Match Structures Changes as the FIRST Robotics Competition Program Evolved

Network Analysis of FRC Matches

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SYSM 6302 Final Project
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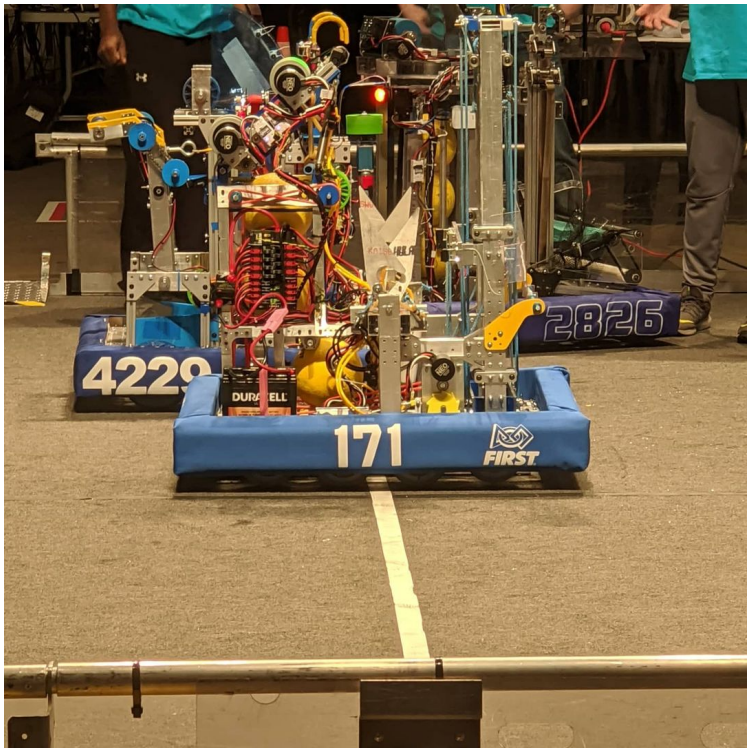
FIRST Robotics Competition

FRC 2826 - Wave Robotics - Oshkosh, WI
World Championship Finalists 2015



FRC 171 - The Cheese Curd Herd - Platteville, WI
Northern Lights Regional 2020 (Duluth, MI)

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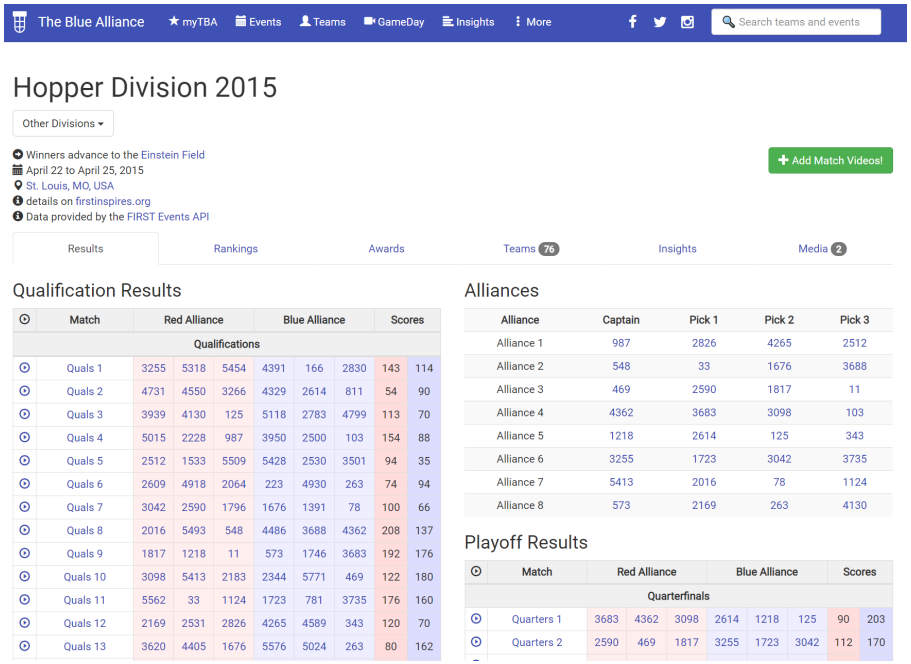
The Blue Alliance

www.thebluealliance.com [1]

The Blue Alliance is a very useful online database of past (and current) match data.



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Accessing The Blue Alliance Database

...nas\OneDrive - The University of Texas at Dallas\2021_Spring\SYSM6302\Project\TBA_database_access.py

test.py | TBA_database_access.py | TBA_Network_Analysis.py | dist_and_centrality_calc.py | graph_visualize.py

```python
# -*- coding: utf-8 -*-
"""
TBA_database_access is a module with functions for requesting from TBA.

Created on Wed Feb 24 18:43:49 2021

@author: Jonas
"""
import requests

# Interaction with TBA database
def getTBA(url, baseURL = 'http://www.thebluealliance.com/api/v3/',
           header = {'X-TBA-Auth-Key': '7uiNdsPDiLnsKapBtr3IlZfb4wYGkvpPD9IpyC
    """
    Get the JSON from The Blue Alliance database for requested url extension.

    Parameters
    ----------
    url : string
        url request extension.
    baseURL : string, optional. Default is TBA API v3
    header: set of strings, optional. Default is just TBA auth key.

    Returns
    -------
    json
        Requested data from The Blue Alliance.

    """
    return requests.get(baseURL + url, headers = header).json()


# Event Specific Queries
def getEventKeys(year):
    """
    Get all the keys of events over the course of a year

    Parameters
    ----------
    year : str (or int)

    Returns
    -------
    list of str (match_keys)

    """
    return getTBA('events/' + str(year) + '/keys')
```

```python
# Match Specific Queries
def getMatchData(key, simple = True):
    """
    Get the match data for a particular match

    Parameters
    ----------
    key : str (match_key)
    simple : bool, optional
        simple match data or not. The default is True.

    Returns
    -------
    matchData : dict
        dict containing all the match data

    """
    if simple == True:
        matchData = getTBA('match/' + key + '/simple')
    else:
        matchData = getTBA('match/' + key)
    return matchData
```

