Utilizing Group Affinity to Predict Community Formation in Social Networks

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Student Research Conference

2019

Collaborators

Faculty	Students
Ben Webb	Julia Bohman
Emily Evans	Jason Kinghorn

Motivation

Motivation: Given an individual's previous group/community affiliations can we predict which group/community they will belong to in the future?

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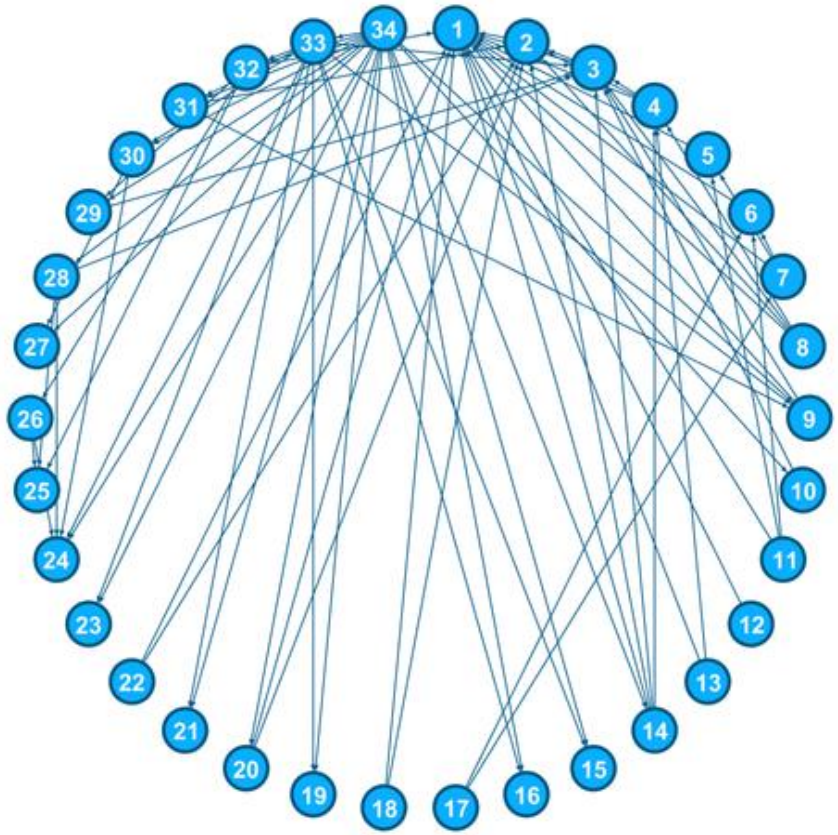
Potential Applications:

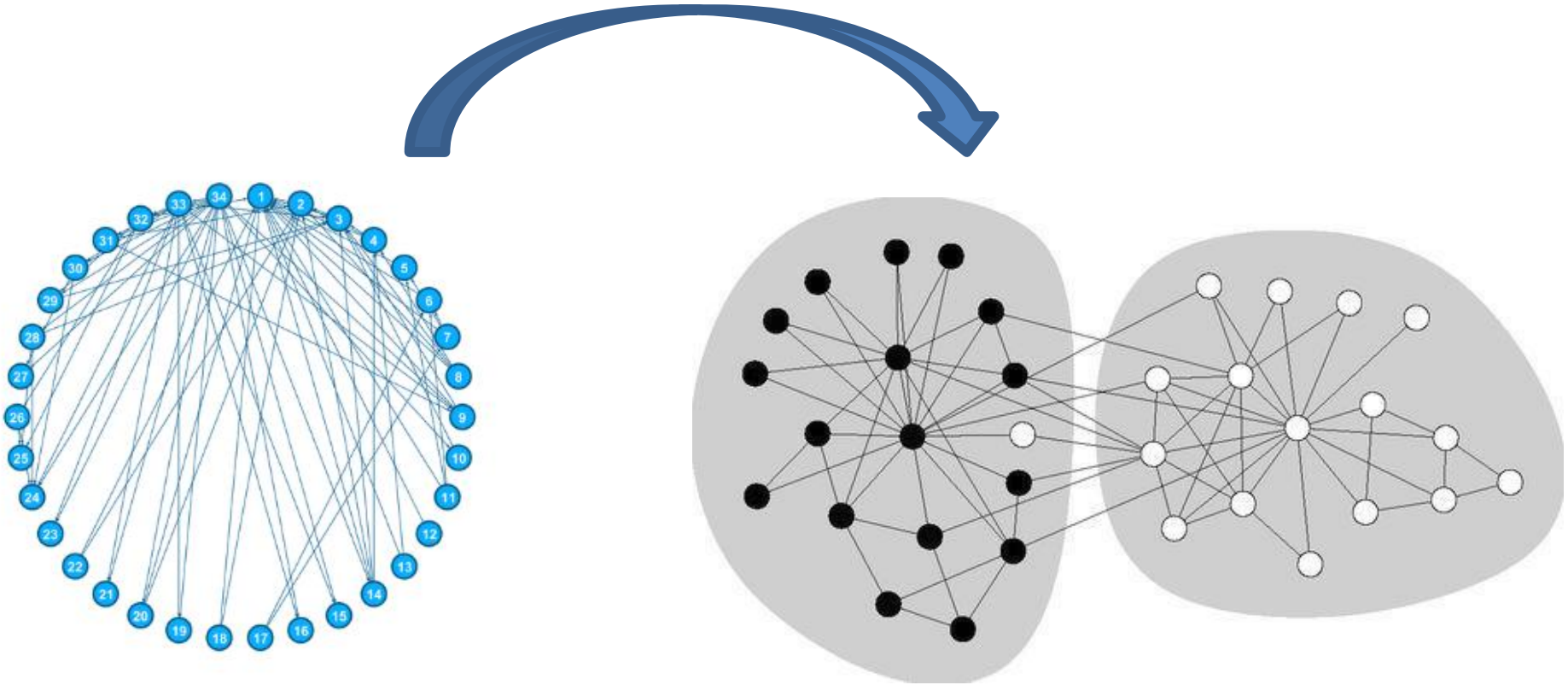
- Organizational structure
  - Terrorist Groups
  - Workplace Formation
  - School study groups

Zachary's Karate Club



https://en.wikipedia.org/wiki/Zachary%27s_karate_club

Zachary's Karate Club



- Community detection on Zachary's Karate Club with Simple Modularity Maximization

Networks: An Introduction(Newman)

Southern Women Dataset

Observed 18 women over the course of a year:

- Bi-Partite Graph
- Different communities depending on the algorithm
- Allows us to glimpse at the communities at periodic time periods

