Improving Seizure Forewarning using Graph Dissimilarity and Layout Analysis

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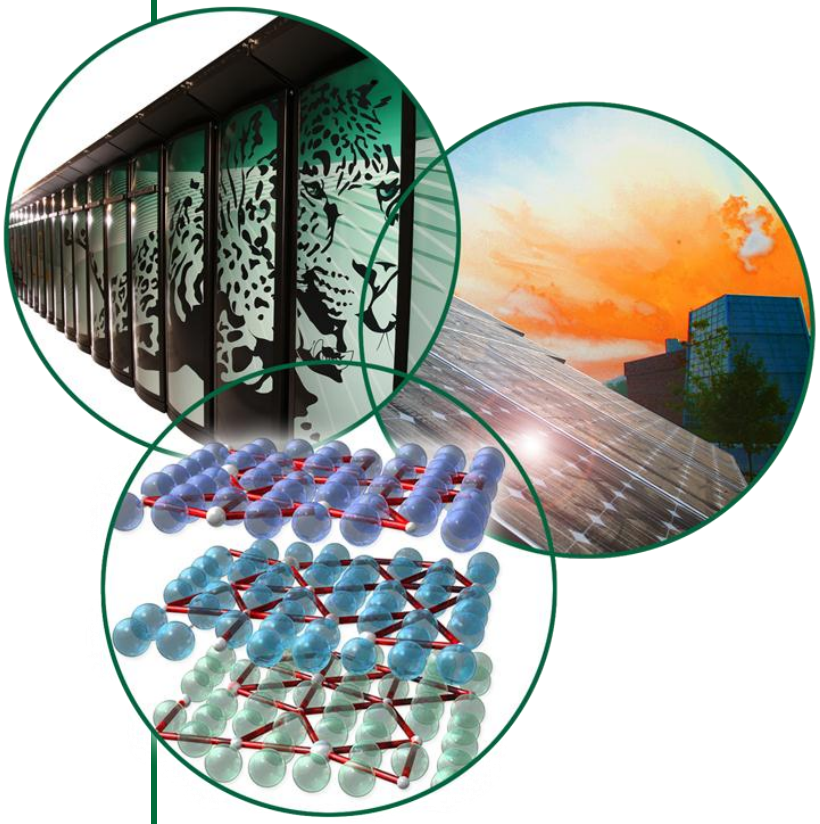

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Outline

- Background
- Methodology
- Results
- Conclusion
- Summary
- Questions

Background – seizure forewarning

Epileptic seizure forewarning

- Early research began 1970s
- Advances through science, technology, engineering, math (STEM)
- 3 million Americans
- 50 million people worldwide

Research goal

Out of 60 observations the objective is to improve the forewarning analysis by identifying shifts in a false positive and false negative observations using graph layouts and dissimilarity measures.

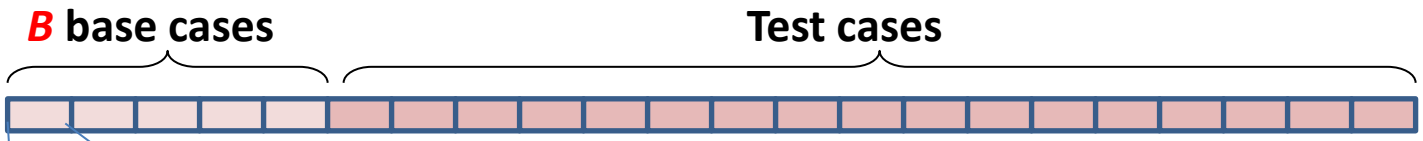
Analyze brain-wave data (EEG)

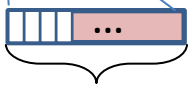
- Gather data from dynamical system using electroencephalography
- Time series analysis shows pattern of data through time

Epileptic seizure onset

Multiple EEG channels

Time →

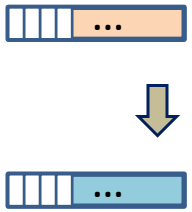




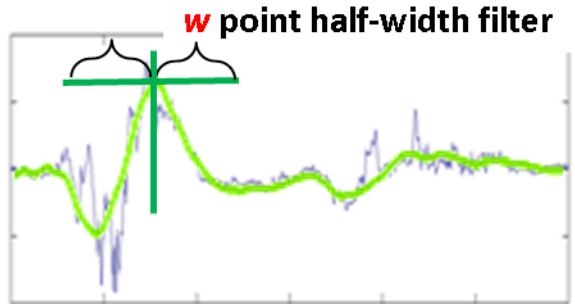
N points

Raw data e_i @ t_i

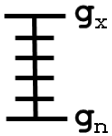
Artifact data f_i @ t_i



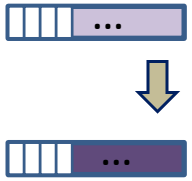
Artifact filtered data $g_i = e_i - f_i$