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Network Generation

...as\OneDrive - The University of Texas at Dallas\2021_Spring\SYSM6302\Project\TBA_Network_Analysis.py

test.py | TBA_database_access.py | TBA_Network_Analysis.py* | dist_and_centrality_calc.py | graph_visualize.py

```
10  # Nessicary Packages
11  import networkx as nx
12  import itertools
13  import TBA_database_access as tba
14  import numpy as np
15  from os import path
16  import matplotlib.pyplot as plt
17  import time
18
19  ## TBA_Network class ------------------------------------------------------
20  class TBA_Network:
21      """
22      TBA_NETWORK is a class for creating and analyzing networks made up from
23      FIRST Robotics Competition match data from The Blue Alliance.
24
25      Atributes
26      ---------
27      year : str
28          year of frc season.
29      event : list of str
30          list of event_keys for all events in network.
31      nodeType : str
32          node type (only programmed for teams as nodes).
33      edgeType : str
34          edge type (only programmed for matches as edges).
35      nodeMeta : list of str
36          list of meta elements to be stored as node attibutes.
37      edgeMeta : list of str
38          list of meta elements to be stored as edge attibutes.
39      nodeKeys : list of str
40          list of keys for all the nodes in the network.
41      edgeKeys : list of str
42          list of keys for all the (meta-)edges in the network.
43          (These edges are actually more like clusters... each is a match)
44      nodeData : dict of dicts
45          dictionary of all node attributes keyed by the nodeKeys.
46      edgeData : dict of dicts
47          dictionary of all edge attributes keyed by the nodeKeys.
48          (These edges are actually more like clusters... each is a match)
49      edgeTuples : list of tuples
50          list containing tuples related to every node within a the network.
51          (used to generate all the edges within the nx.MultiGraph)
52      G : nx.MultiGraph
53          nx.MultiGraph constructed with all the nodes and edges with the metadata
54          stored as attributes.
55      G_default : nx.Graph
56          nx.Graph that is the default weighted undirected projection representing
57          the total number of edges that connects them.
58      G_----- : nx.Graphs
59          many additional projections will be saved to the network class itself
60
61      Methods
62      -------
```

```
    Methods
    -------
    GetProjection(self, projection = 'none')
        Locates or generates a specific projection
    GraphProjections(self, alliancePartners = 0, weightCalc = 'default')
        Generates undirected weighted projections of the network with weighting
        calculated acording to specific parameters.
    WeightCalc(self, team1, team2, weightCalc)
        Function for detirmining the weighting between two nodes.
    TeamKeys(self)
        Method that returns a list of team keys
    MatchKeys(self)
        Method that returns a list of match keys

    Centrality(self, node=-1, projection='none', mode='degree', print_top_nodes=-1)
        Calculates the a particular centrality metric fo a specified projection
    Diameter(self, projection='none')
        Calculates the diameter of a particular projection
    DegreeSequence(self, projection = 'none')
        Returns a sorted list with team keys and degrees
    DegreeDist(self, projection='none')
        Returns a list of the degree distribution
    PlotDDist(self, projection='none', axes=-1)
        Plots a Degree Distribution for a particular projection
    DrawGraph(self, projection='none', -------)
        Draw a simple projection of the graph using built in commands

    """

    def __init__(self, year = -1, event = -1,
                 nodeType = 'team', edgeType = 'match',
                 nodeMeta = ['nickname', 'name', 'state_prov', 'country'],
                 edgeMeta = ['match_key', 'event_key', 'scores', 'teams',
                             'winning_alliance', 'alliancePartners',
                             'comp_level', 'match_number'],
                 filename_base = 'Data/TBA_Network_',
                 ):
        """
        TBA_NETWORK constructor function. Creates a TBA_Network object
        constructed with TBA data acorrding to specific inputs

        Parameters
        ----------
        year : int or str, optional
            year specifier. The default is -1.
```

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Full Season Network

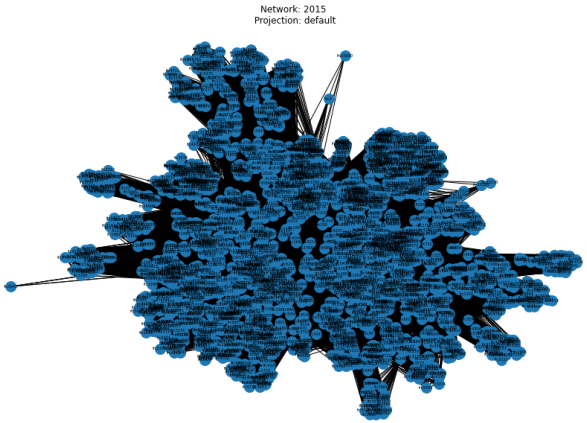
2015 (my favorite season)

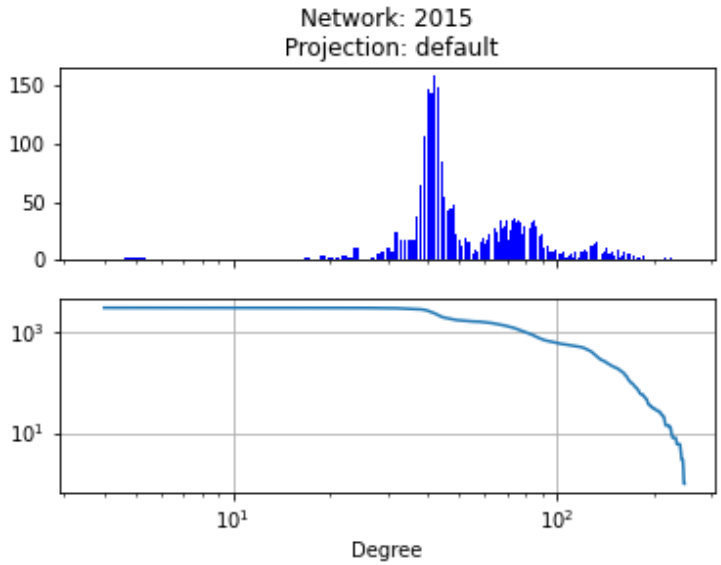
Network: Entire 2015 Season

TBA_Network_2015.gml (45 MB)

(https://www.thebluealliance.com/events/2015)

- Nodes: 2,935 Teams
- Mult-edges: 195,152 Matches
- Edges: 106,889 Unique Matches
- Components: 1
- Diameter: 4
- Clustering Coefficient: 0.635
- Degree Assortativity: 0.296 (0.358)
- Average Degree: 73.49 (132.98)
- Density: 0.02527 (0.04532)