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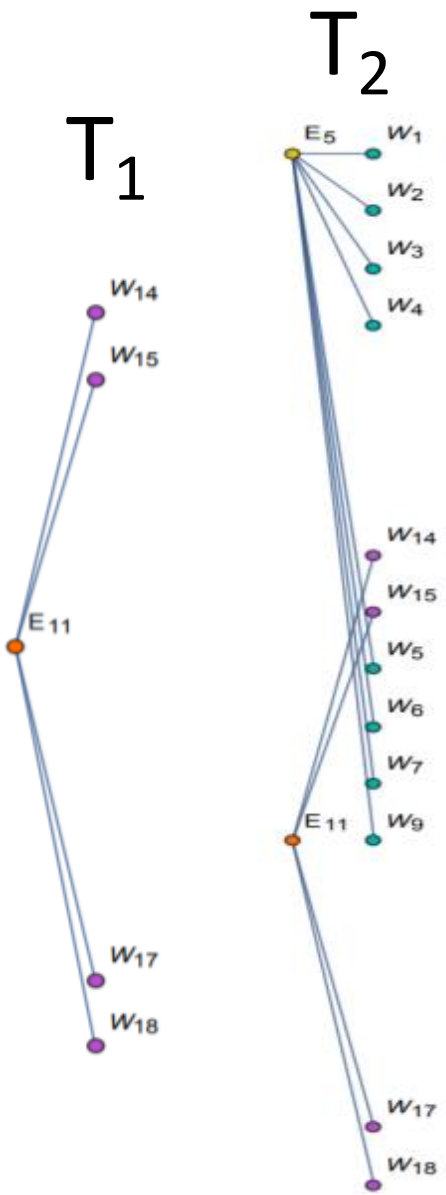
Gathered in 1941 by five sociologists who observed the women attend different events

Southern Women Dataset

T_1

Southern Women Dataset



Southern Women Dataset

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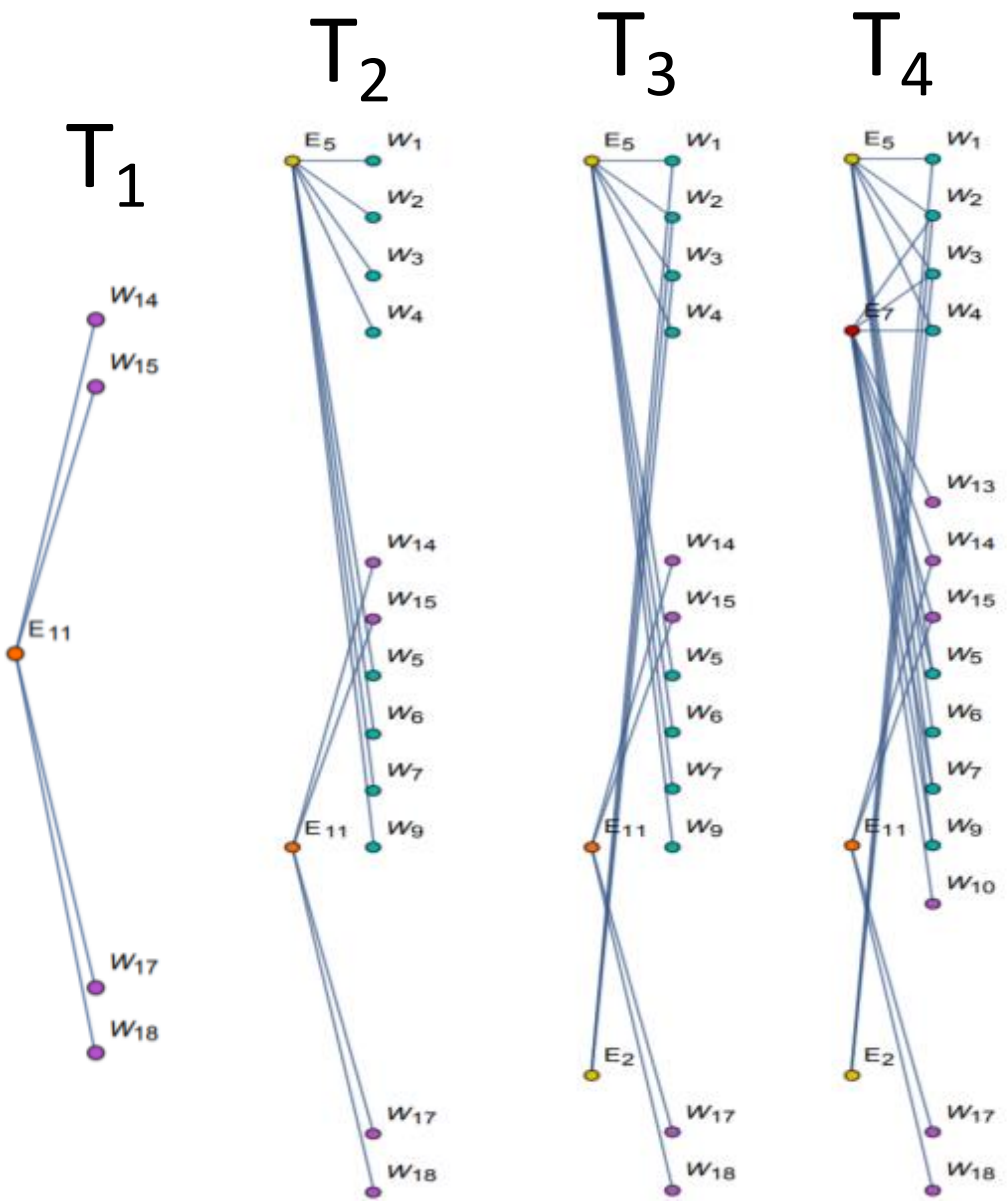

