Triad Motif Significance Profile

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Background: Motif

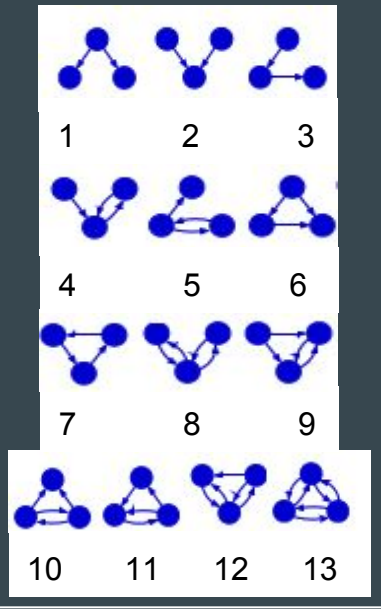
Motif

subgraph patterns which appear significantly more often than expected at random

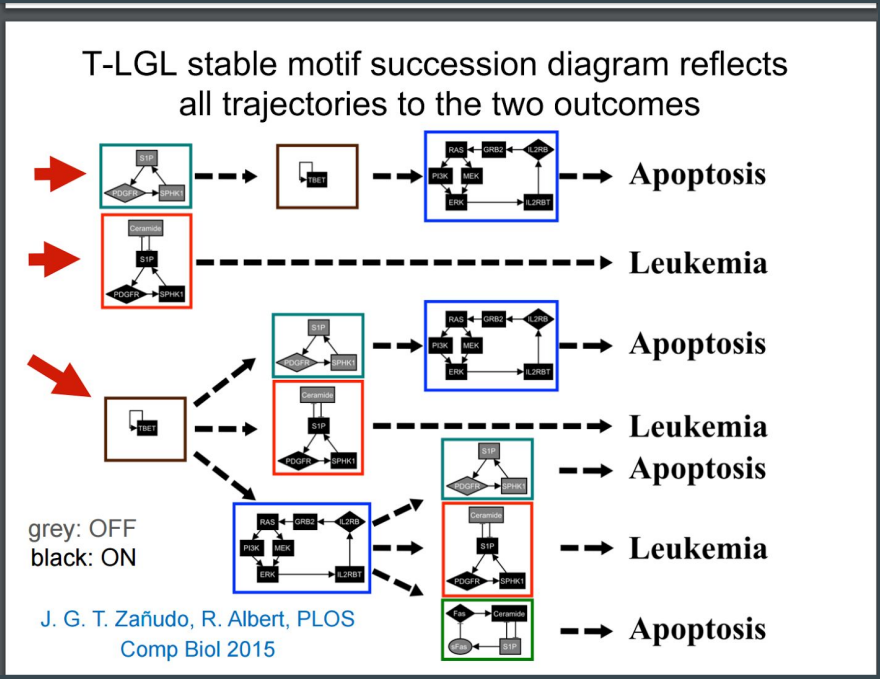
Importance

Assist in understanding the structural design principles of a complex network

13 Triad motifs DG



Stable Motifs



Background: Z-score

Z-score analysis

Track significance of an over- and underrepresentation for each motif using a z-score

Calculation

For a motif i,

$$Z_i = \frac{N_{original,\,i} - \langle N_{random,\,i} \rangle}{\sigma_{random,\,i}}$$

Terms

$N_{original,\,i}$ = frequency of motif i in the original network

$\langle N_{random,\,i} \rangle$ = avg frequency of motif i in randomized networks