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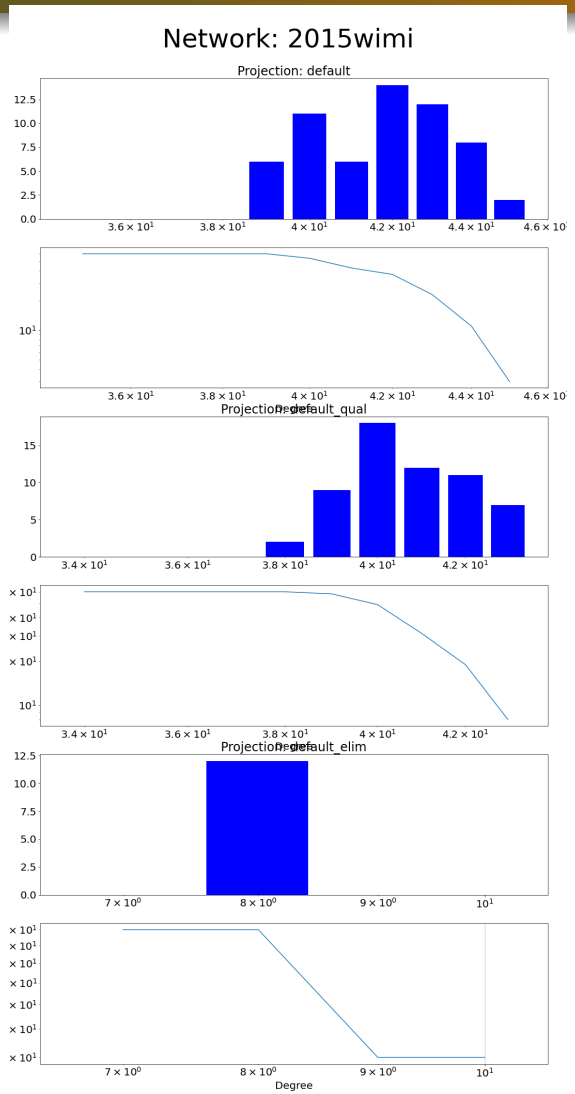
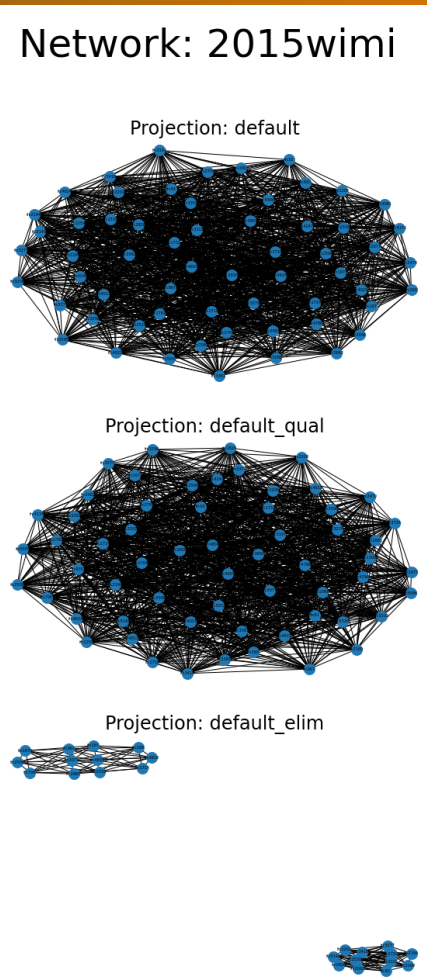
2015 Wisconsin Regional Analysis

Milwaukee, WI

```
Getting Projection: default
Diameter =  2
----------------------------------------------
Getting Projection: default
degree centrality
----------------------
  1. frc706 (0.7797)
  2. frc269 (0.7627)
  3. frc3102 (0.7627)
  4. frc1732 (0.7458)
  5. frc2077 (0.7458)
  6. frc2506 (0.7458)
  7. frc2883 (0.7458)
  8. frc4818 (0.7458)
  9. frc967 (0.7458)
  10. frc167 (0.7458)
----------------------
Getting Projection: default
eigenvector centrality
----------------------
  1. frc706 (0.1419)
  2. frc3102 (0.1389)
  3. frc269 (0.1389)
  4. frc2506 (0.1361)
  5. frc2077 (0.1358)
  6. frc1732 (0.1356)
  7. frc2883 (0.1355)
  8. frc967 (0.1355)
  9. frc167 (0.1354)
  10. frc4818 (0.1352)
----------------------
Getting Projection: default
katz centrality
----------------------
  1. frc706 (0.1864)
  2. frc3102 (0.1806)
  3. frc269 (0.1755)
  4. frc2506 (0.1650)
  5. frc2826 (0.1641)
  6. frc2077 (0.1629)
  7. frc1732 (0.1627)
  8. frc2883 (0.1602)
  9. frc1675 (0.1595)
  10. frc93 (0.1571)
----------------------
```