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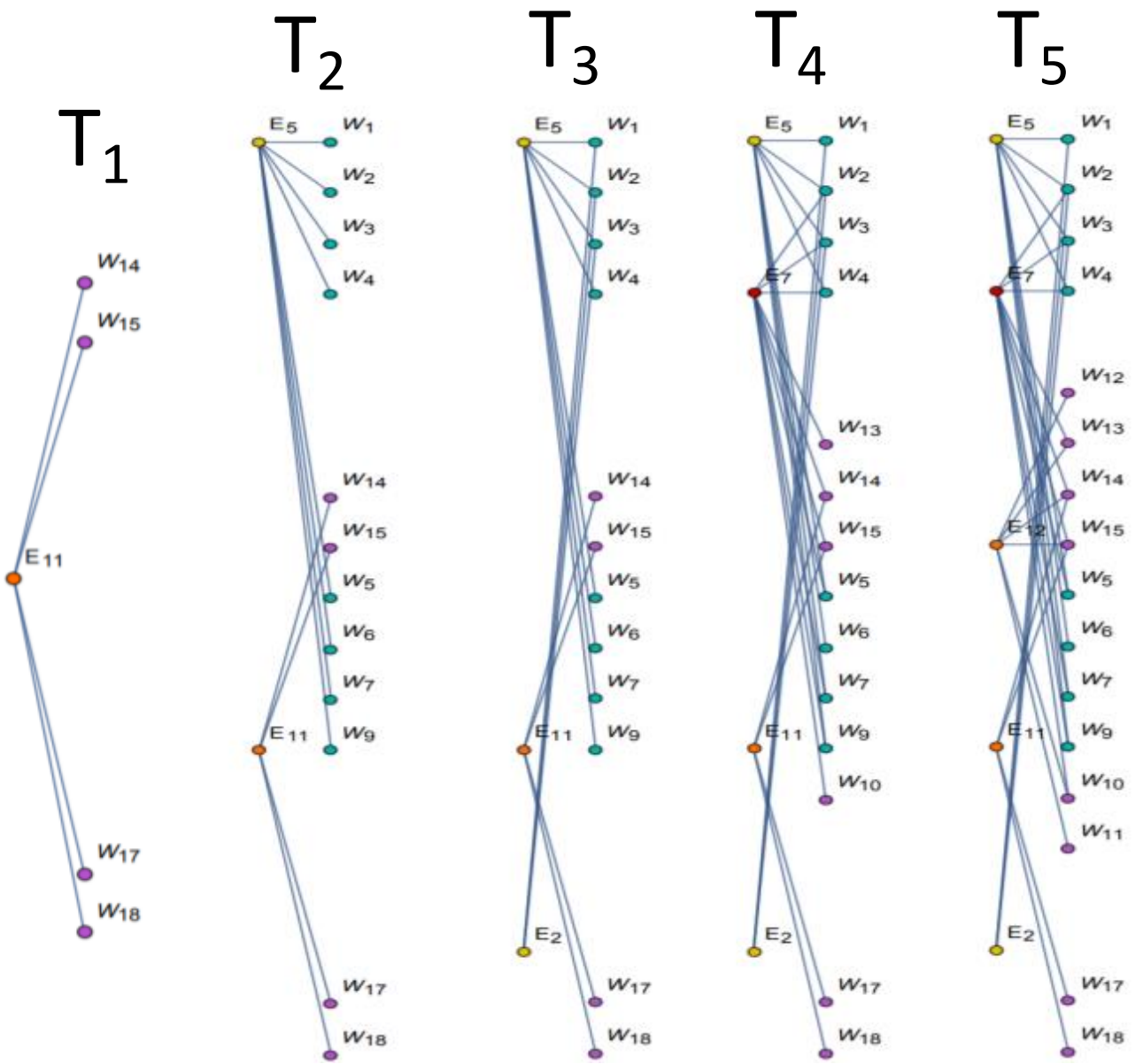

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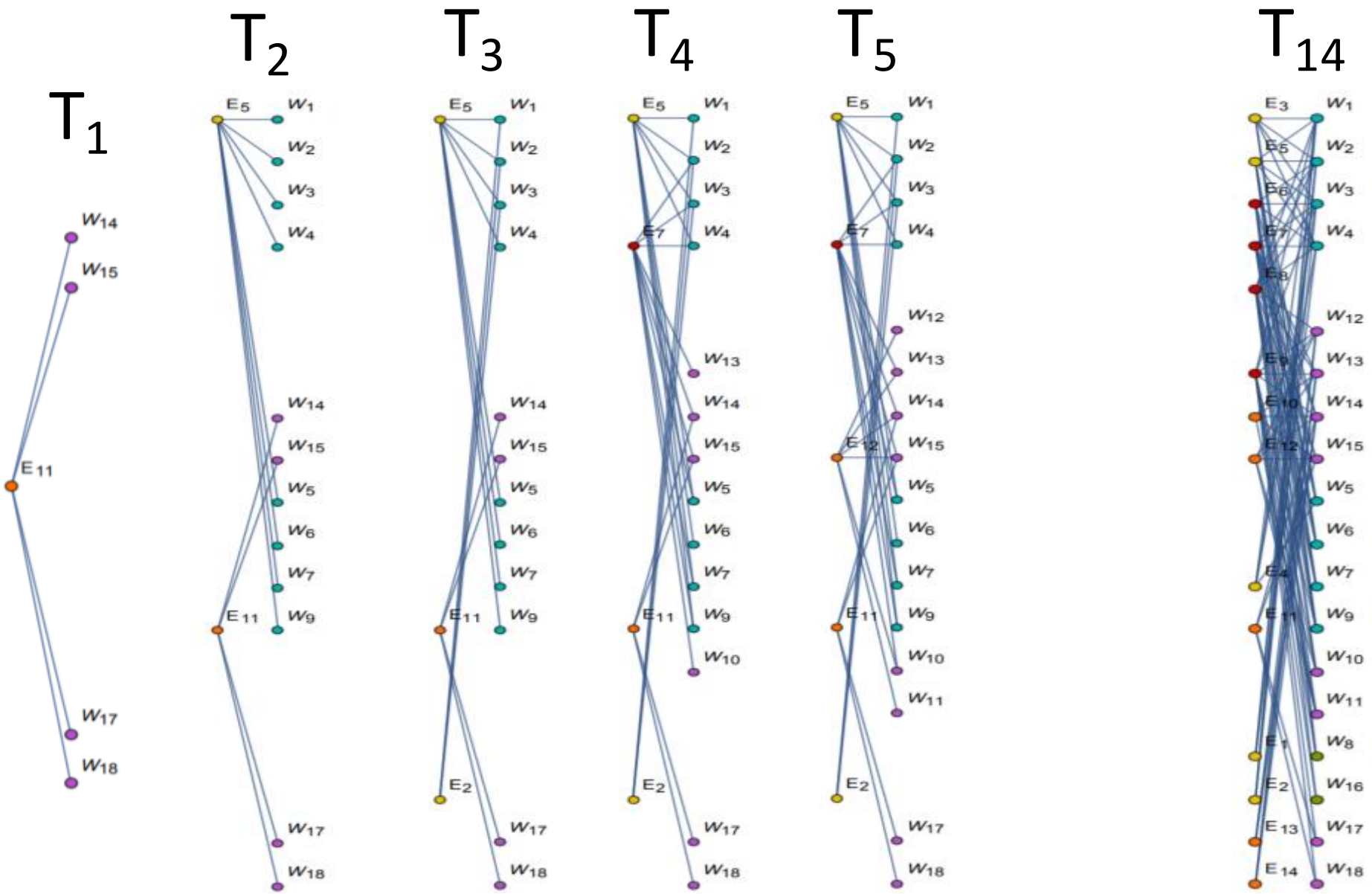


Community Detection Algorithms

There are many algorithms for community detection.

