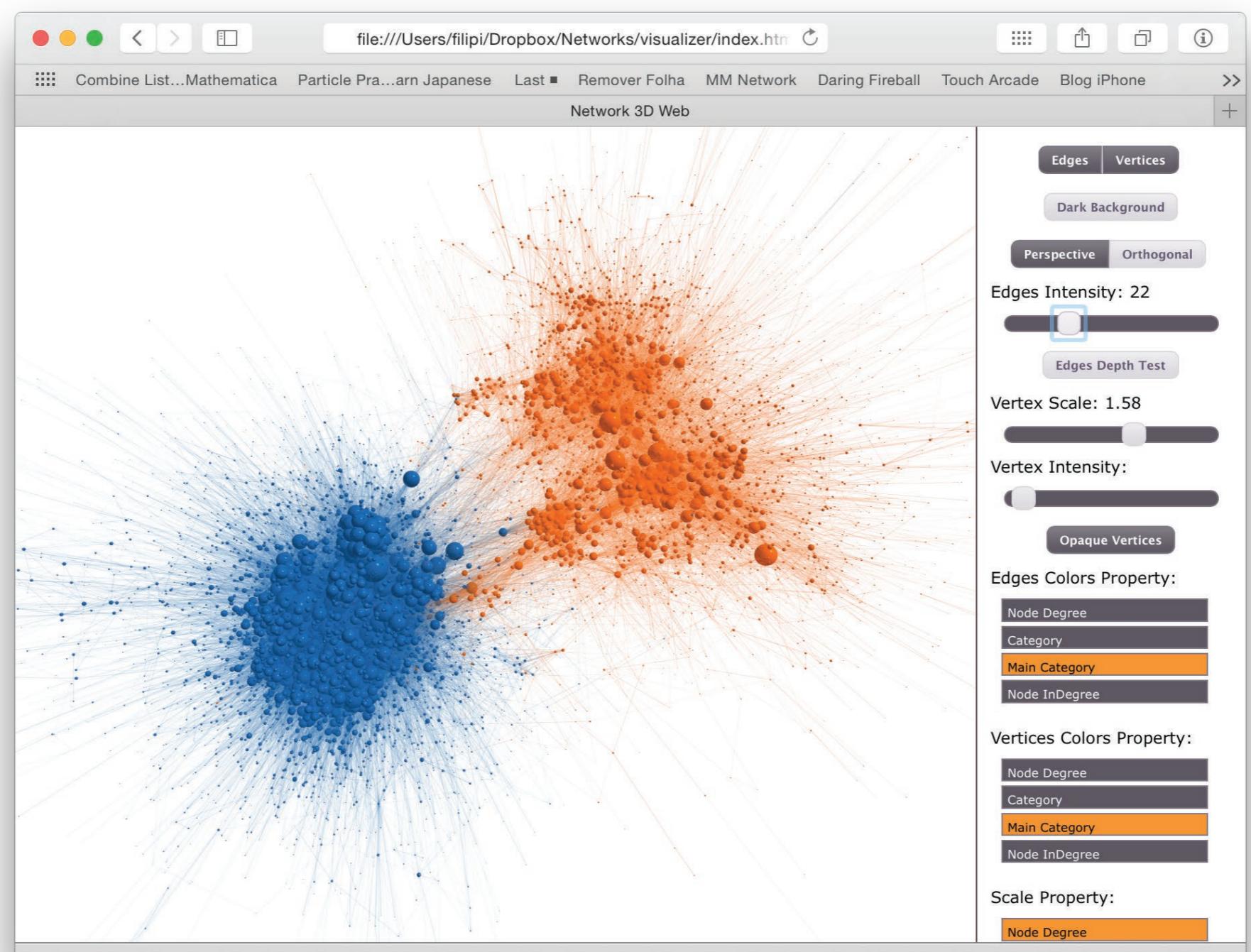
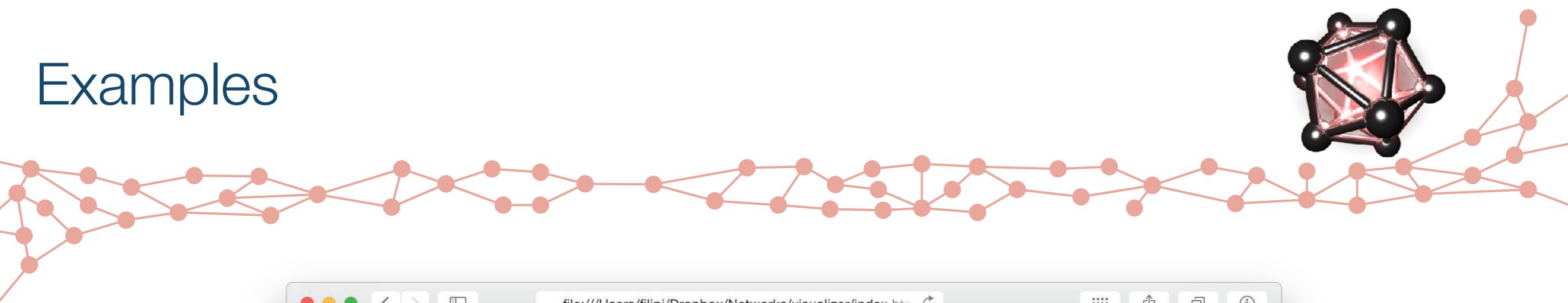
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Examples



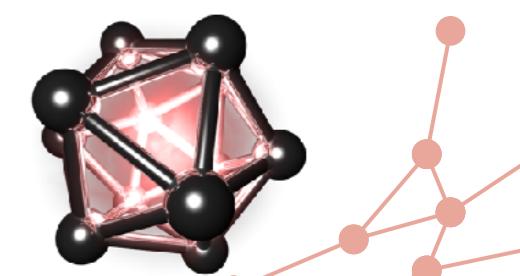
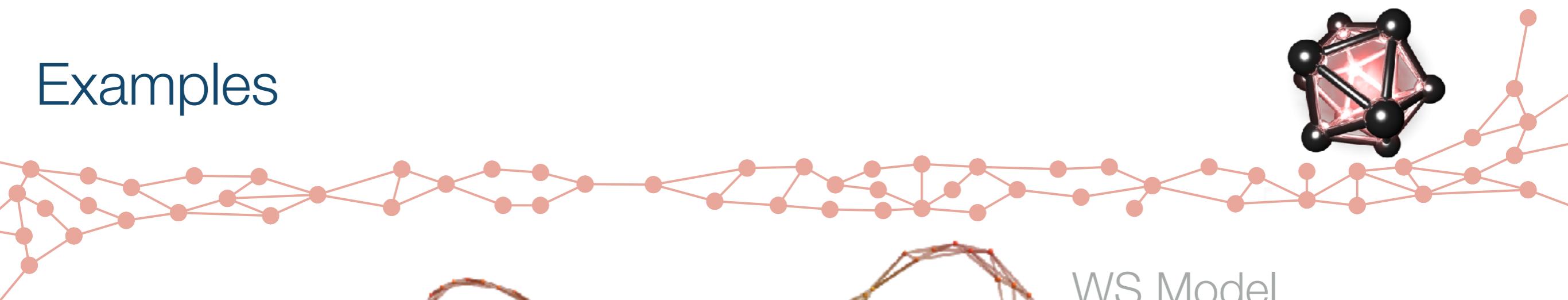
Software Interface

Examples

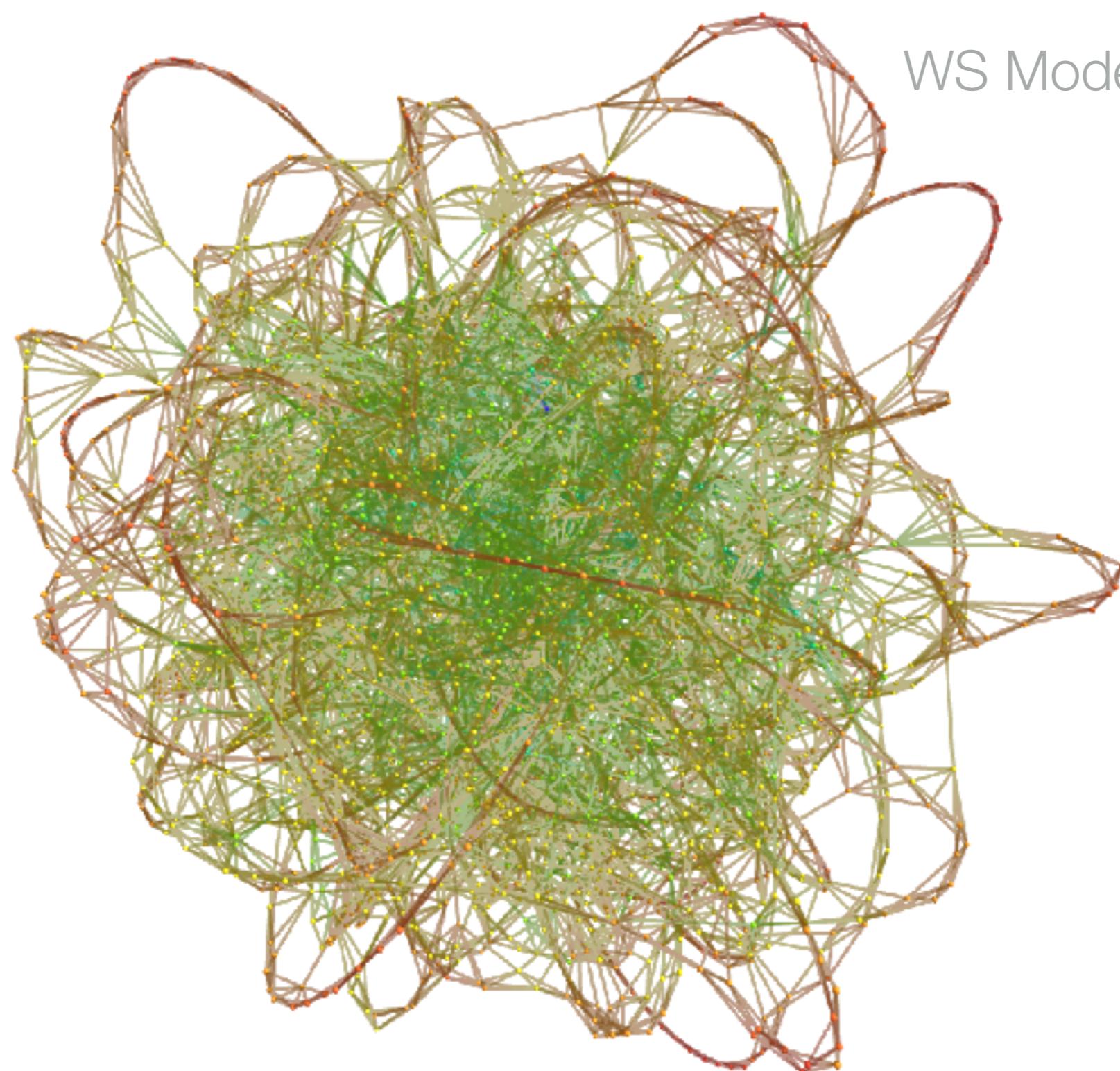


Web interface

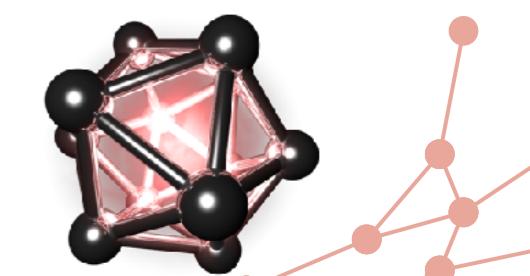
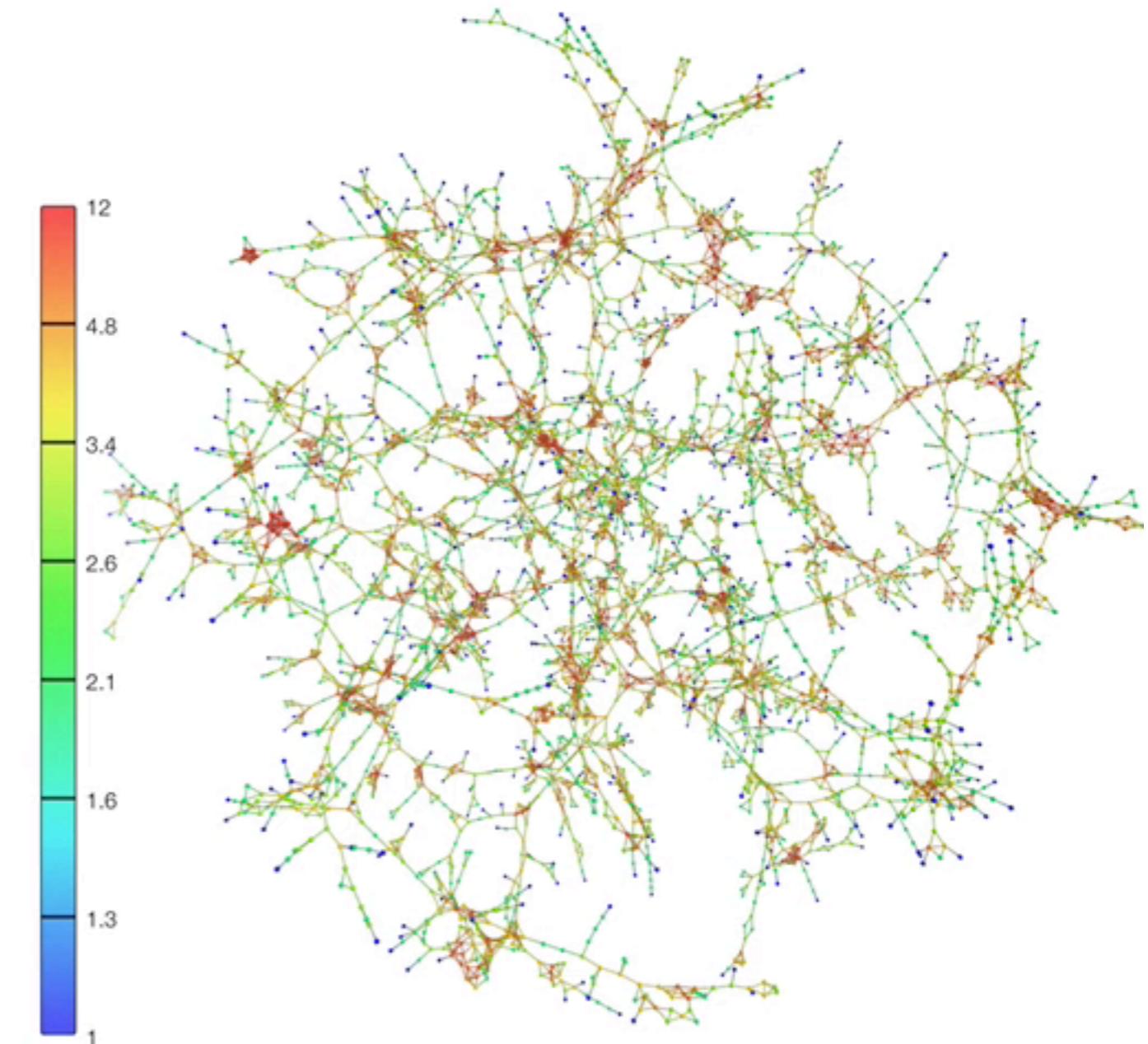
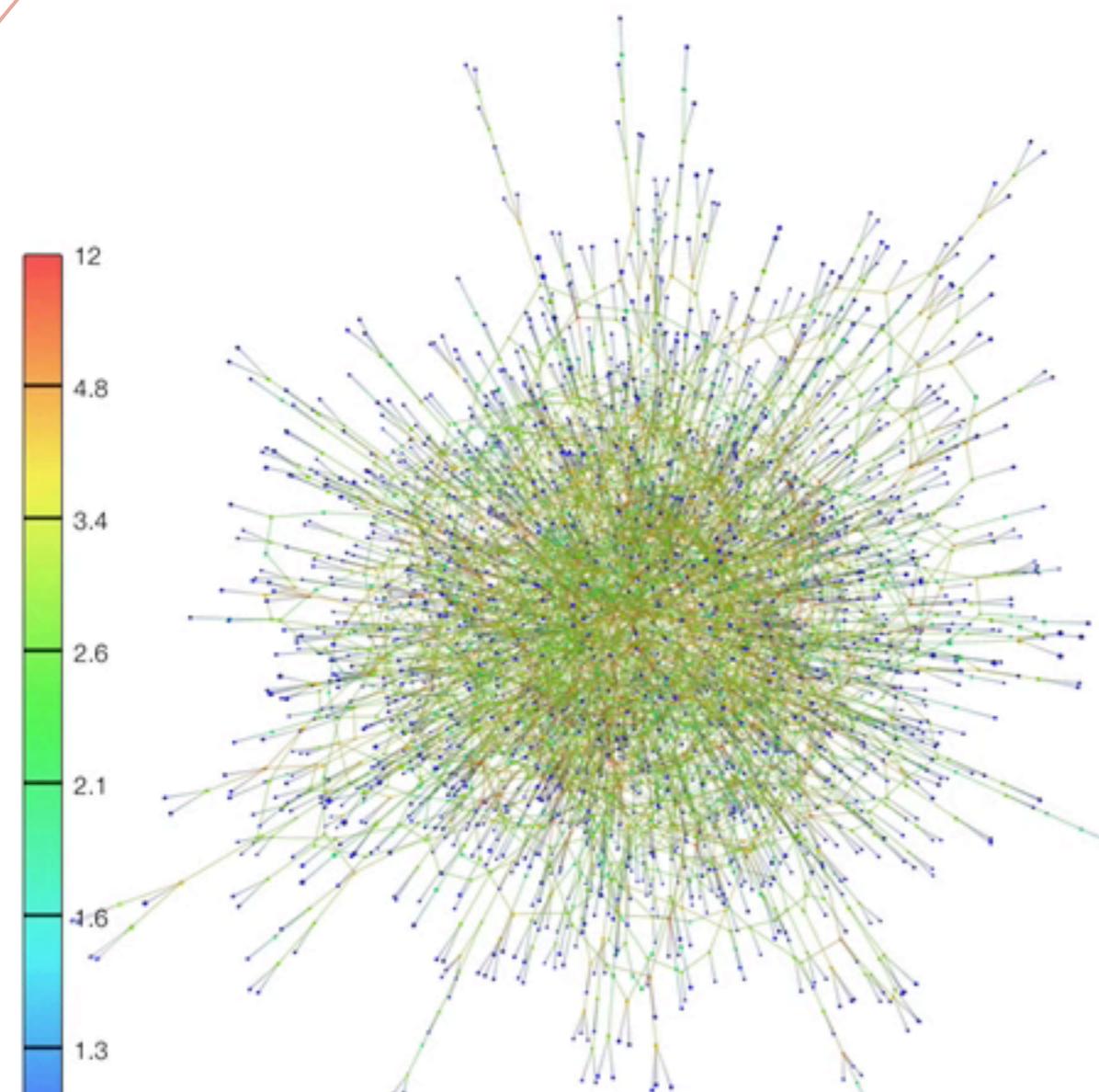
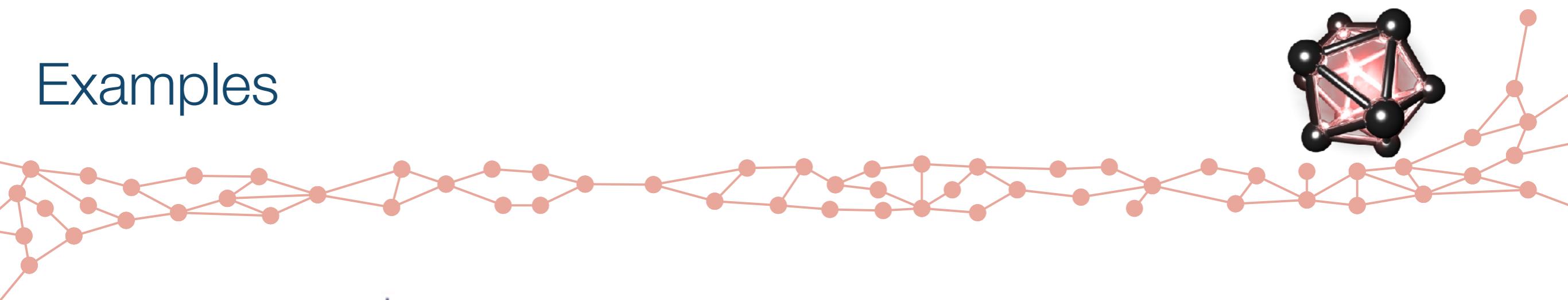
Examples



WS Model

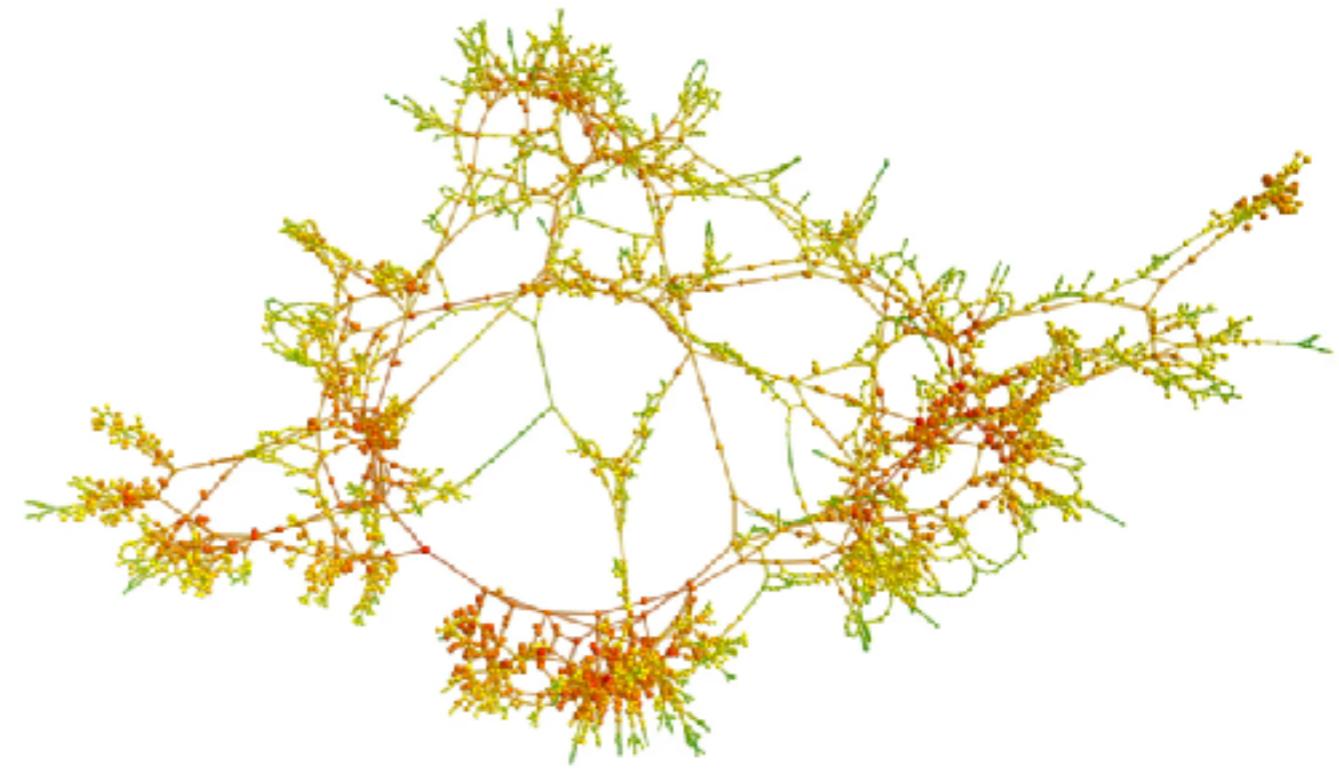
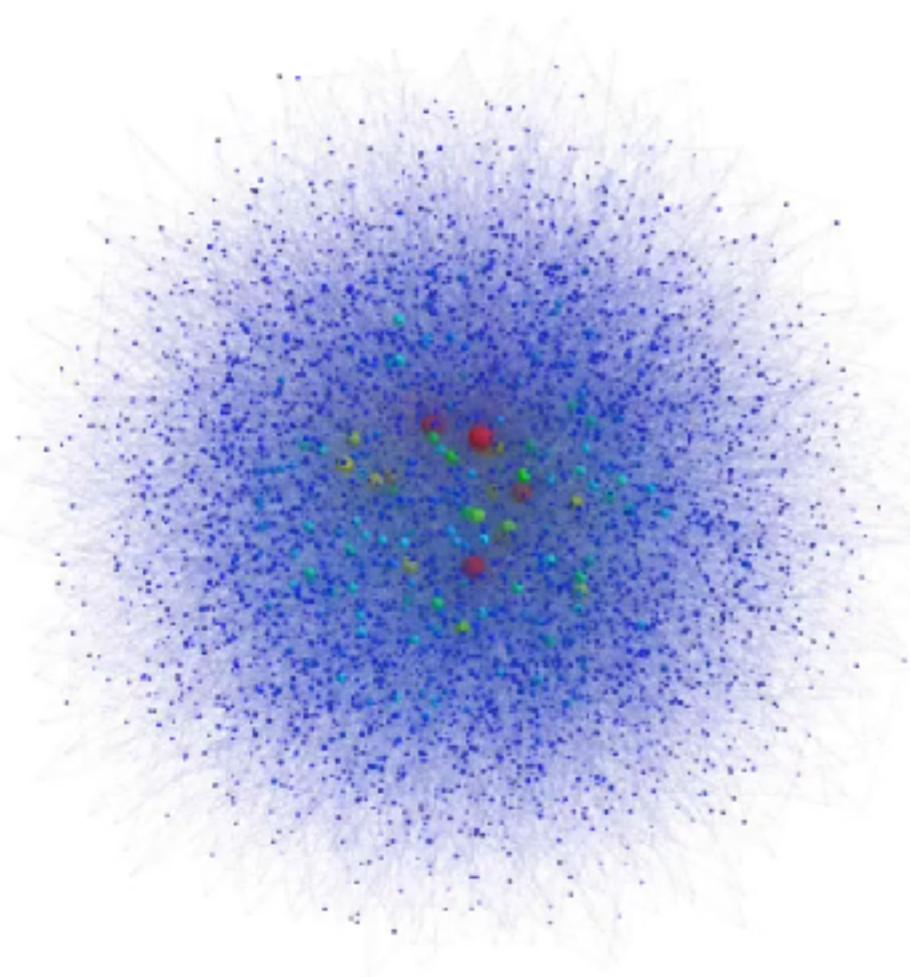
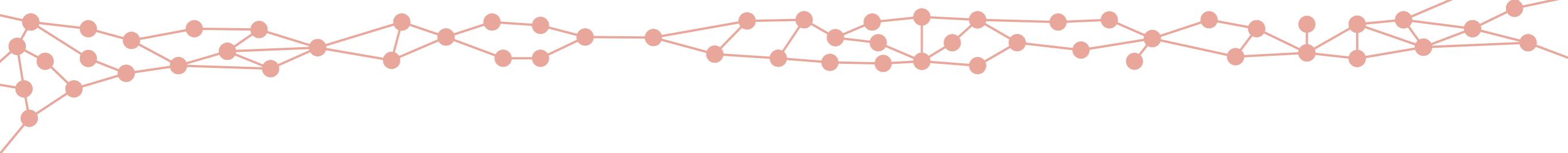
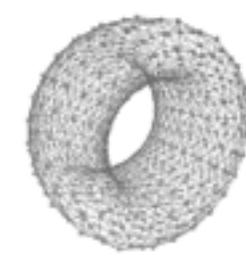


Examples

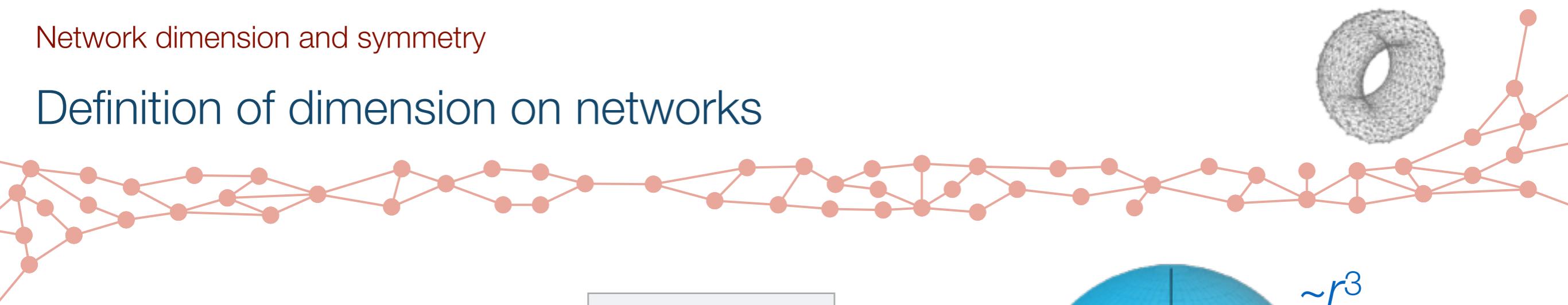


Network dimension and symmetry

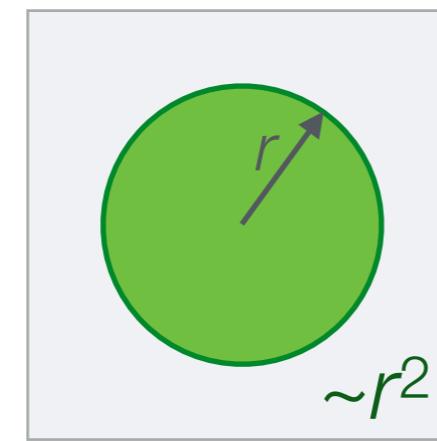
Network dimension



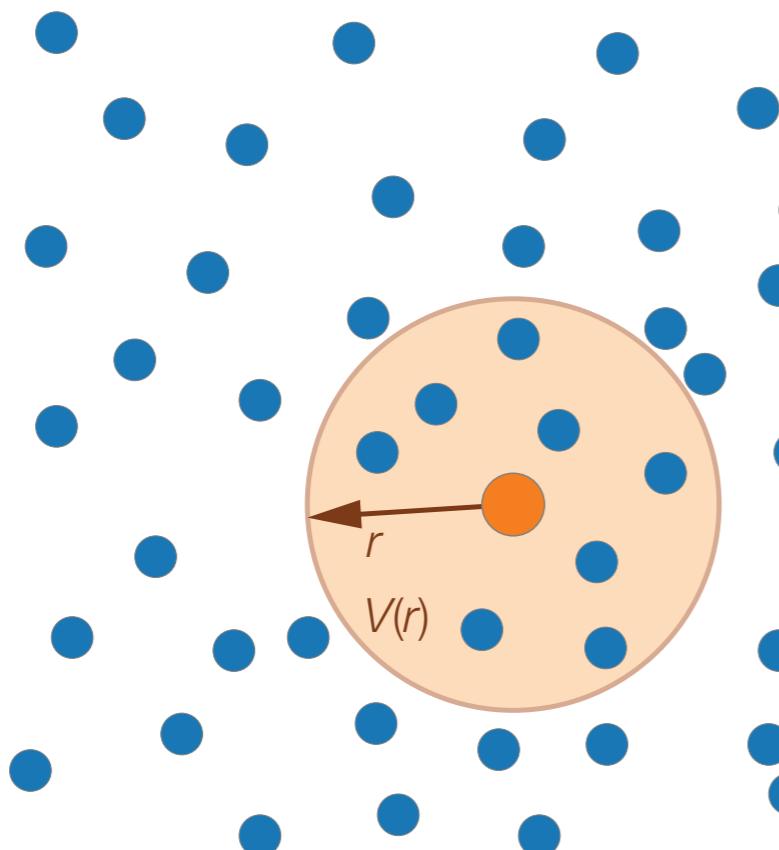
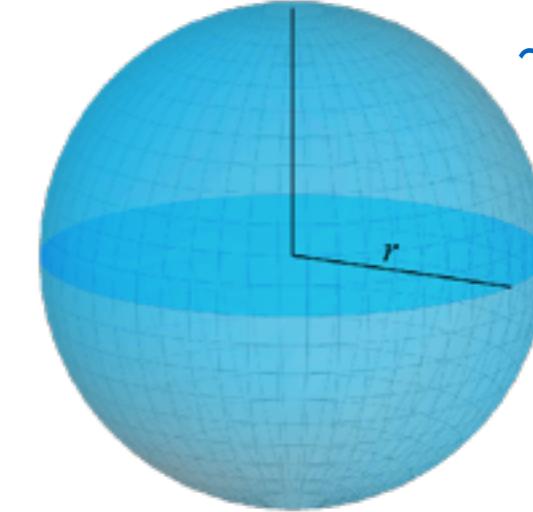
Definition of dimension on networks