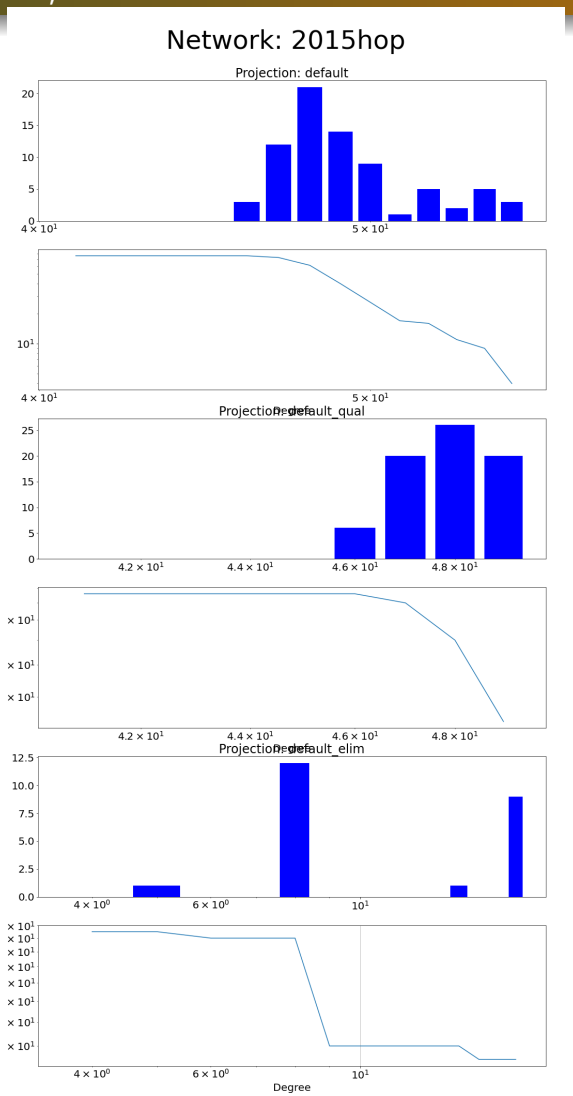


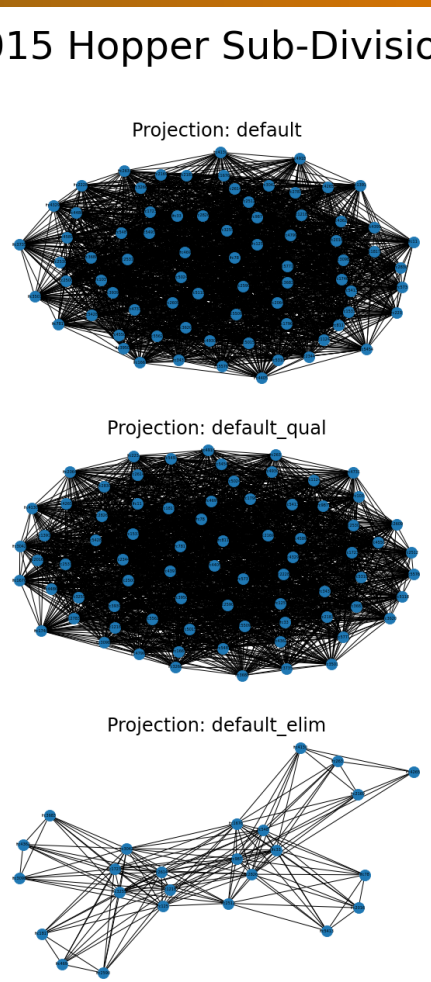


2015 Hopper Sub-Division Analysis

FIRST Championships 2015: St. Louis, MO

```
Getting Projection: default
Diameter =  2
--------------------------------------------
Getting Projection: default
degree centrality
----------------------
  1. frc3042 (0.7467)
  2. frc1676 (0.7333)
  3. frc1723 (0.7333)
  4. frc125 (0.7333)
  5. frc3255 (0.7200)
  6. frc548 (0.7200)
  7. frc987 (0.7200)
  8. frc2512 (0.7200)
  9. frc33 (0.7200)
  10. frc2826 (0.7067)
----------------------
Getting Projection: default
eigenvector centrality
----------------------
  1. frc3042 (0.1303)
  2. frc1676 (0.1284)
  3. frc1723 (0.1281)
  4. frc125 (0.1280)
  5. frc3255 (0.1263)
  6. frc987 (0.1262)
  7. frc2512 (0.1260)
  8. frc33 (0.1260)
  9. frc548 (0.1257)
  10. frc2826 (0.1237)
----------------------
Getting Projection: default
katz centrality
----------------------
  1. frc987 (0.2103)
  2. frc3255 (0.2103)
  3. frc1676 (0.2078)
  4. frc3042 (0.1954)
  5. frc33 (0.1936)
  6. frc1723 (0.1912)
  7. frc548 (0.1883)
  8. frc2512 (0.1864)
  9. frc2826 (0.1839)
  10. frc2614 (0.1804)
----------------------
```

