Advanced Computational Science

Articulation Points in Multiplex Networks

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January 2023

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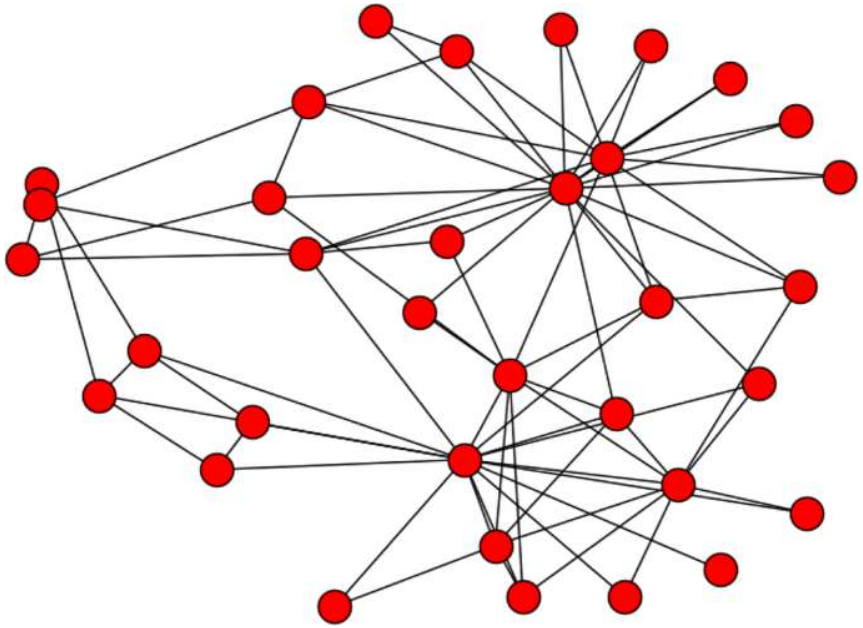
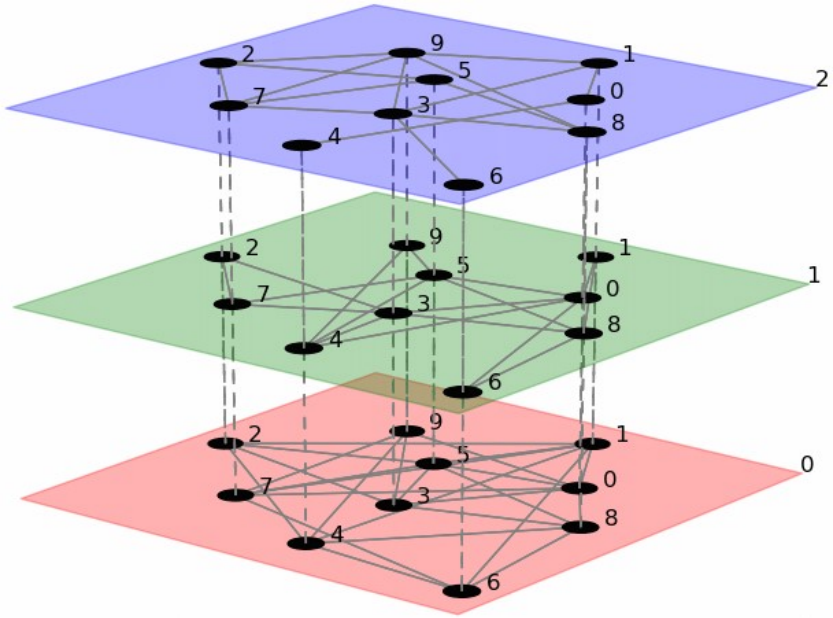
Introduction. Networks



Simple network



Multiplex network

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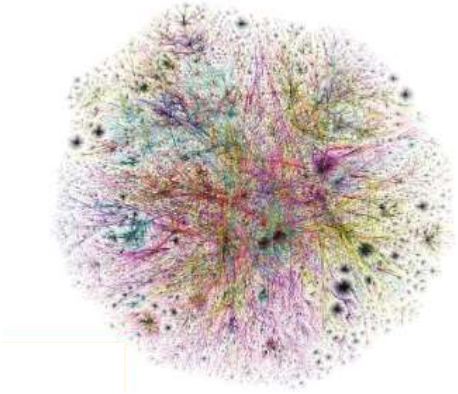
Introduction. Networks