$\sim r^1$



$\sim r^3$

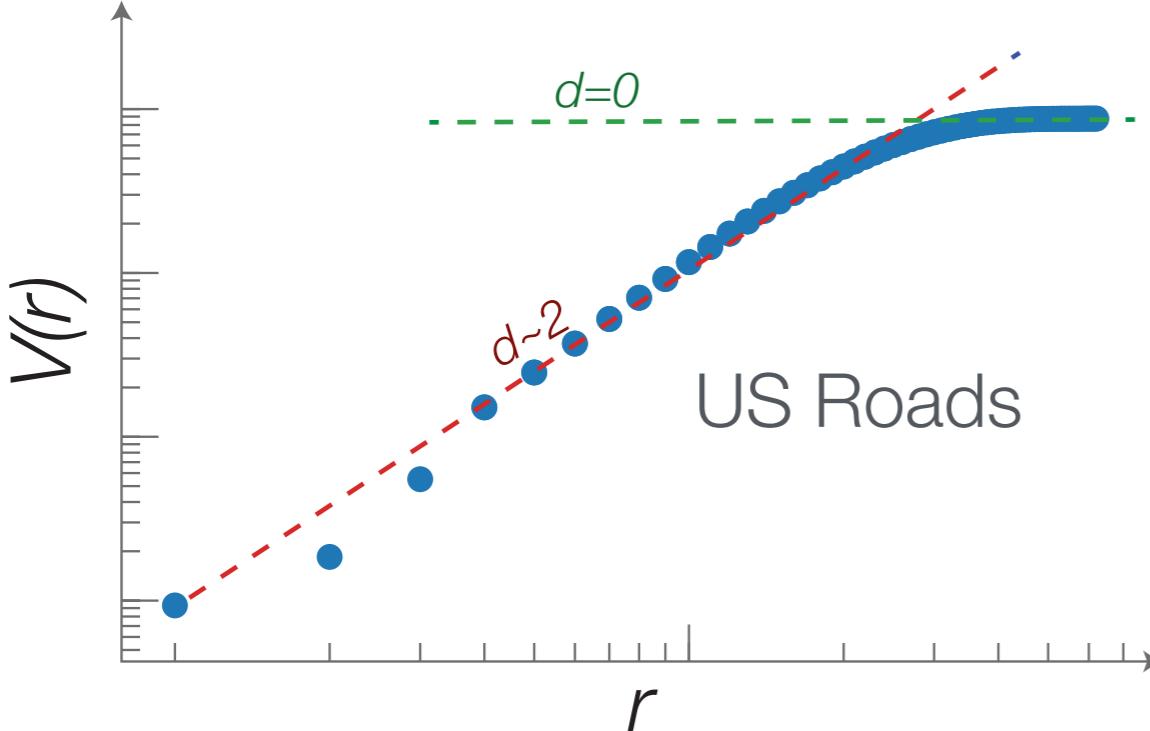


$\ln V(r)$

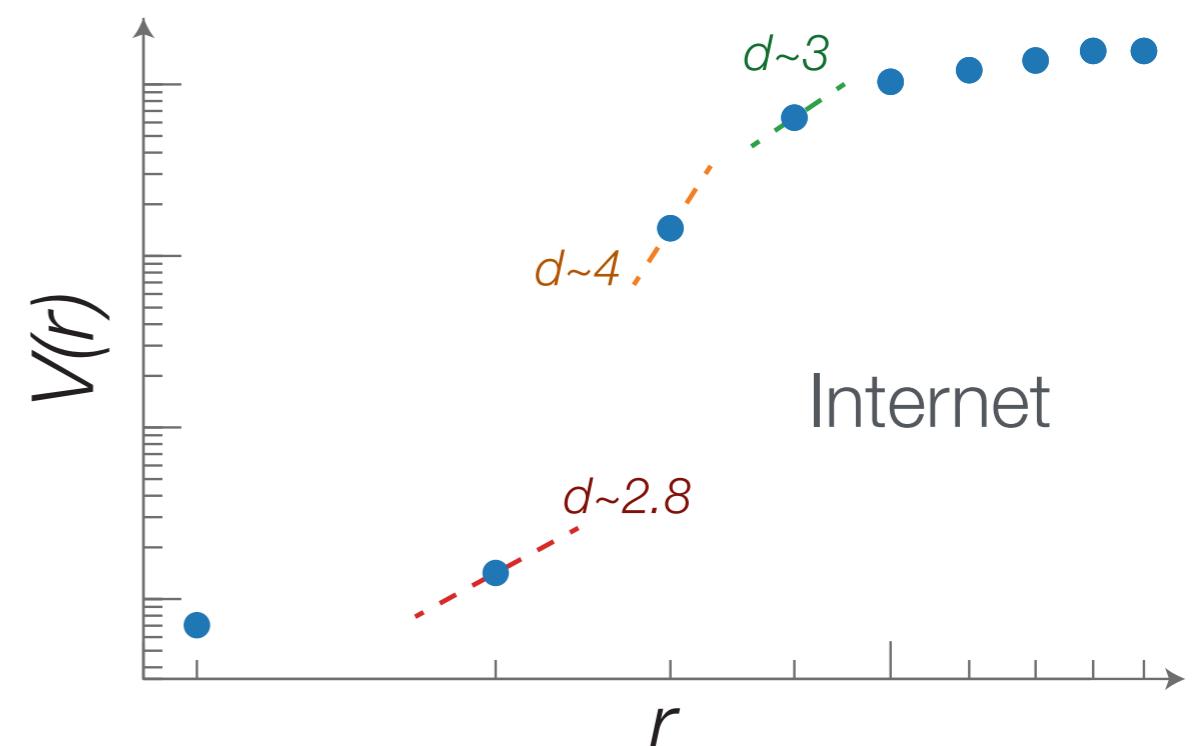
$\ln r$

d_C

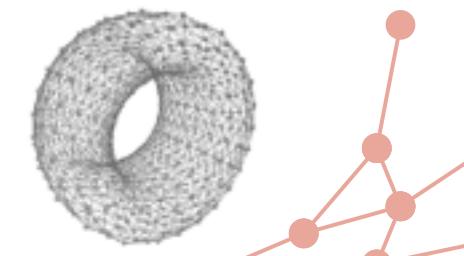
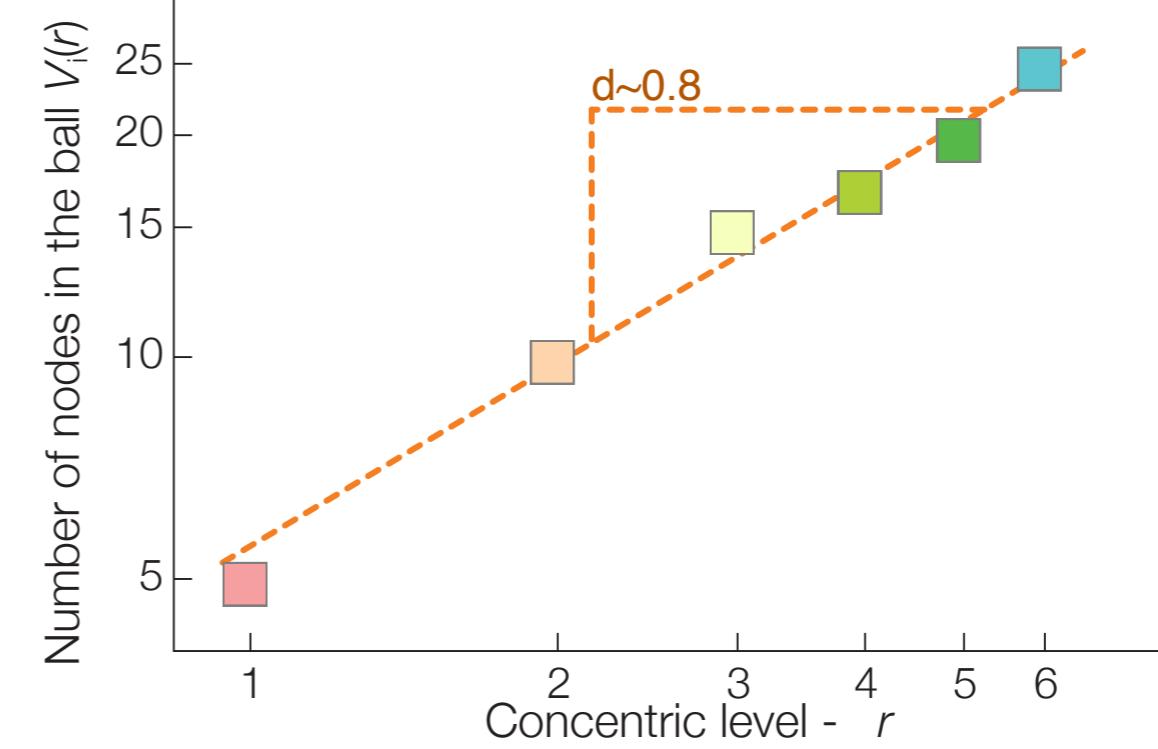
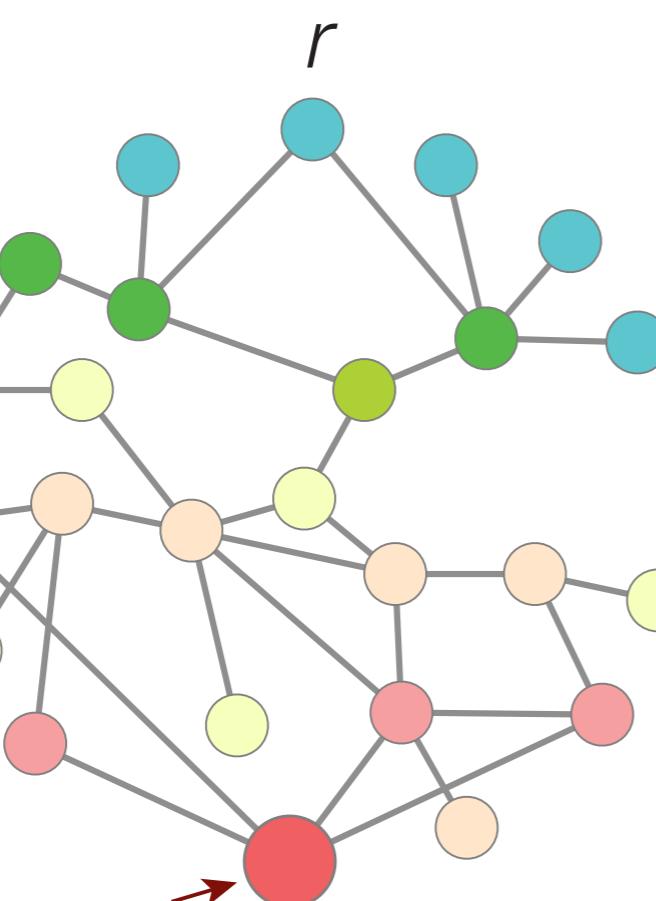
Problems



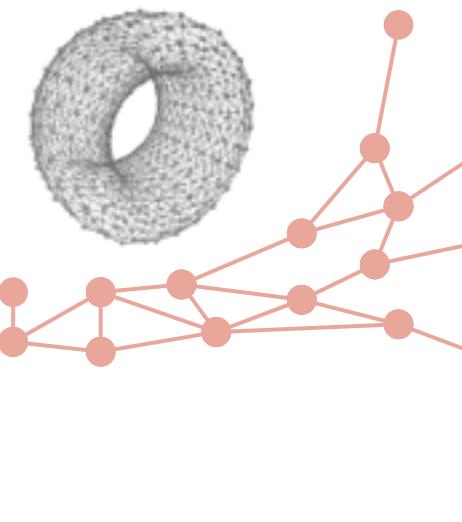
US Roads



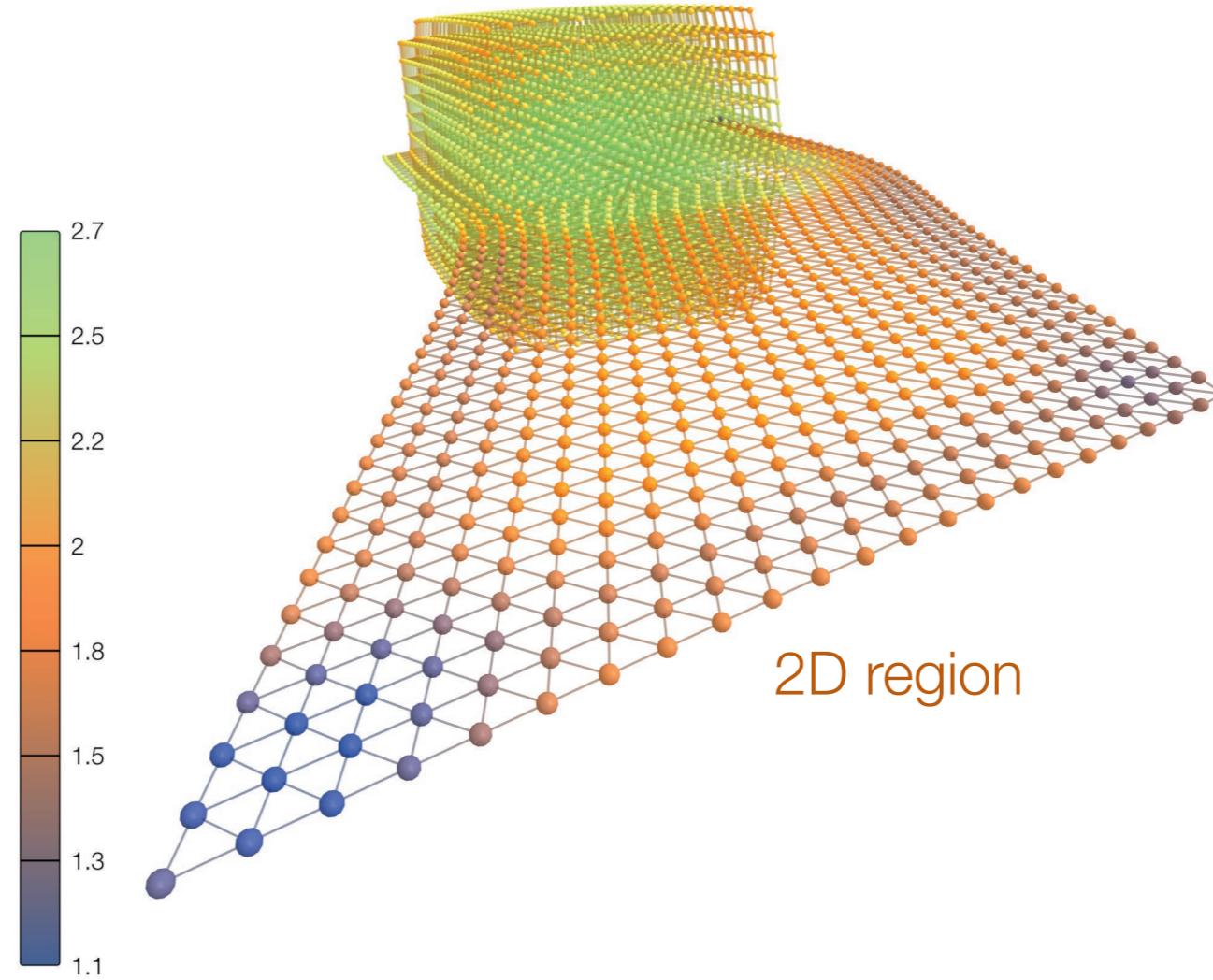
Internet



Validating the multiscale dimension



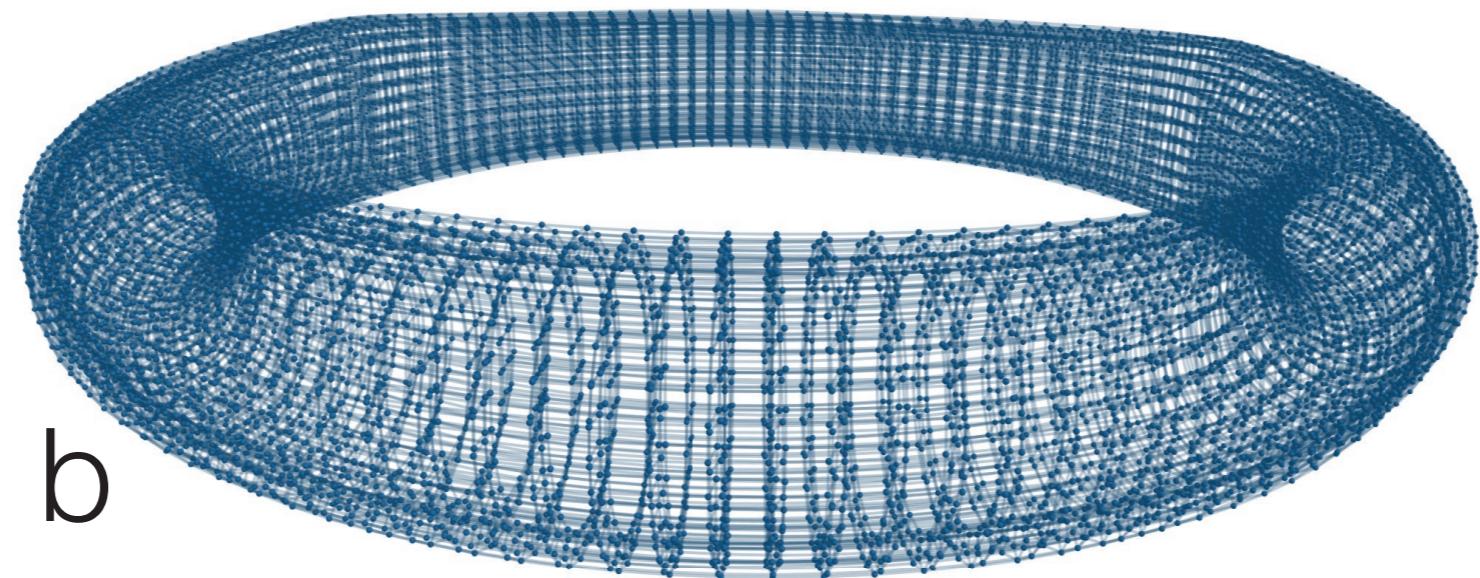
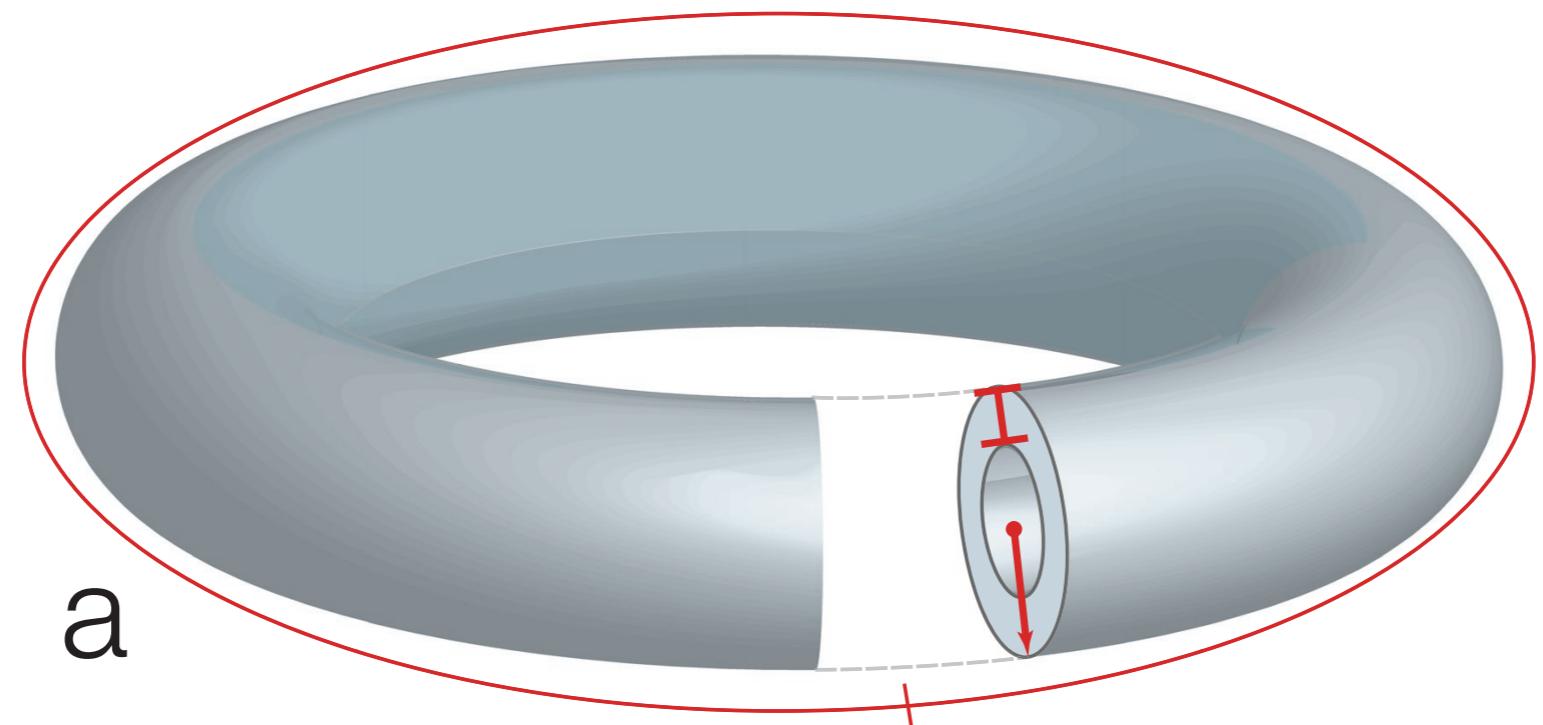
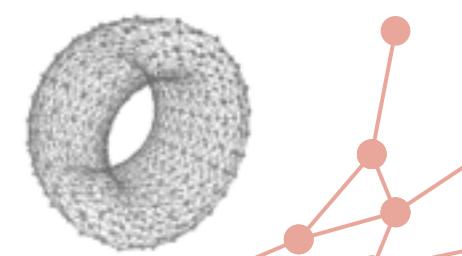
3D region



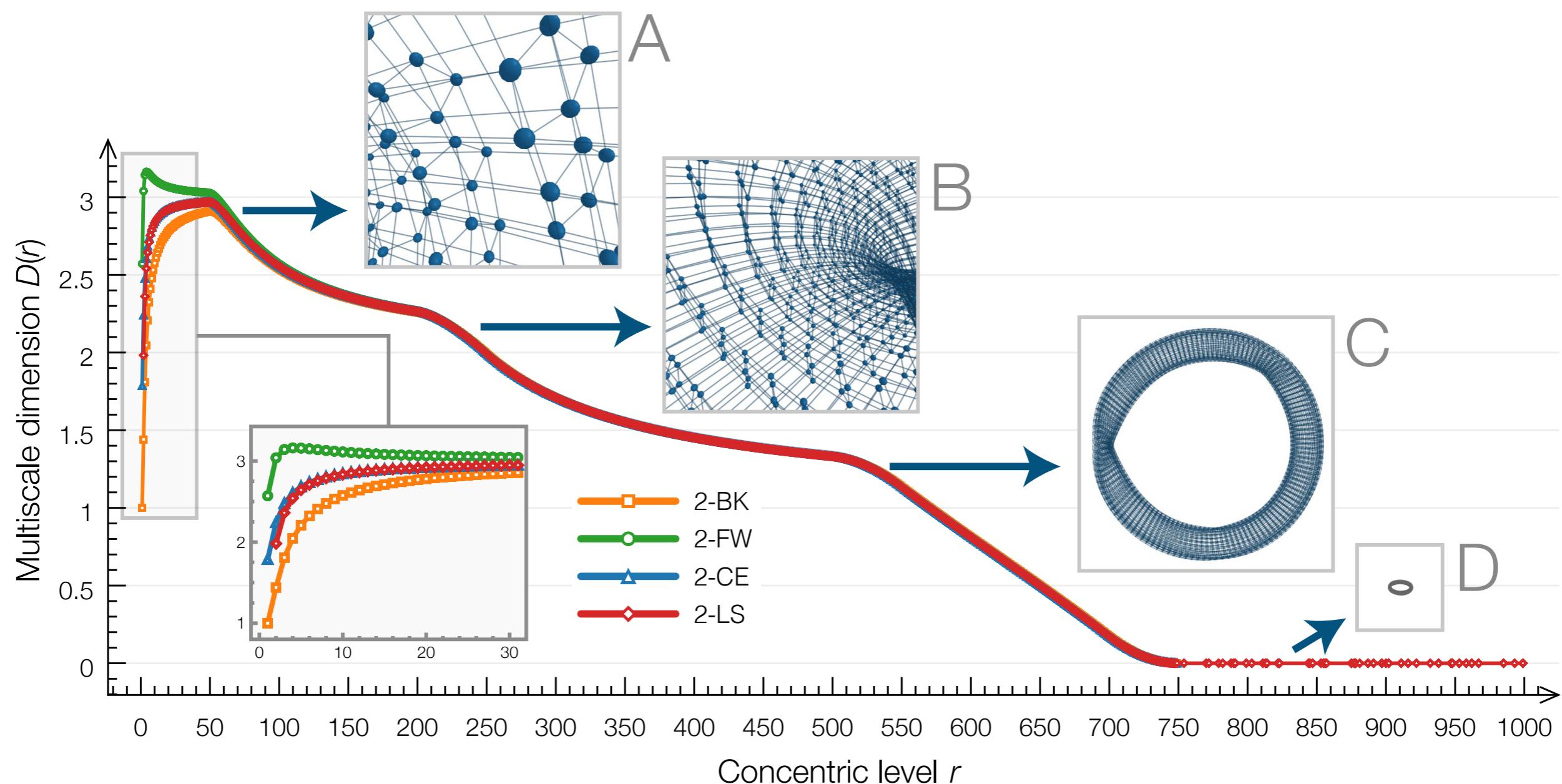
Local dimension $r=4$.