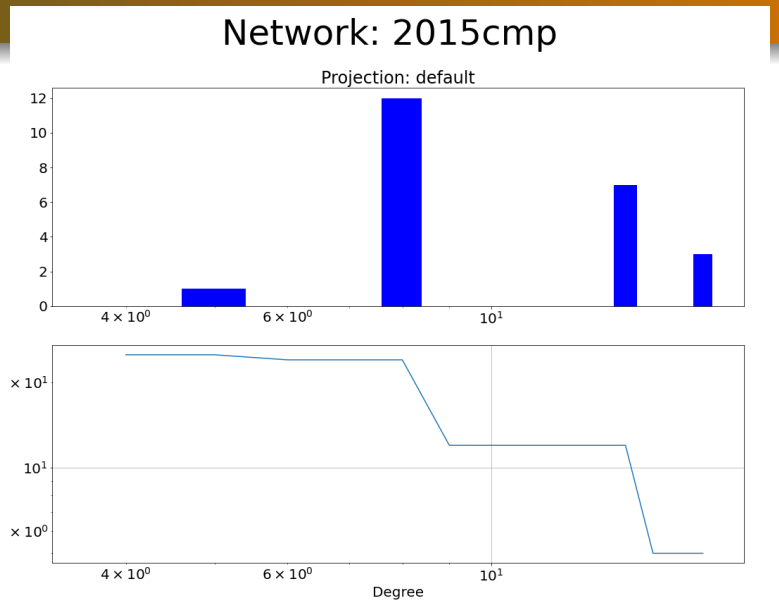


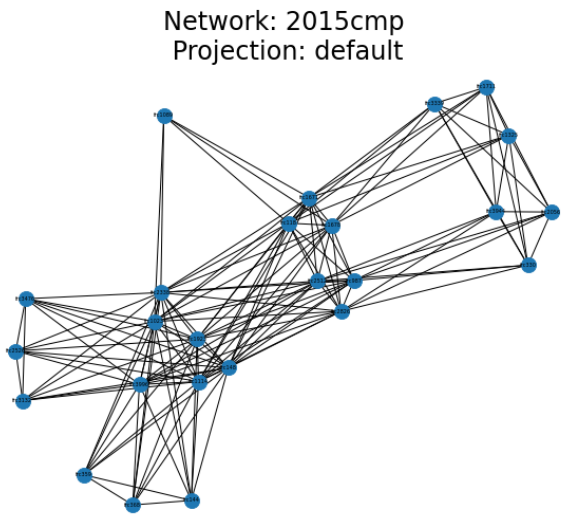


2015 Einstein Analysis

FIRST Championships 2015: St. Louis, MO

```
Getting Projection: default
Diameter =  3
-----------------------------------------------
Getting Projection: default
degree centrality
----------------------
  1. frc1023 (0.7500)
  2. frc2338 (0.7500)
  3. frc1114 (0.7083)
  4. frc148 (0.7083)
  5. frc1923 (0.7083)
  6. frc118 (0.5833)
  7. frc1671 (0.5833)
  8. frc1678 (0.5833)
  9. frc2512 (0.5833)
  10. frc2826 (0.5833)
----------------------
Getting Projection: default
eigenvector centrality
----------------------
  1. frc1023 (0.2931)
  2. frc2338 (0.2931)
  3. frc1114 (0.2861)
  4. frc148 (0.2861)
  5. frc1923 (0.2861)
  6. frc2512 (0.2397)
  7. frc2826 (0.2397)
  8. frc987 (0.2397)
  9. frc3996 (0.2370)
  10. frc118 (0.2293)
----------------------
Getting Projection: default
katz centrality
----------------------
  1. frc1023 (0.3181)
  2. frc2338 (0.3181)
  3. frc1114 (0.3122)
  4. frc148 (0.3122)
  5. frc1923 (0.3122)
  6. frc3996 (0.2535)
  7. frc2826 (0.2338)
  8. frc987 (0.2338)
  9. frc2512 (0.2338)
  10. frc1678 (0.2152)
----------------------
```





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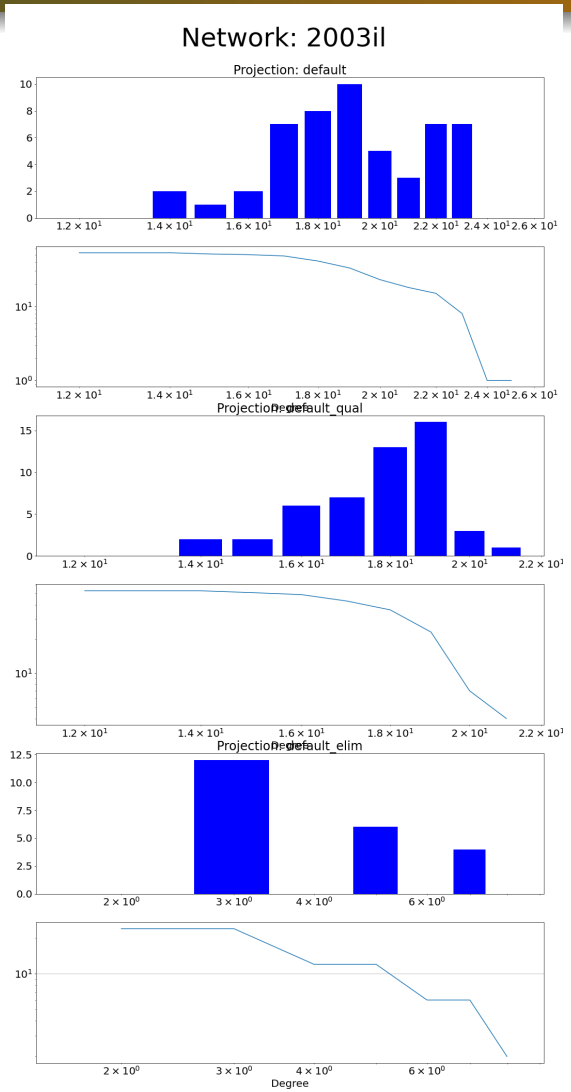
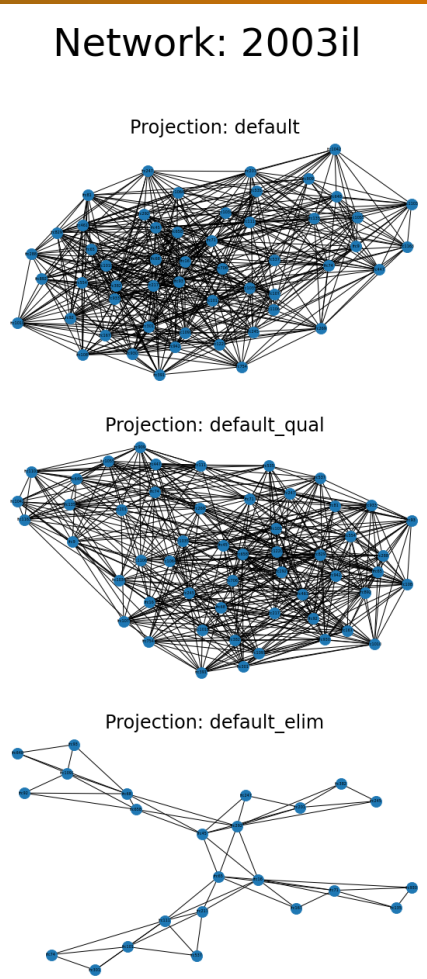
2003 Midwest Regional Analysis

Pre-WI Regional: In Evanston, IL

```
Getting Projection: default
Diameter =  3
--------------------------------------------
Getting Projection: default
degree centrality
----------------------
  1. frc16 (0.5000)
  2. frc111 (0.4423)
  3. frc217 (0.4423)
  4. frc292 (0.4423)
  5. frc1091 (0.4423)
  6. frc45 (0.4423)
  7. frc658 (0.4423)
  8. frc71 (0.4423)
  9. frc101 (0.4231)
  10. frc461 (0.4231)
----------------------
Getting Projection: default
eigenvector centrality
----------------------
  1. frc16 (0.1884)
  2. frc217 (0.1677)
  3. frc292 (0.1667)
  4. frc45 (0.1647)
  5. frc658 (0.1639)
  6. frc1091 (0.1637)
  7. frc92 (0.1627)
  8. frc461 (0.1621)
  9. frc829 (0.1603)
  10. frc65 (0.1558)
----------------------
Getting Projection: default
katz centrality
----------------------
  1. frc461 (0.2297)
  2. frc92 (0.2296)
  3. frc217 (0.2144)
  4. frc1010 (0.2119)
  5. frc167 (0.1995)
  6. frc1091 (0.1979)
  7. frc16 (0.1943)
  8. frc829 (0.1929)
  9. frc65 (0.1904)
  10. frc292 (0.1891)
----------------------
```