- **Spectral Partitioning**
- **Kernighan-Lin Algorithm**
- Simple Modularity Maximization
- Fluid Communities

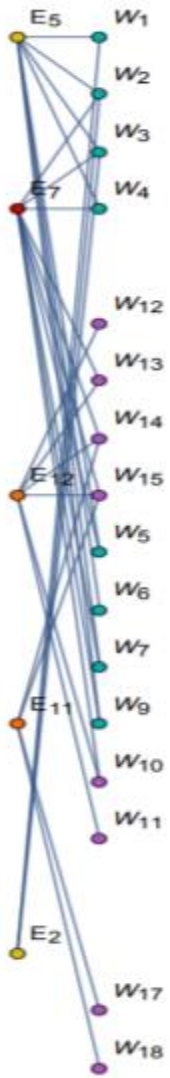
Southern Women Dataset – 2nd Event

Kernighan-Lin/
Spectral Partitioning
Division

Southern Women Dataset – 5th Event

Kernighan-Lin Division

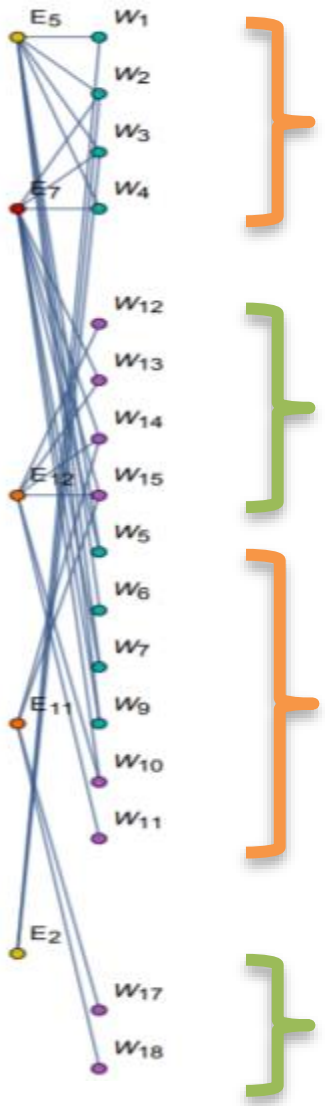
T_5



Southern Women Dataset – 5th Event

Kernighan-Lin Division

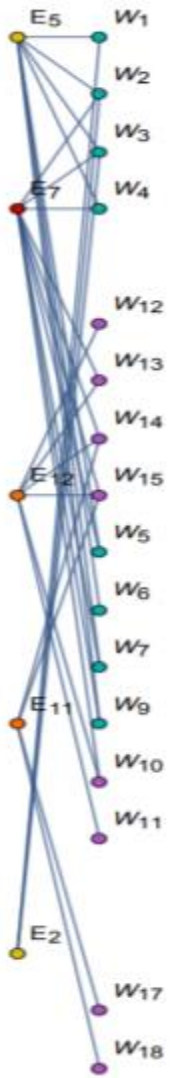
T_5



Southern Women Dataset – 5th Event

Spectral Partitioning Division

T_5



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Spectral Partitioning Division

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Affinity Score

Determining an Affinity Score:

A measurement that suggests how inclined an individual is to one group or the other

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- No general rule for this in current literature

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- Kernighan Lin Algorithm (modularity based algorithms)

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Based on nature of the Community Detection Algorithm

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  Ran several times to find a probability of belonging to one group or the other