and

$\sigma_{random,\,i}$ = respective standard deviation

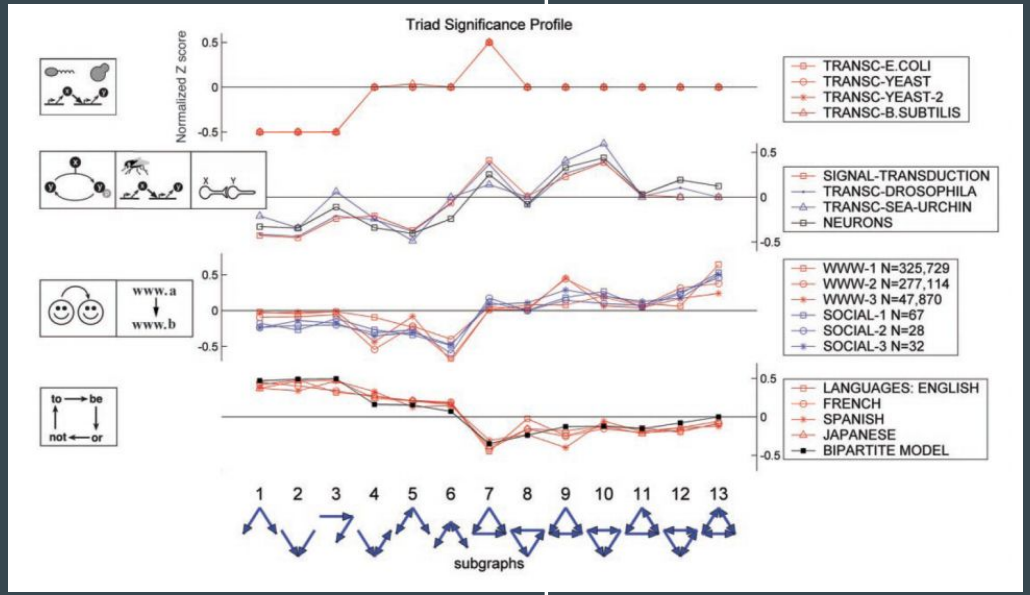
Background: Significance Profile

Significance Profile SP

Is the vector of normalized Z-scores for a network

$$SP_i = \frac{Z_i}{\sqrt{\Sigma Z_i^2}}$$

Example SP



R. Milo *et al.*, *Science* 303, 1538 (2004)

Main Objective

- To extract and visualize various triad motif significance profiles
  - Determine input networks
  - Calculate Z-score of each motif and creating the SP
  - Plot and display profiles and networks

Input Networks

- Biological networks
  - **E-coli transcription**
  - Yeast transcription
- Social Networks
  - Prison network
    - Macrae, Sociometry 23, 360-371 (1960)
  - Leadership course network
    - L. D. Zeleny, Sociometry 13, 314-328 (1950).
- Circuit Networks

Calculating Z-scores

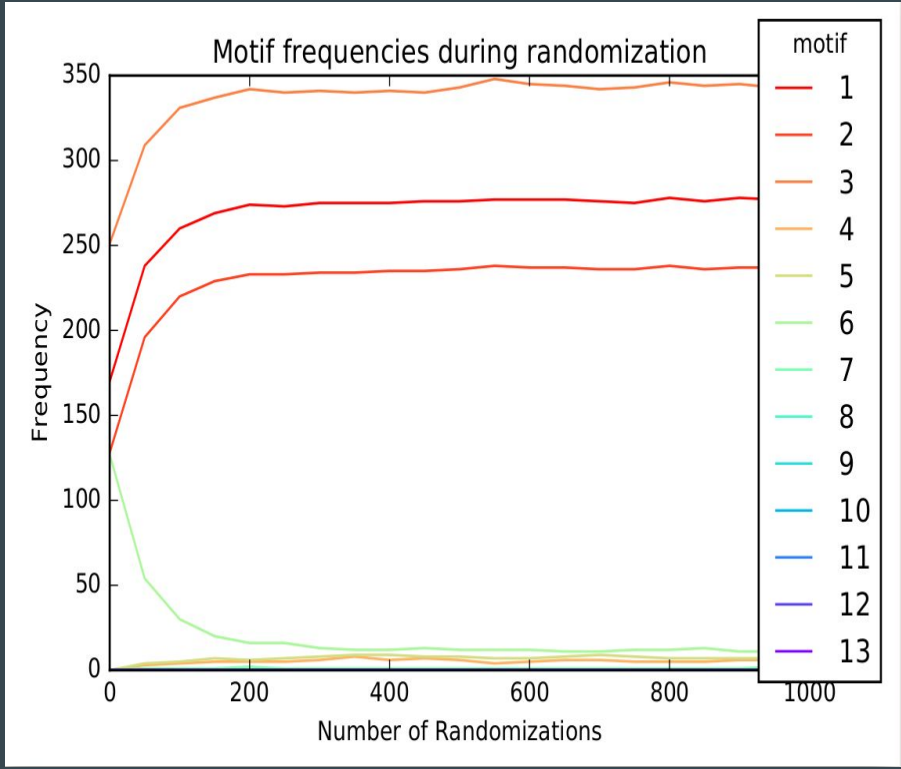
- $N_{original}$
  - triadic_census
- $\langle N_{random} \rangle$
  - Implement a randomization method
    - Need degree preservation
    - Keep track of changing motif frequencies
- σ_{random}
  - numpy.std