Symbolize $s_i = s\left(\frac{g_i - g_n}{g_x - g_n}\right)$



Takens' Theorem

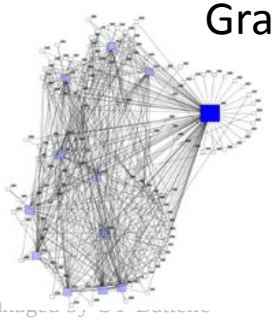


States (nodes) $y(i) = [s_i, s_{i+L}, s_{i+2L}, \ldots, s_{i+(d-1)L}]$

State transitions (links) $y(i) \rightarrow y(i + M)$

Graph Theorems

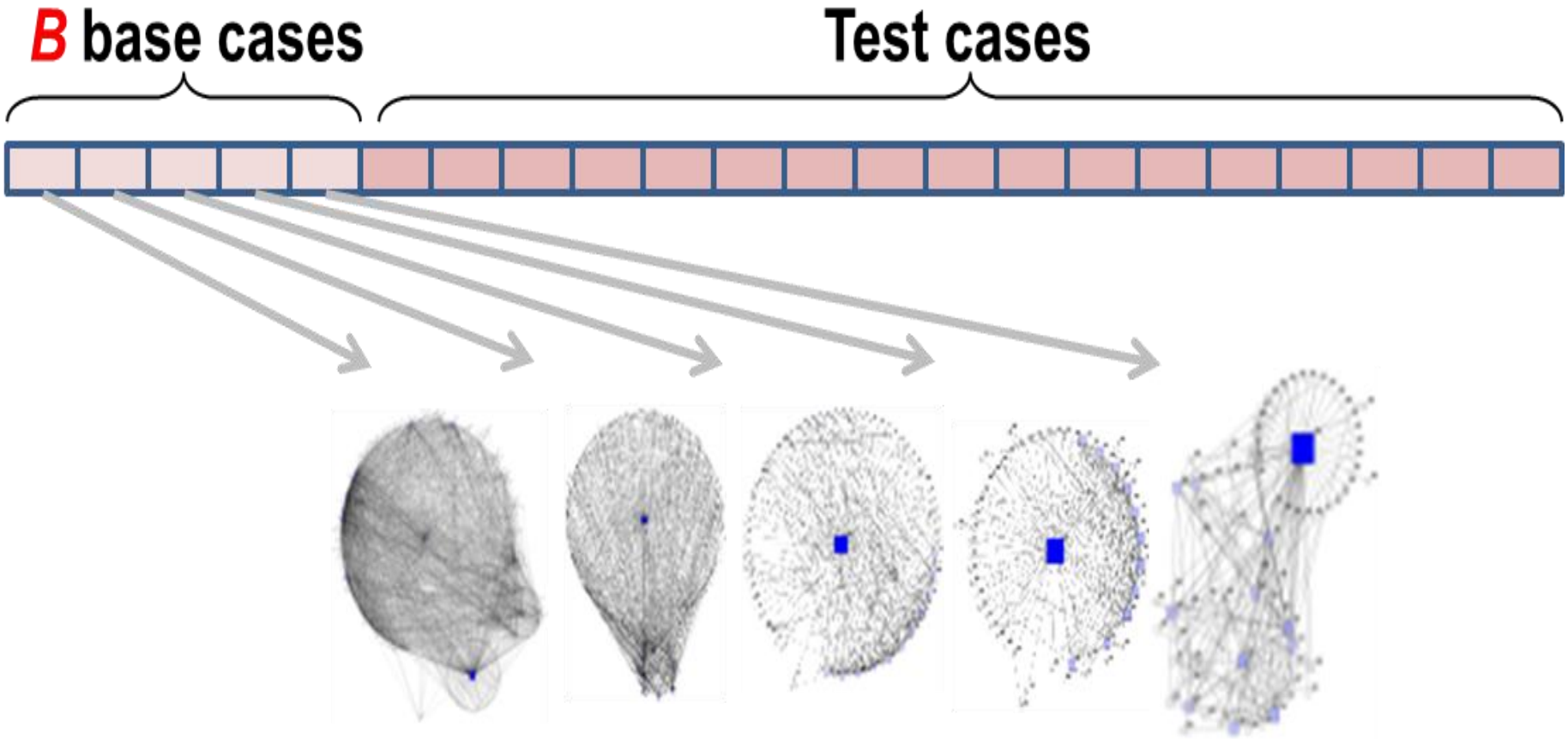
Graph

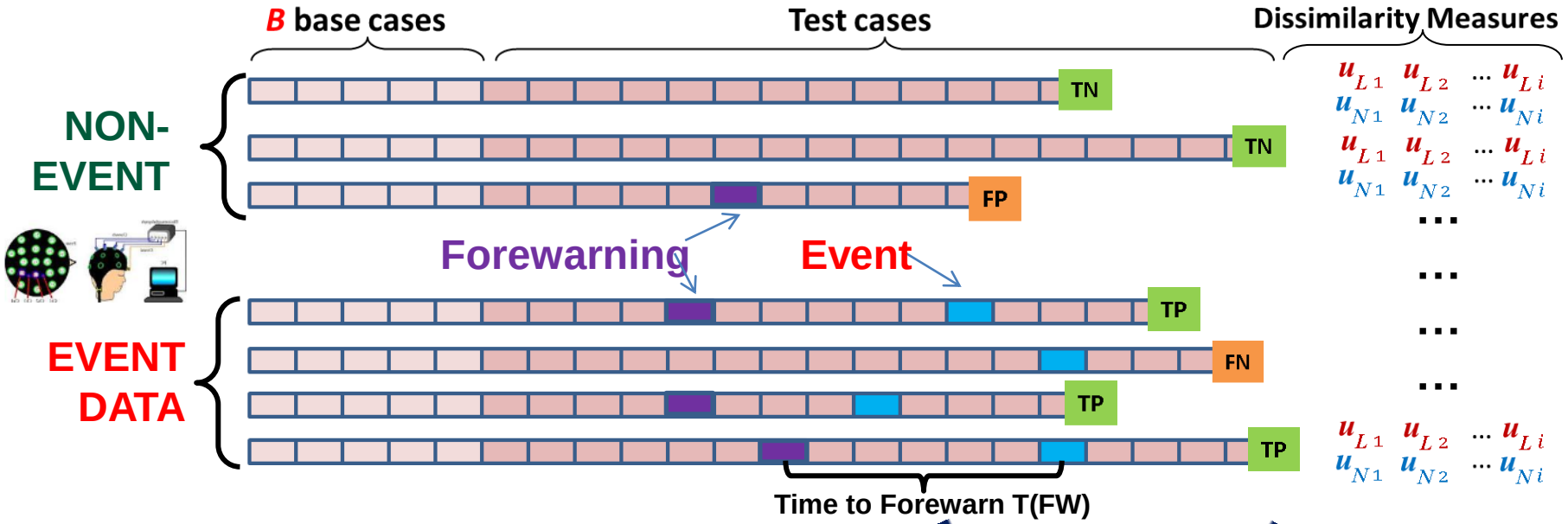


Parameter space

B: # base cases	5..20
N: # points in cutset	5000..90000
w: # points in halfwidth	2..99