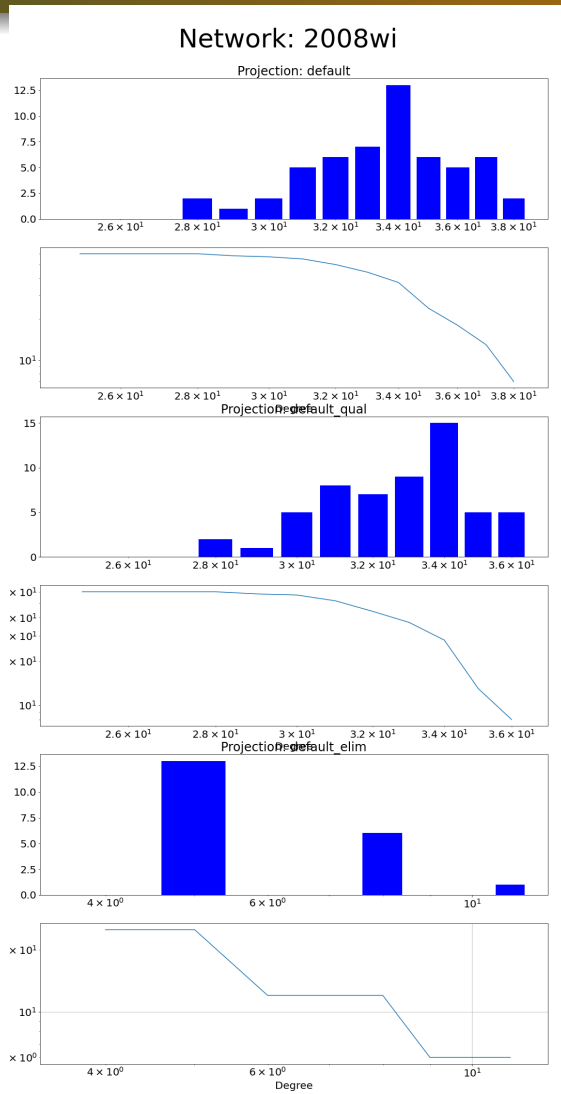


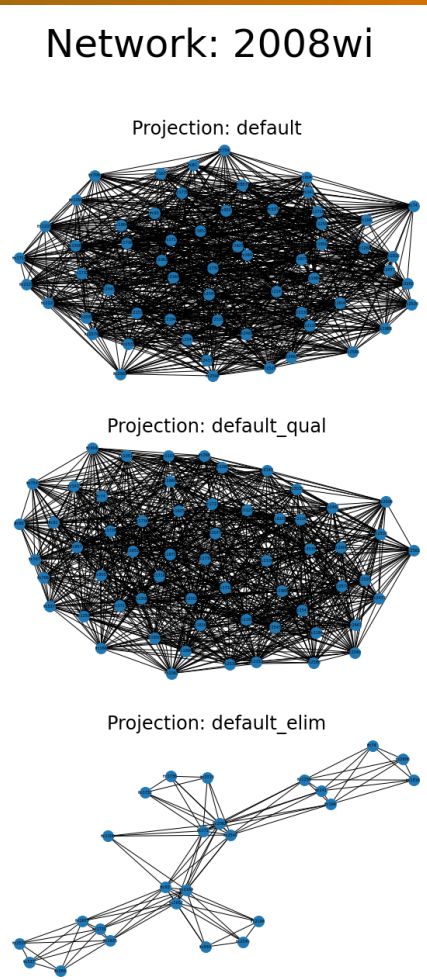


2008 Wisconsin Regional Analysis

Milwaukee, WI

```
Getting Projection: default
Diameter =  2
--------------------------------------------
Getting Projection: default
degree centrality
----------------------
  1. frc1652 (0.6610)
  2. frc171 (0.6610)
  3. frc1816 (0.6610)
  4. frc269 (0.6610)
  5. frc1675 (0.6610)
  6. frc1625 (0.6441)
  7. frc2549 (0.6441)
  8. frc1259 (0.6271)
  9. frc1306 (0.6271)
  10. frc1730 (0.6271)
----------------------
Getting Projection: default
eigenvector centrality
----------------------
  1. frc1652 (0.1478)
  2. frc171 (0.1475)
  3. frc269 (0.1475)
  4. frc1675 (0.1465)
  5. frc1816 (0.1464)
  6. frc2549 (0.1434)
  7. frc1625 (0.1430)
  8. frc1306 (0.1416)
  9. frc2169 (0.1414)
  10. frc1259 (0.1406)
----------------------
Getting Projection: default
katz centrality
----------------------
  1. frc2549 (0.2124)
  2. frc2169 (0.2025)
  3. frc2153 (0.1844)
  4. frc2574 (0.1835)
  5. frc1652 (0.1816)
  6. frc1816 (0.1809)
  7. frc1306 (0.1799)
  8. frc269 (0.1792)
  9. frc171 (0.1781)
  10. frc1675 (0.1723)
----------------------
```