Network dimension and symmetry

Validating the multiscale dimension

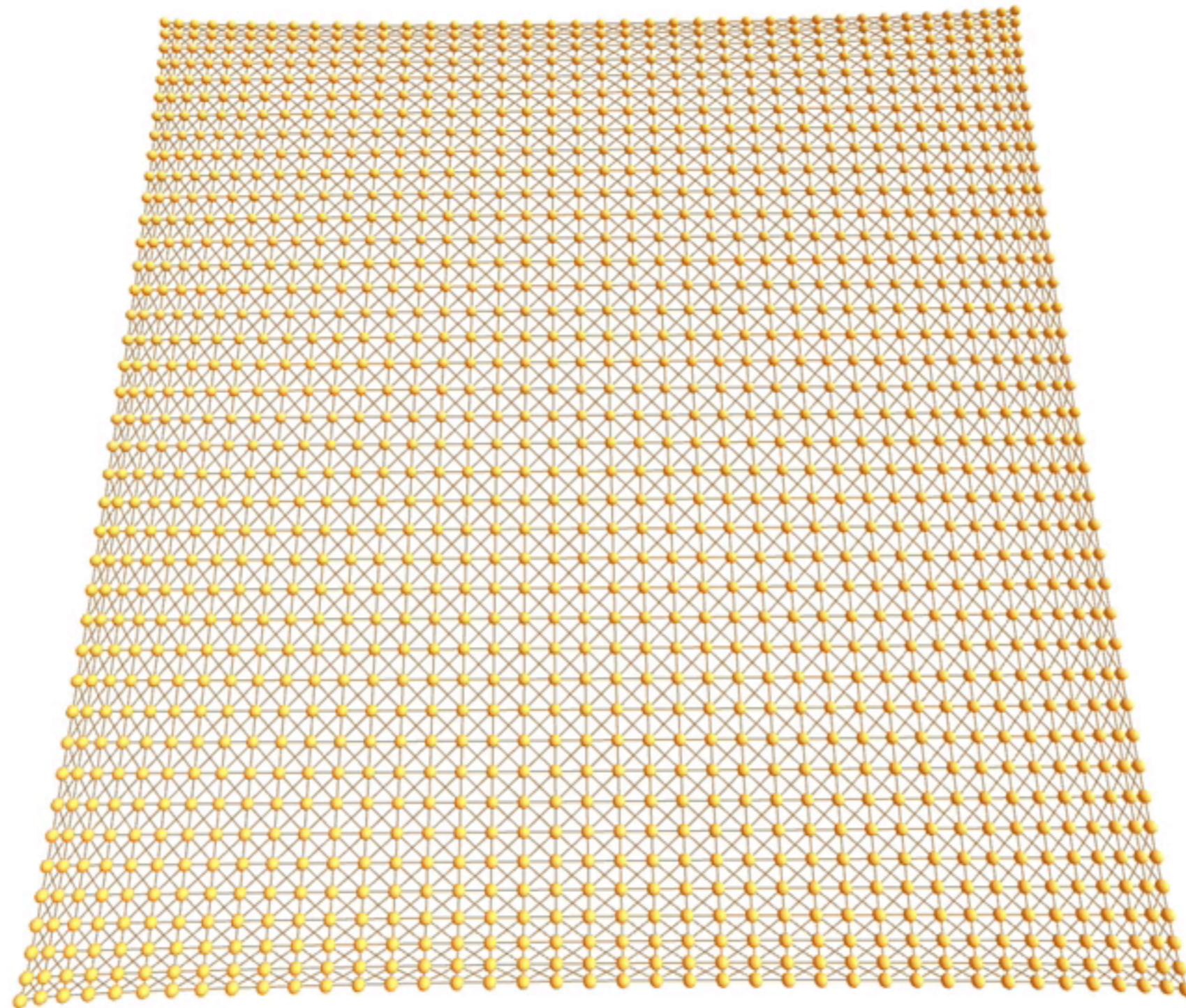
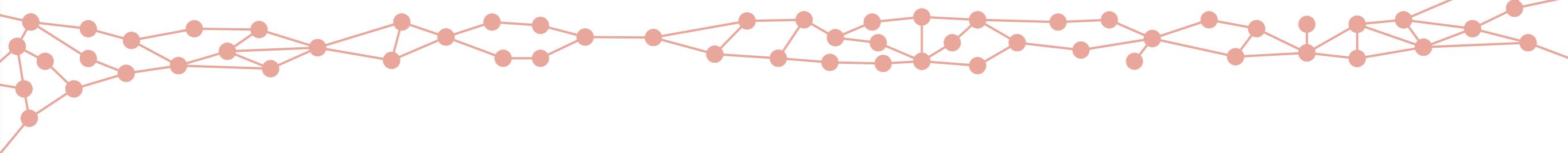
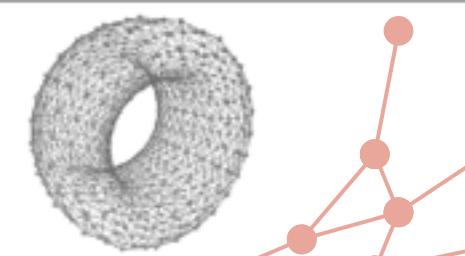


Validating the multiscale dimension



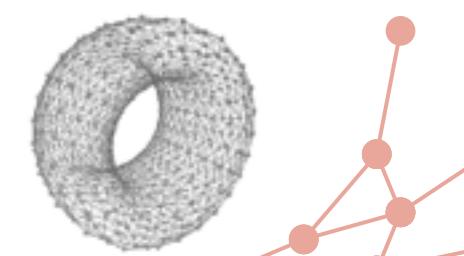
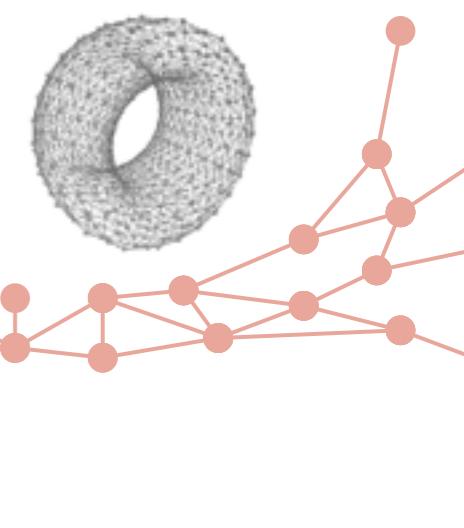
Network dimension and symmetry

Wrapping effect of networks

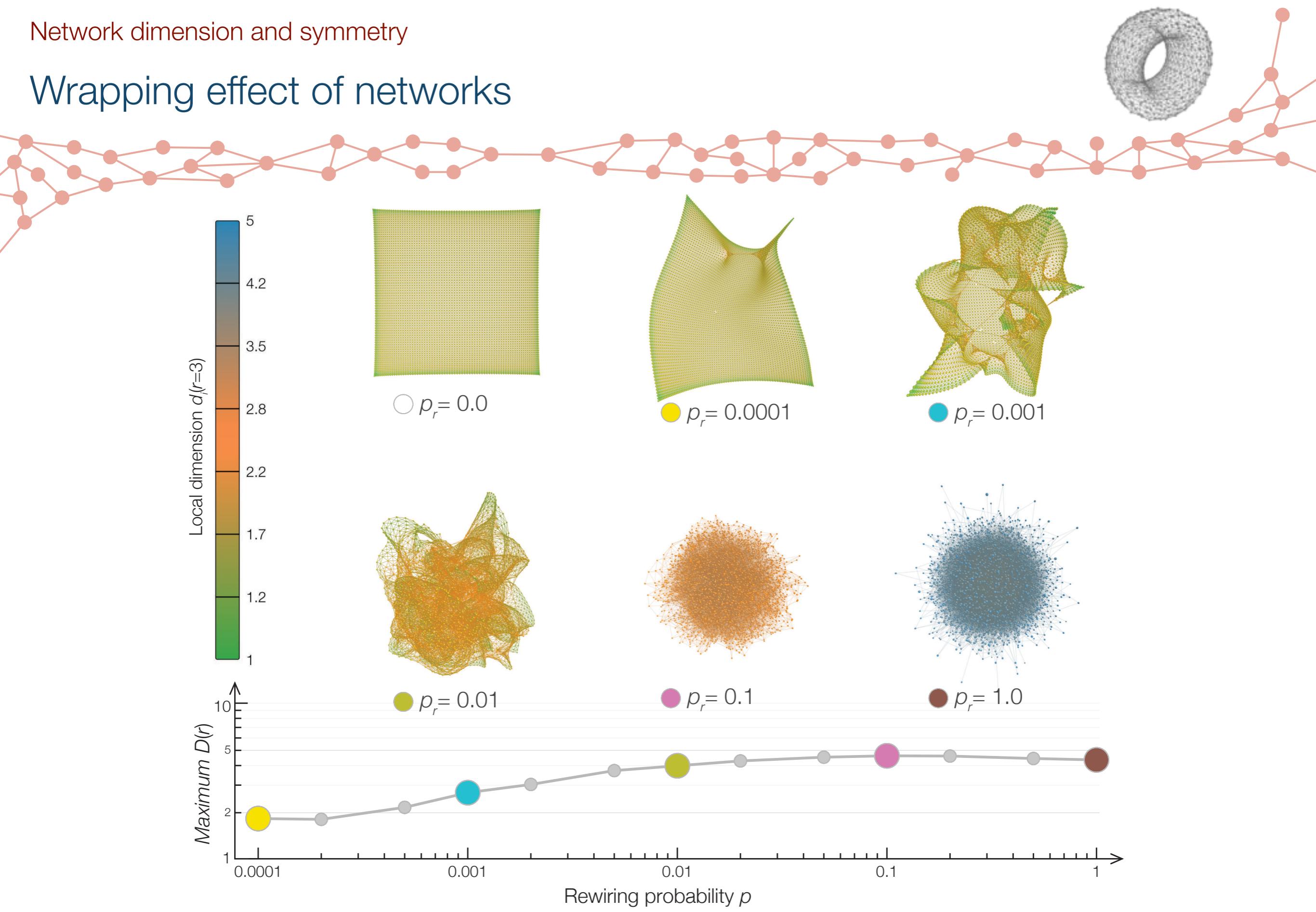


Network dimension and symmetry

Wrapping effect of networks

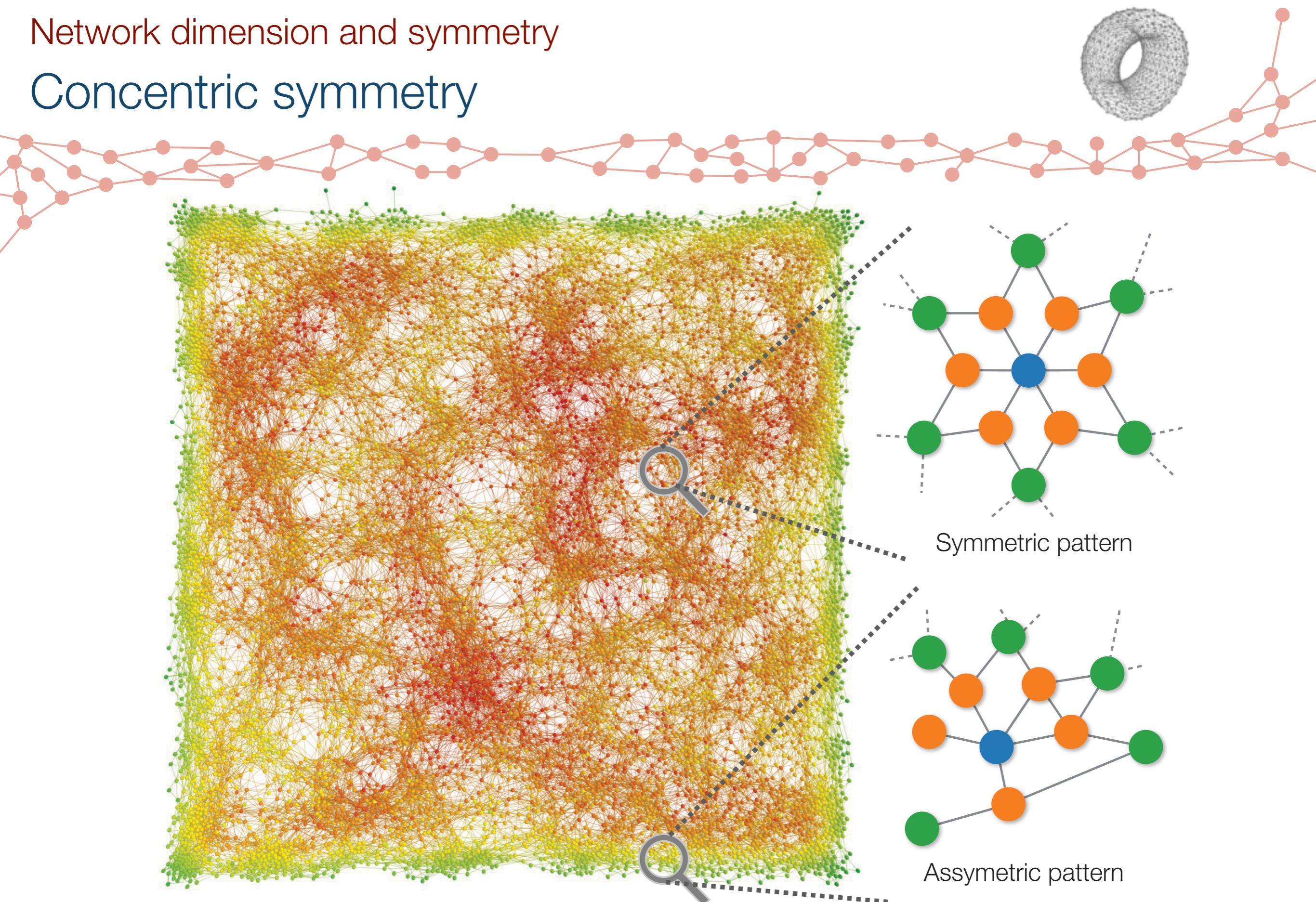


Wrapping effect of networks



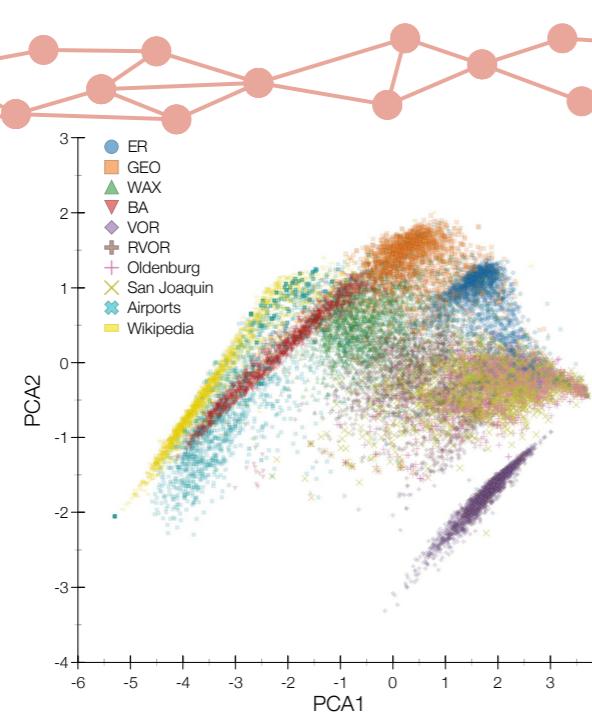
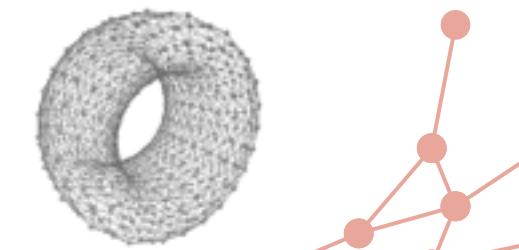
Network dimension and symmetry

Concentric symmetry

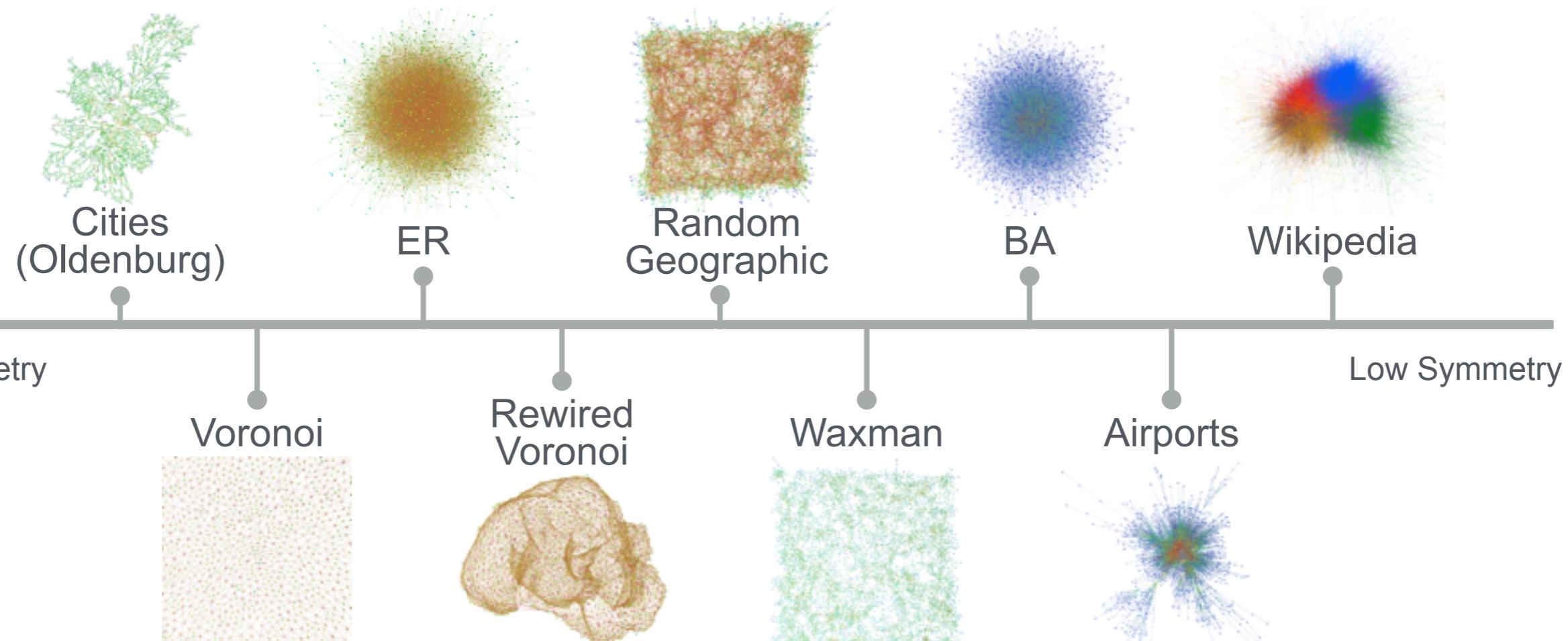


Network dimension and symmetry

Results

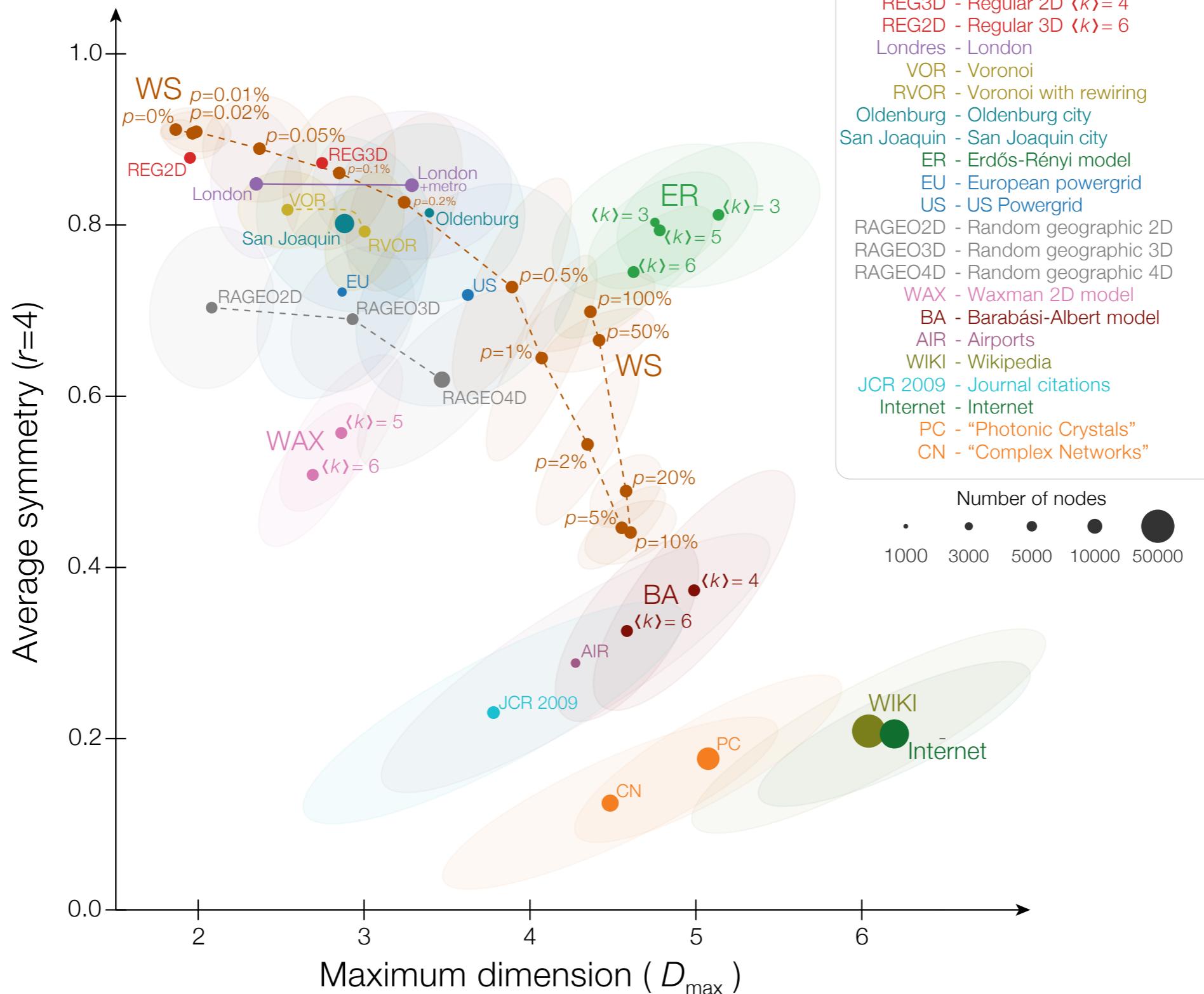
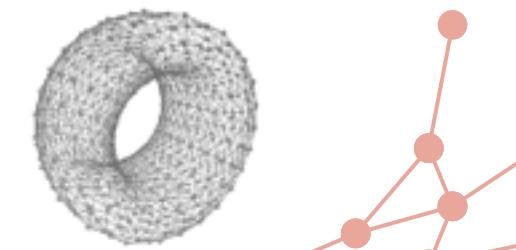


- Concentric symmetries
 - Do not correlate with traditional network measurements.
 - Discriminate between a diverse range of models and real networks.
 - Allowed us to rank networks by their "average" symmetry.



Network dimension and symmetry

Dimension and symmetry

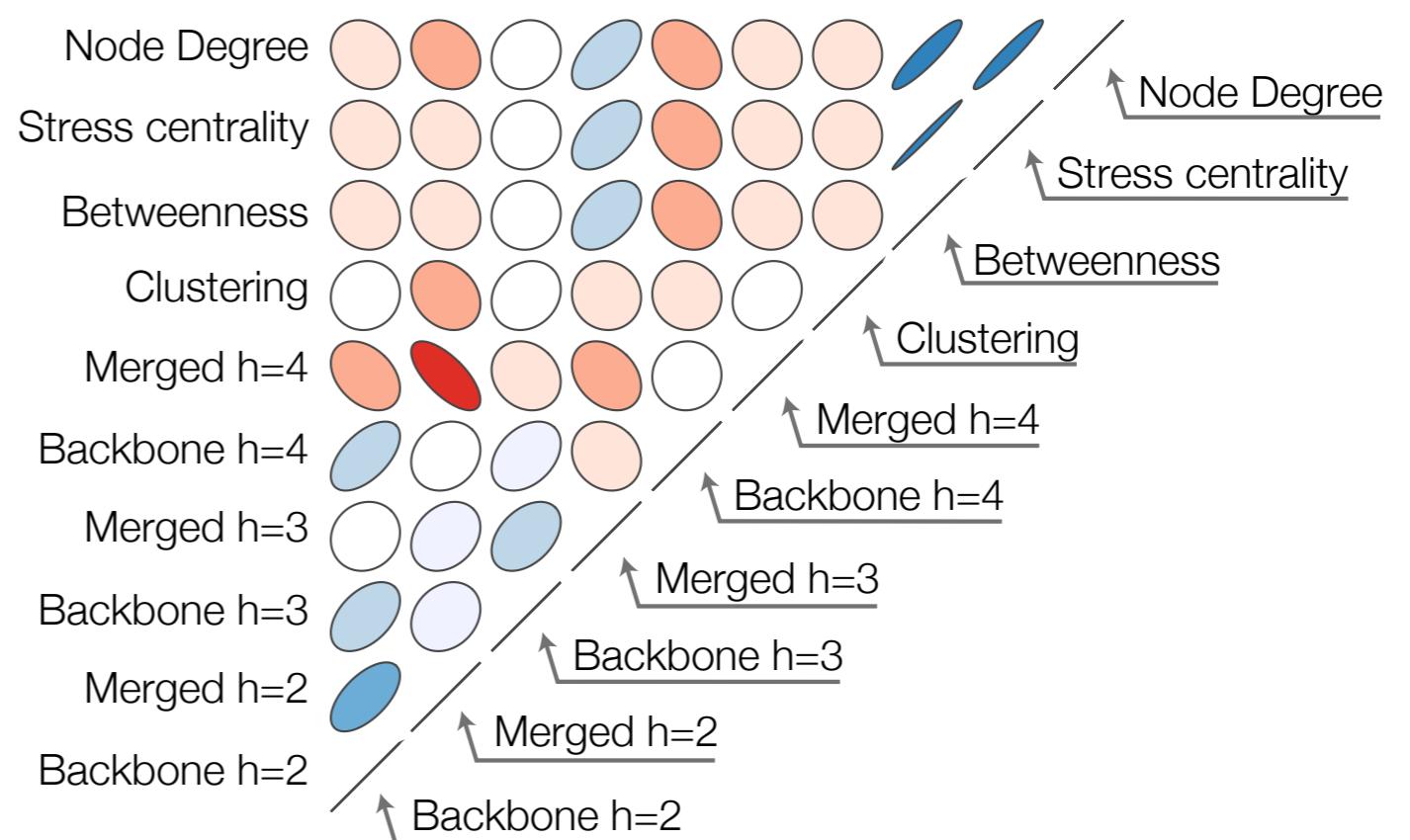


Symmetry in word adjacency networks

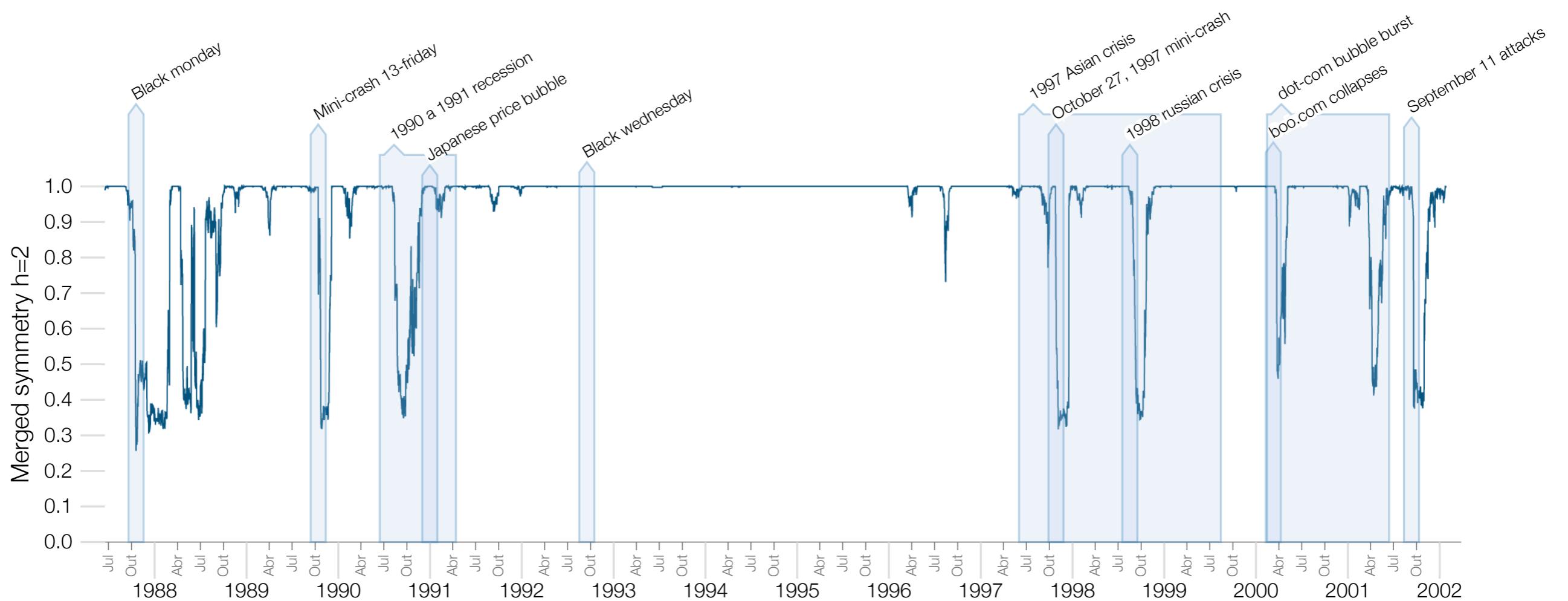
Symmetry	SVM	MLP	KNN	NBY
Merged $h = 2$	75.0%	72.5%	55.0%	42.5%
Merged $h = 3$	70.0%	62.5%	65.0%	40.0%
Merged $h = 4$	82.5%	82.5%	57.5%	42.5%
Backbone $h = 2$	32.5%	32.5%	20.0%	20.0%
Backbone $h = 3$	70.0%	72.5%	57.5%	27.5%
Backbone $h = 4$	70.0%	82.5%	57.5%	42.5%

Accuracy rates found for the authorship detection task.