S: # of symbols	2..99
D: # of dimensions	1..26
L: lag	1..99
M: mu	1..99

Graph analysis foundation





Given Parameter Set: {*B, N, w, S, d, L, M*}

Forewarning Analysis

For Each Data Set	No Forewarning	Forewarn Indicated
No Event	True Negative (TN)	False Positive (FP)
Event Occurred	False Negative (FN)	True Positive (TP)

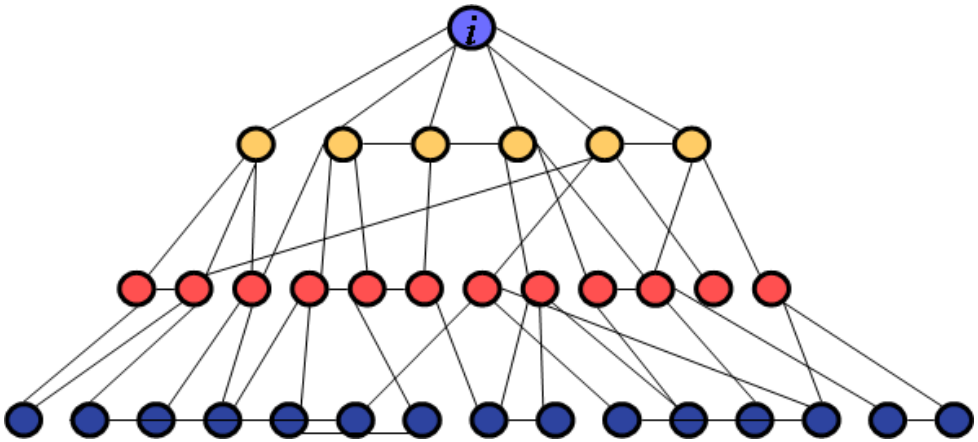
+ T(FW)

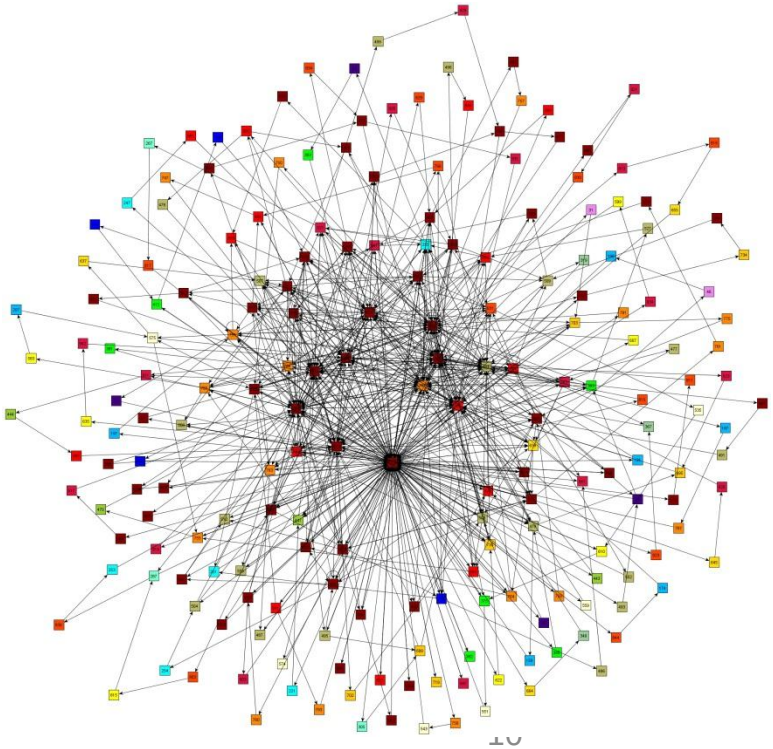
Graphing parameter and forewarning results