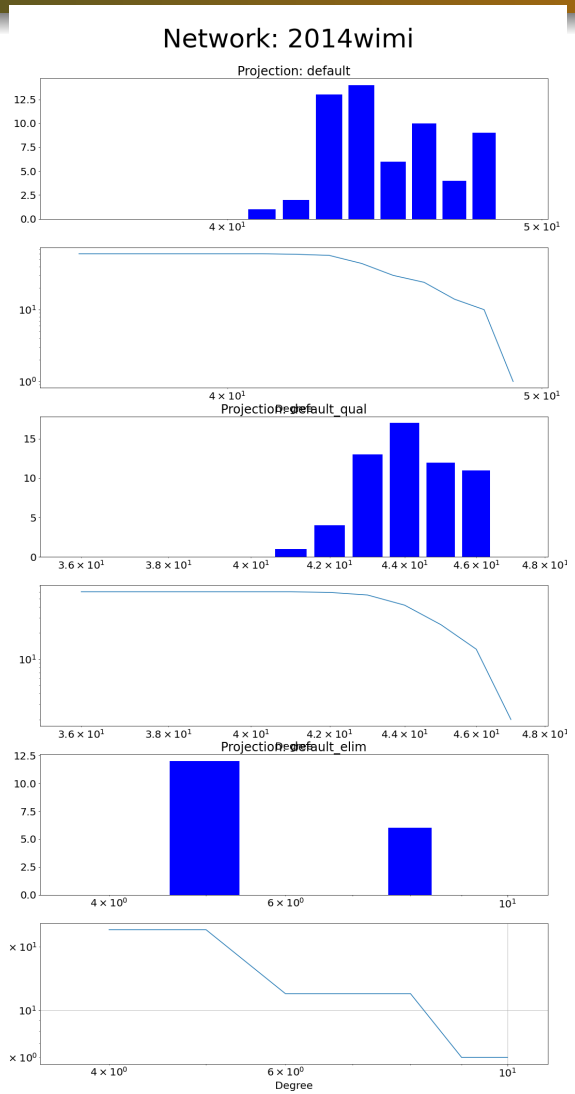


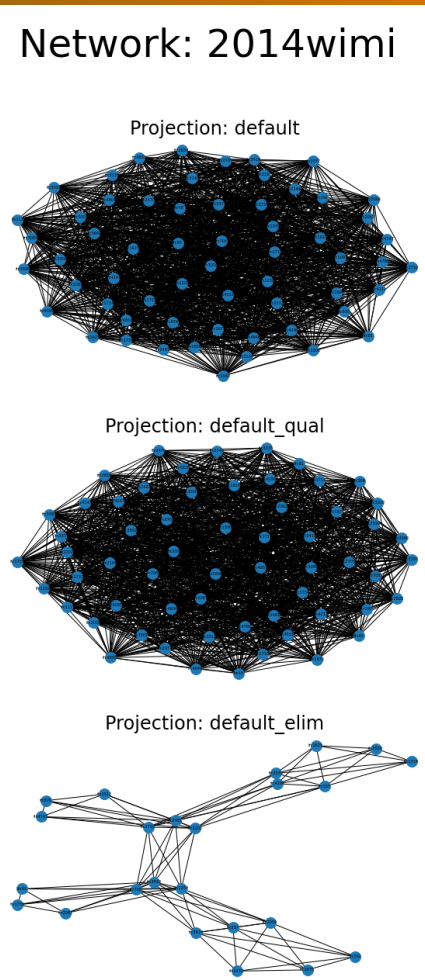


2014 Wisconsin Regional Analysis

Milwaukee, WI

```
Getting Projection: default
Diameter =  2
--------------------------------------------
Getting Projection: default
degree centrality
----------------------
  1. frc3018 (0.8475)
  2. frc1732 (0.8136)
  3. frc2039 (0.8136)
  4. frc2705 (0.8136)
  5. frc2826 (0.8136)
  6. frc3418 (0.8136)
  7. frc4296 (0.8136)
  8. frc706 (0.8136)
  9. frc2202 (0.8136)
  10. frc2194 (0.8136)
----------------------
Getting Projection: default
eigenvector centrality
----------------------
  1. frc3018 (0.1427)
  2. frc2194 (0.1383)
  3. frc4296 (0.1379)
  4. frc2039 (0.1377)
  5. frc2202 (0.1376)
  6. frc706 (0.1375)
  7. frc1732 (0.1375)
  8. frc2826 (0.1371)
  9. frc3418 (0.1371)
  10. frc2705 (0.1370)
----------------------
Getting Projection: default
katz centrality
----------------------
  1. frc3018 (0.1842)
  2. frc2194 (0.1831)
  3. frc4296 (0.1745)
  4. frc1259 (0.1691)
  5. frc706 (0.1688)
  6. frc2202 (0.1663)
  7. frc2039 (0.1661)
  8. frc1732 (0.1660)
  9. frc167 (0.1614)
  10. frc2826 (0.1603)
----------------------
```