Social Network

The topology of the Internet



Multiplex network examples

Transport
- Underground layer
- Bus layer

Social
- Twitter layer
- LinkedIn layer

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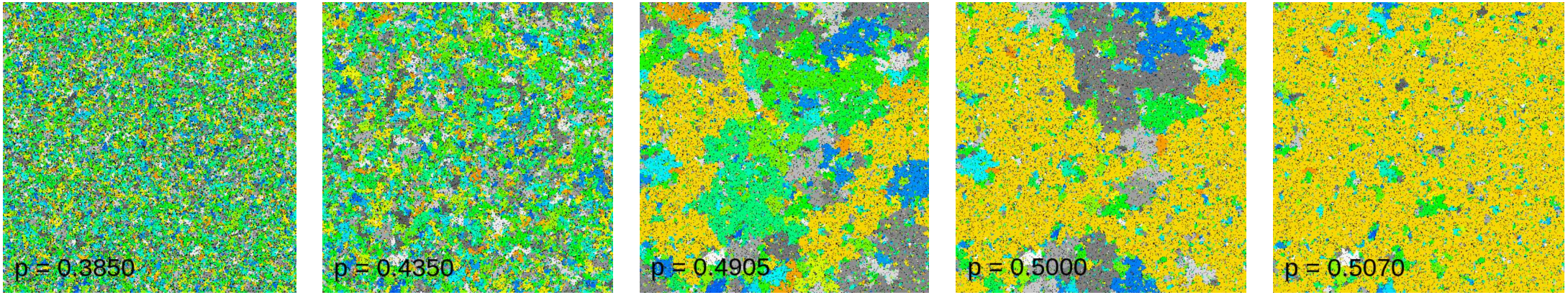
Introduction. Percolation



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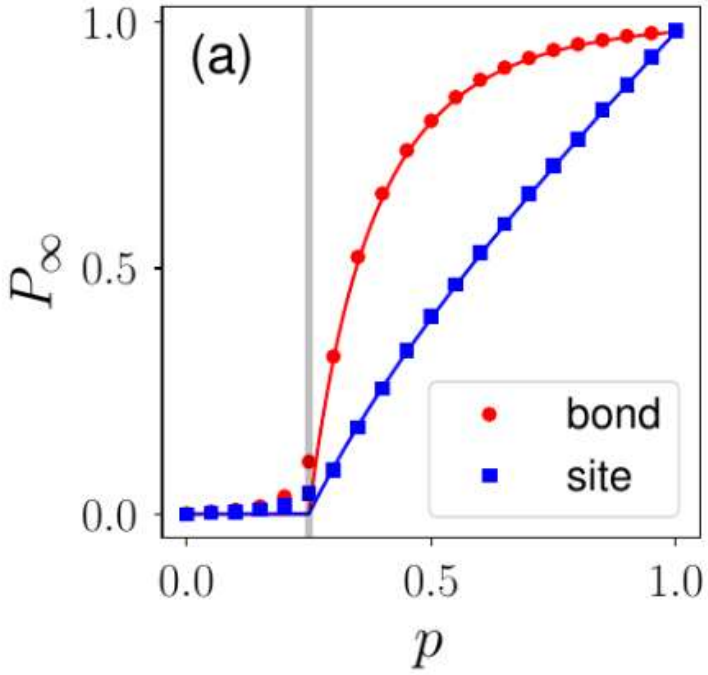
Introduction. Percolation

Monoplex case: probability of the giant component to exist vs. p, if $1 - p$ fraction of nodes are removed