Plotting Results

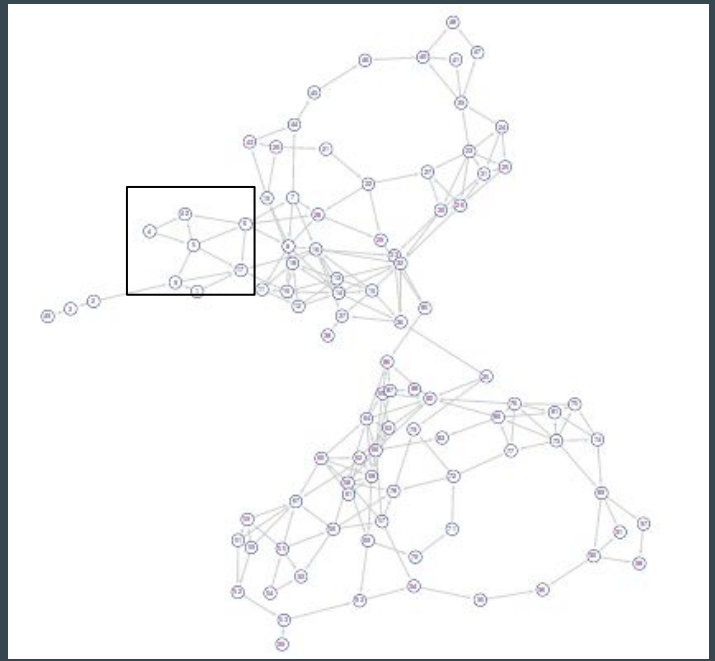
- Plotting graphs after and before randomization w/Cytoscape + networkx
- Plotting SP w/networkx

Results: Randomization

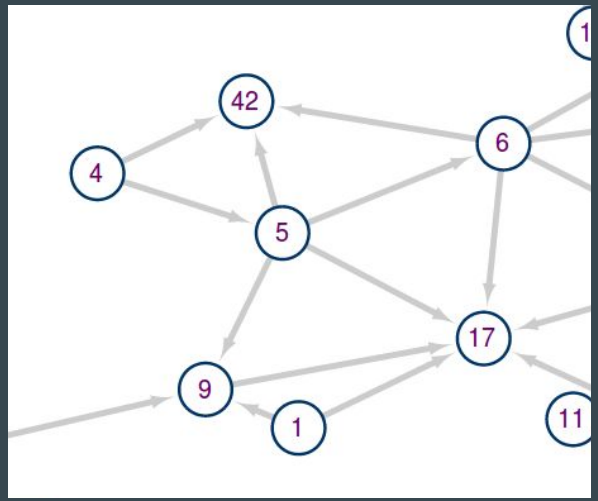
Randomization: E.coli Transcription Network