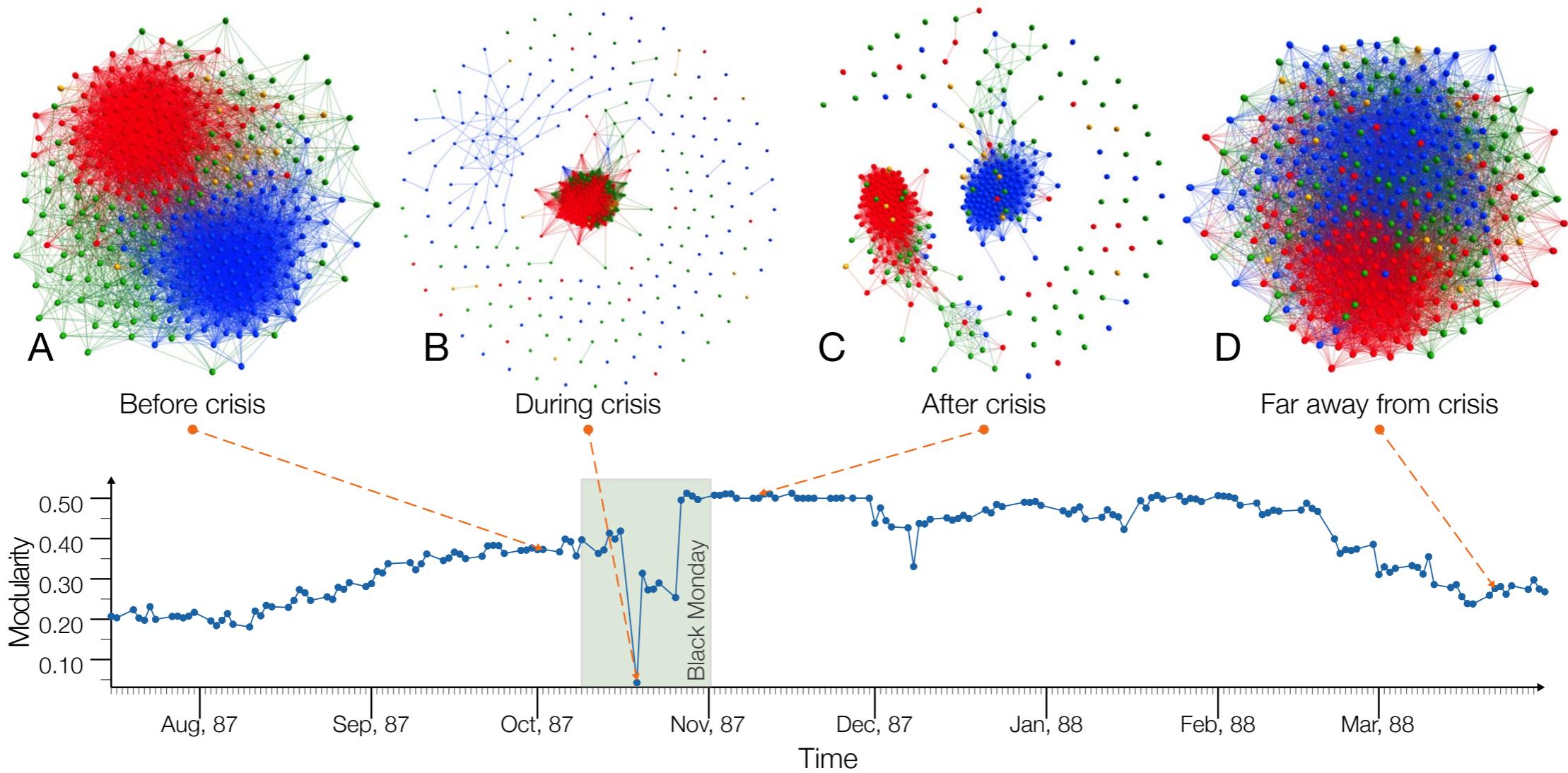
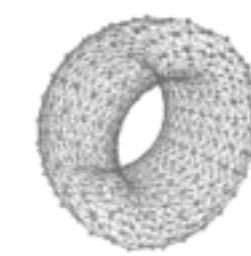
Pearson correlation coefficients between symmetry and other traditional network measurements



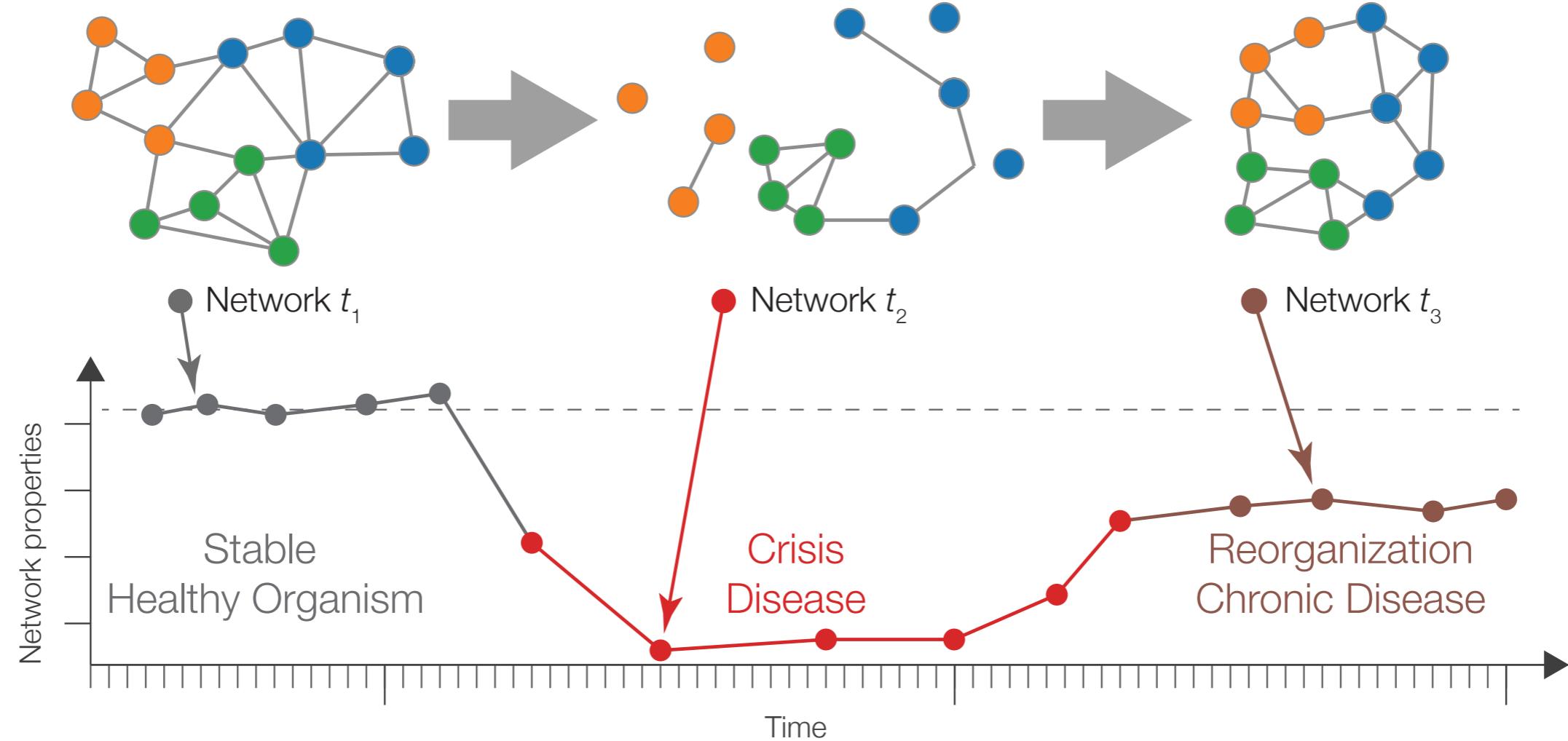
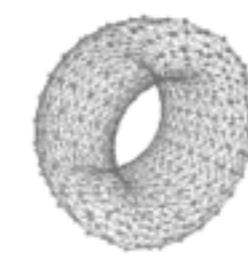
Symmetry applied to the financial market network



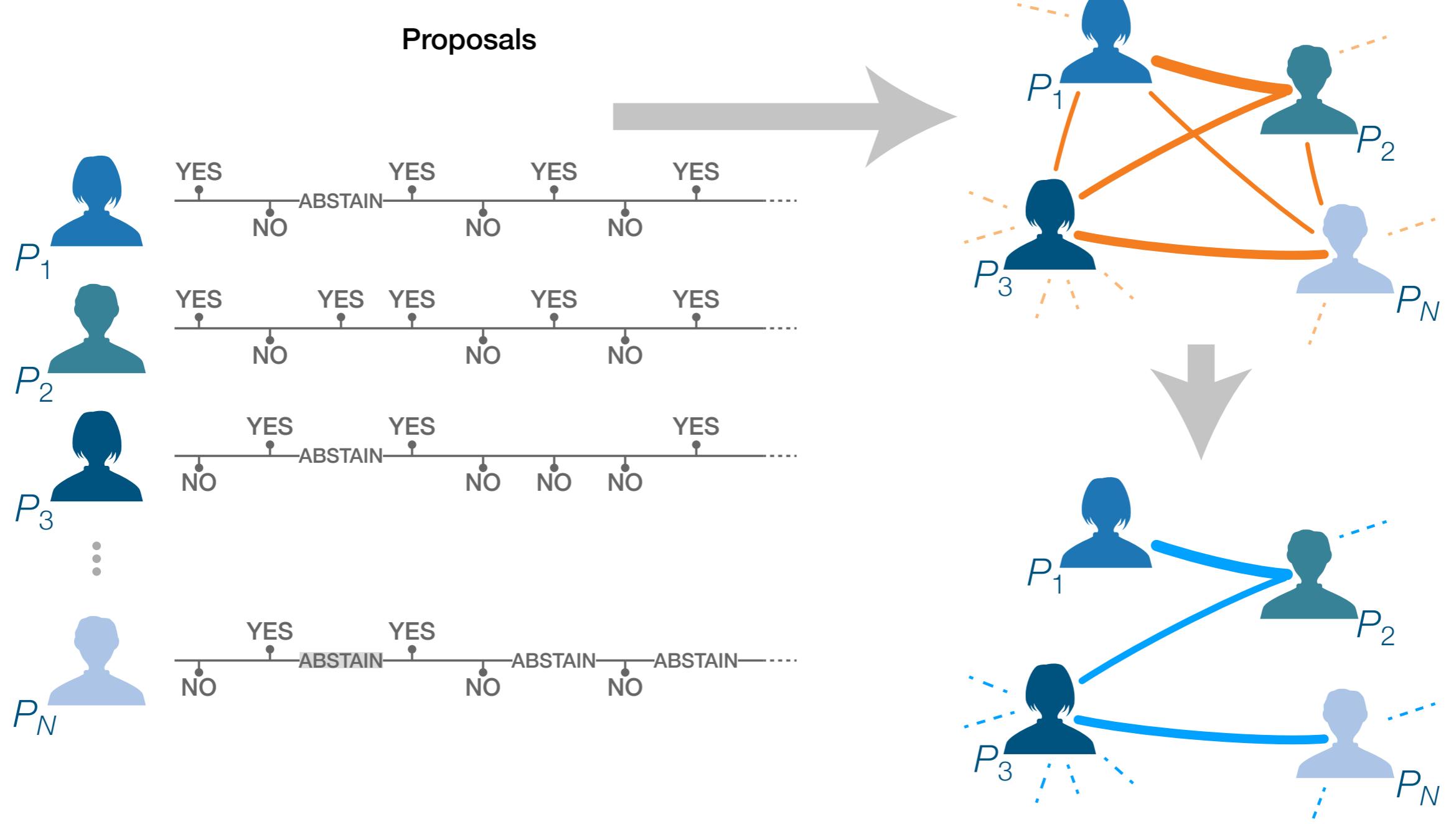
Financial market networks



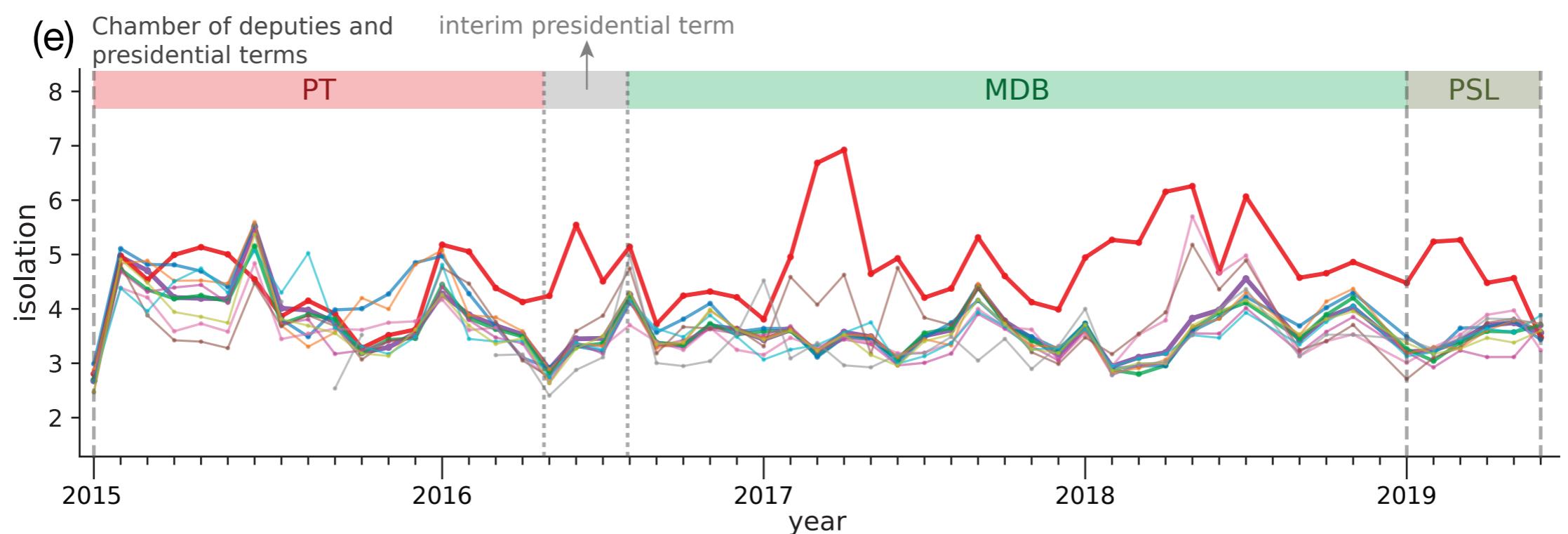
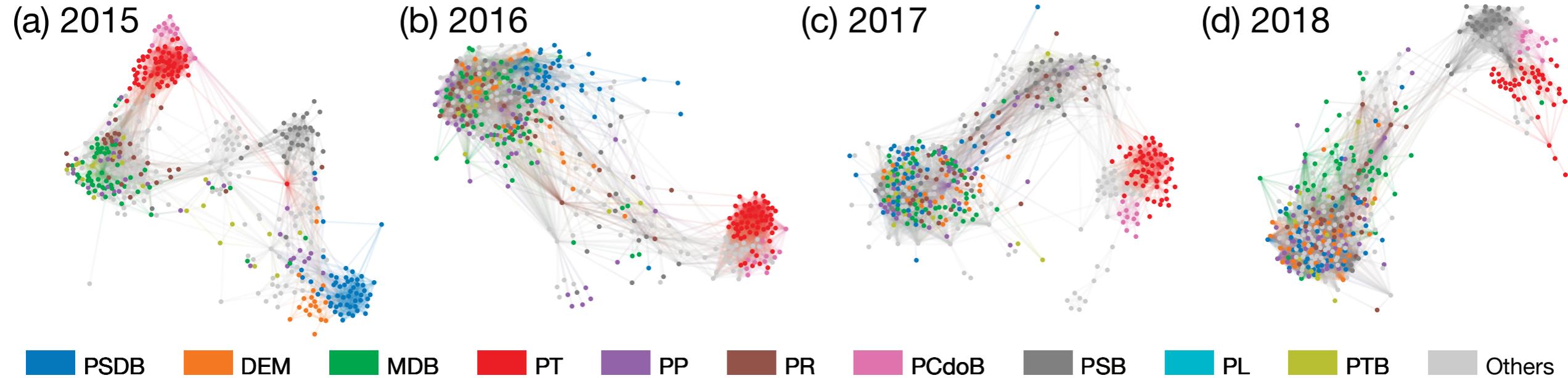
Time evolving network during crisis



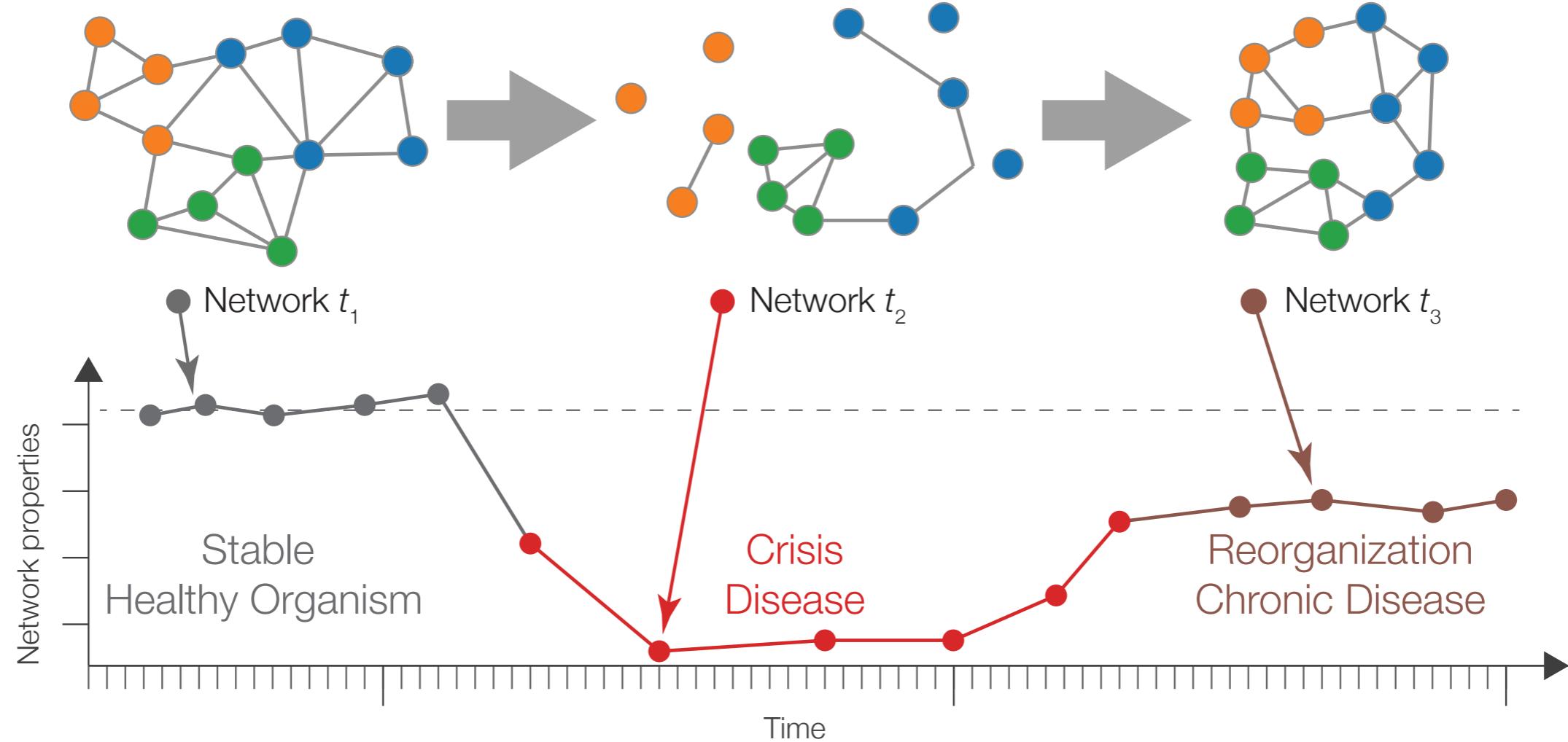
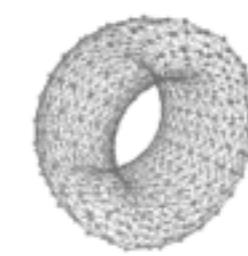
Political networks



Political networks

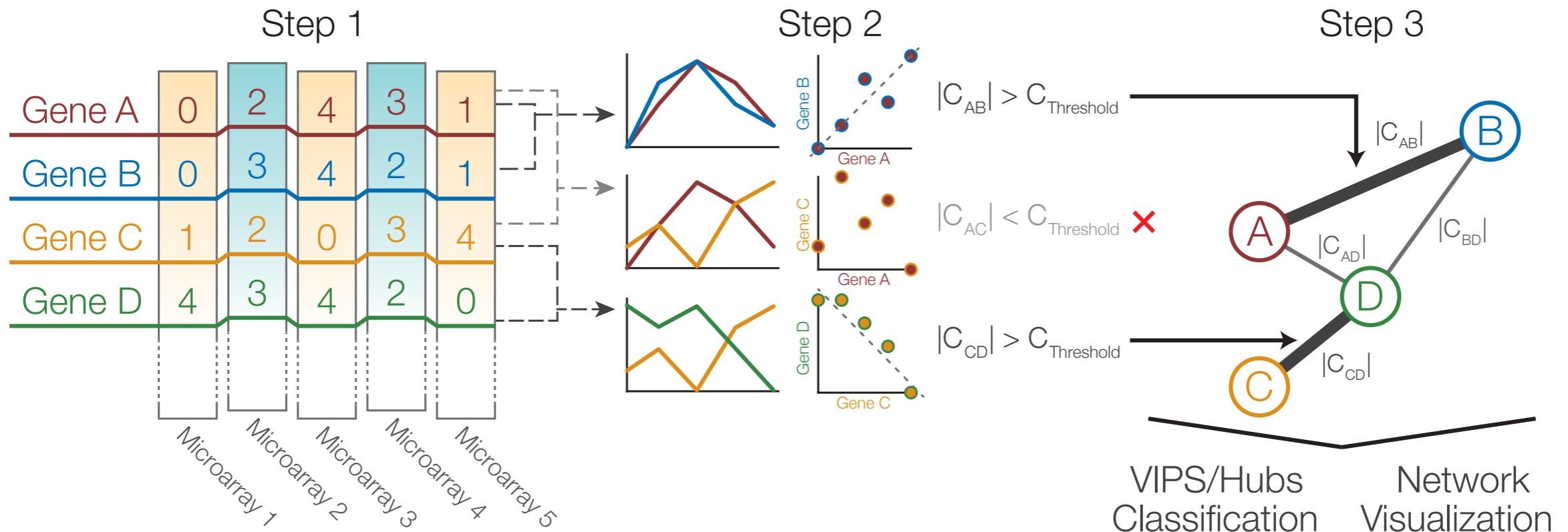
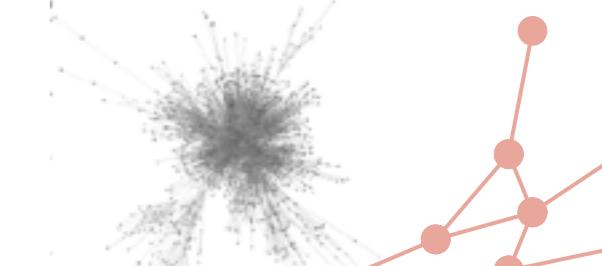


Time evolving network during crisis



Other applications

Gene co-expression networks

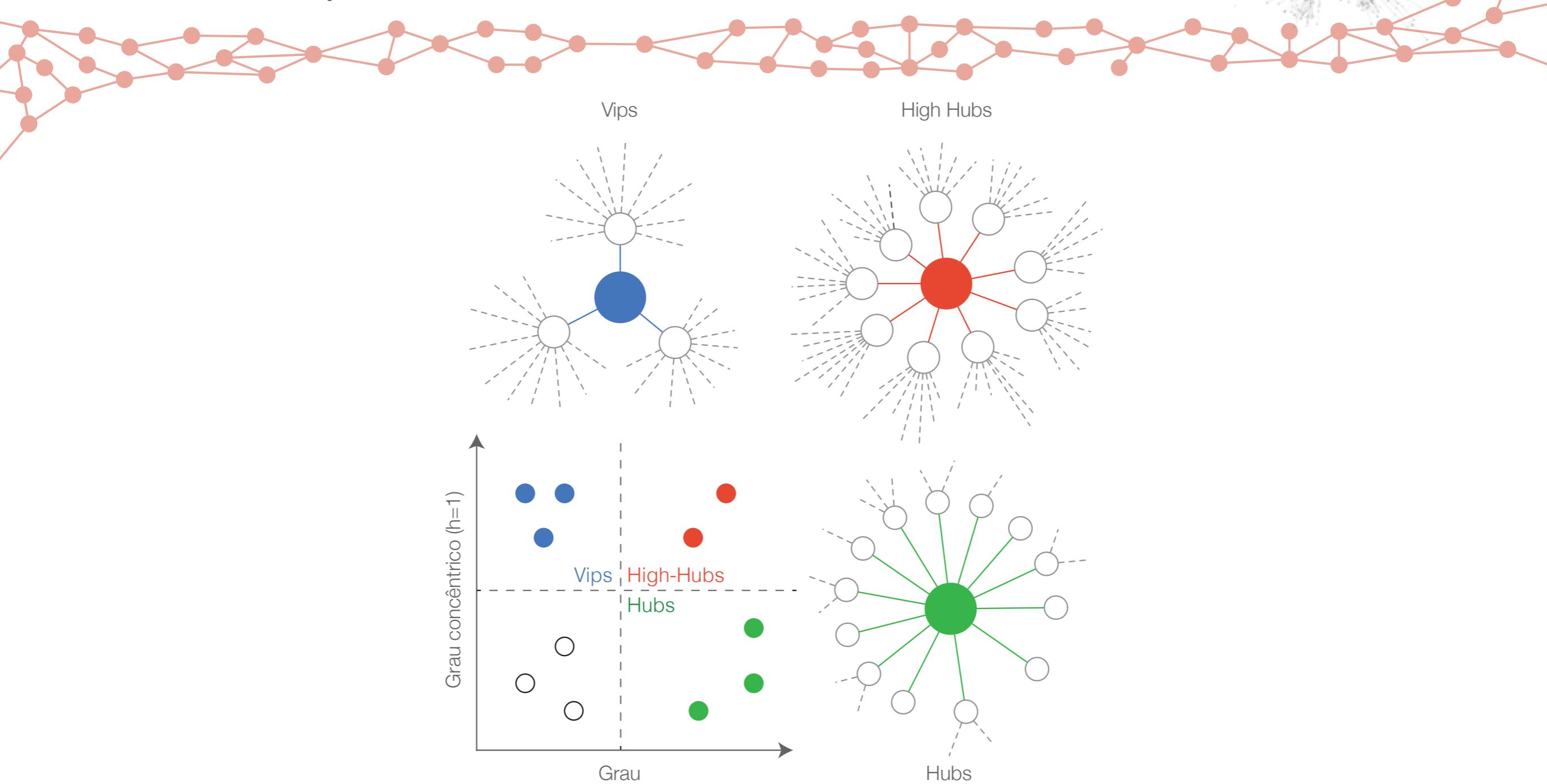
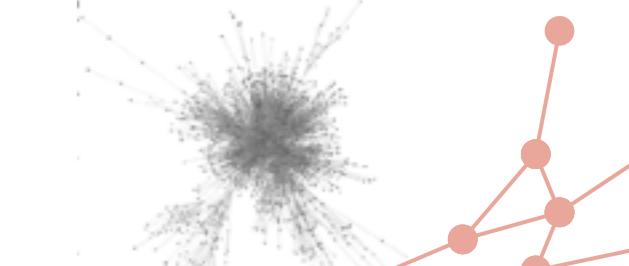


BANDO, S. Y.; SILVA, F. N.; COSTA, L. da F.; SILVA, A. V.; PIMENTEL-SILVA, L. R.; CASTRO, L. H. M.; WEN, H.-T.; AMARO JUNIOR, E.; MOREIRA-FILHO, C. A. Complex network analysis of CA3 transcriptome reveals pathogenic and compensatory pathways in refractory temporal lobe epilepsy. *PLoS ONE*, v. 8, n. 11, p. e79913, 2013.

MOREIRA-FILHO, C. A.; BANDO, S. Y.; BERTONHA, F. B.; SILVA, F. N.; COSTA, L. da F. Methods for gene coexpression network visualization and analysis. In: PASSOS, G. A. (Ed.). *Transcriptomics in health and disease*. Berlin: Springer, 2014. cap. 4, p. 79–94.

Other applications

Gene co-expression networks

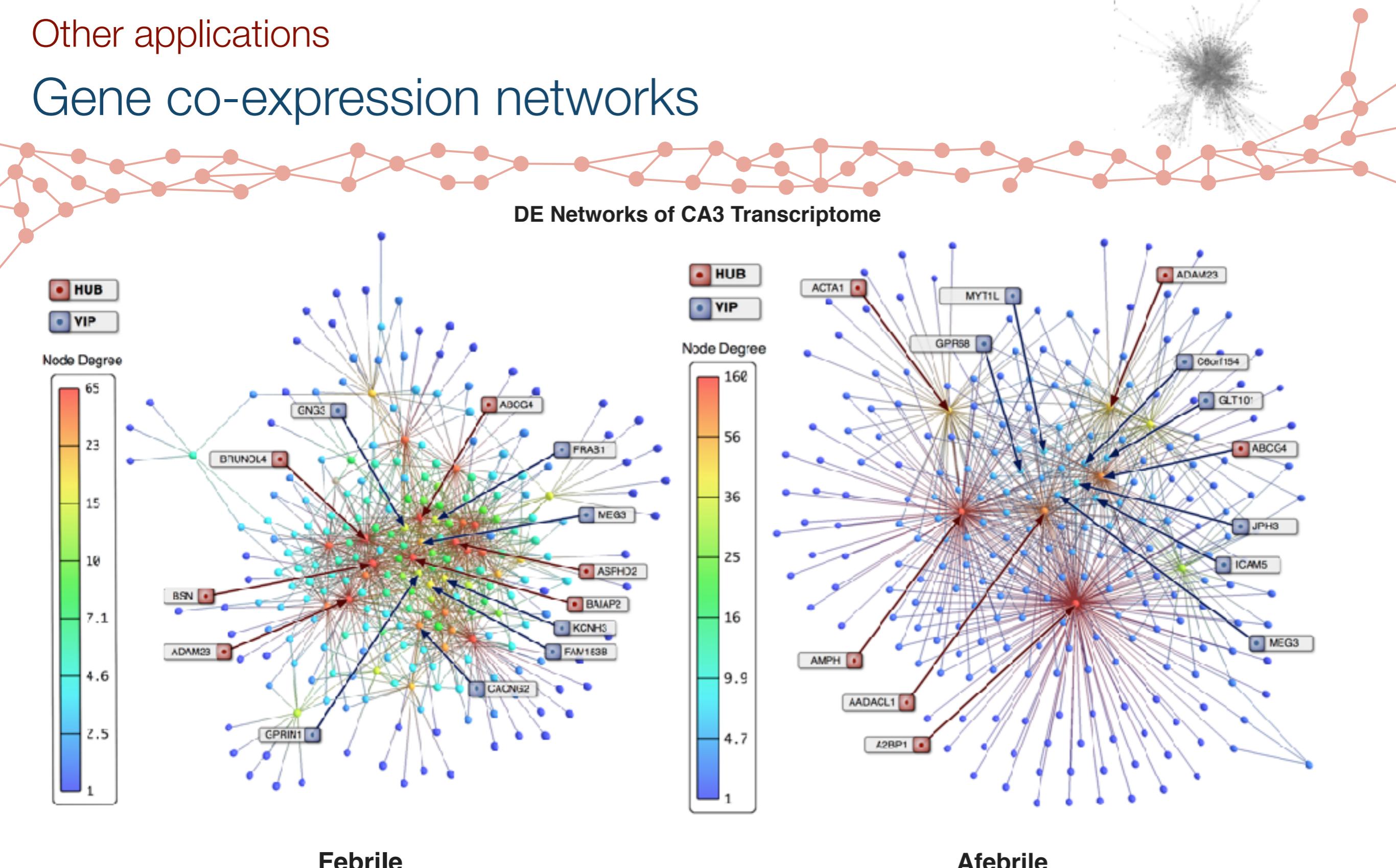


MOREIRA-FILHO, C. A.; BANDO, S. Y.; BERTONHA, F. B.; IAMASHITA, P.; SILVA, F. N.; COSTA, L. da F.; SILVA, A. V.; CASTRO, L. H. M.; WEN, H.-T. Community structure analysis of transcriptional networks reveals distinct molecular pathways for early- and late-onset temporal lobe epilepsy with childhood febrile seizures. *PLoS ONE*, v. 10, n. 5, p. e0128174, 2015.

BANDO, S. Y.; BERTONHA, F. B.; SILVA, F. N.; COSTA, L. da F.; FERREIRA, L.; FURLANETTO, G.; CHACUR, P.; ZERBINI, M. C.; CARNEIRO-SAMPAIO, M.; MOREIRA-FILHO, C. A. Modular Transcriptional Repertoire and MicroRNA target Analyses Characterize Genomic Dysregulation in the Thymus of Down Syndrome Infants. Submetido à *Oncotarget*.