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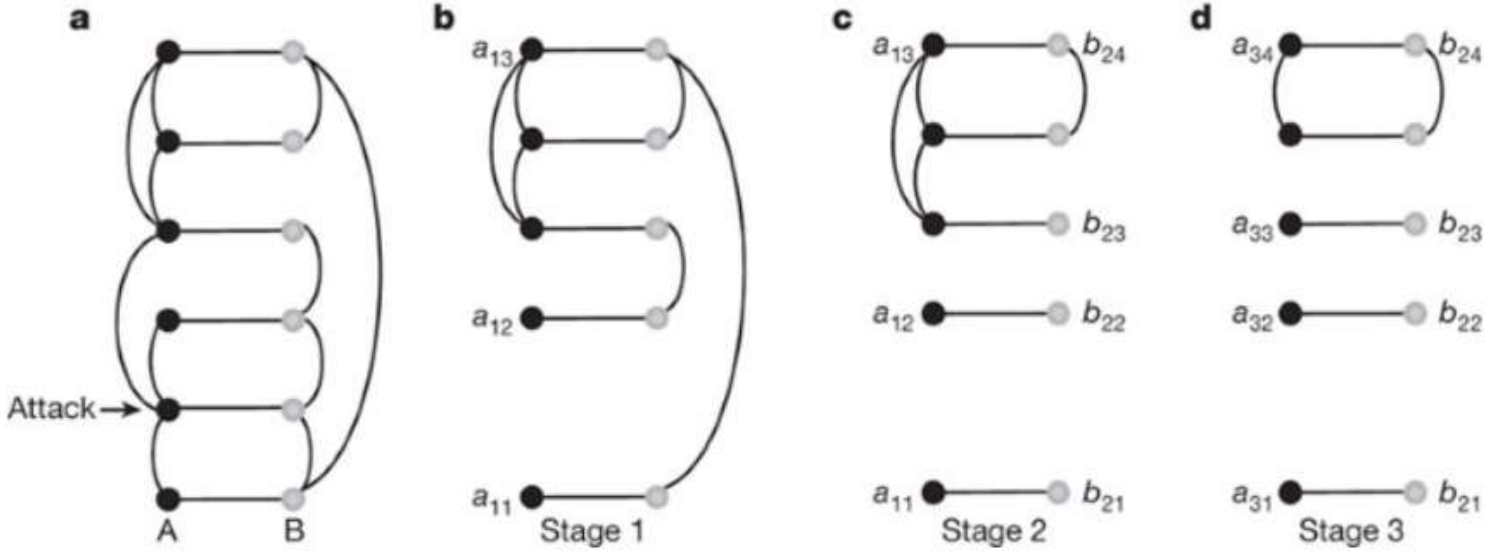
Introduction. Percolation



Buldyrev, Sergey V., et al.
Nature 464.7291 (2010): 1025-1028

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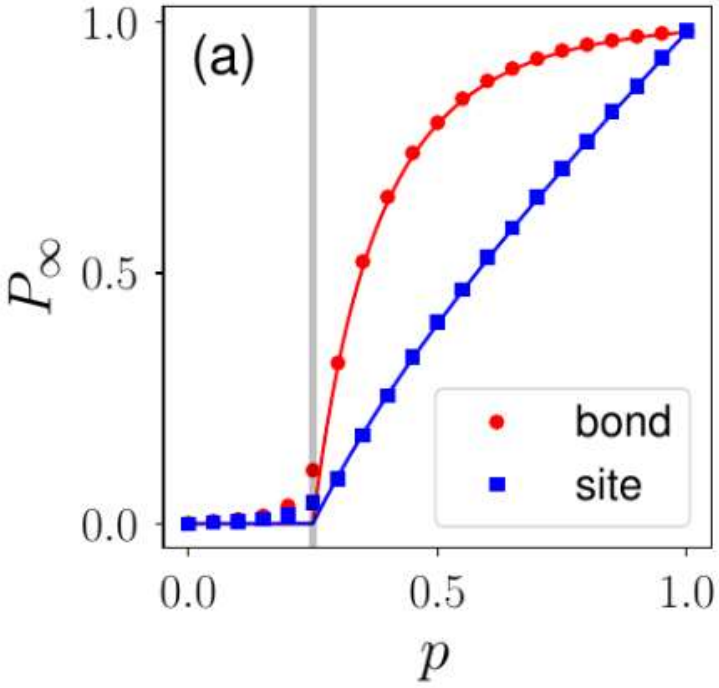
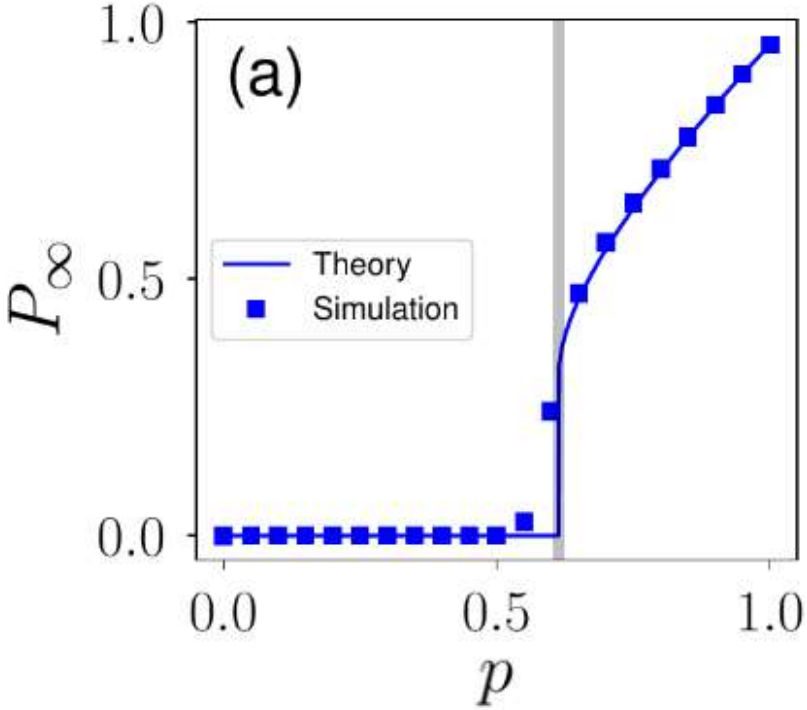
Introduction. Percolation