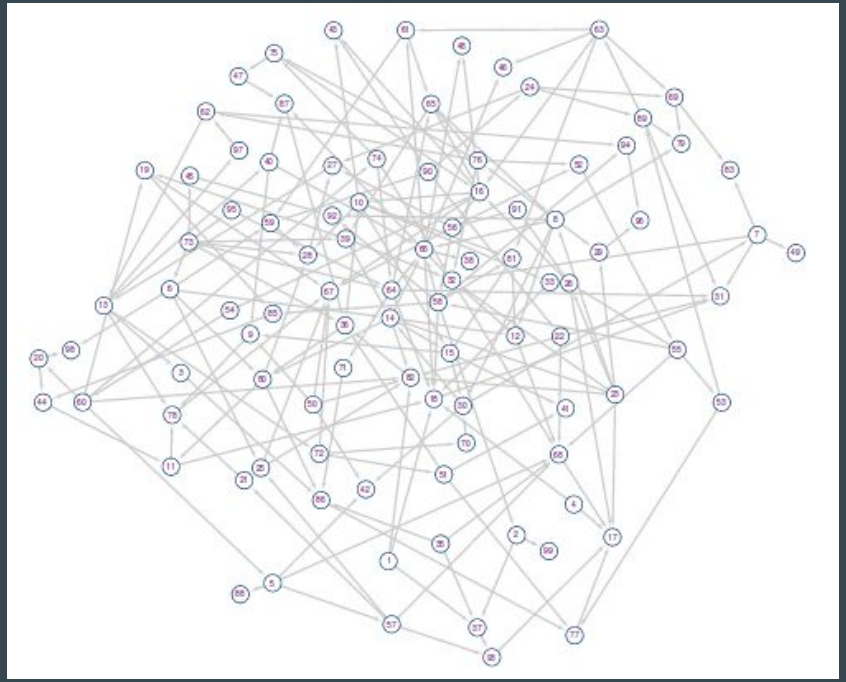
Before Randomization: E.Coli



Motif 6

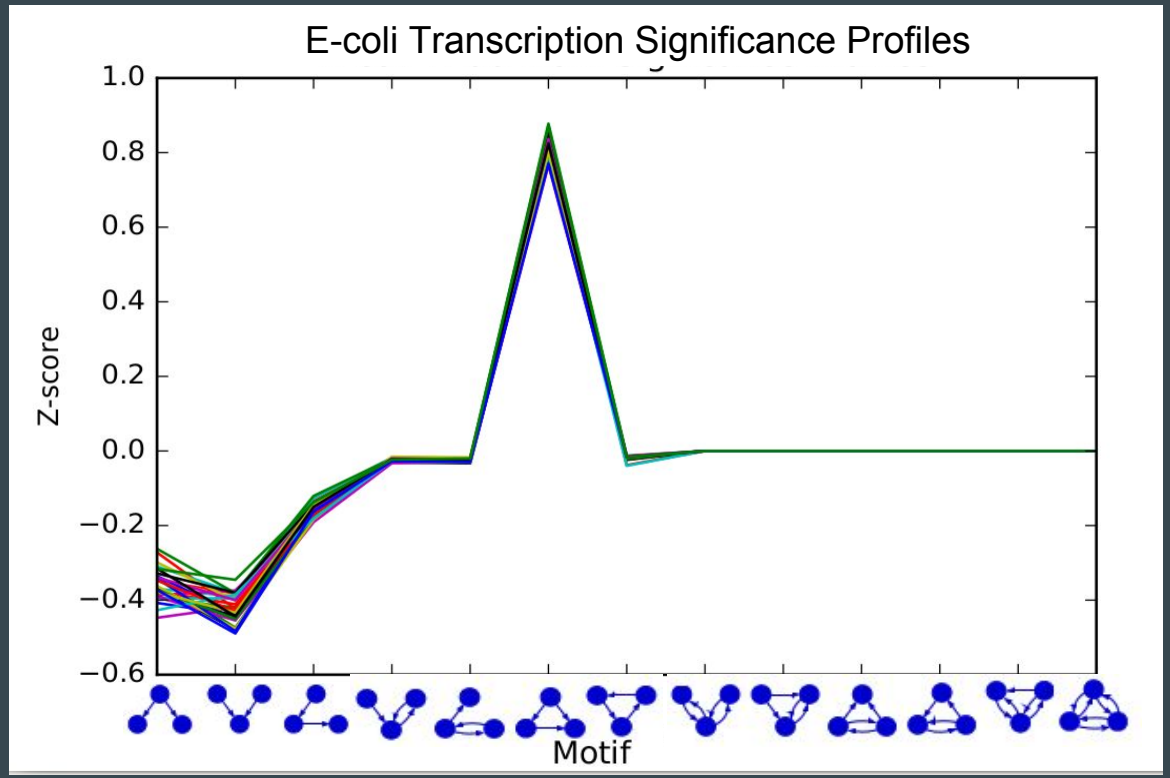


After Randomization:E.coli

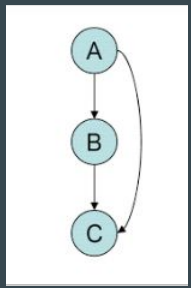