- Spectral Partitioning

  Used the eigenvalues of the Graph Laplacian as a score

Affinity Score

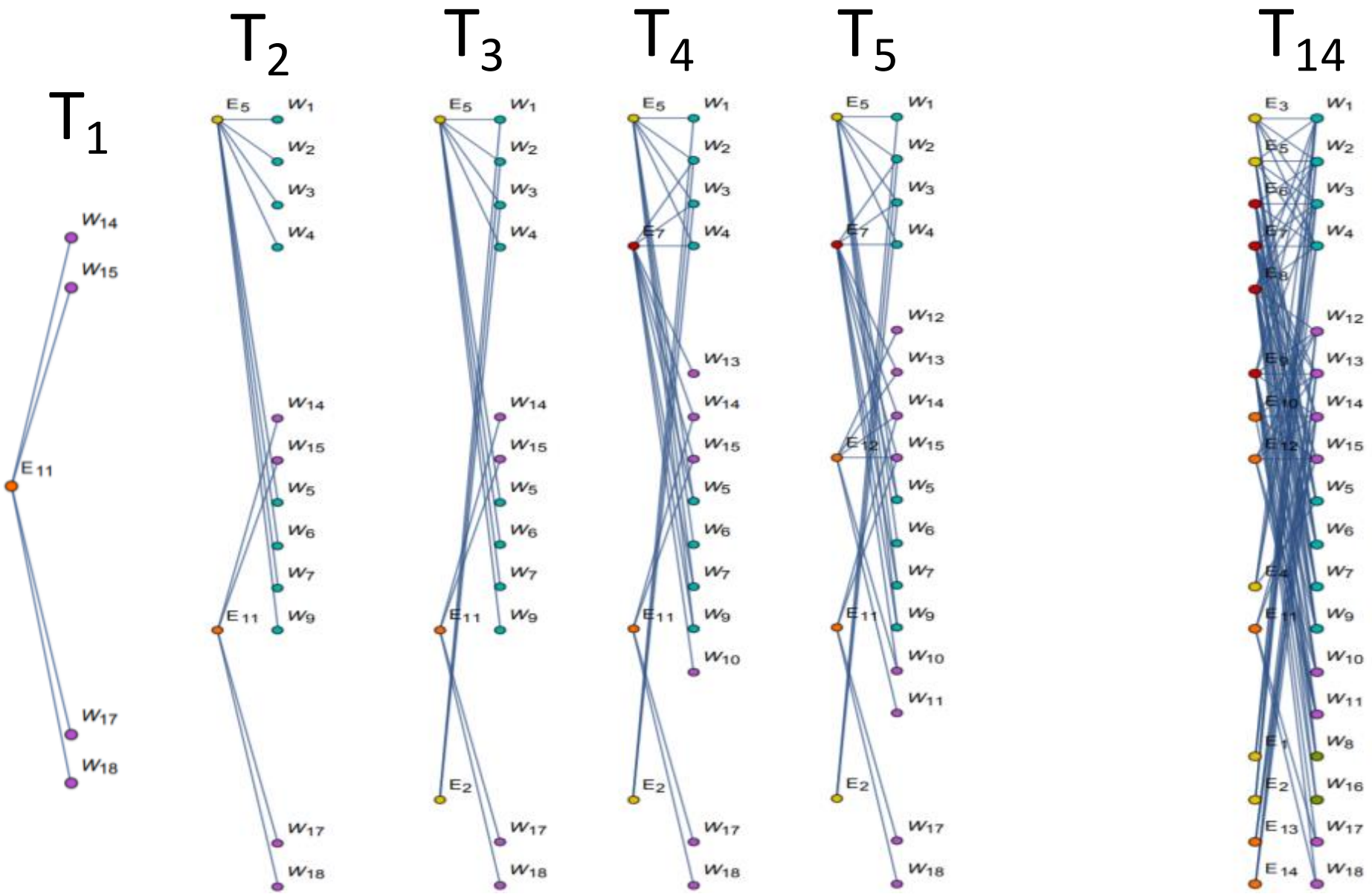
	Afg14	Afg15	Afg16	Afg17	Afg18	Afg19	Afg110	Afg111	Afg112	Afg113	Afg114
W14	3.63E-02	0.0280551	6.21E-02	6.21E-02	1.58E-17	1.58E-17	1.58E-17	1.58E-17	1.36E-17	1.36E-17	1.36E-17
W15	3.63E-02	0.0280551	2.51E-02	2.51E-02	-3.01E-02	-3.01E-02	-3.01E-02	-3.01E-02	-1.15E-16	-1.15E-16	-1.15E-16
W17	6.36E-01	0.6461203	2.17E-01	2.17E-01	-2.75E-01	-2.75E-01	-2.75E-01	-2.75E-01	4.47E-01	4.47E-01	4.47E-01
W18	6.36E-01	0.6461203	2.17E-01	2.17E-01	-2.75E-01	-2.75E-01	-2.75E-01	-2.75E-01	4.47E-01	4.47E-01	4.47E-01
W1	-1.84E-01	-0.1695486	-2.23E-03	-2.23E-03	3.06E-03	3.06E-03	3.06E-03	3.06E-03	-1.35E-15	-1.35E-15	-1.35E-15
W2	-1.26E-01	-0.1154864	-2.18E-01	-2.18E-01	2.45E-01	2.45E-01	2.45E-01	2.45E-01	-1.52E-01	-1.52E-01	-1.52E-01
W3	-1.26E-01	-0.1154864	-2.44E-17	-2.44E-17	9.14E-17	9.14E-17	9.14E-17	9.14E-17	7.21E-17	7.21E-17	7.21E-17
W4	-1.26E-01	-0.1154864	-2.18E-01	-2.18E-01	2.45E-01	2.45E-01	2.45E-01	2.45E-01	-1.52E-01	-1.52E-01	-1.52E-01
W5	-1.26E-01	-0.1154864	-2.18E-01	-2.18E-01	3.03E-01	3.03E-01	3.03E-01	3.03E-01	-6.84E-01	-6.84E-01	-6.84E-01
W6	-1.84E-01	-0.1695486	-6.99E-01	-6.99E-01	5.58E-01	5.58E-01	5.58E-01	5.58E-01	-1.52E-01	-1.52E-01	-1.52E-01
W7	-1.26E-01	-0.1154864	-2.18E-01	-2.18E-01	2.45E-01	2.45E-01	2.45E-01	2.45E-01	-1.52E-01	-1.52E-01	-1.52E-01
W9	-1.26E-01	-0.1154864	-1.28E-16	-1.28E-16	3.60E-16	3.60E-16	3.60E-16	3.60E-16	5.34E-17	5.34E-17	5.34E-17
W10	-1.12E-01	-0.0944937	6.21E-02	6.21E-02	-5.69E-02	-5.69E-02	-5.69E-02	-5.69E-02	1.22E-16	1.22E-16	1.22E-16
W13	-1.12E-01	-0.0944937	6.21E-02	6.21E-02	-5.69E-02	-5.69E-02	-5.69E-02	-5.69E-02	6.07E-17	6.07E-17	6.07E-17
W11		-0.0636739	2.17E-01	2.17E-01	-2.75E-01	-2.75E-01	-2.75E-01	-2.75E-01	9.93E-02	9.93E-02	9.93E-02
W12		-0.0636739	2.17E-01	2.17E-01	-2.75E-01	-2.75E-01	-2.75E-01	-2.75E-01	9.93E-02	9.93E-02	9.93E-02
W16			2.47E-01	2.47E-01	-3.26E-01	-3.26E-01	-3.26E-01	-3.26E-01	9.93E-02	9.93E-02	9.93E-02
W8			2.47E-01	2.47E-01	-3.09E-02	-3.09E-02	-3.09E-02	-3.09E-02	9.93E-02	9.93E-02	9.93E-02

Benchmark

Based off the most recent period

We see how close t_c matches t_f, and use that precision as a benchmark

Southern Women Dataset



Machine Learning Algorithms

Question: If we have the "community history" of a group can we correctly predict using some "affinity score" which communites individuals will end up in?

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Various Machine Learning Algorithms.

- Random Forrest
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Various Machine Learning Algorithms.

- Random Forrest
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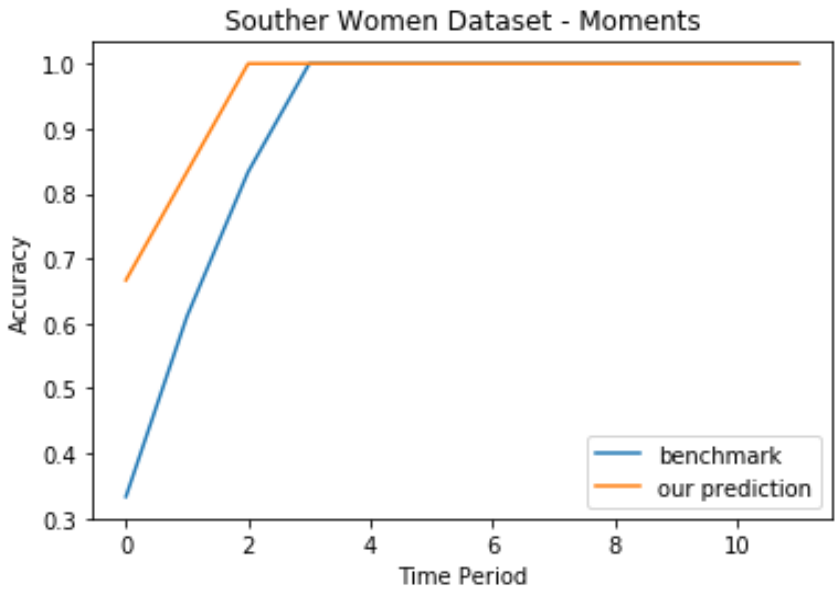
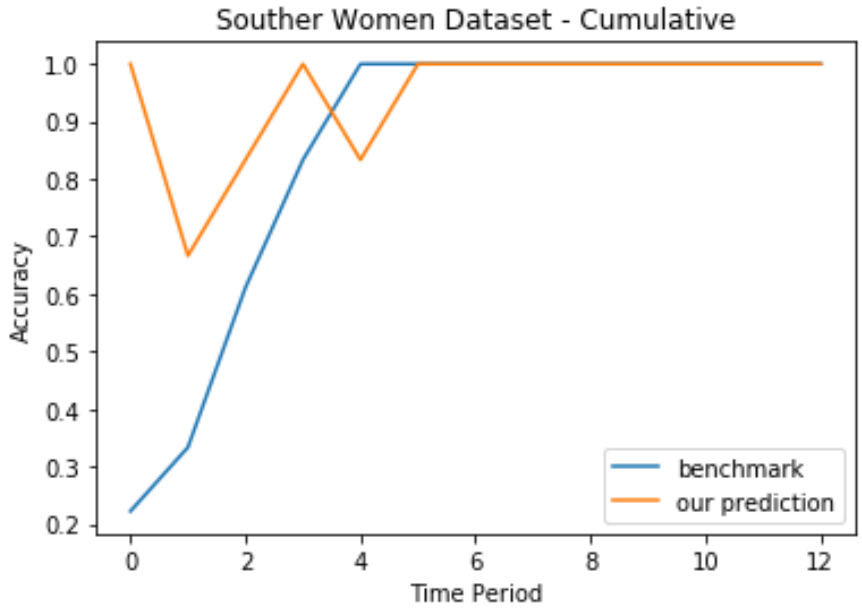
Existing Question: Is there a way to match the algorithm to the kind of network we observe?