- Parameters:
  - Base cases: 12
  - Number of points in cutset: 22320
  - Points in halfwidth: 19
  - Symbols: 2
  - Dimensions: 10
  - Lag: 50
  - Mu: 24
- Forewarning results:
  - True Negative: 18
  - True Positive: 39
  - False Negative: 1
  - False Positive: 2
- Prediction distance = .10

Graph visual layout algorithms

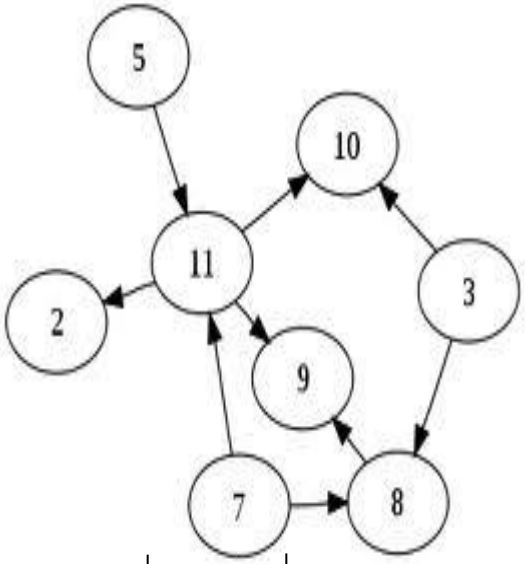
- Organizes a network
  - Hierarchical
  - Tree
  - Circular
  - Organic



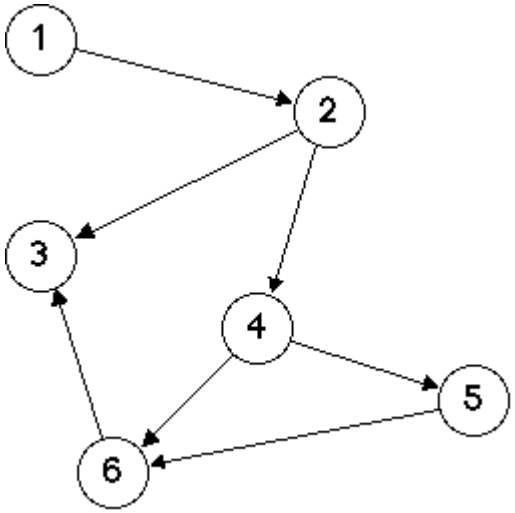


Graph dissimilarity measures

- Two dissimilarity used
  - Link difference $|E_A \backslash E_B| + |E_B \backslash E_A|$
  - Node difference $|V_A \backslash V_B| + |V_B \backslash V_A|$
  - $|V_A \backslash V_B| + |V_B \backslash V_A| = 8$