Monoplex case



Multiplex case

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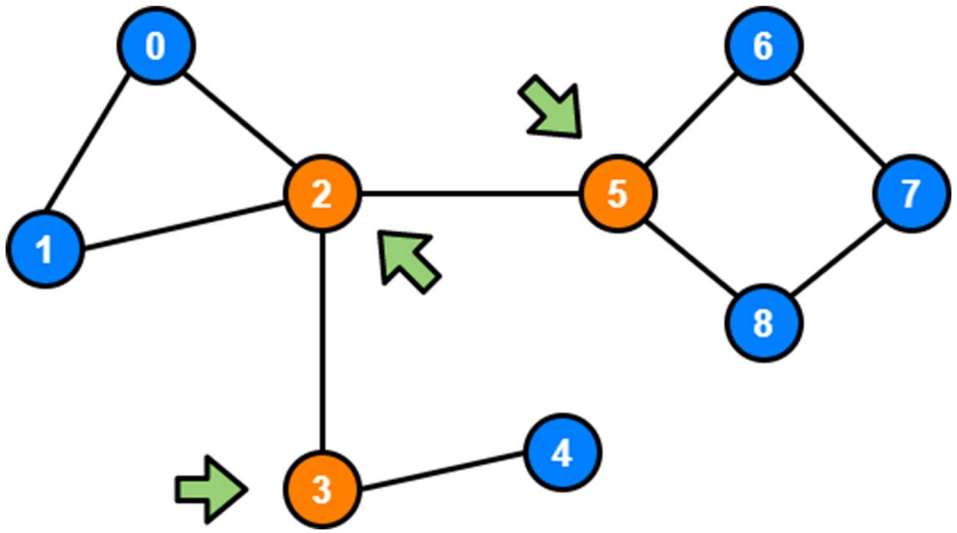
Introduction. Articulation points



Articulation points (AP)

An articulation point (AP) is a node whose removal disconnects the graph

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Aim

Study of articulation points in multiplex networks

Study the difference in behavior (network dismantling, network attacks, node failure) between simple and multiplex cases

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Objectives

1. Reproduce the results for simple networks
2. Study APs in Erdős–Rényi multiplex networks
3. Study APs in configuration networks
4. Check the statistics of real-world multiplex networks

Erdős–Rényi network, configuration network are common types of a random graph

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Algorithms and methodology

1. Generation of a set of networks from a certain distribution
2. Application of cascade of failures
3. Obtaining AP metrics (fraction)