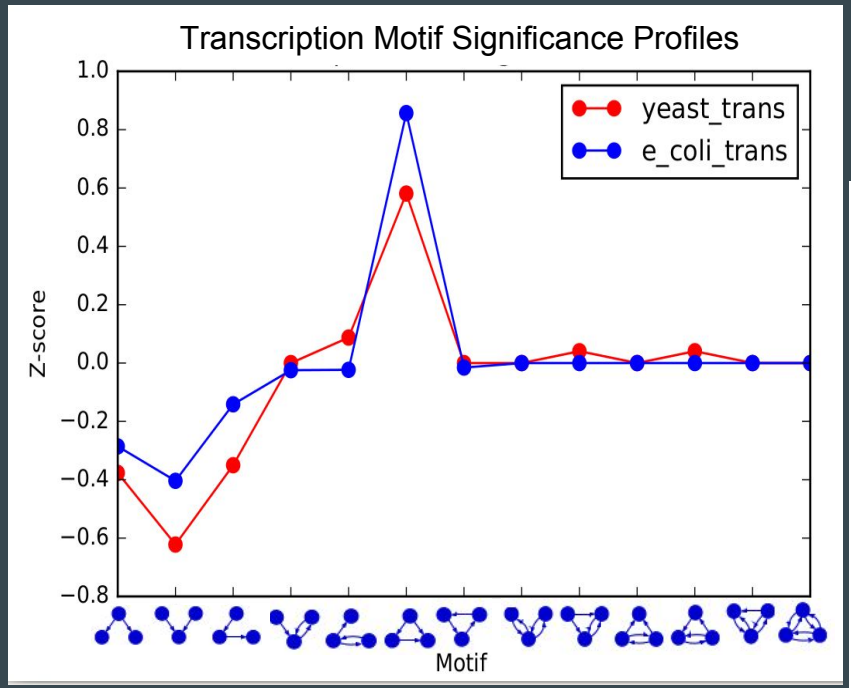
Results: Motif Significance Profiles

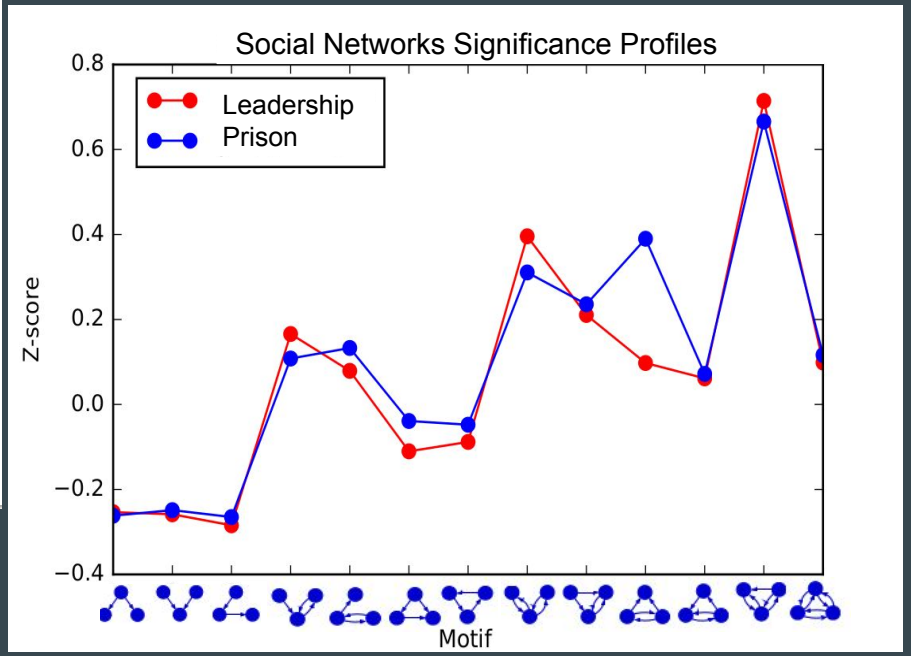
Motif Significance Profile: E.coli Transcription