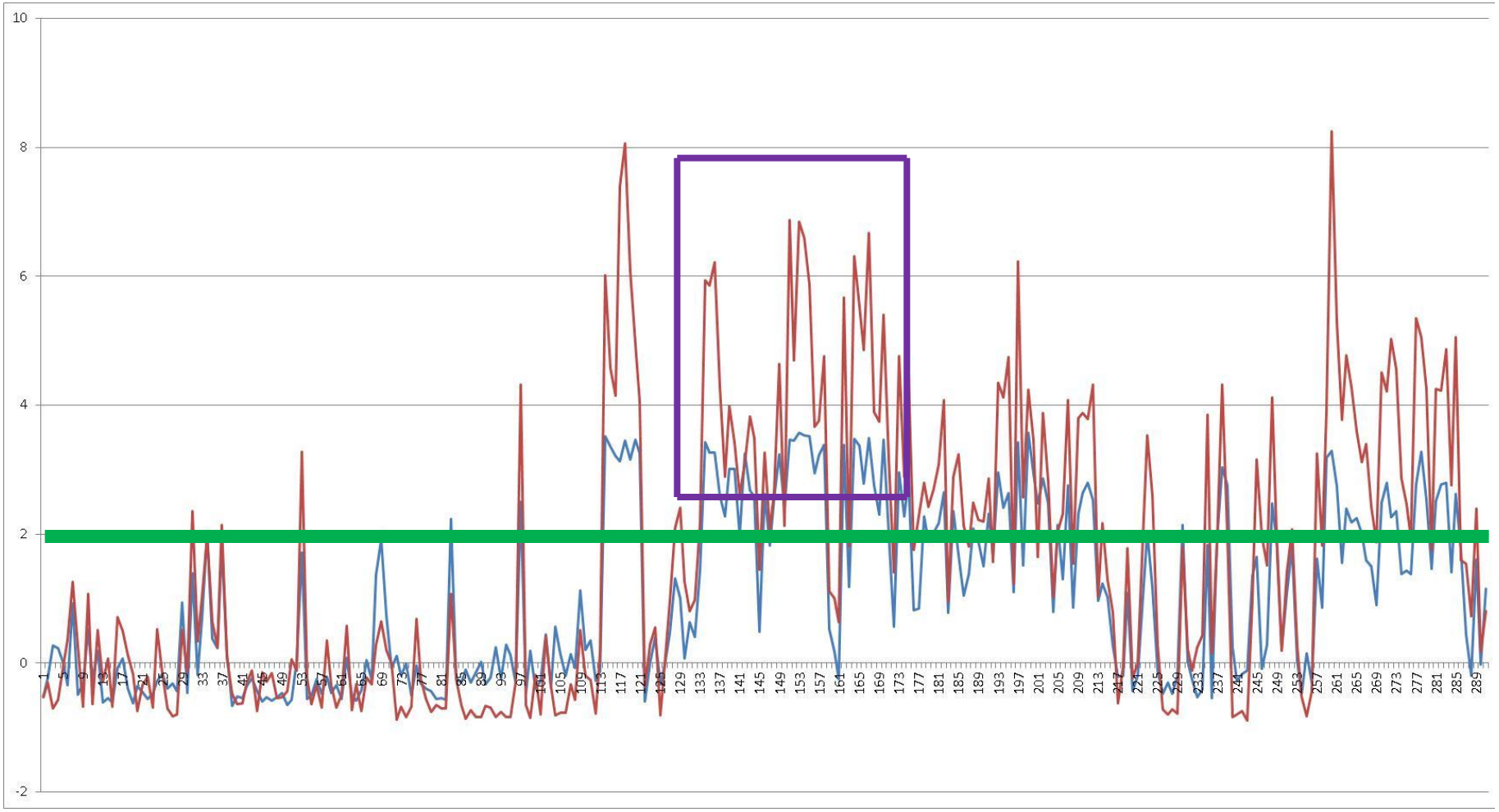


$|V_A \backslash V_B| = 7,8,9,10,11 = 5$



$|V_B \backslash V_A| = 1,4,6 = 3$

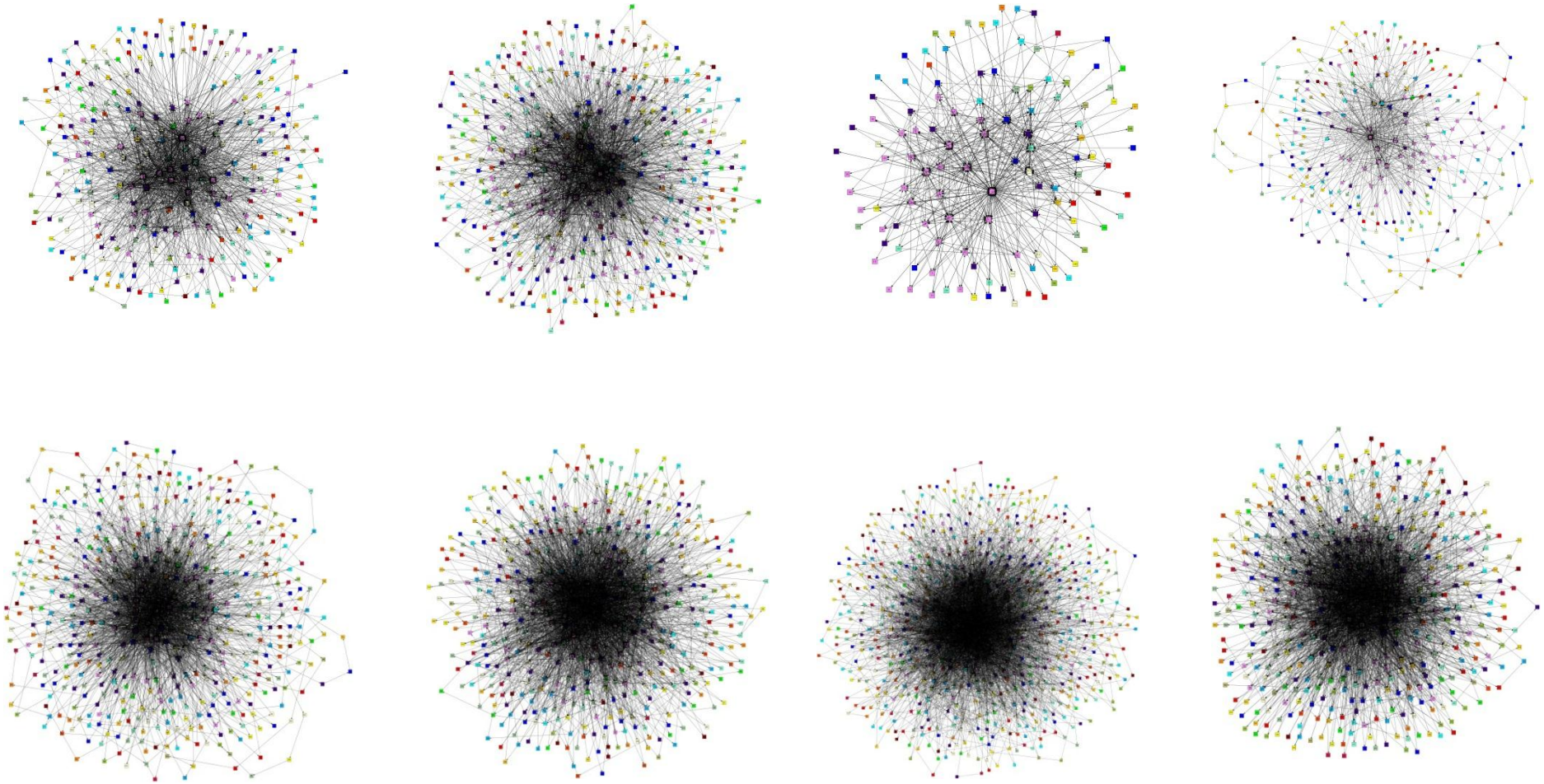
Analysis threshold – Observation 45