Simulations in Python using NetworkX library for graph manipulation

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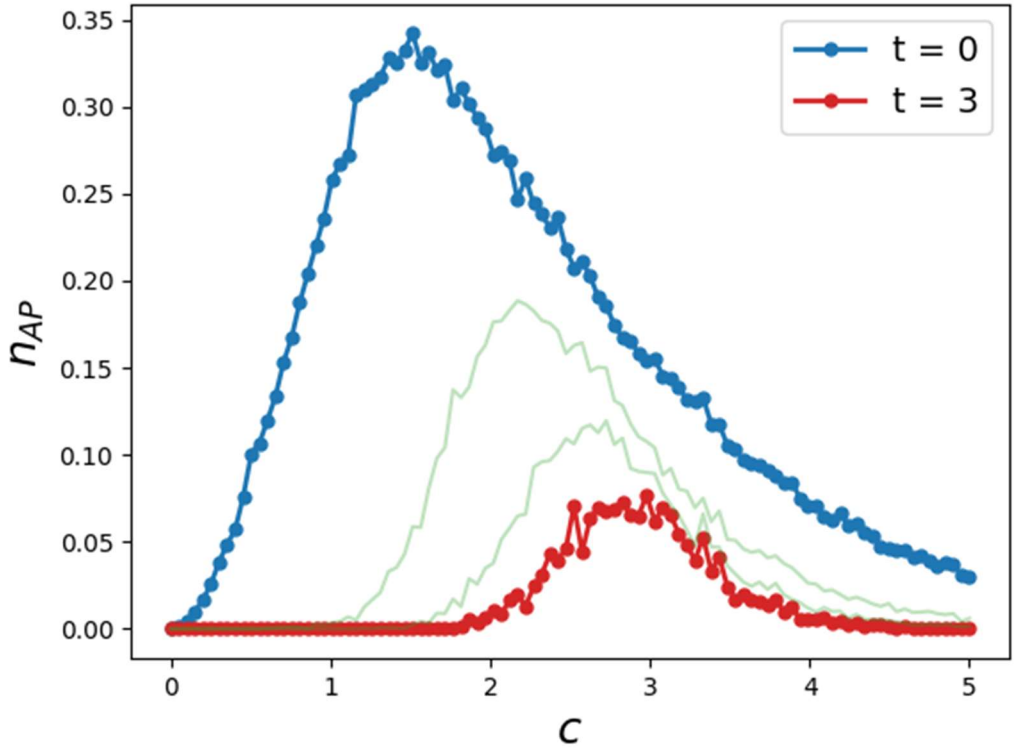
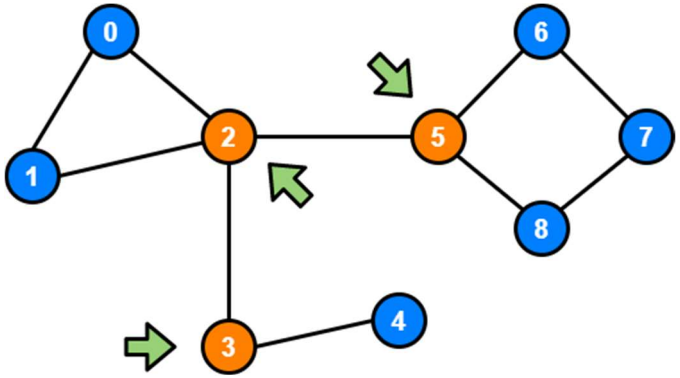
Results. Monoplex network