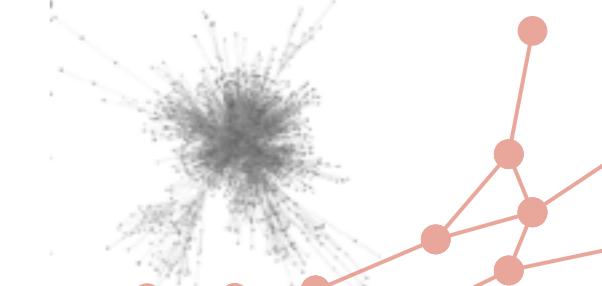
Other applications

Gene co-expression networks



Other applications

Gene co-expression networks



microorganisms



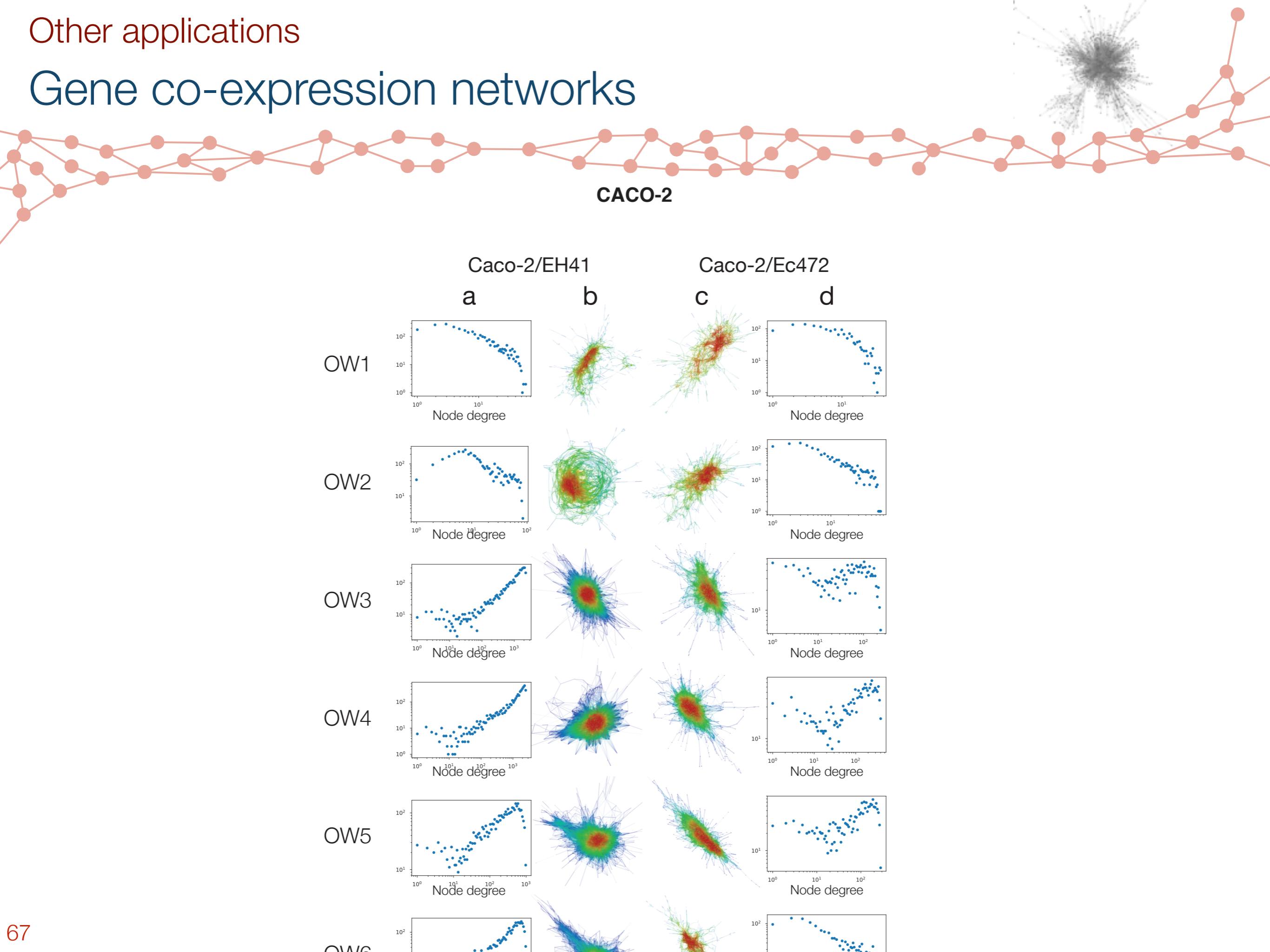
Article

Dynamic Gene Network Analysis of Caco-2 Cell Response to Shiga Toxin-Producing *Escherichia coli*-Associated Hemolytic–Uremic Syndrome

Silvia Y. Bando ^{1,†}, Priscila Iamashita ^{1,†}, Filipi N. Silva ², Luciano da F. Costa ², Cecilia M. Abe ³, Fernanda B. Berthonha ¹, Beatriz E. C. Guth ⁴, André Fujita ⁵, and Carlos A. Moreira-Filho ^{1,*}

Other applications

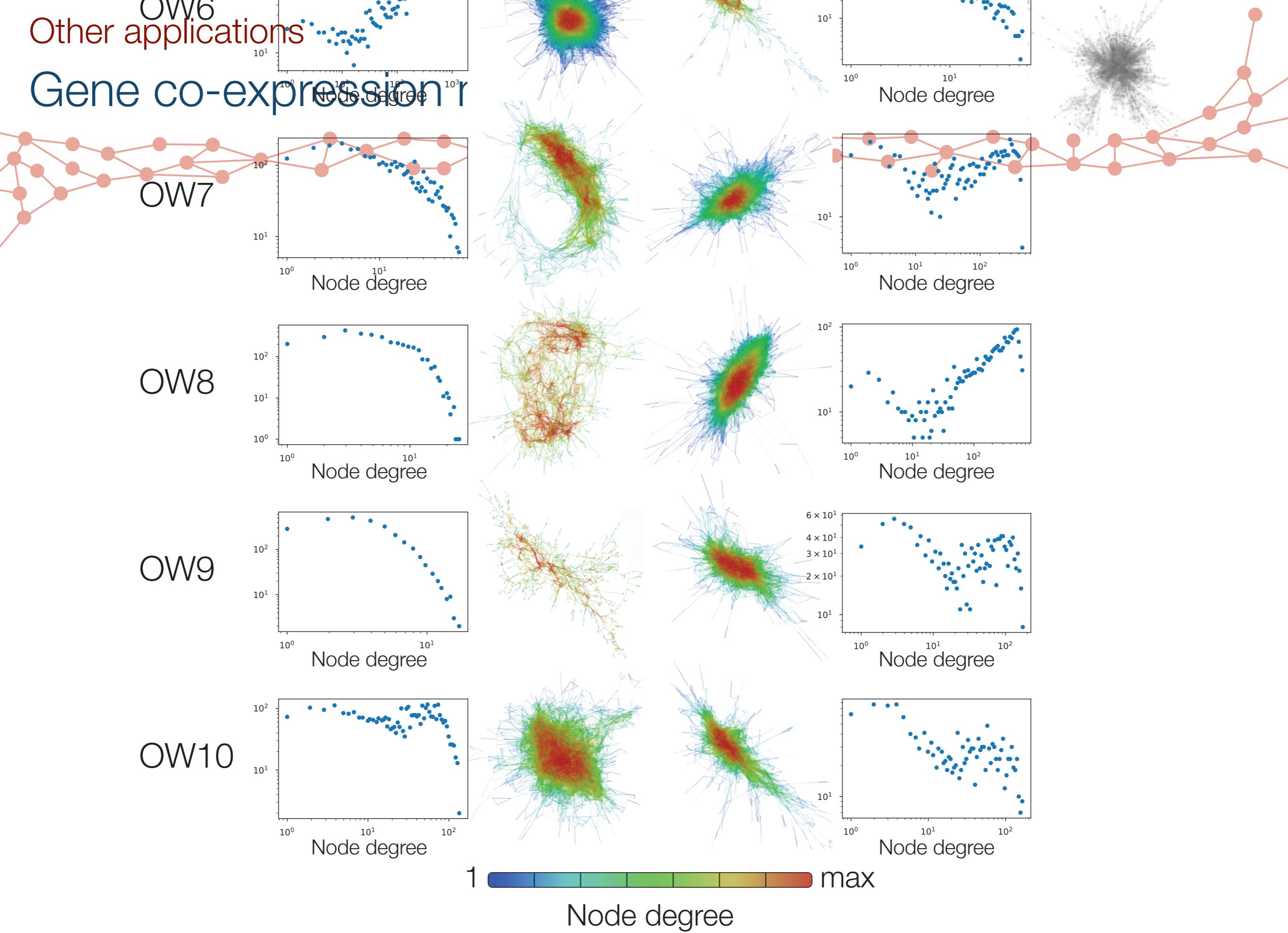
Gene co-expression networks



OW6

Other applications

Gene co-expression



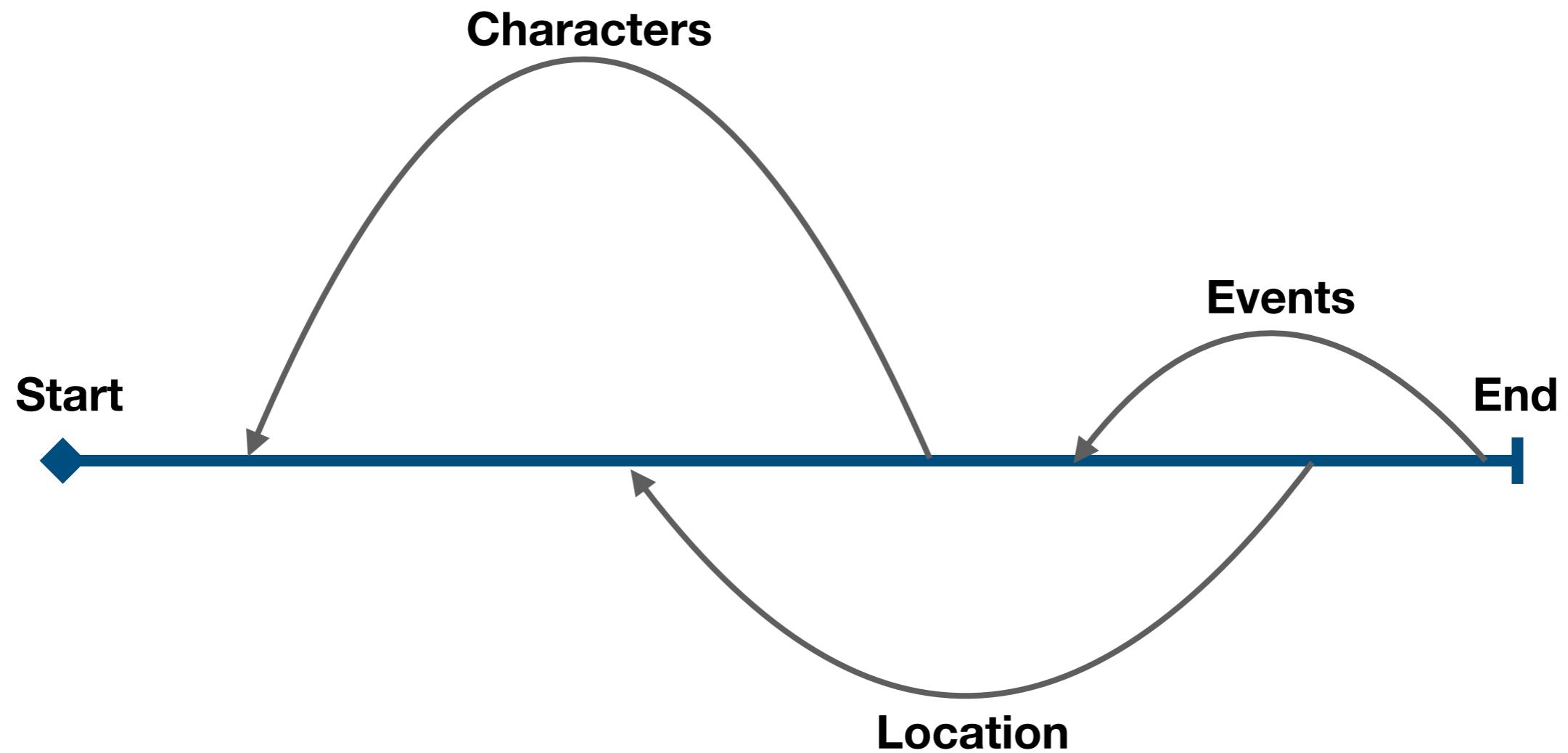
Narrative

Start

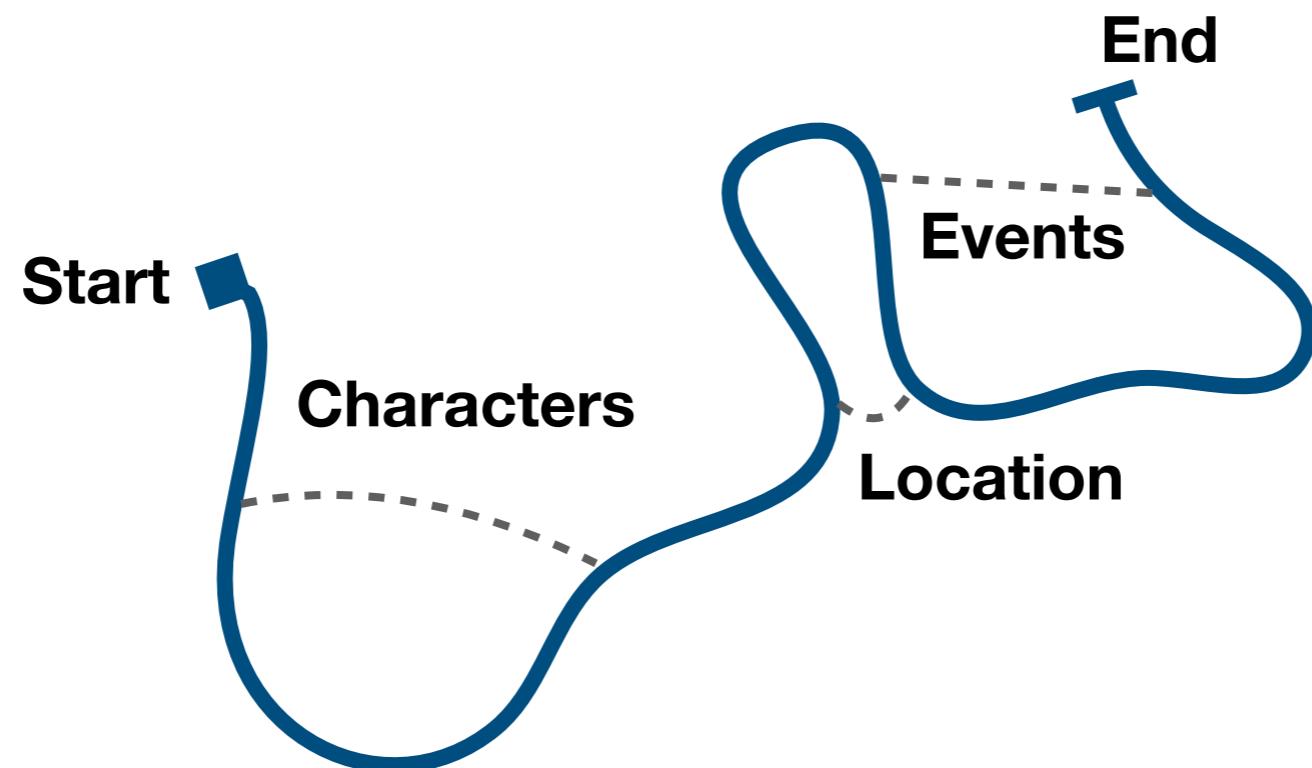


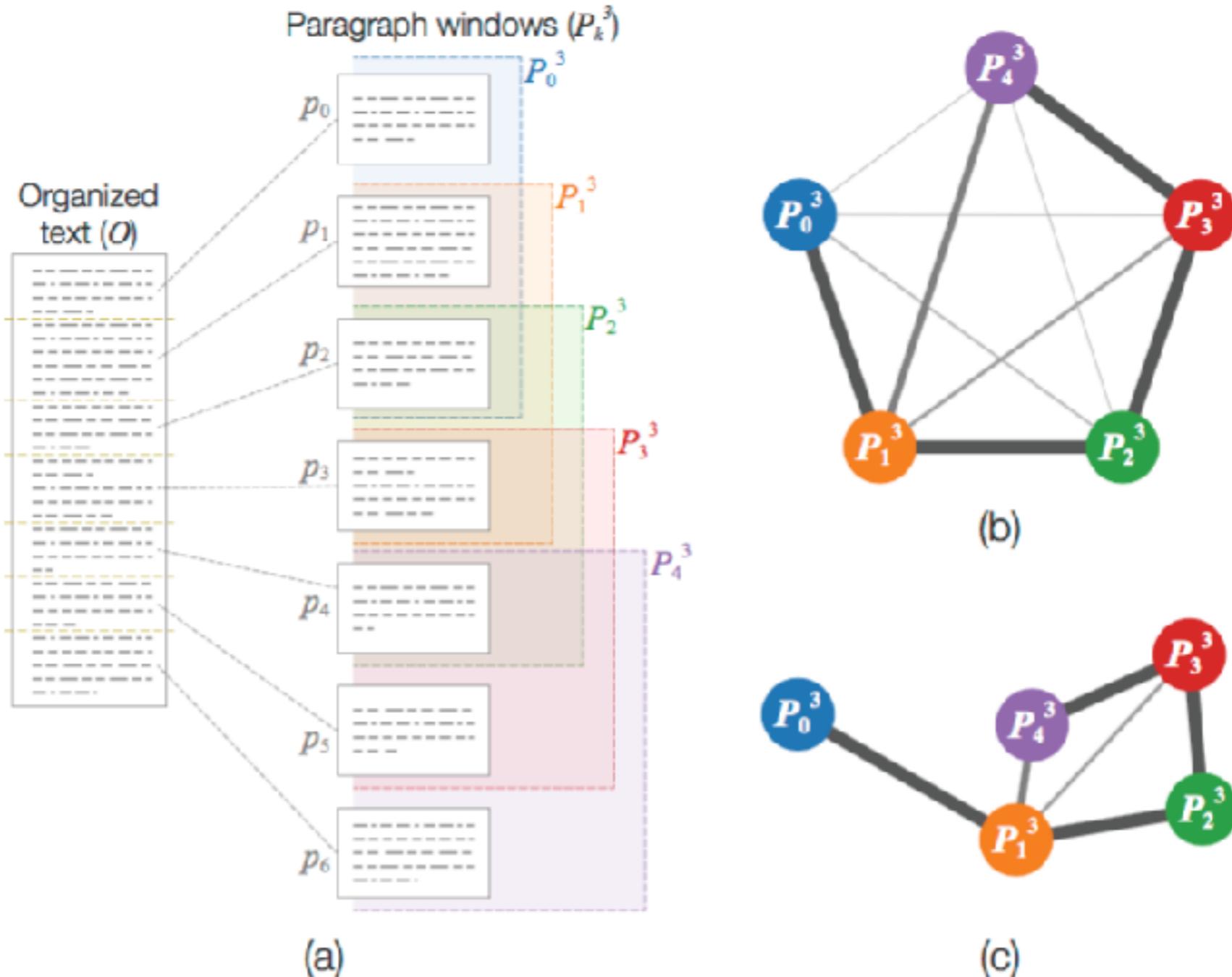
End

Narrative



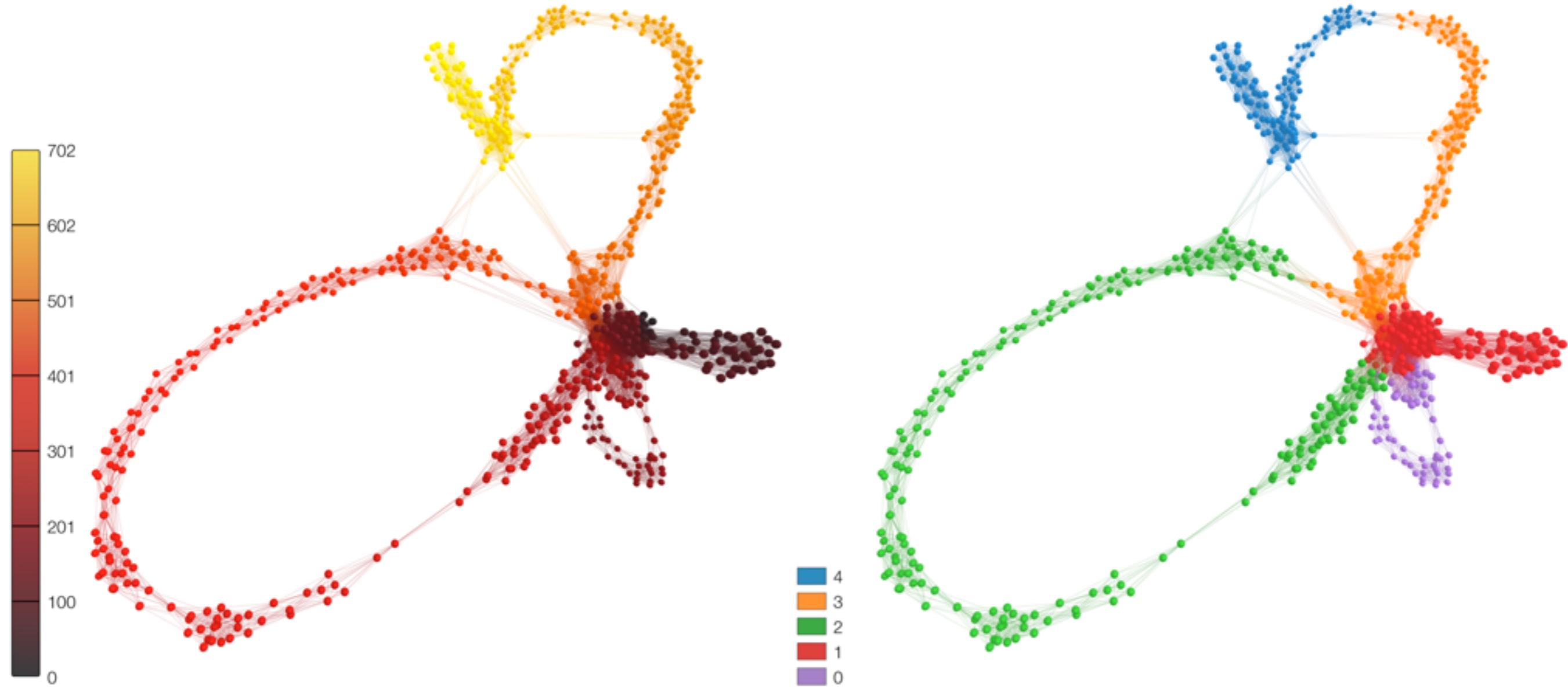
Narrative





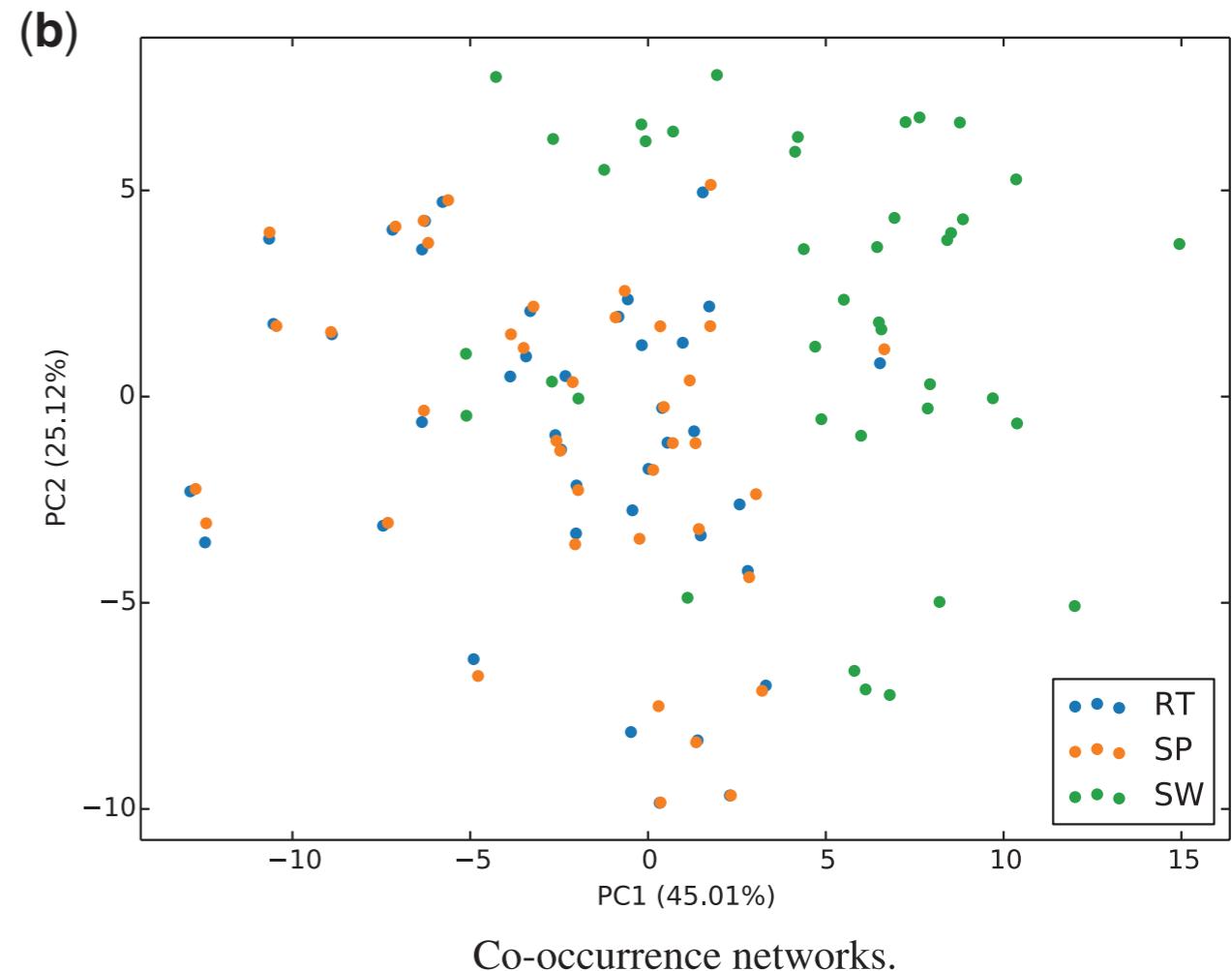
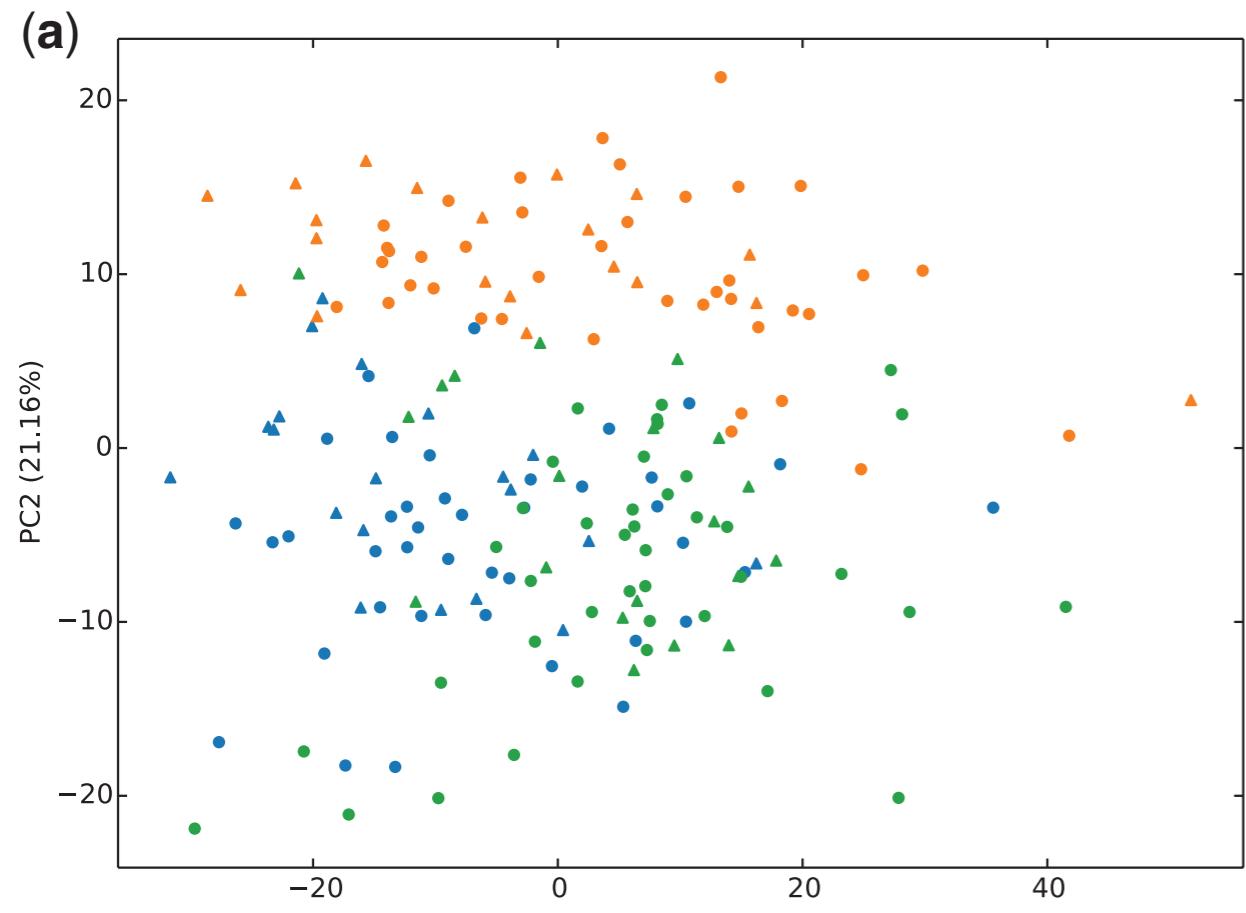
Mesoscopic representation of texts as complex networks
H. F. de Arruda, F. N. Silva, V. Q. Marinho, D. R. Amancio, L. da F. Costa
<https://arxiv.org/abs/1606.09636>