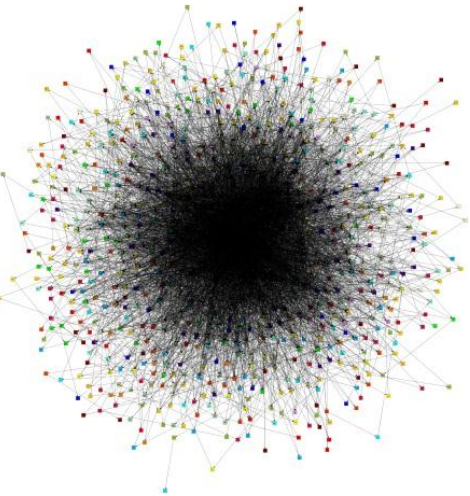
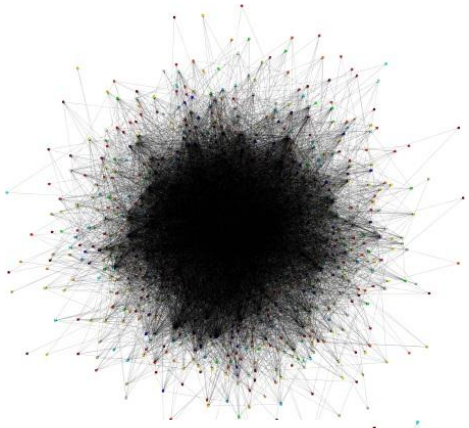
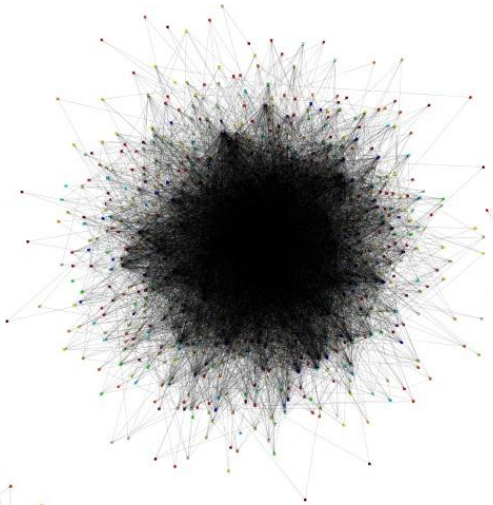
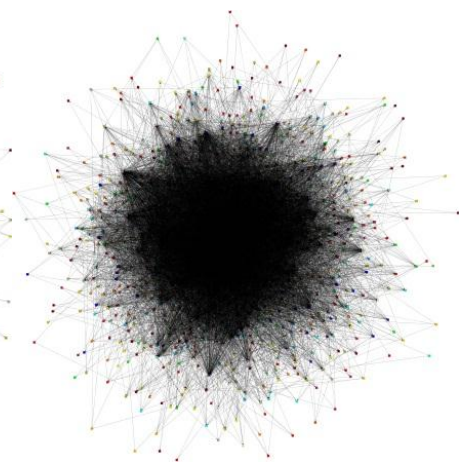
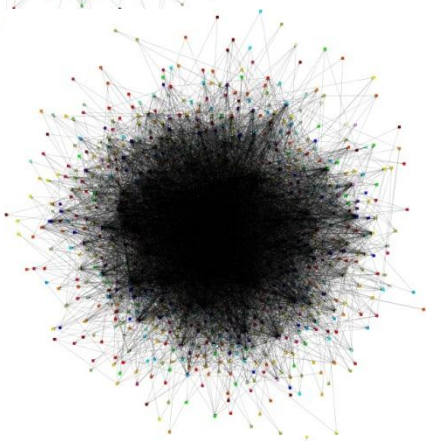
Normalized node difference