Motif 6




Transcription Motif Significance Profiles
yeast_trans
e_coli_trans
Z-score
Motif

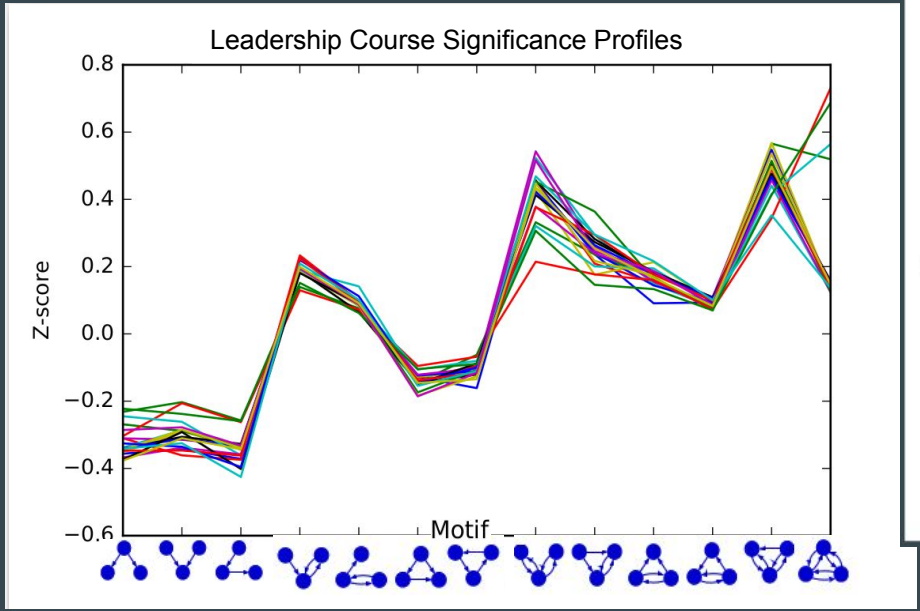

Social Networks Significance Profiles
Leadership
Prison
Z-score
Motif

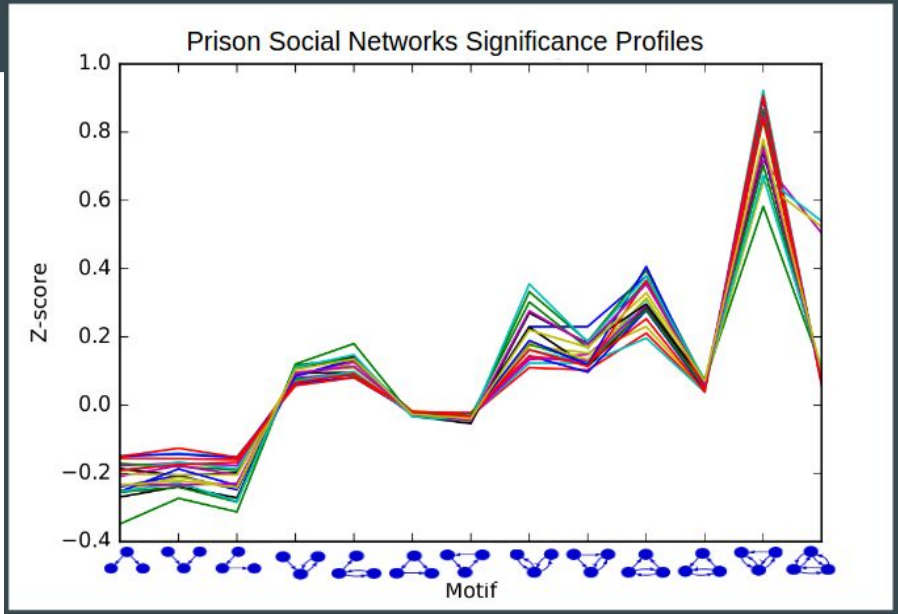
Publications

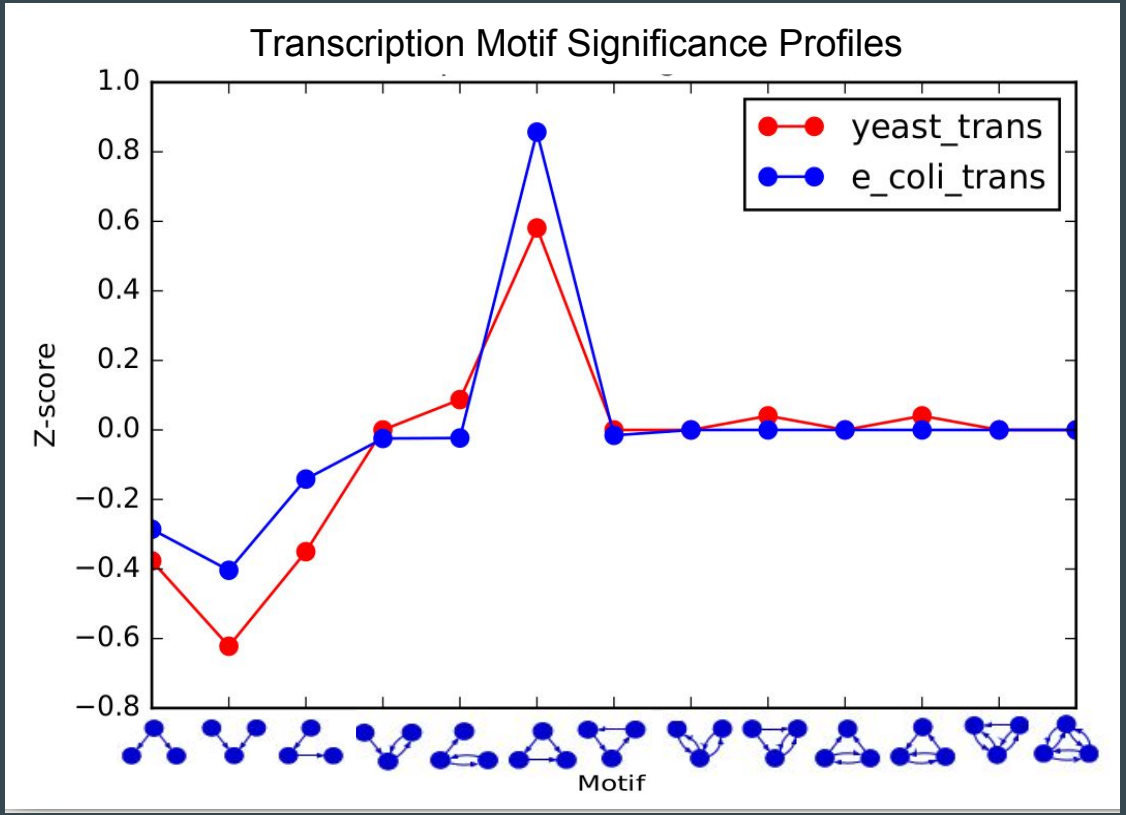
- R. Milo *et al.*, *"Superfamilies of evolved and designed networks."* *Science* 303, 1538 (2004)
- R. Milo *et al.*, *Network Motifs: Simple Building Blocks of Complex Networks Science* 298, 824 - 827 (2002)

Thank you!

Motif Significance Profiles: Social Networks






Transcription Motif Significance Profiles
yeast_trans
e_coli_trans
Z-score
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8
Motif