Experimental Results

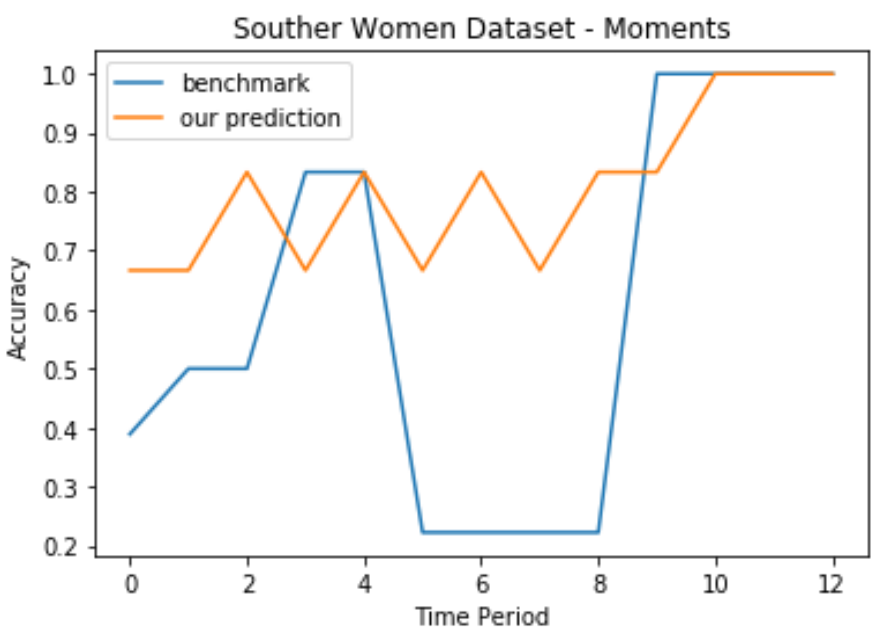
Results vary depending on community detection algorithm

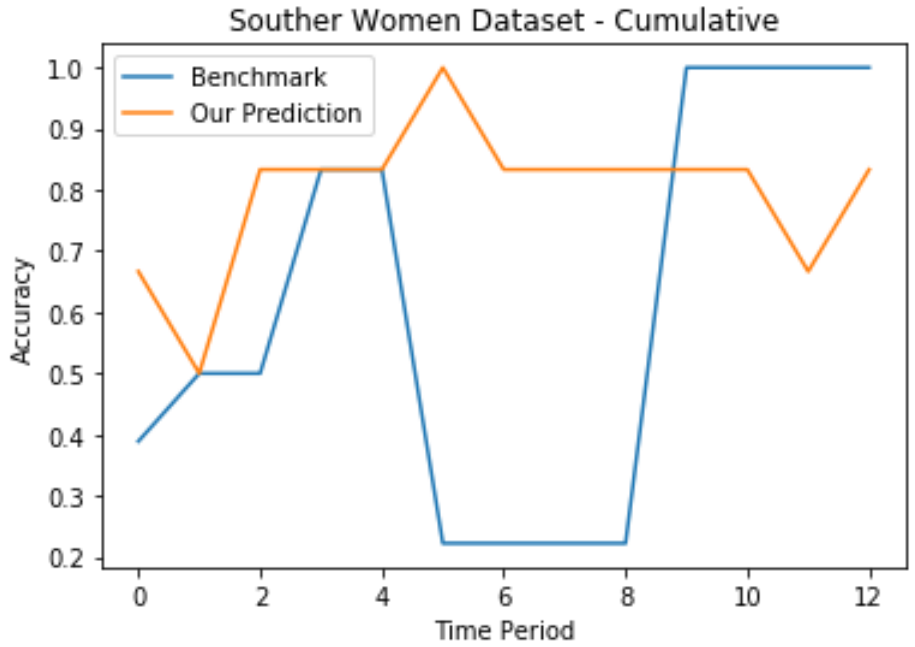
Experimental Results – Kernighan-Lin





Experimental Results – Spectral Partitioning





Other Networks

Advantages of using Southern Women Dataset

- Small => manageable
- Groups are intuitive

Disadvantages:

- Too small
- May not generalize

Other Networks

Other networks

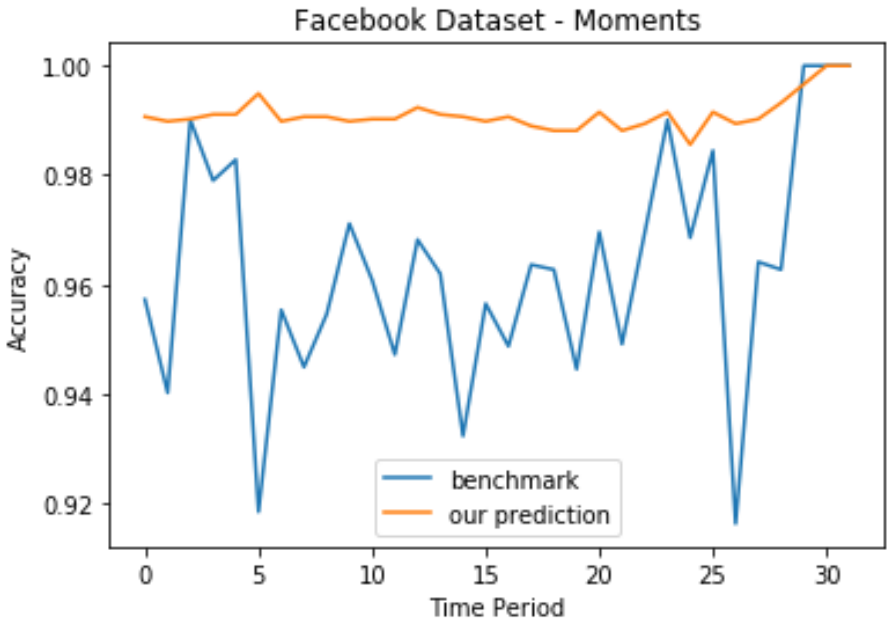
Facebook Dataset – Konect Database (2006-2009)