Normalized link difference

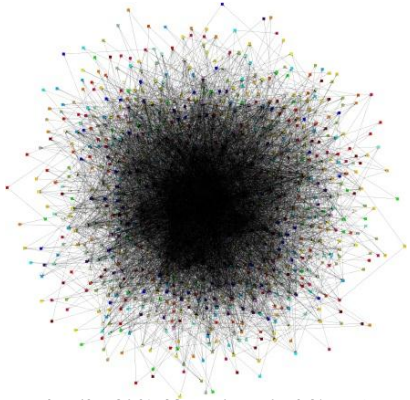
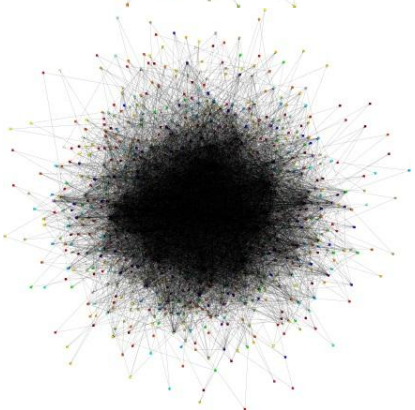
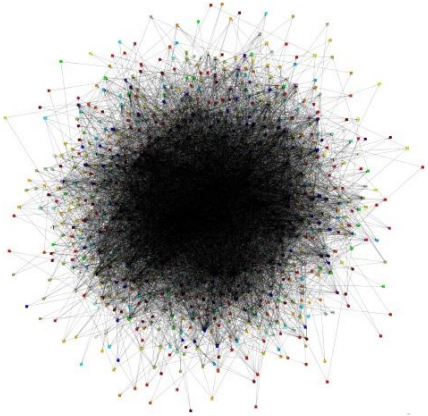
False positive base case (45 organic)



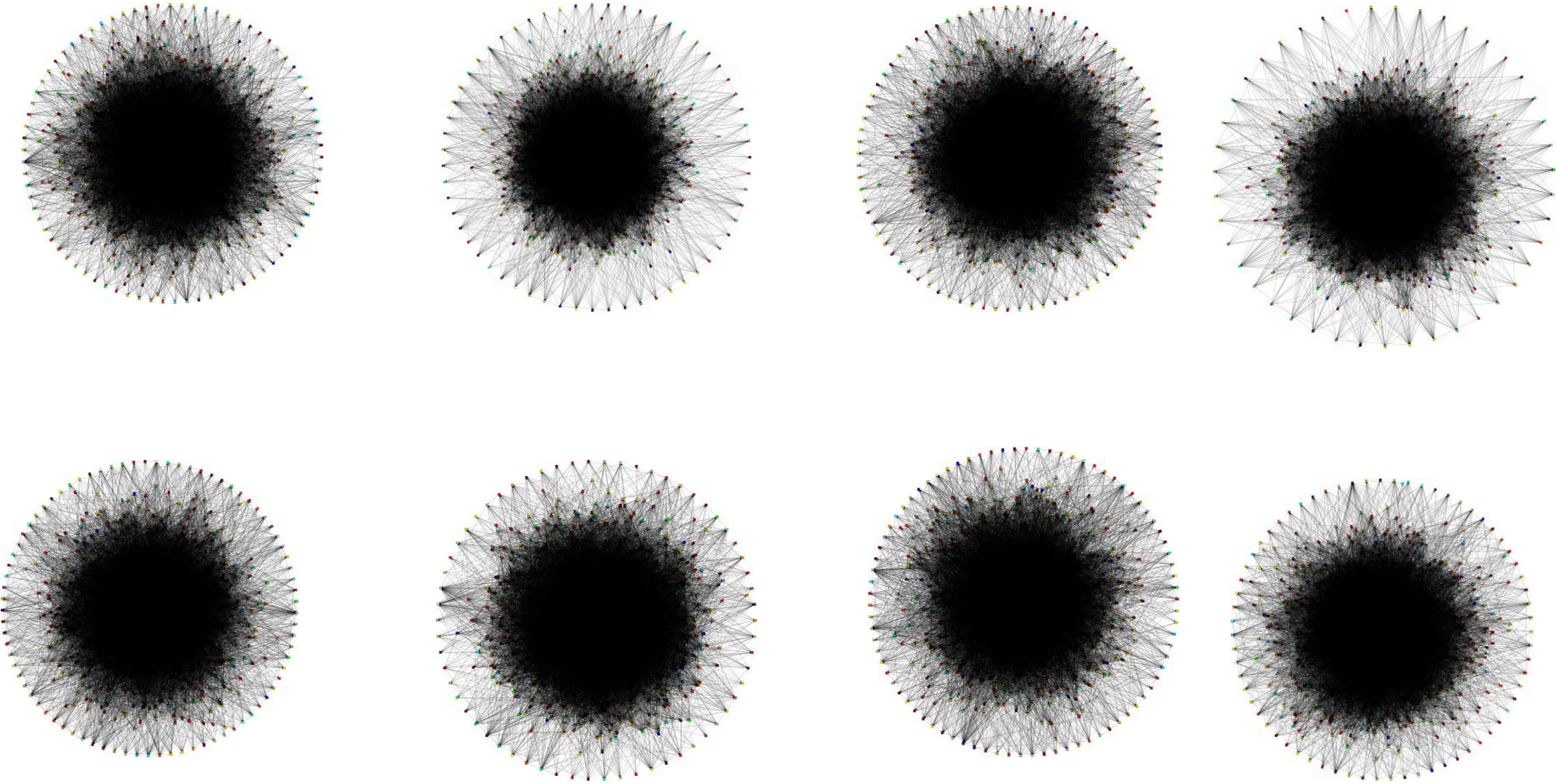
False positive test case (45 organic)