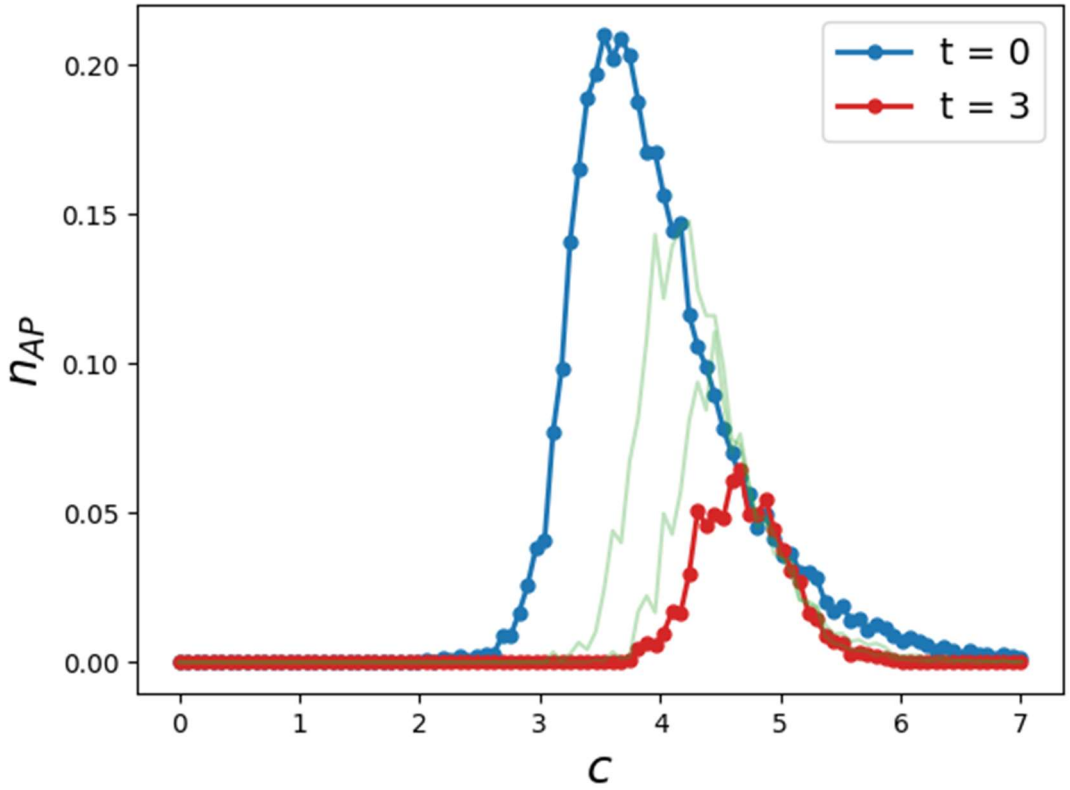


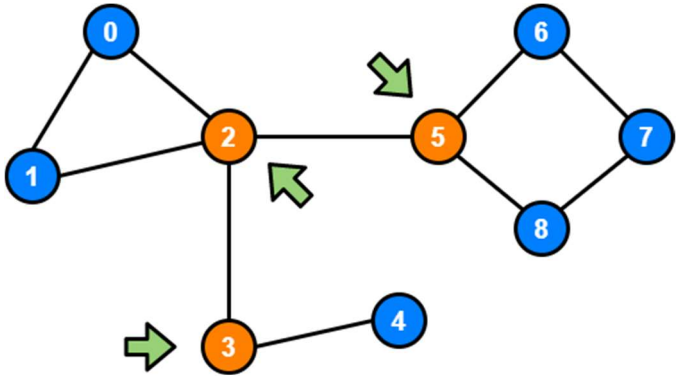
Fraction of articulation points in Erdős–Rényi (ER) monoplex network. c is the mean degree of the network nodes.



Review: Tian, L. et al. Articulation points in complex networks. Nat. Commun. 8, 14223 doi: 10.1038/ncomms14223 (2017).