Alice in Wonderland

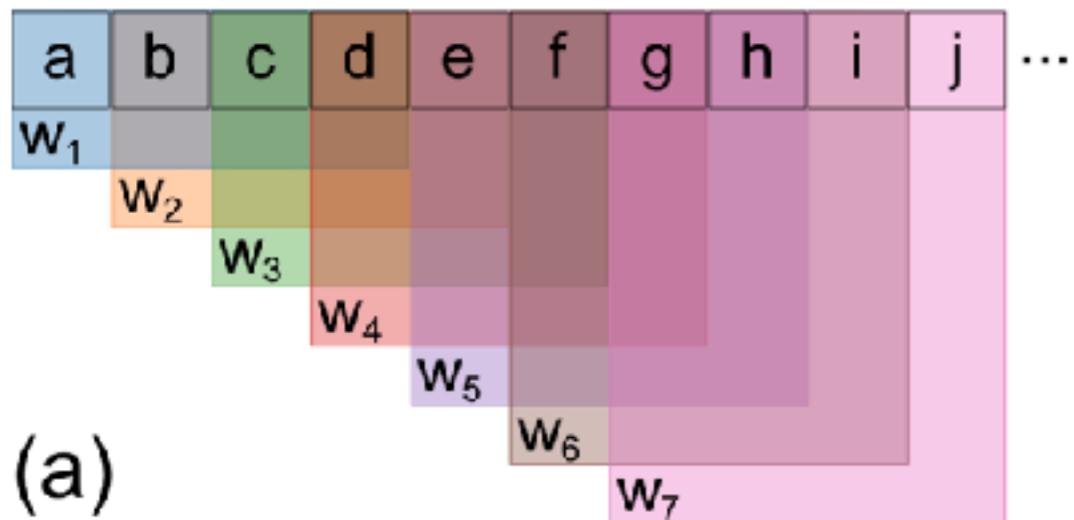


Mesoscopic representation of texts as complex networks
H. F. de Arruda, F. N. Silva, V. Q. Marinho, D. R. Amancio, L. da F. Costa
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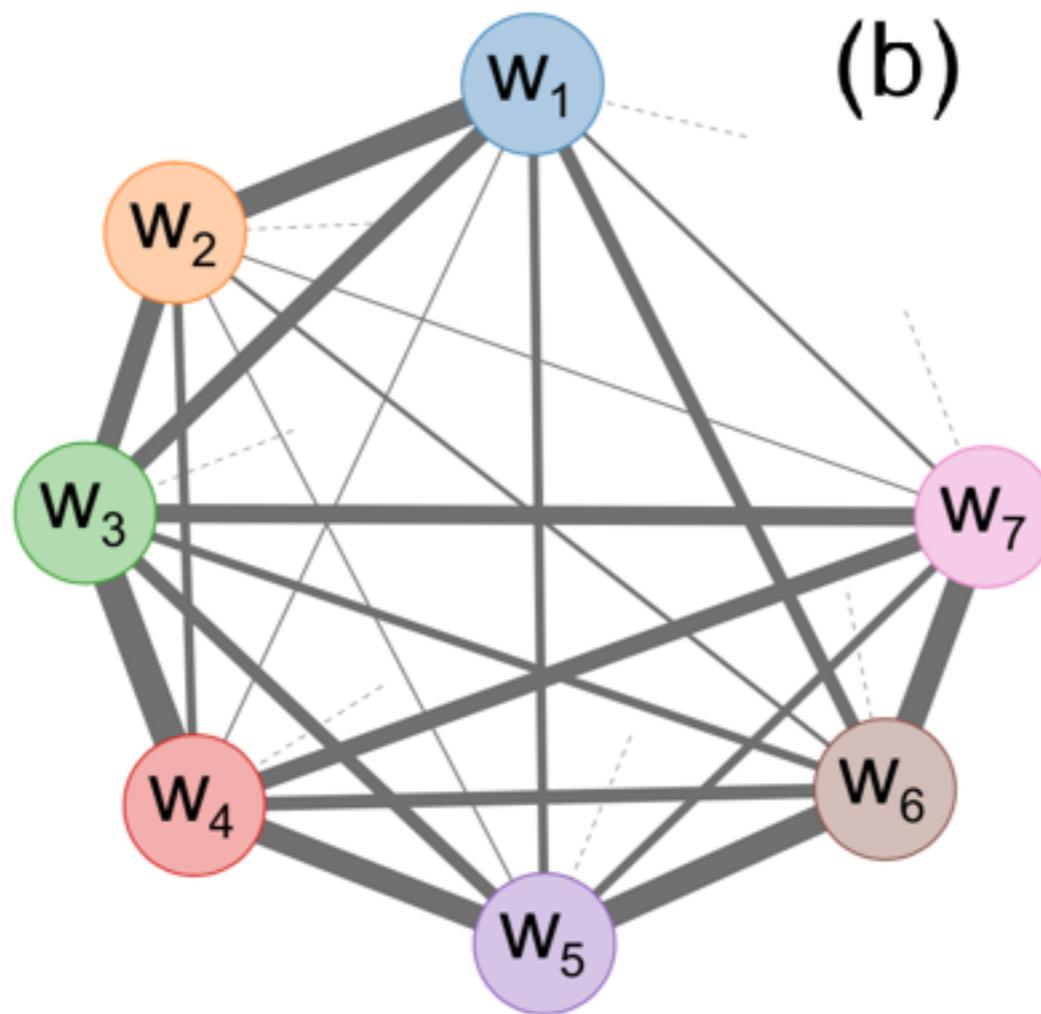
Classification using mesoscopic representation



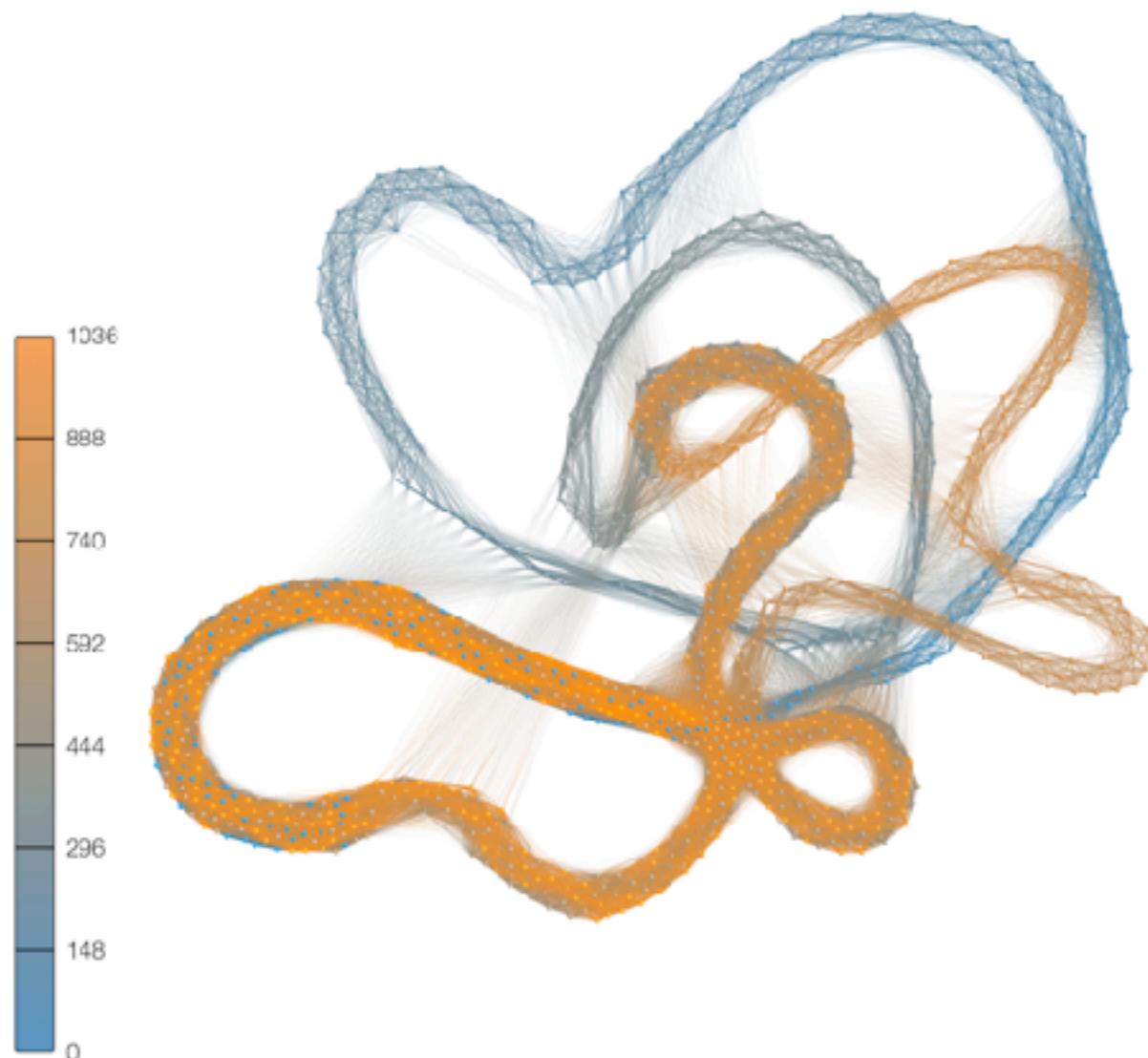
Lyrics



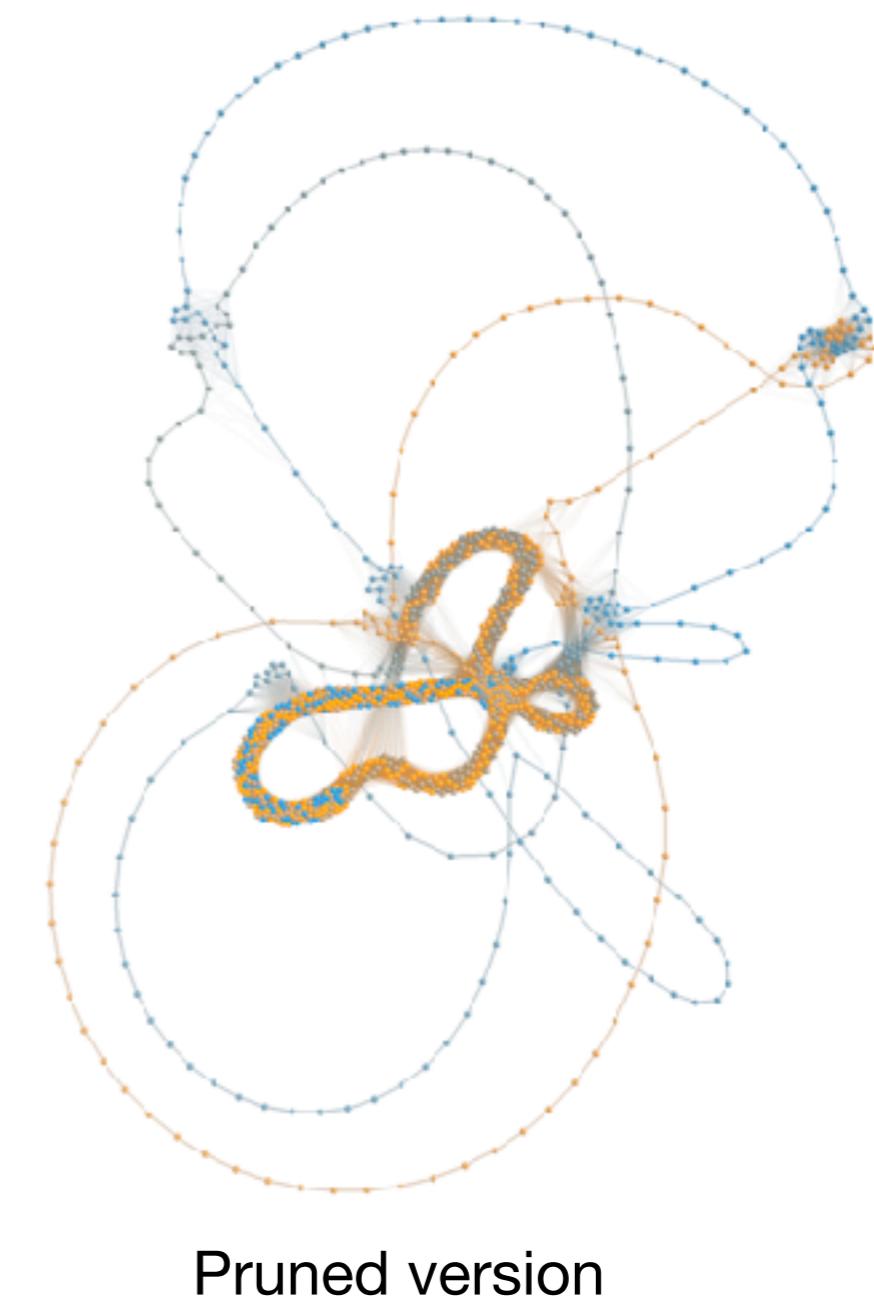
w₁: "ab", "bc", and "cd"
w₂: "bc", "cd", and "de"
w₃: "cd", "de", and "ef"
w₄: "de", "ef", and "fg"
w₅: "ef", "fg", and "gh"
w₆: "fg", "gh", and "hi"
w₇: "gh", "hi", and "ij"
:



Lyrics

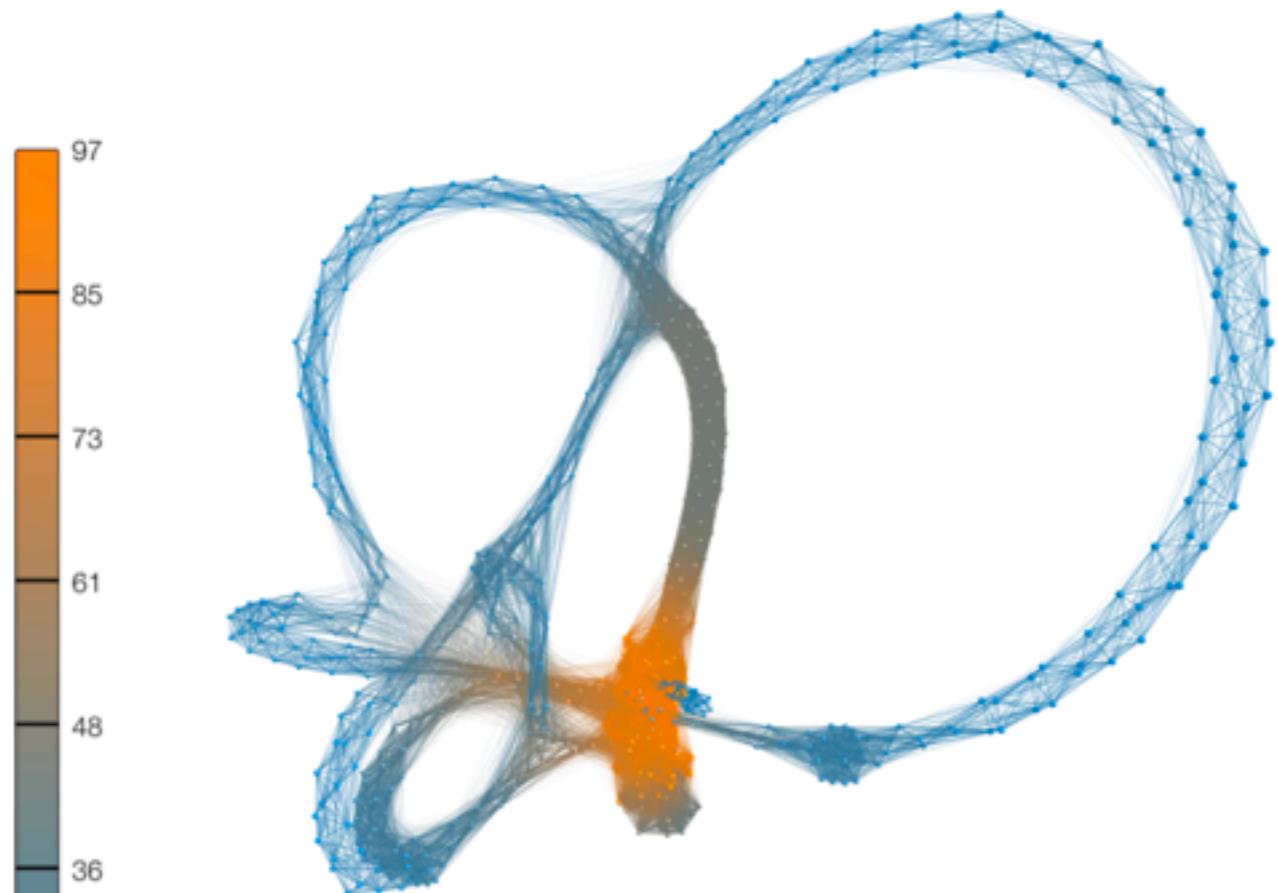


Dancing Queen - ABBA

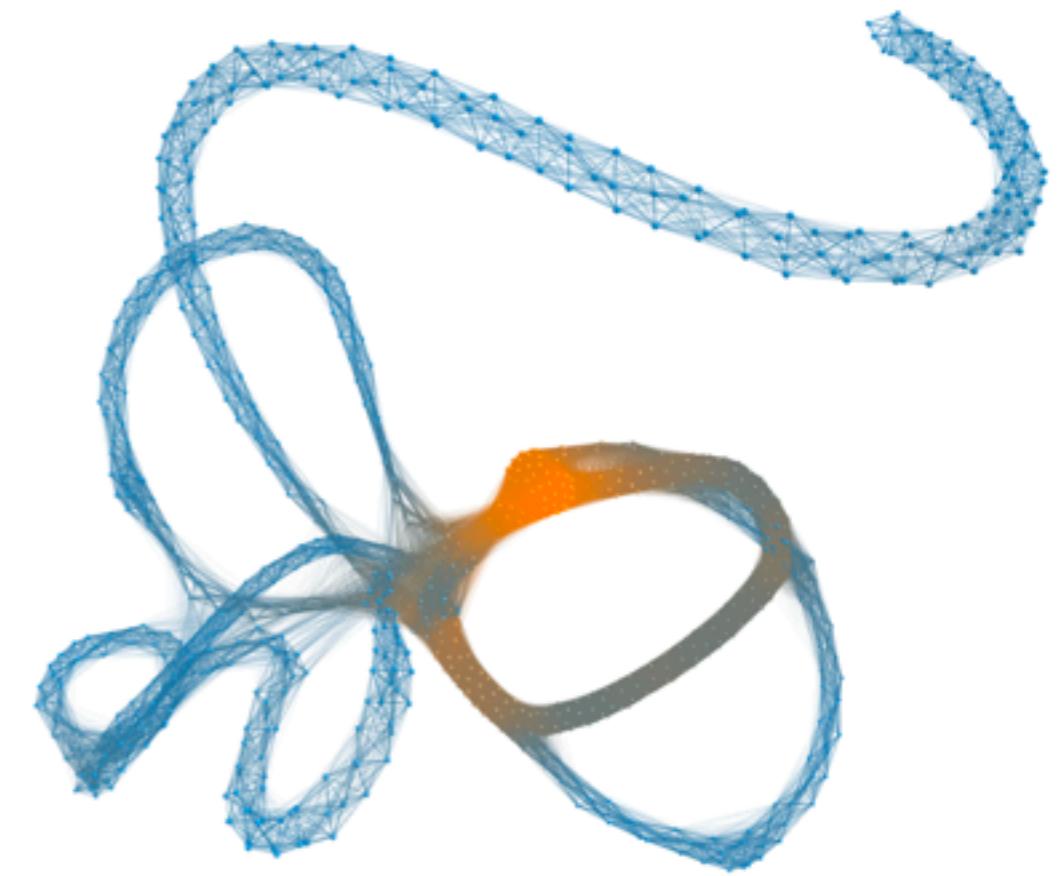
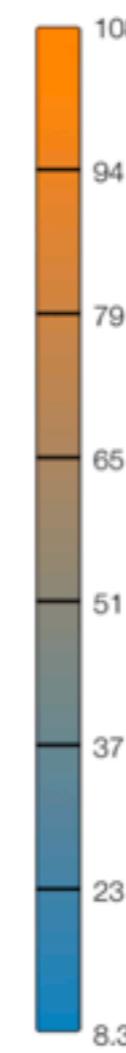


Pruned version

Lyrics

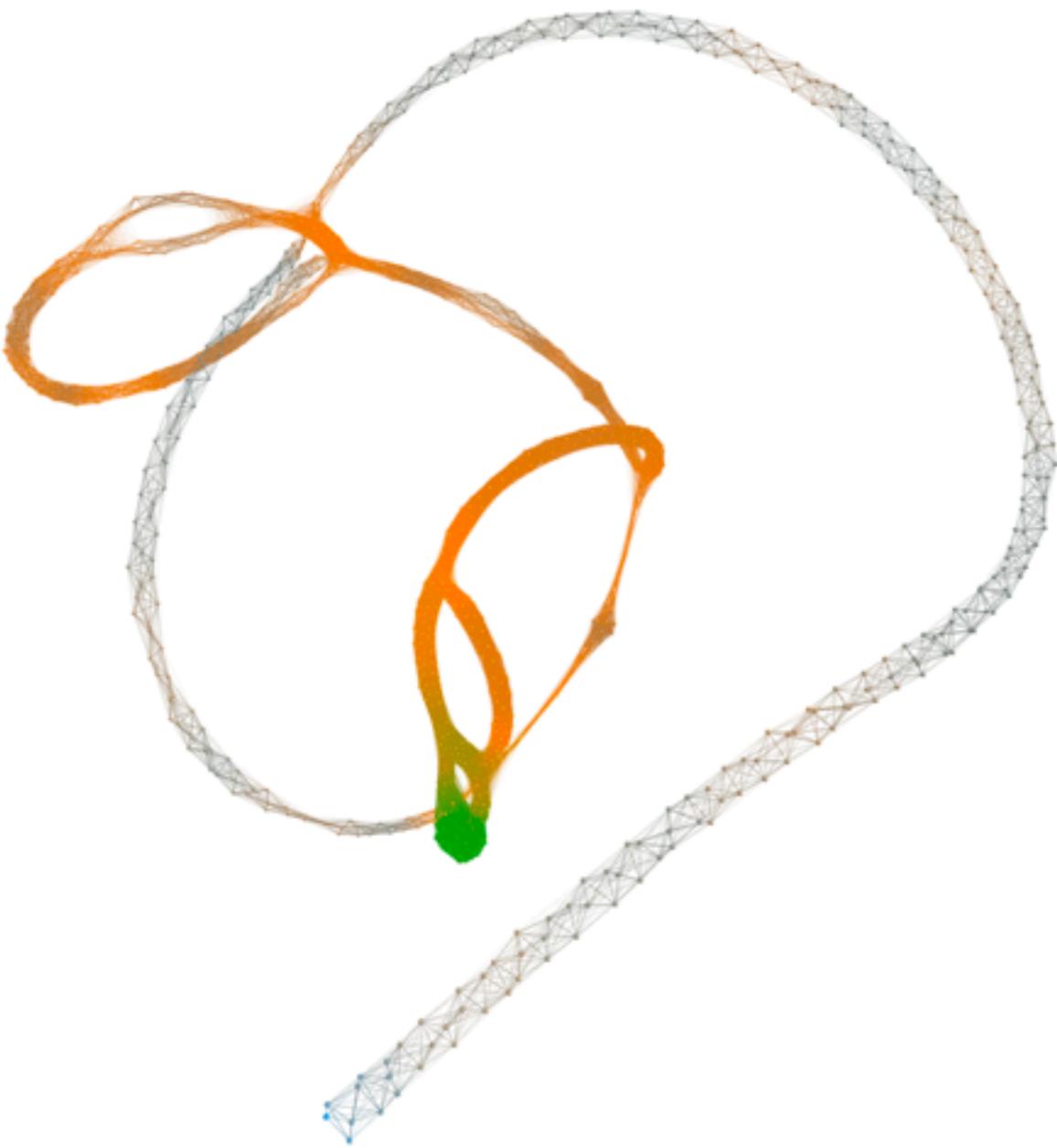
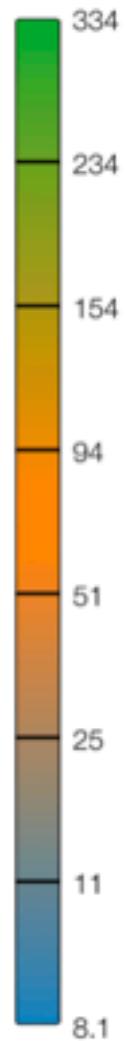


My Girl - The Temptations

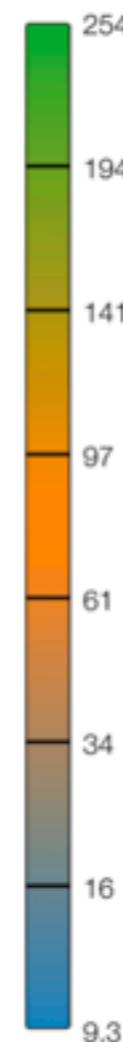


Footloose - Kenny Loggins

Lyrics

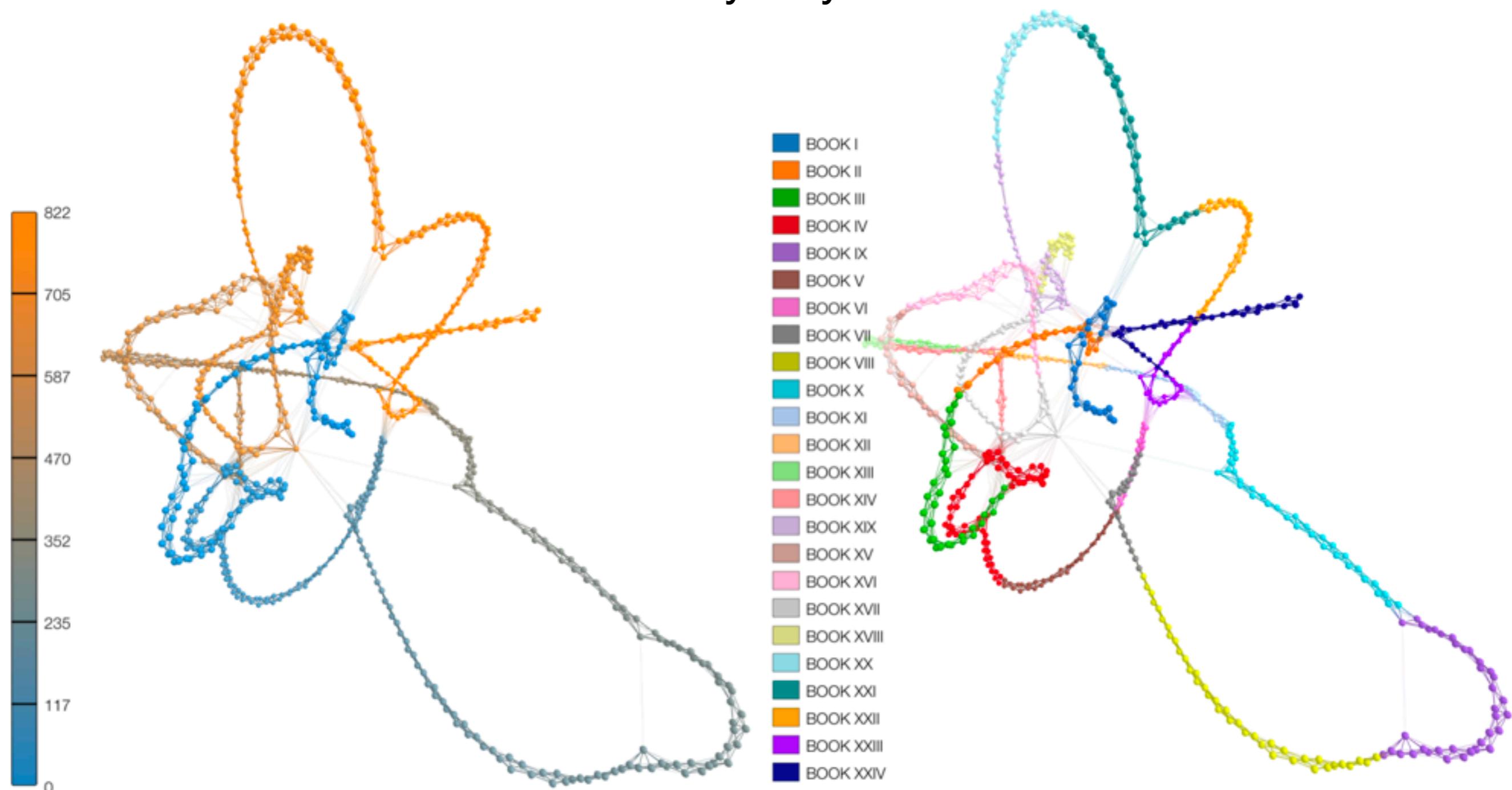


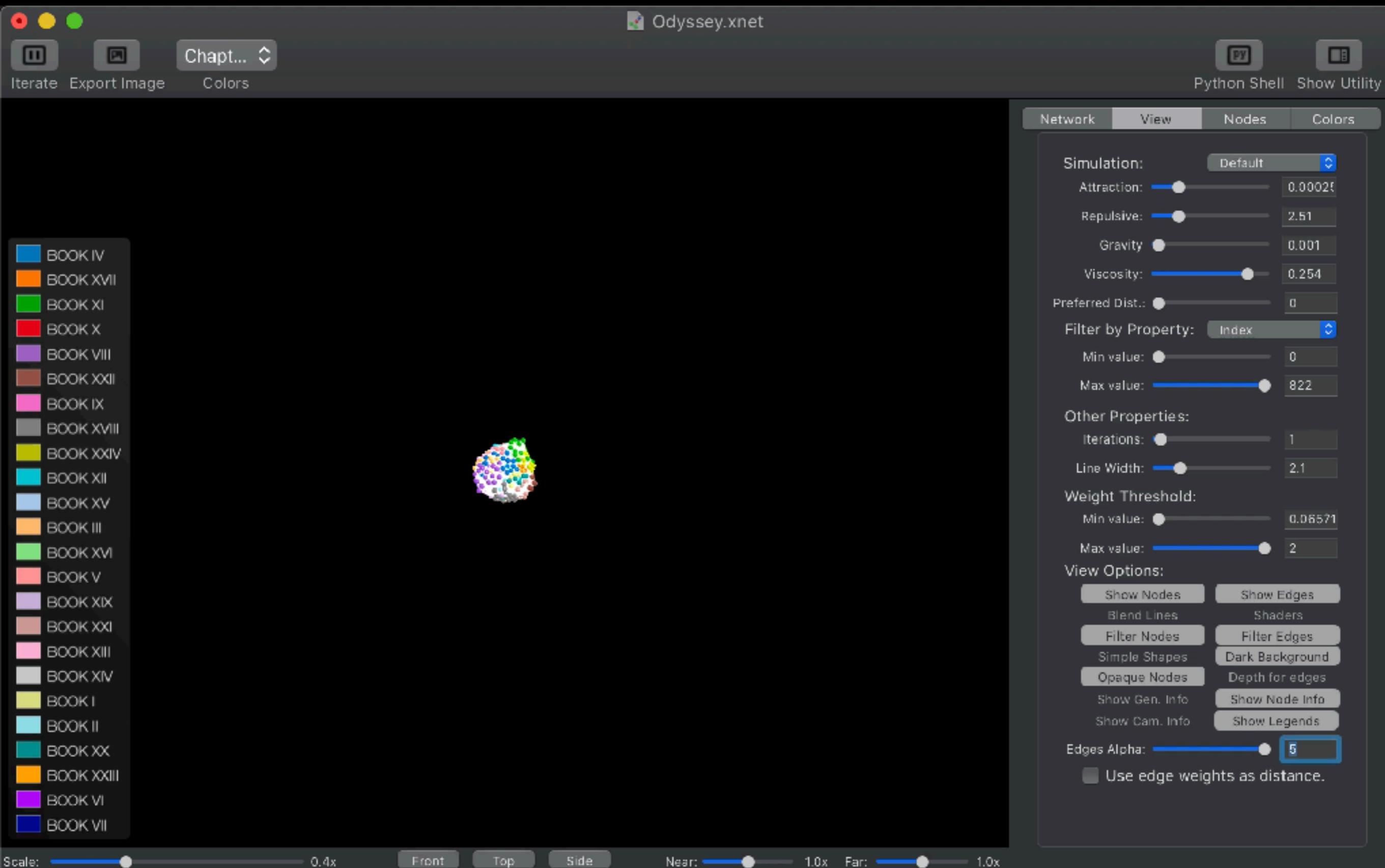
Roar - Kate Perry



Baby - Justin Bieber

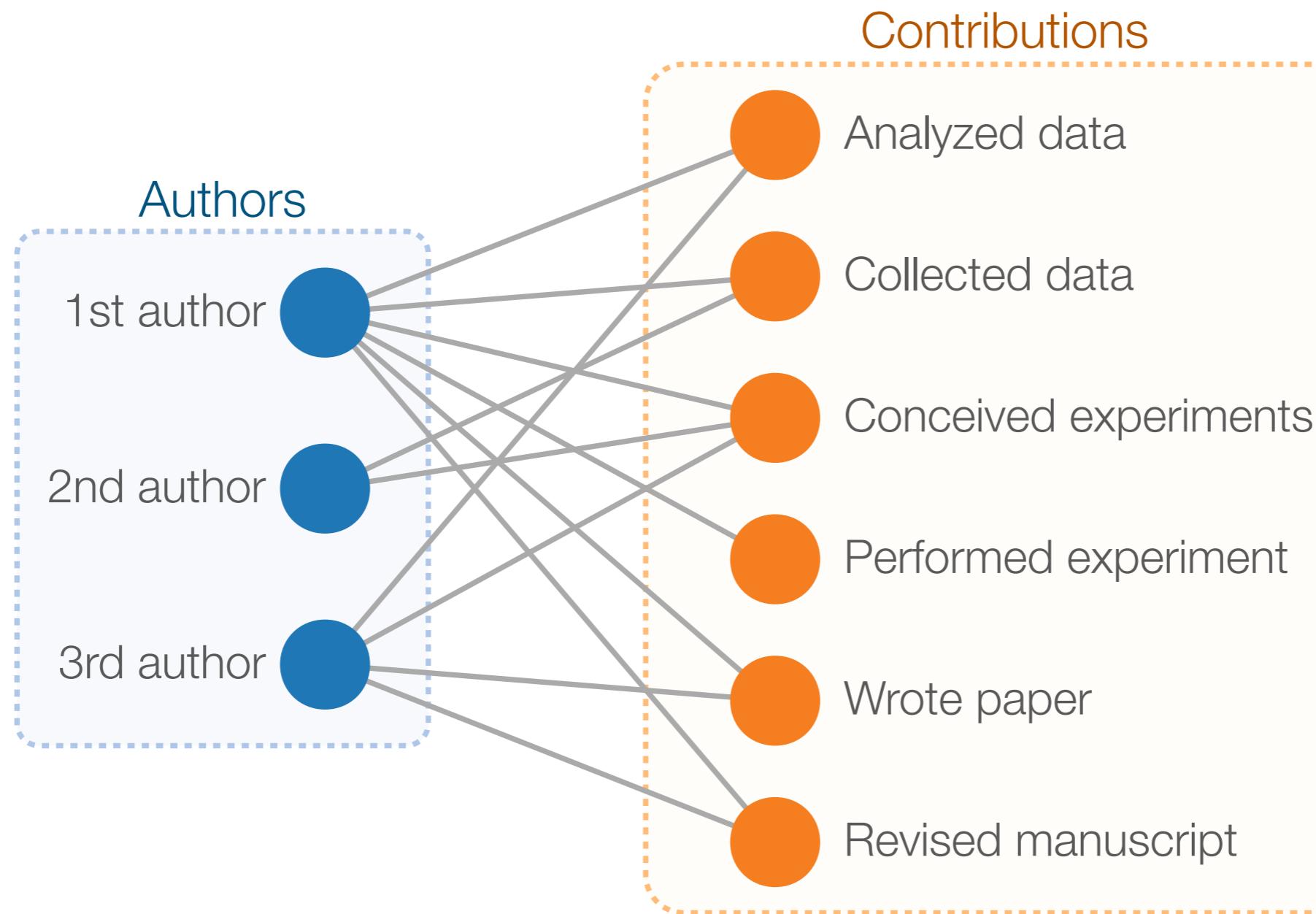
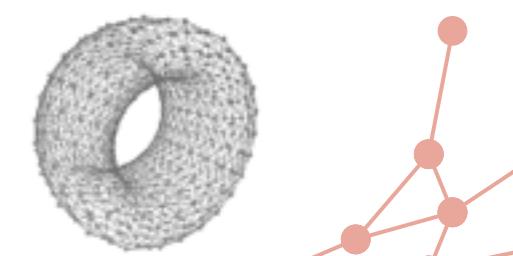
Odyssey