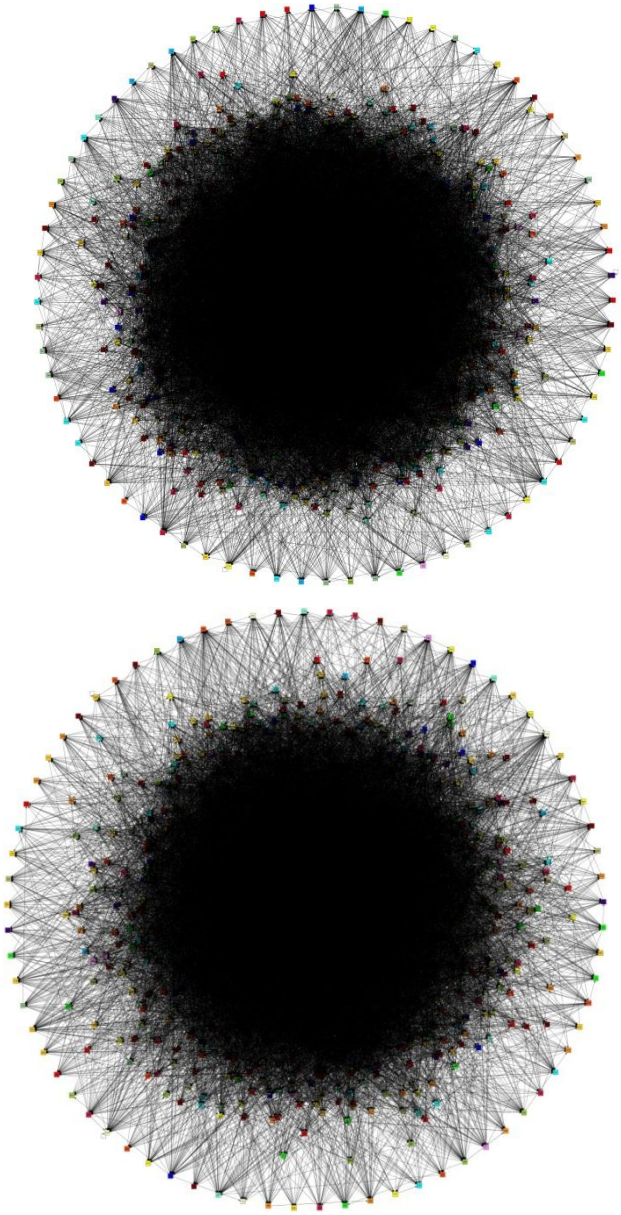
Forewarning cutset

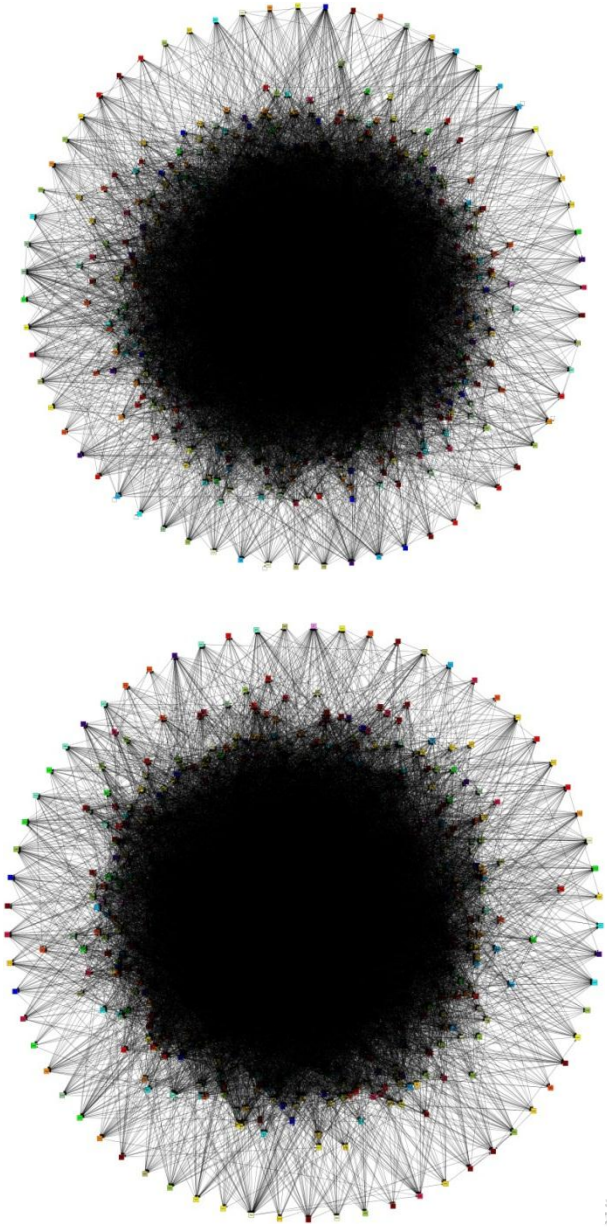




False negative base case (57 circular)



False negative test case (57 circular)





Conclusion

- Visually hard to see some graphs
- Some layout algorithms were not beneficial for this study
- Node difference and link difference has given a true rate of 58/60
- Prediction distance = .05
- Other dissimilarity measure being considered to get a perfect true rate

Summary

- Improvement of physiological and electronic-base systems
- Hardware failure prediction
- Cyber event detection

Future work

- To use computed graph invariants from cytoscape.
- Continue to improve forewarning analysis

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- Many unmentioned

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