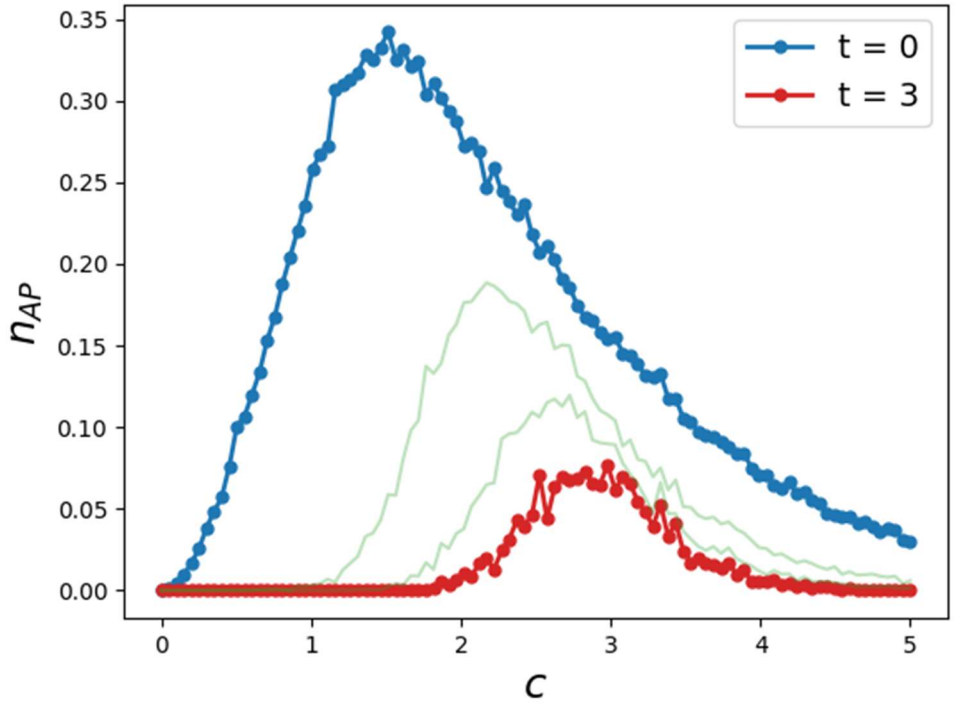
Results. Multiplex network



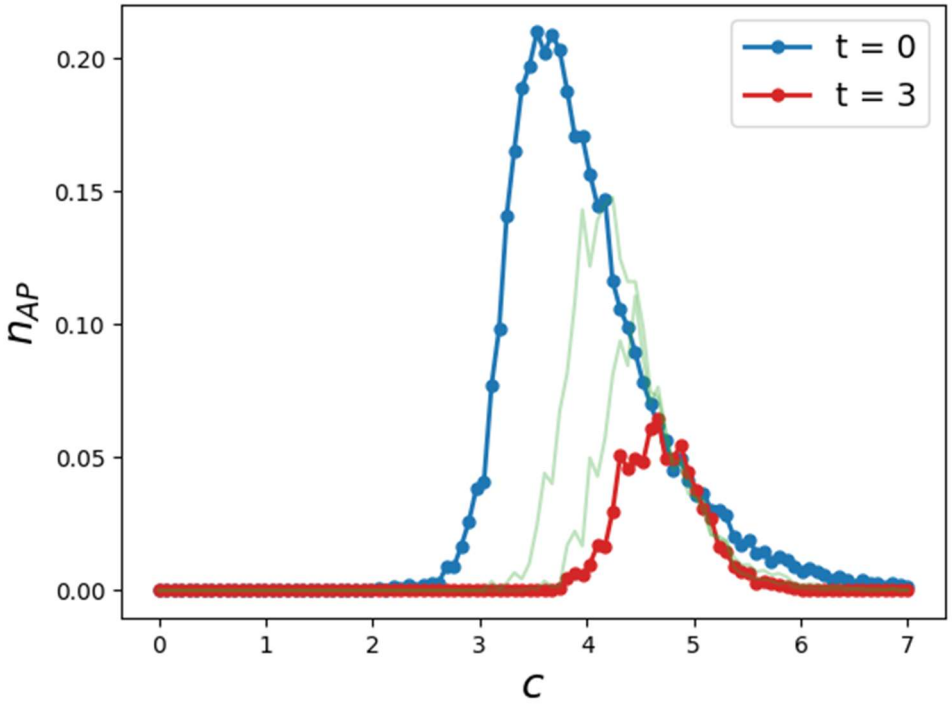


Fraction of articulation points in Erdős–Rényi (ER) two-layer network. c is the mean degree of the network nodes.