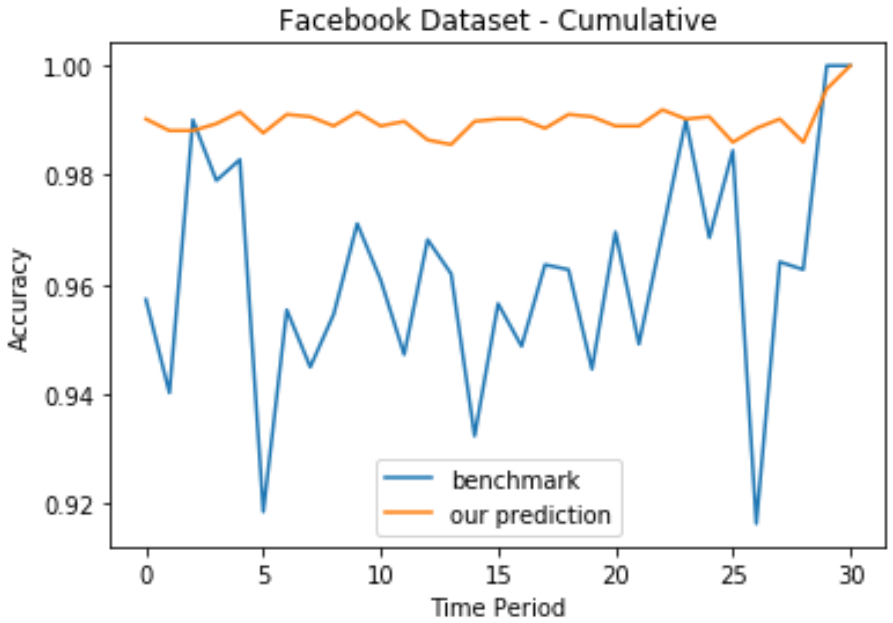
Subset of the Facebook social network

MIT Reality Mining Project – Konect Database

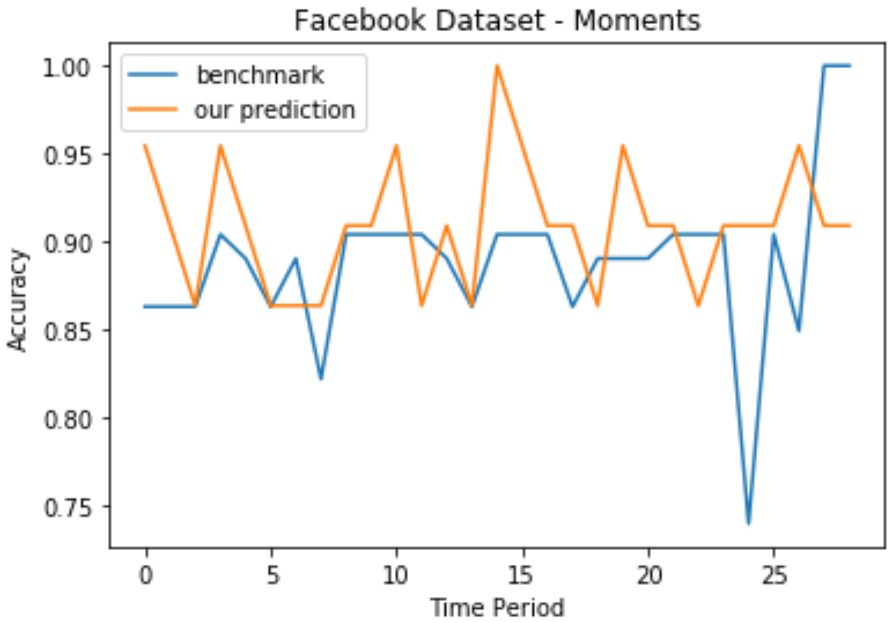
Contact between 100 individuals over time

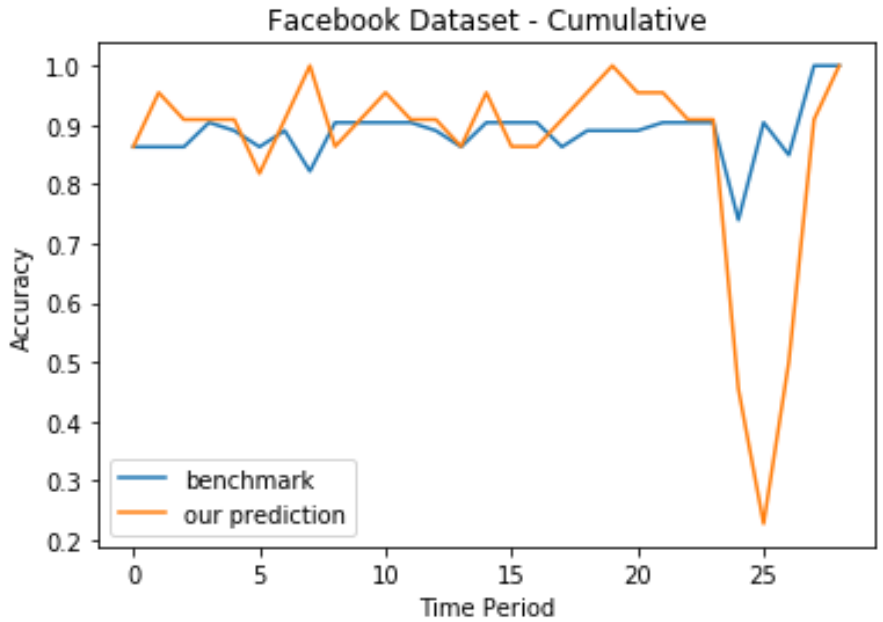
Experimental Results – Spectral Partitioning (2008-11)





Experimental Results – (growth around a single node)