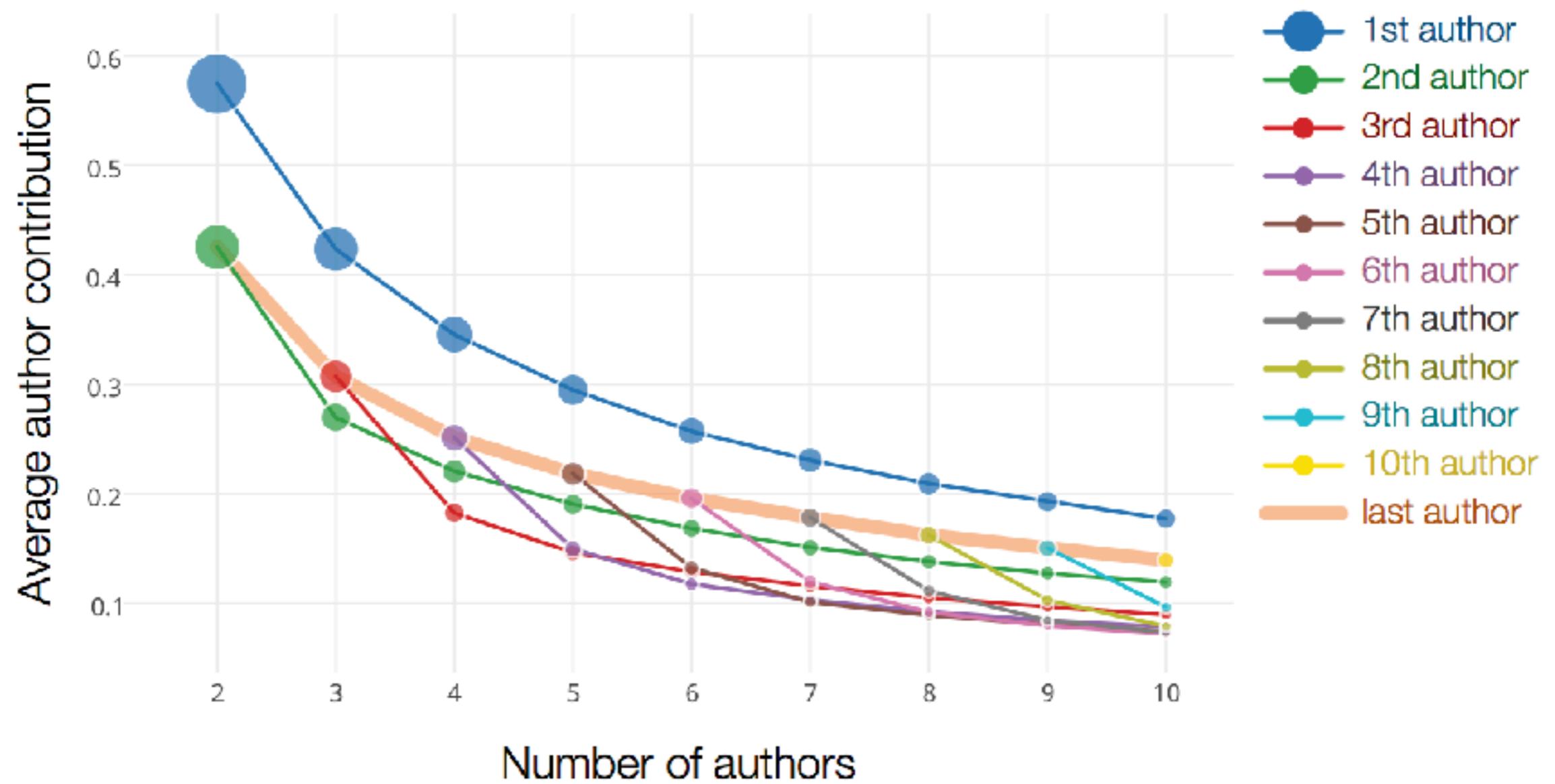
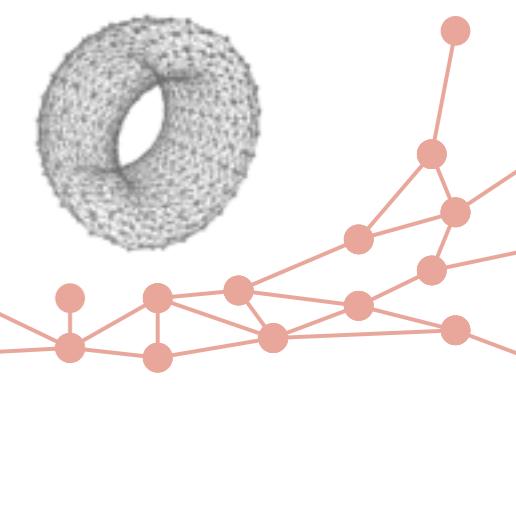
Other applications

Patterns of authors contribution in scientific manuscripts



Other applications

Patterns of authors contribution in scientific manuscripts

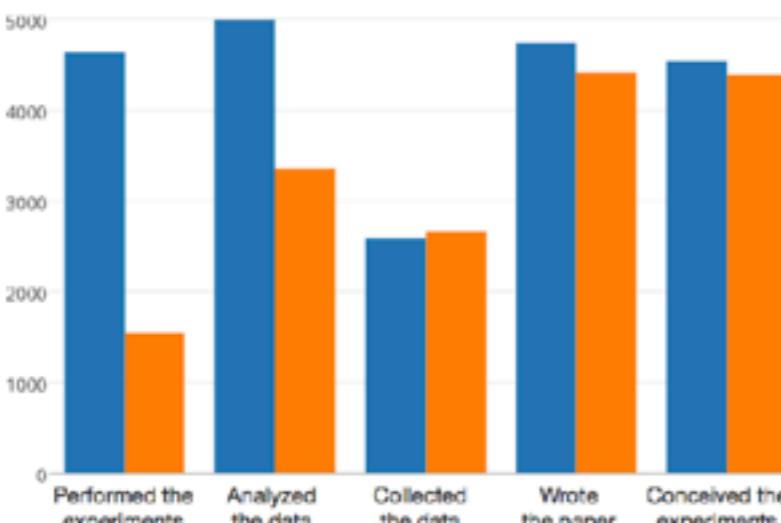
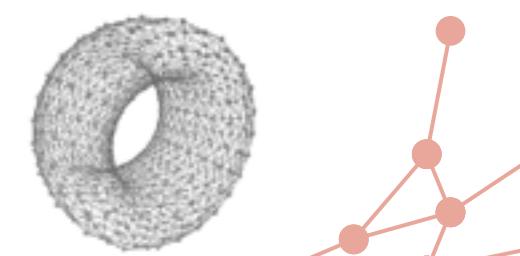


Edilson A. Corrêa Jr., Filipi N. Silva, Luciano da F. Costa, Diego R. Amancio.

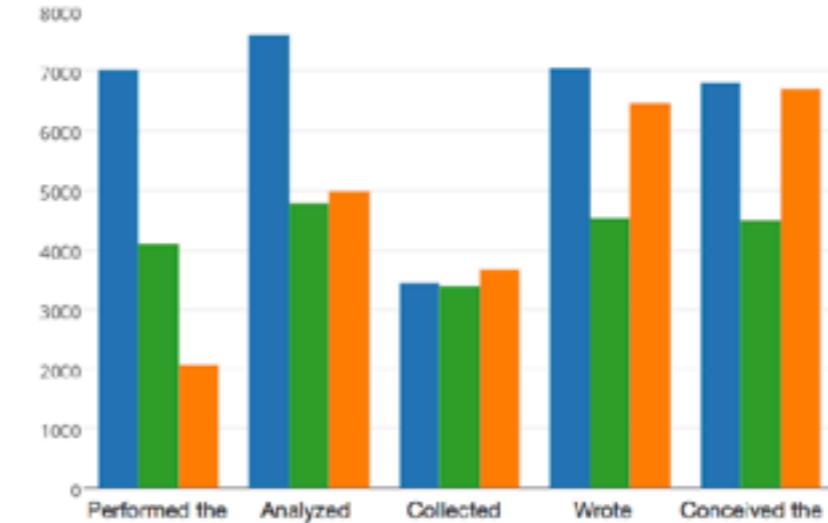
Patterns of authors contribution in scientific manuscripts. 2015 arXiv:1609.05545 [cs.DL]

Other applications

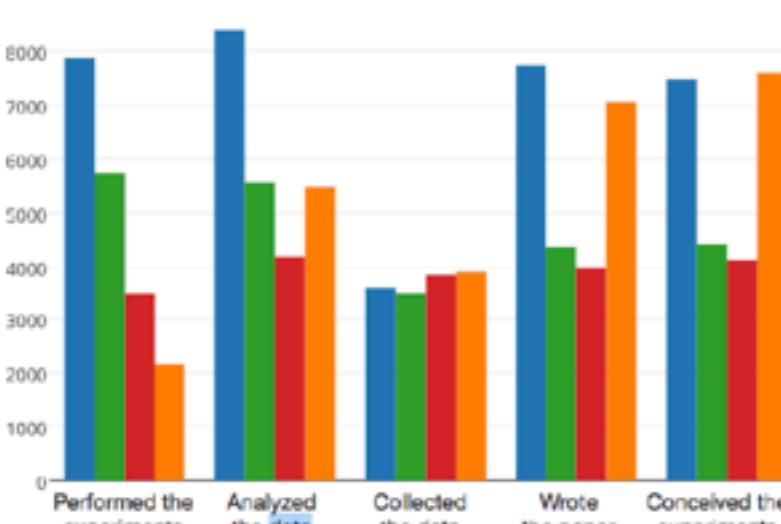
Patterns of authors contribution in scientific manuscripts



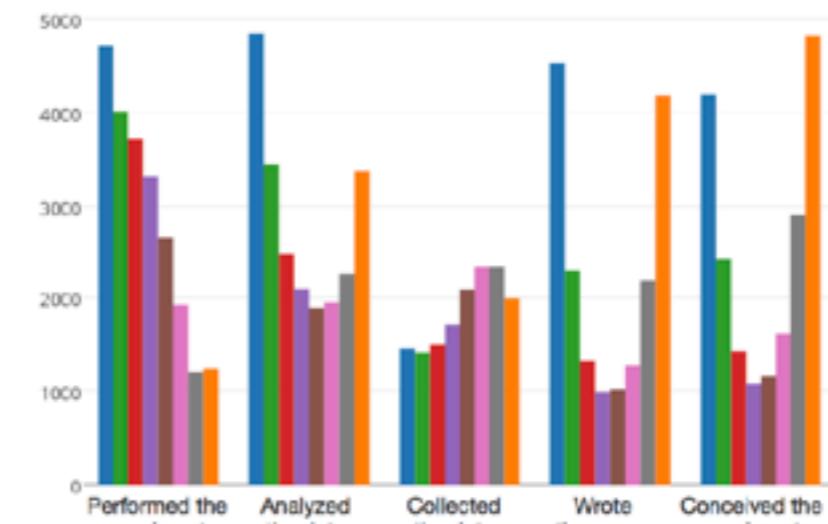
(a)



(b)

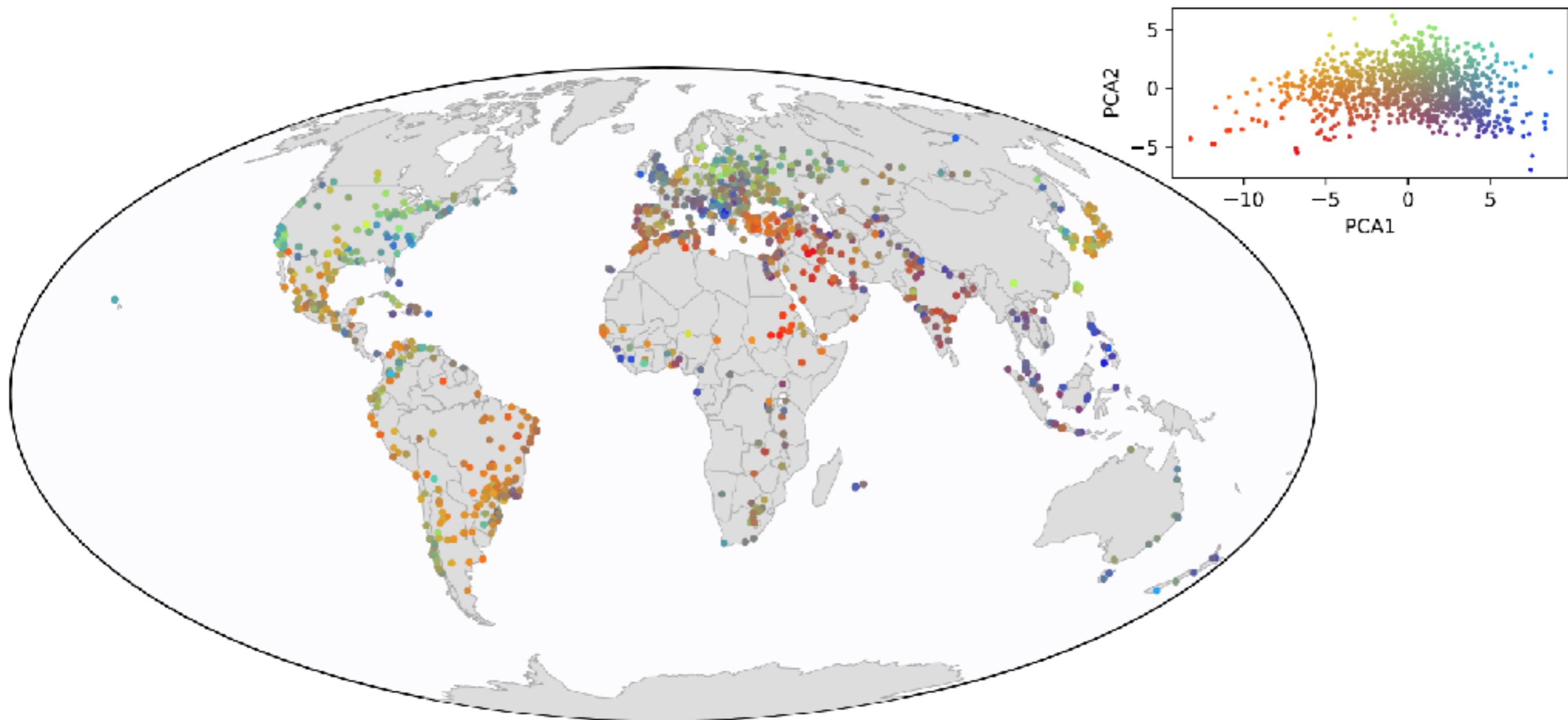


(c)

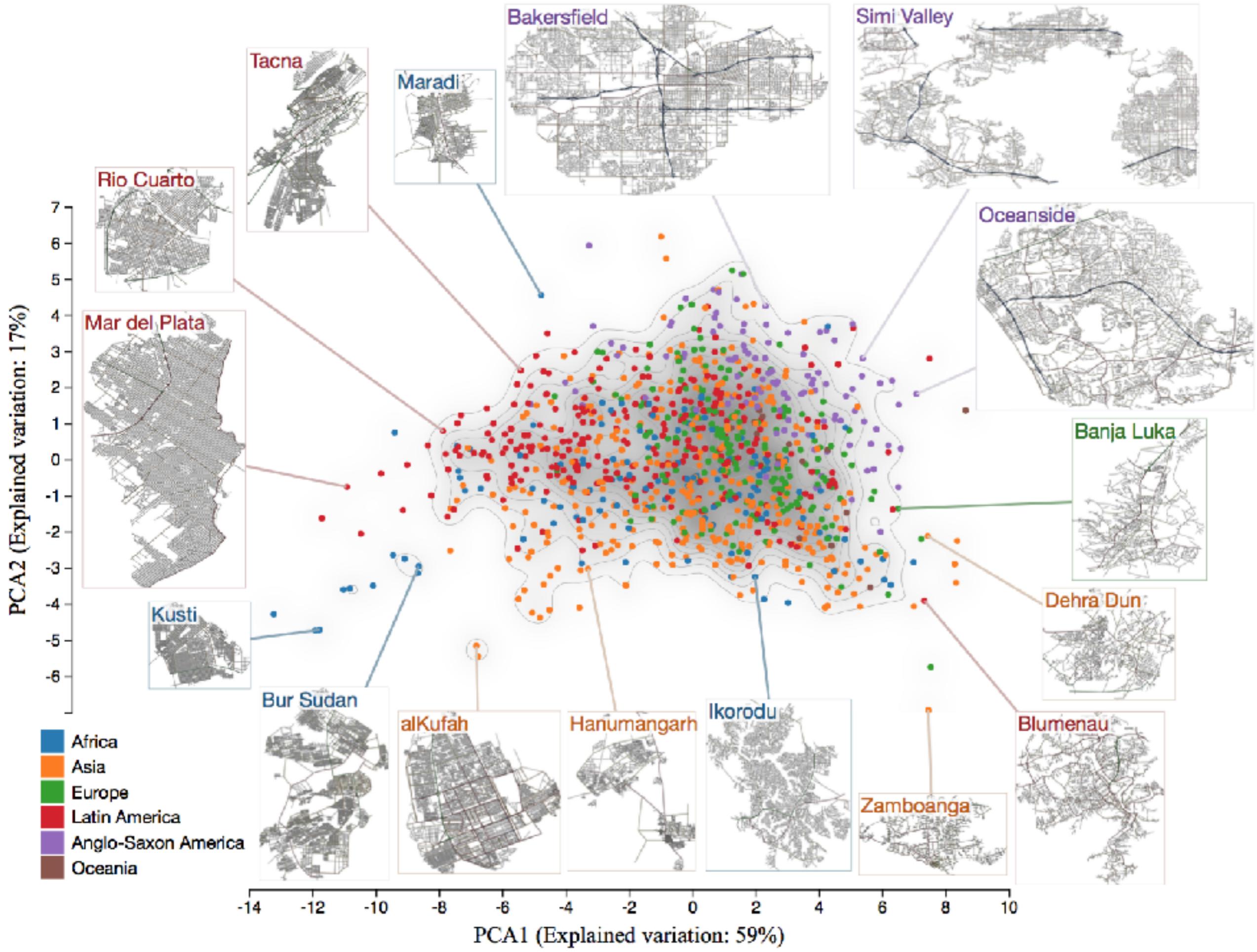


(d)

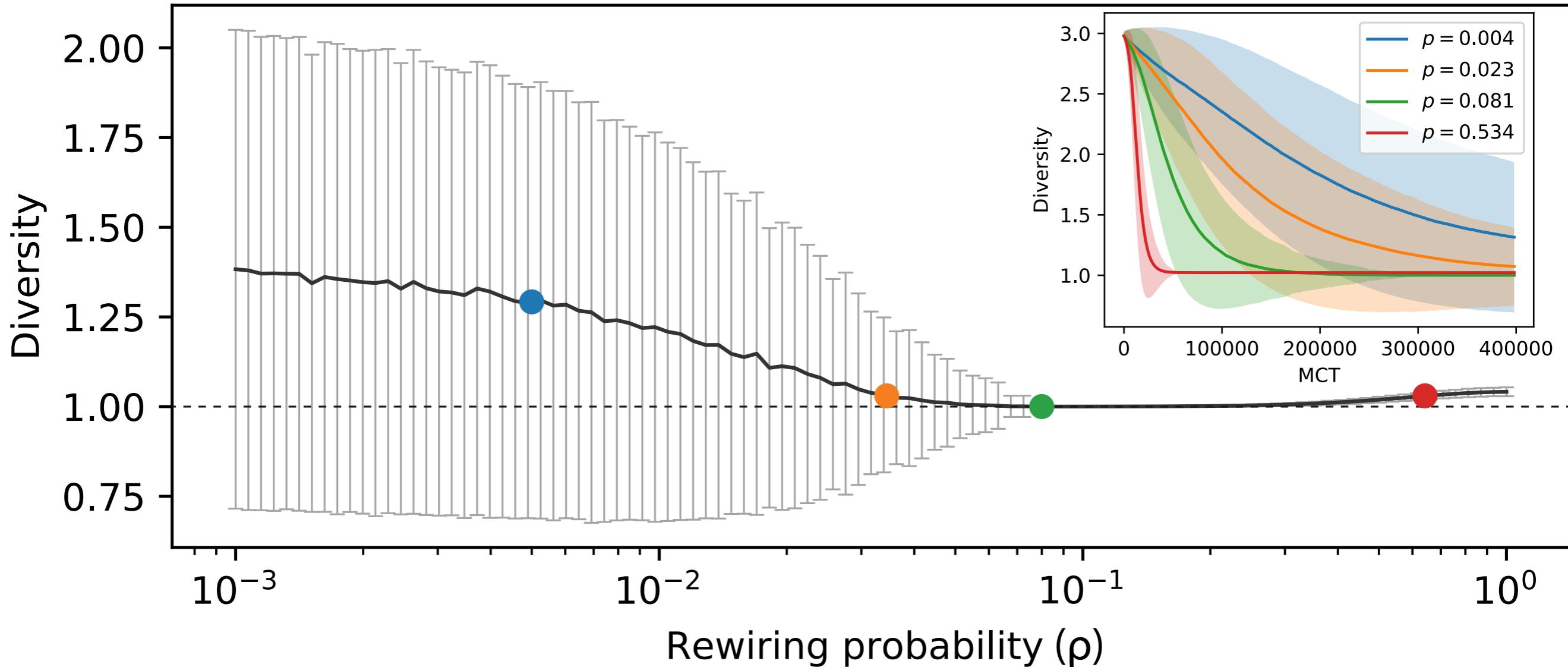
Topological structure of world cities



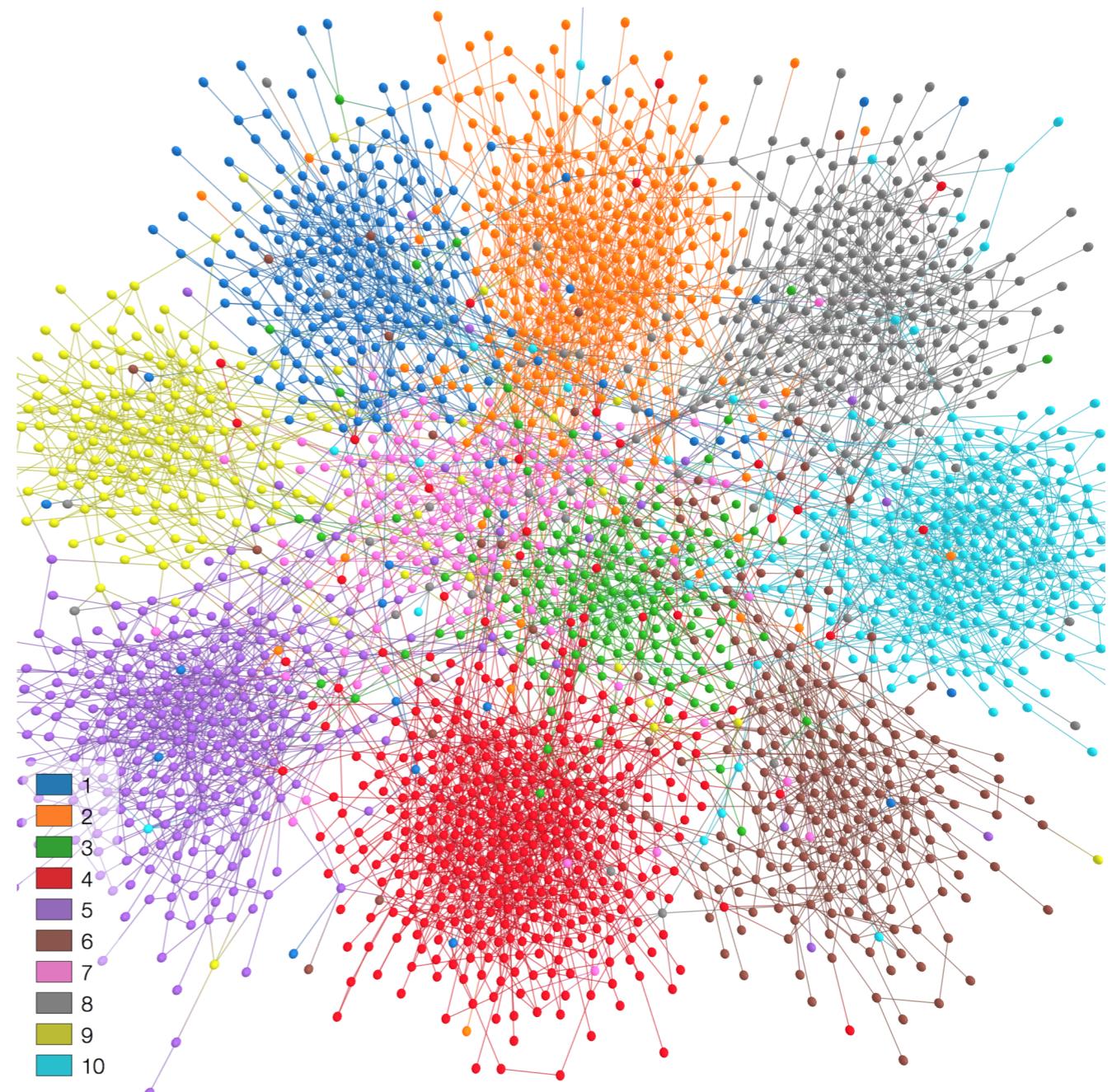
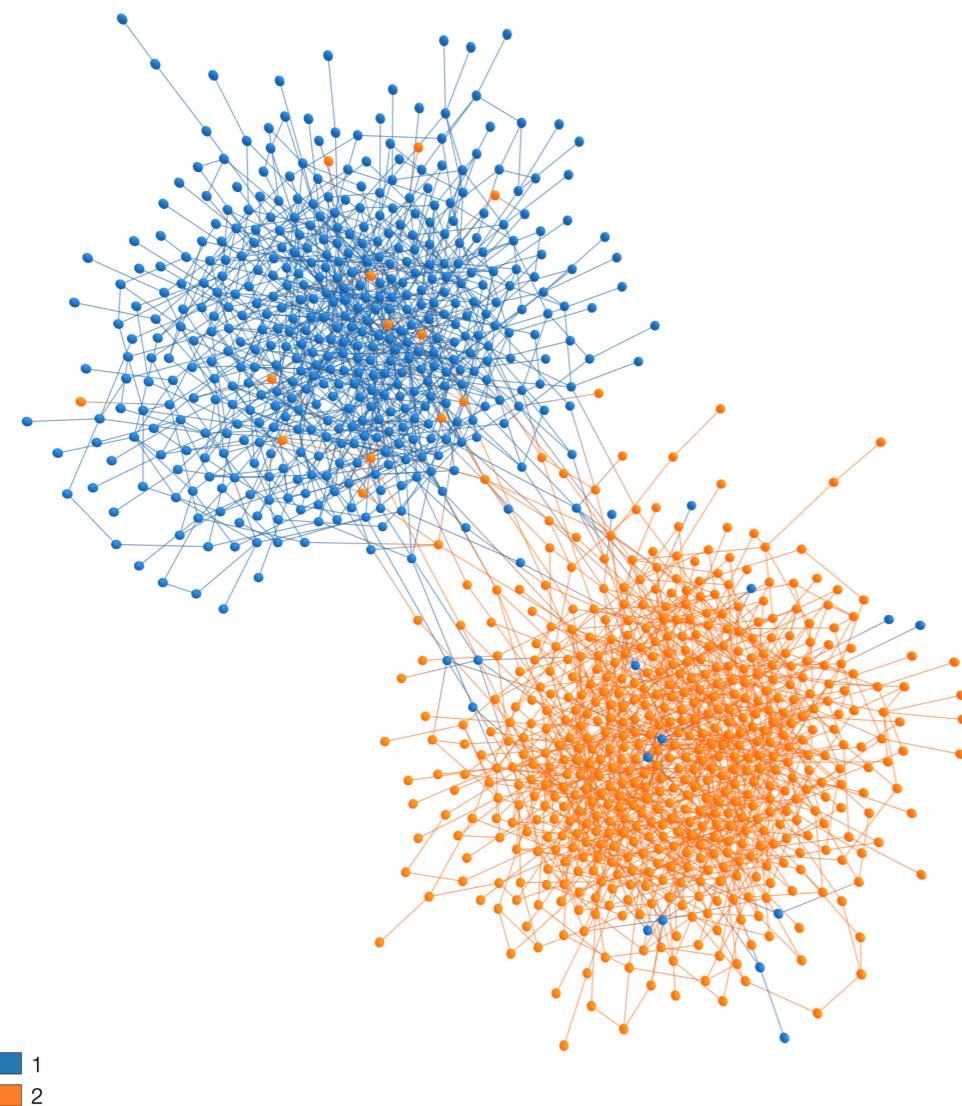
Domingues, G. S., Silva, F. N., Comin, C. H., & da F Costa, L. (2018). Topological characterization of world cities. Journal of Statistical Mechanics: Theory and Experiment, 2018(8), 083212.