Results



Monoplex case



Multiplex case

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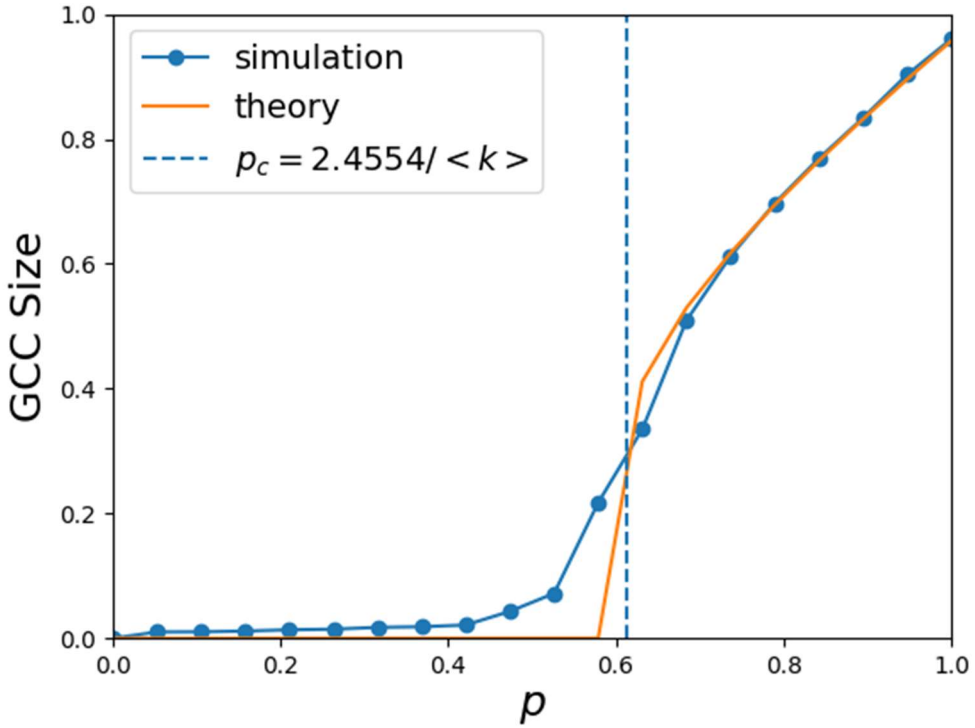
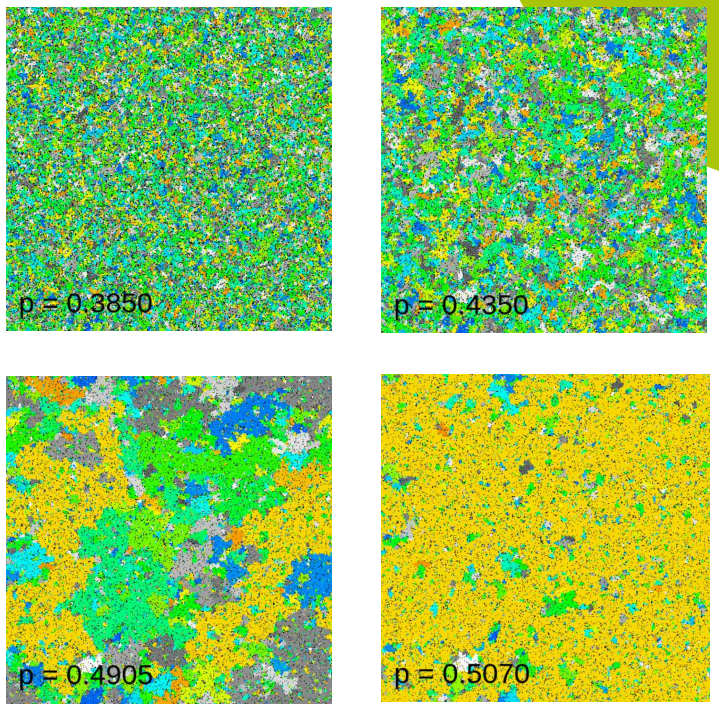
Results



Size of the Giant Connected Component (GCC) that is left after a cascade of node failures in a two-layer ER network. p is the fraction of nodes that are left after the first failure



Review: Buldyrev, S., Parshani, R., Paul, G. et al. Catastrophic cascade of failures in interdependent networks. Nature 464, 1025–1028 (2010). https://doi.org/10.1038/nature08932

Discussion and conclusions

1. For monoplex networks, results agree with previous studies and theoretical predictions

2. For multiplex networks, we see the change in the fraction of APs because of the cascading behavior

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Current status and outlook

Literature review has been the main focus so far.
A number of published results reproduced.
Initial results on multiplex networks.

Next steps:

- Feb 2023: study APs in configuration networks
- Mar 2023: real-world network analysis
- Apr 2023: paper
- May-June 2023: thesis

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Acknowledgements

Prof. Vladimir Palyulin

Saeed Osat

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Thank you for attention

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