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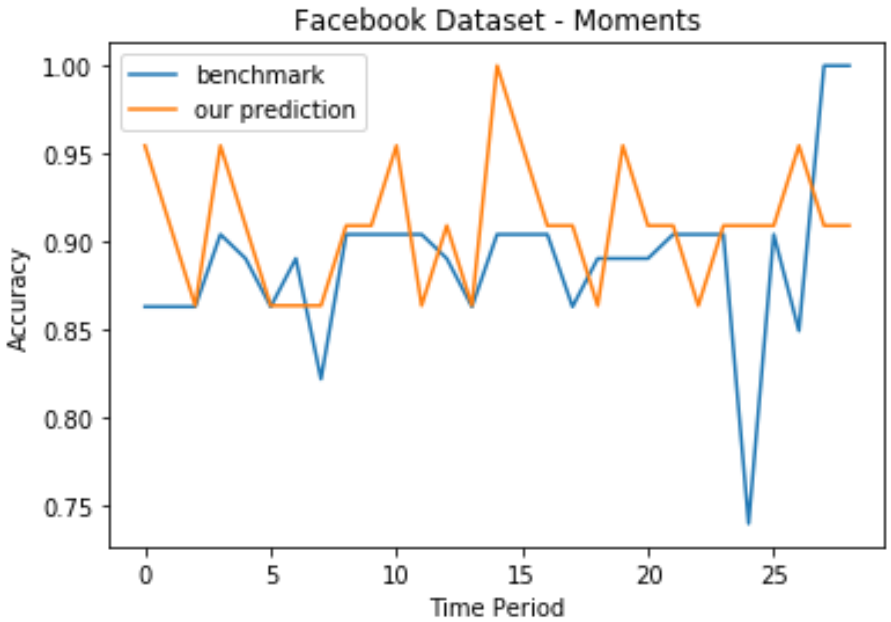
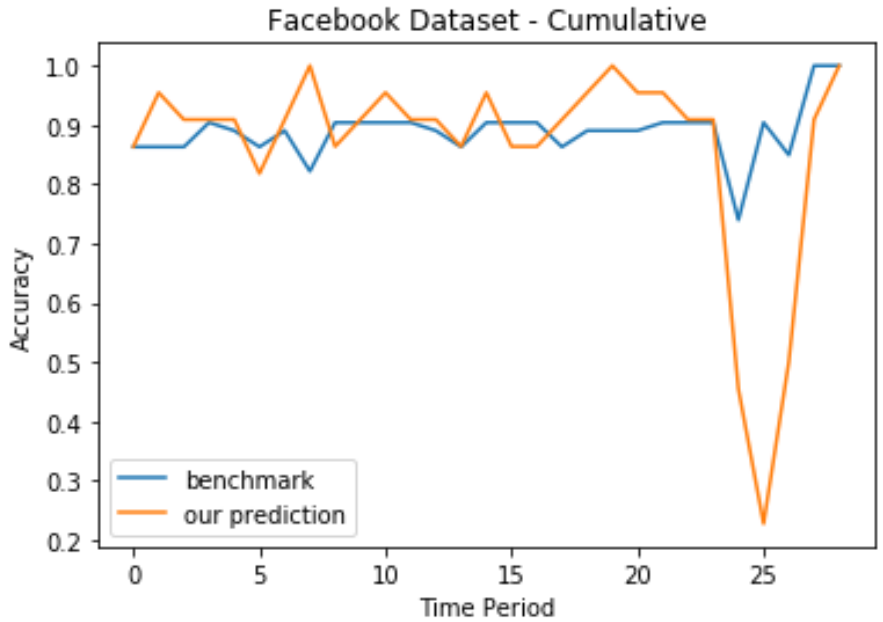
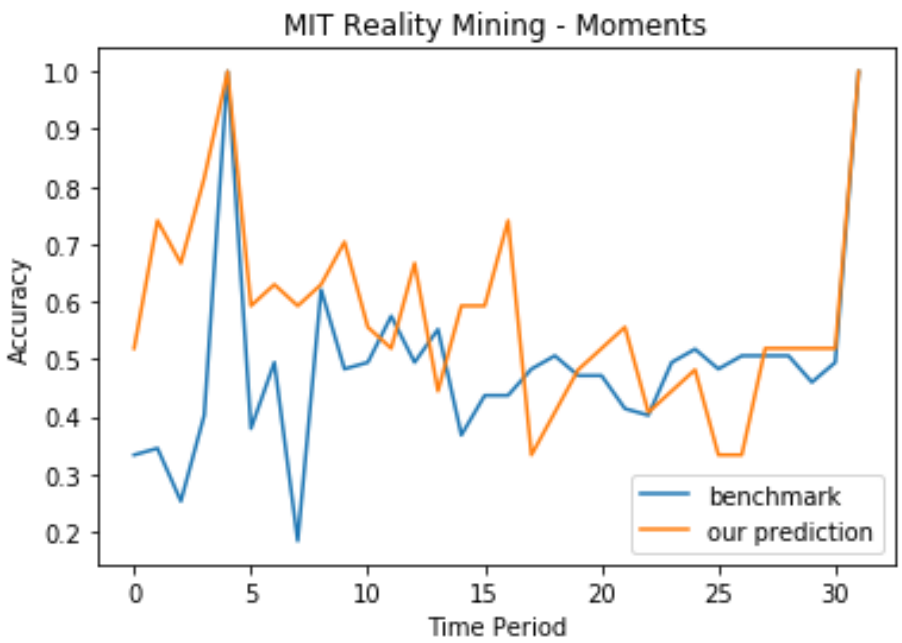


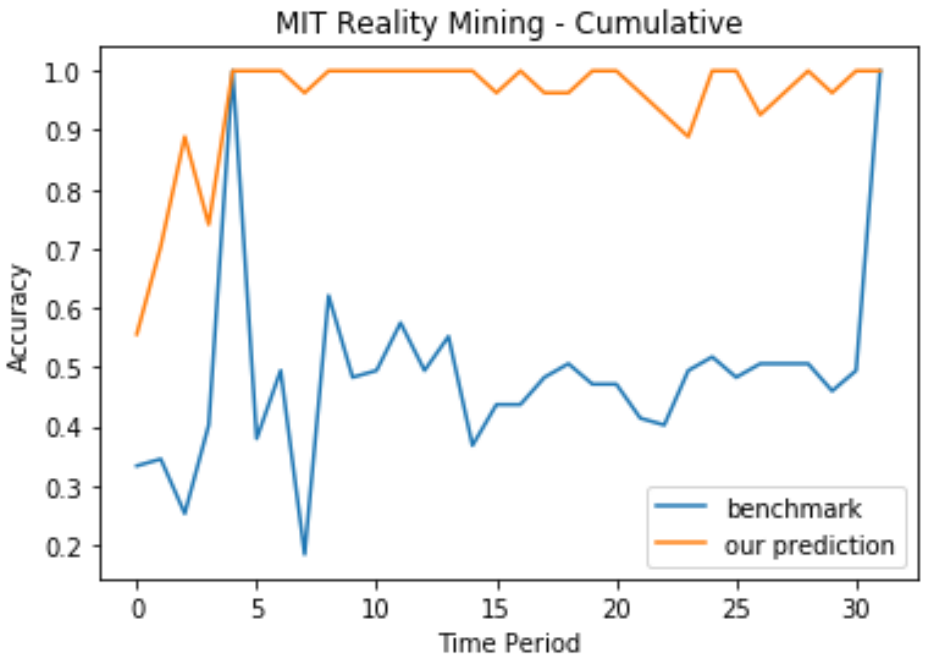


Result varies when observing the network around an individual or the entire network over a period of time

- Regardless, result is consistently better than the benchmark

Experimental Results – MIT





Summary

We can accurately predict group formation at a later point in time by observing the current structure of the communities based off of varying community detection algorithms

The End

Thank you!