Locality vs Diversity (Sznajd dynamics)

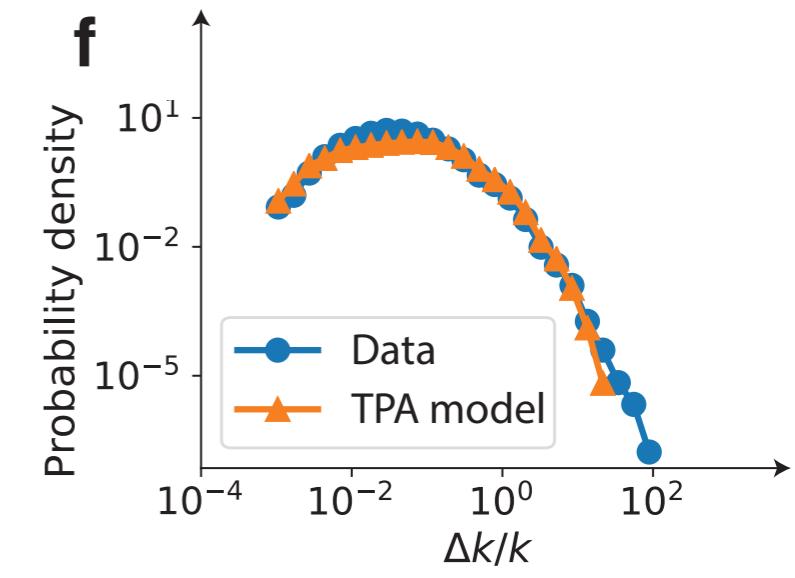
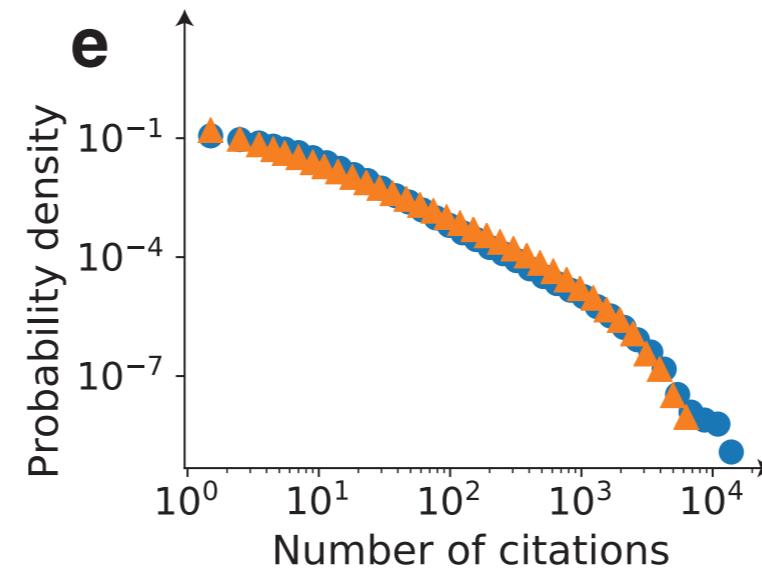
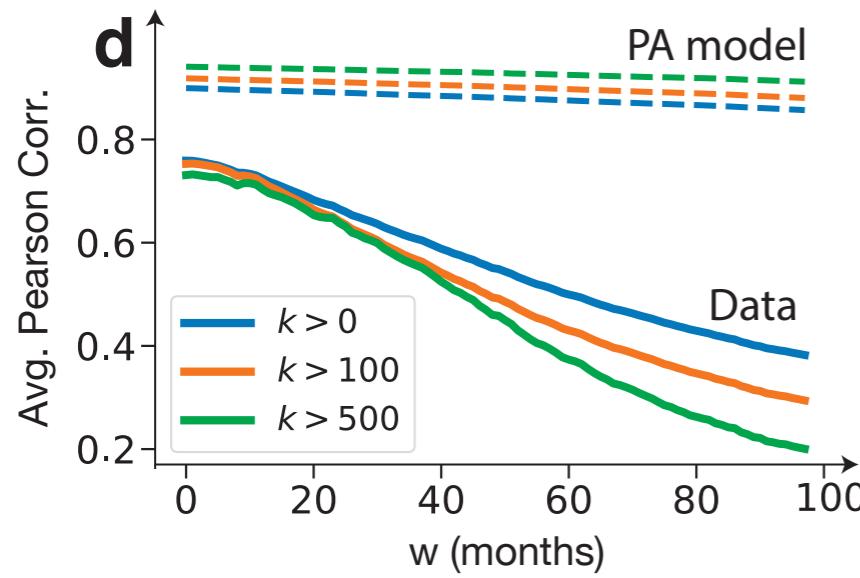
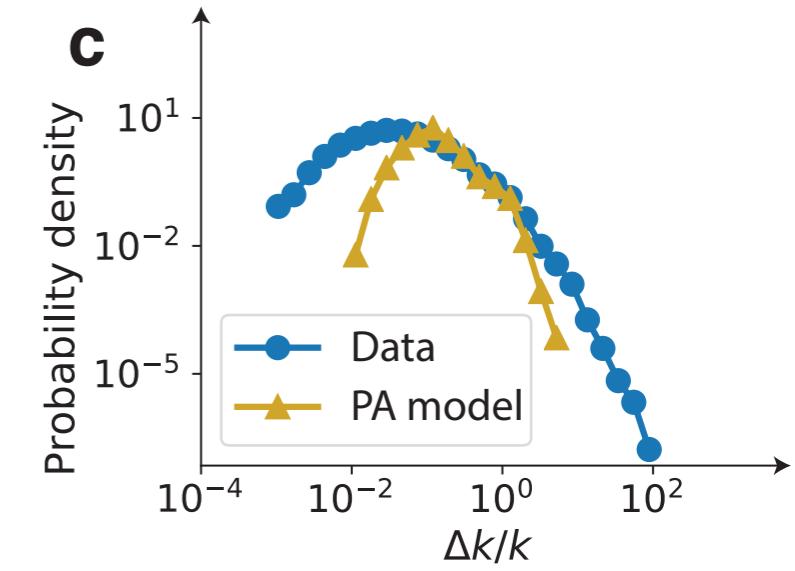
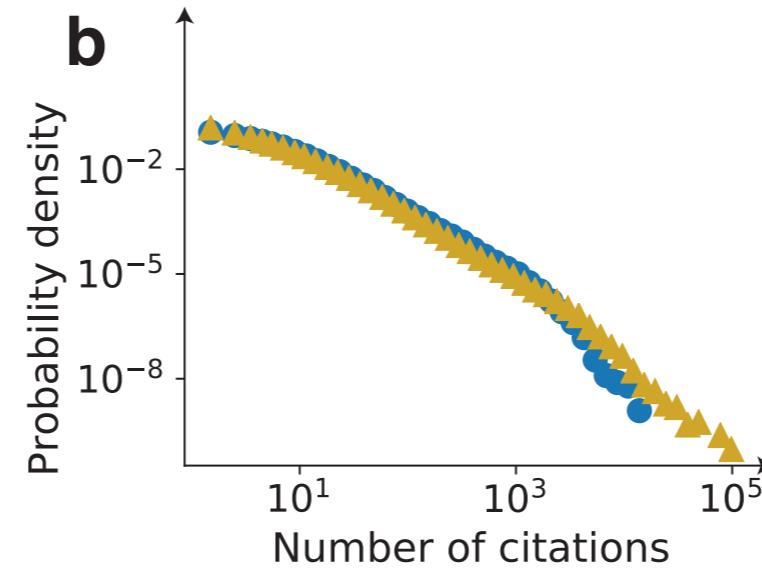
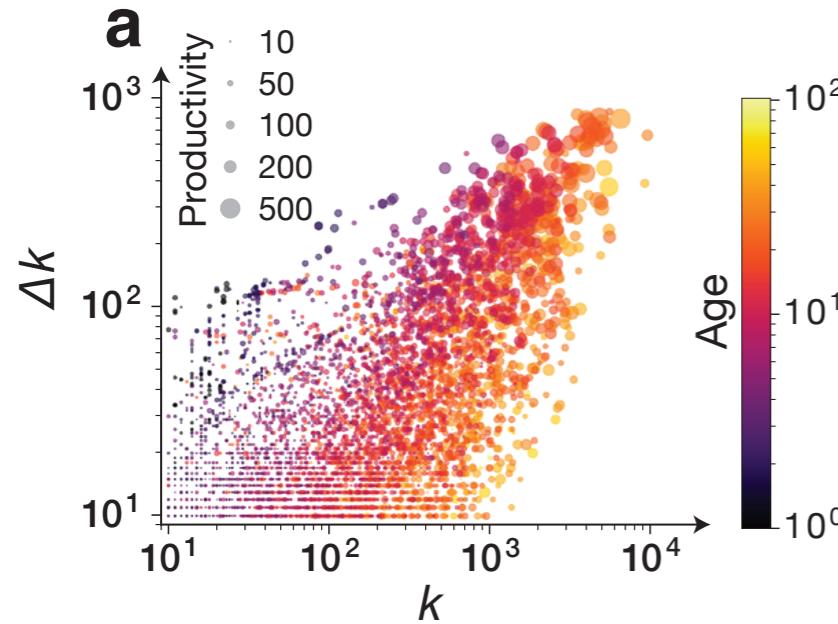


Social Bubbles dynamics using Sznajd Model



Opinion Diversity and Social Bubbles in Adaptive Sznajd Networks
A Benatti, HF de Arruda, FN Silva, CH Comin, LF Costa
arXiv preprint arXiv:1905.00867

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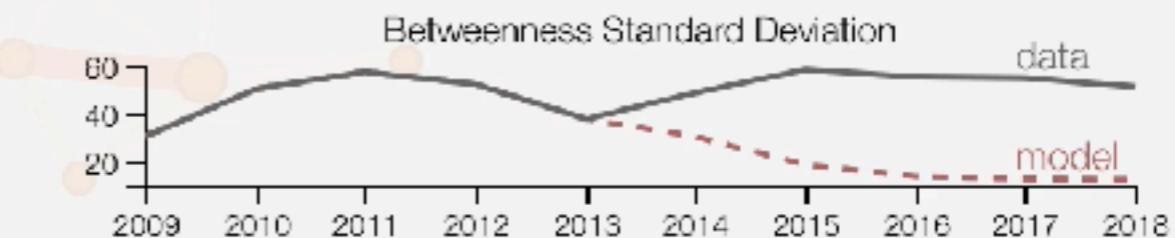
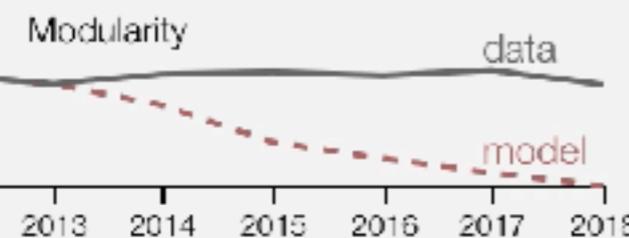
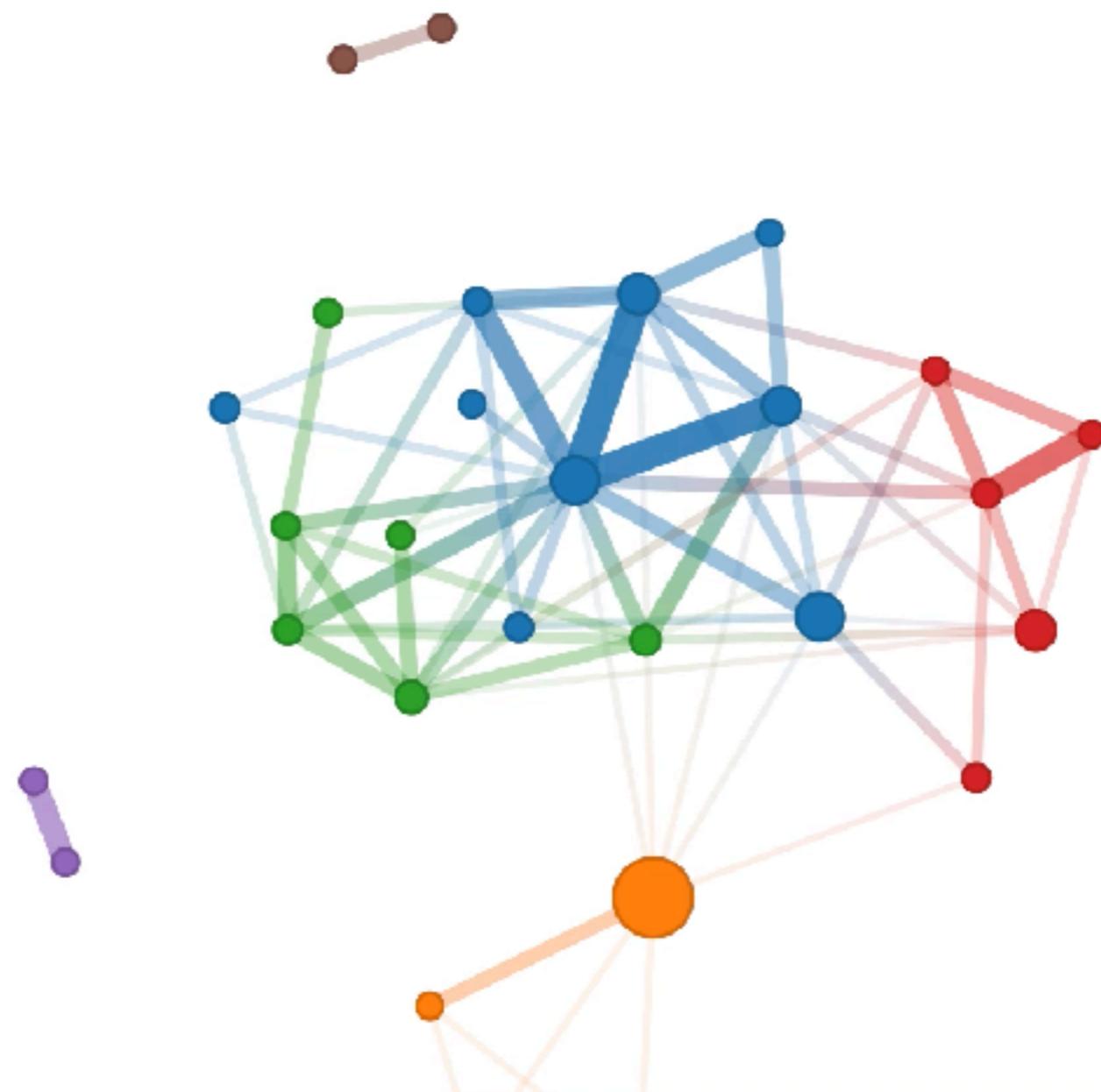
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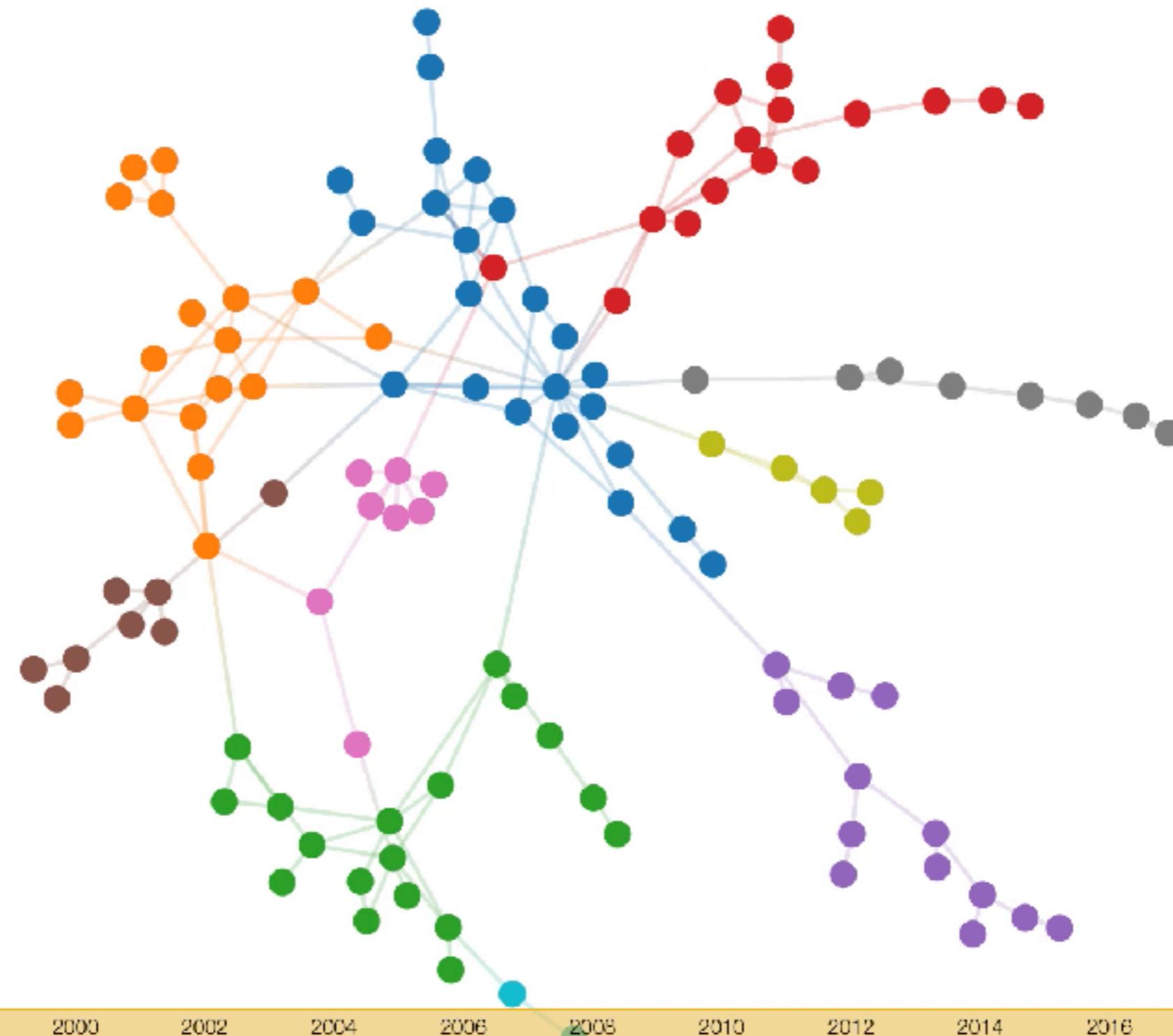
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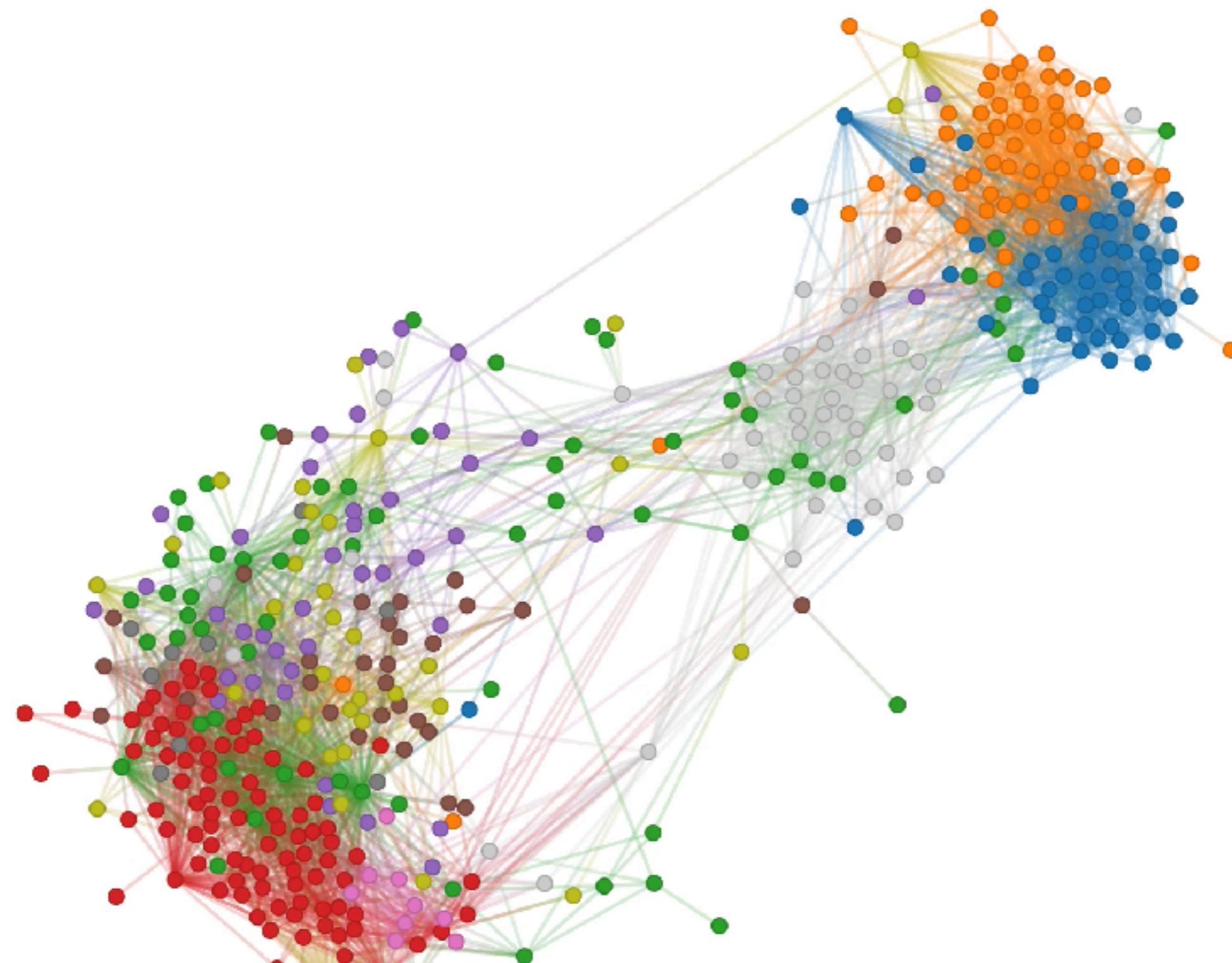
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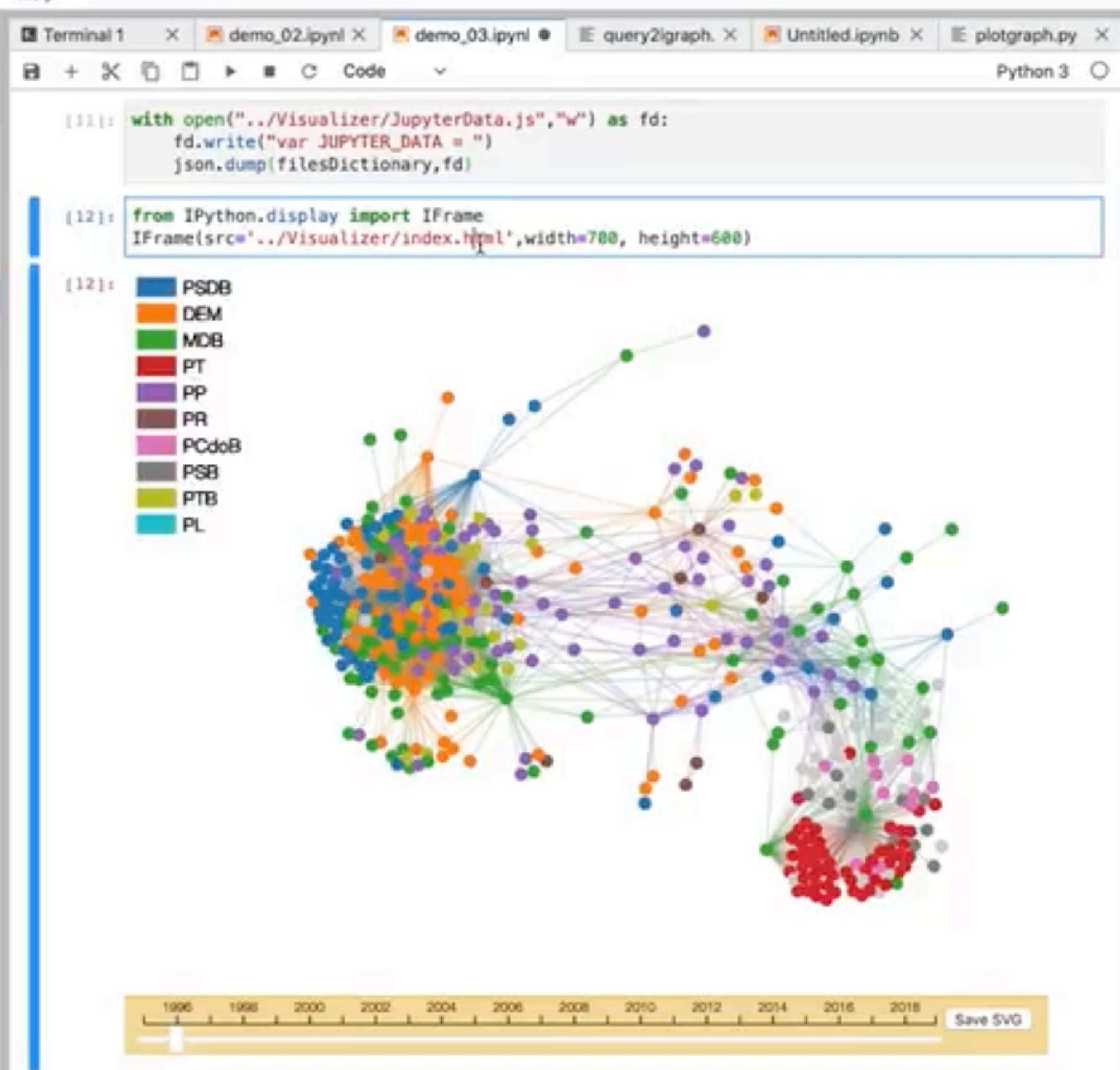
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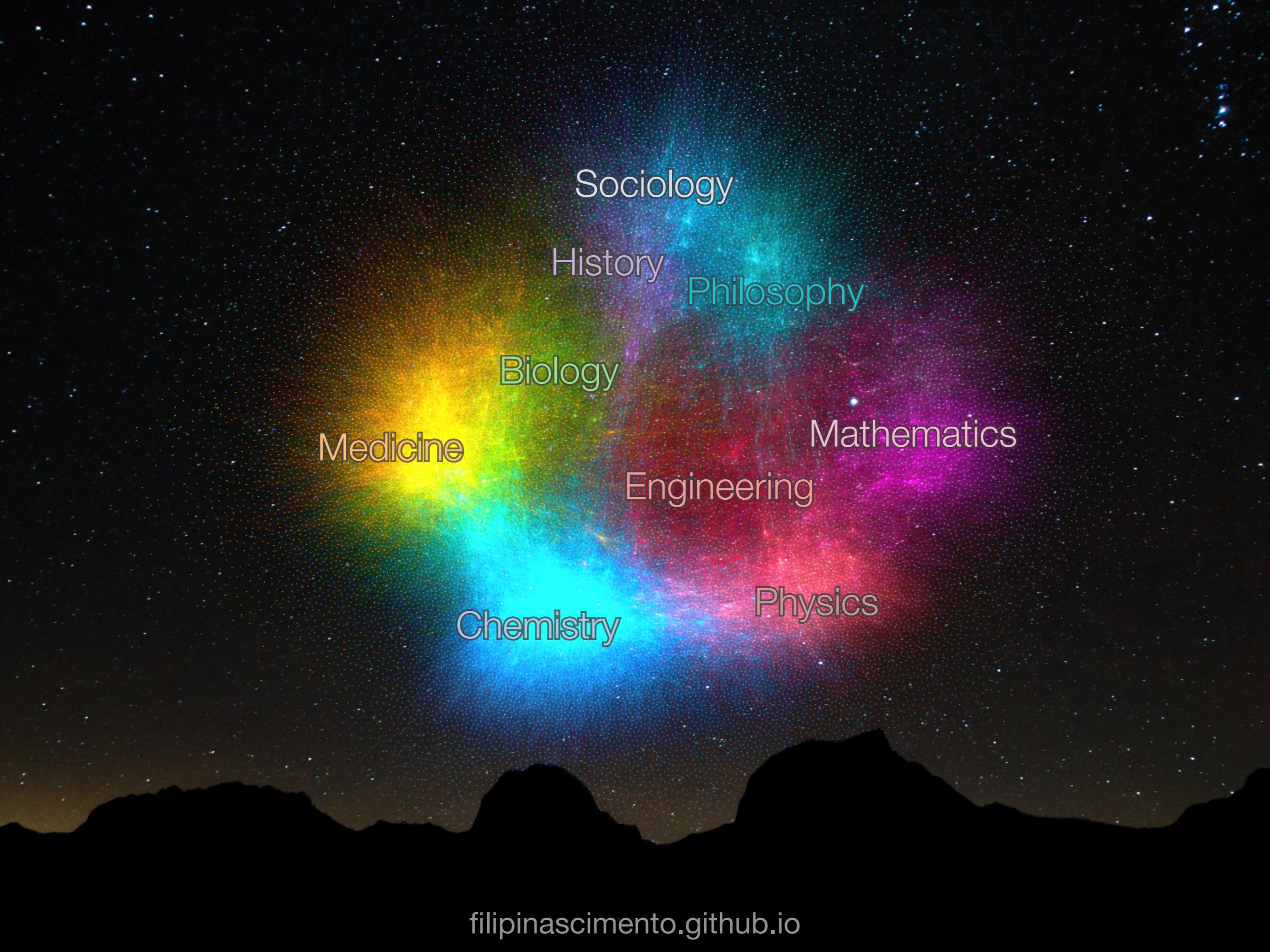


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