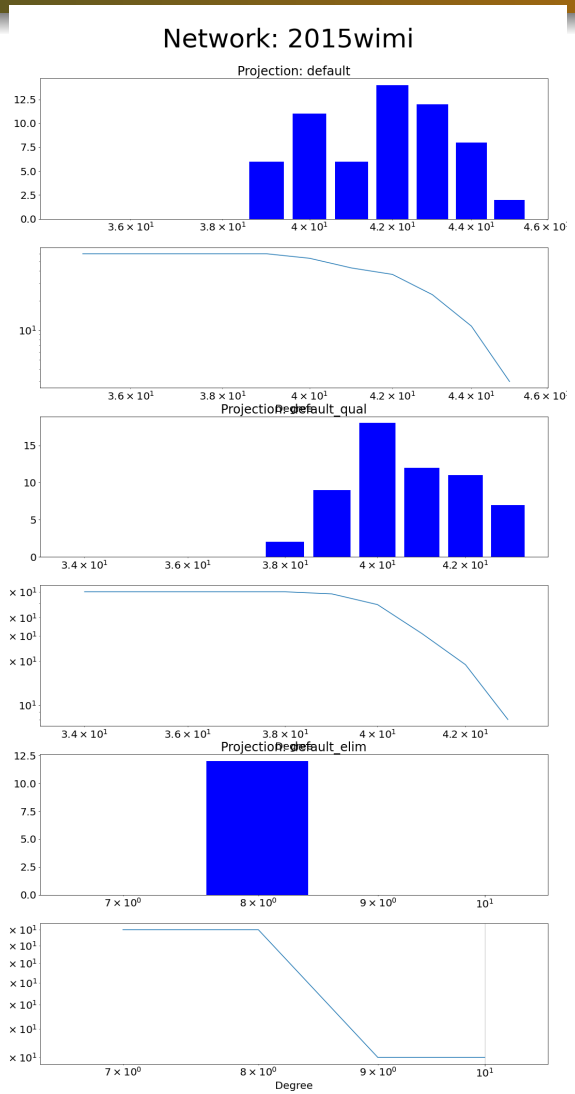


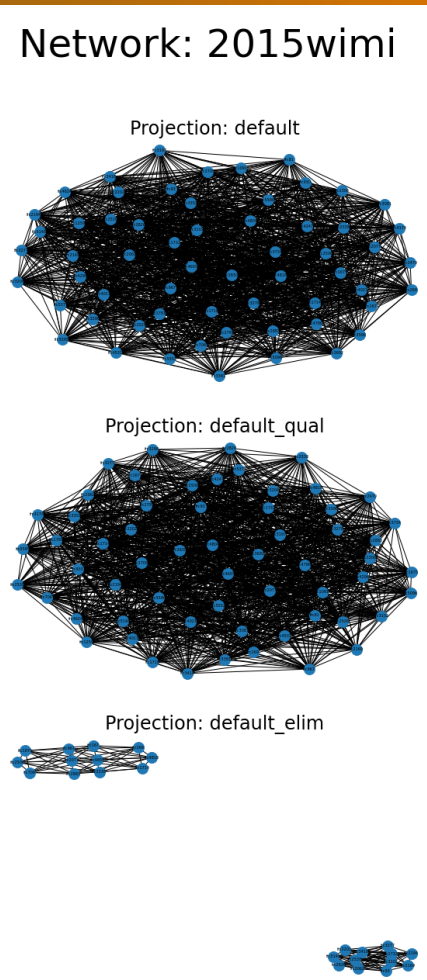


2015 Wisconsin Regional Analysis

Milwaukee, WI

```
Getting Projection: default
Diameter =  2
----------------------------------------------
Getting Projection: default
degree centrality
----------------------
  1. frc706 (0.7797)
  2. frc269 (0.7627)
  3. frc3102 (0.7627)
  4. frc1732 (0.7458)
  5. frc2077 (0.7458)
  6. frc2506 (0.7458)
  7. frc2883 (0.7458)
  8. frc4818 (0.7458)
  9. frc967 (0.7458)
  10. frc167 (0.7458)
----------------------
Getting Projection: default
eigenvector centrality
----------------------
  1. frc706 (0.1419)
  2. frc3102 (0.1389)
  3. frc269 (0.1389)
  4. frc2506 (0.1361)
  5. frc2077 (0.1358)
  6. frc1732 (0.1356)
  7. frc2883 (0.1355)
  8. frc967 (0.1355)
  9. frc167 (0.1354)
  10. frc4818 (0.1352)
----------------------
Getting Projection: default
katz centrality
----------------------
  1. frc706 (0.1864)
  2. frc3102 (0.1806)
  3. frc269 (0.1755)
  4. frc2506 (0.1650)
  5. frc2826 (0.1641)
  6. frc2077 (0.1629)
  7. frc1732 (0.1627)
  8. frc2883 (0.1602)
  9. frc1675 (0.1595)
  10. frc93 (0.1571)
----------------------
```

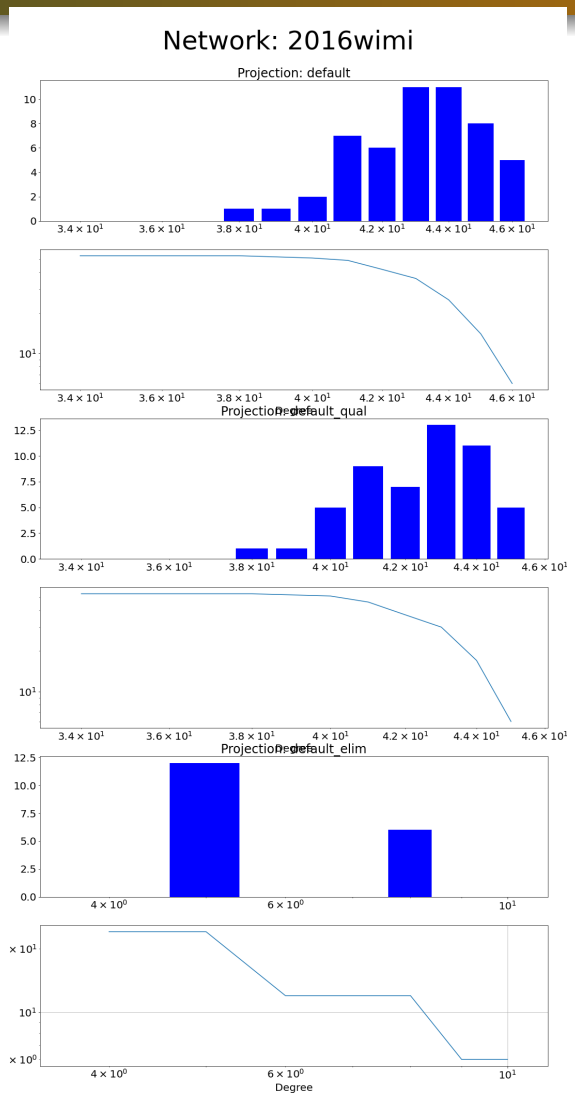


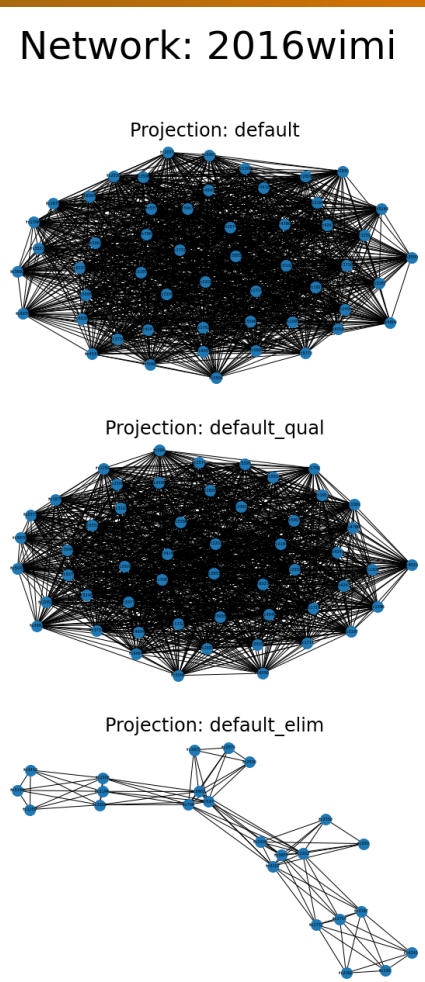


2016 Wisconsin Regional Analysis

Milwaukee, WI

```
Getting Projection: default
Diameter =  2
--------------------------------------------
Getting Projection: default
degree centrality
----------------------
  1. frc2574 (0.9038)
  2. frc1259 (0.8846)
  3. frc1306 (0.8846)
  4. frc2194 (0.8846)
  5. frc5003 (0.8846)
  6. frc2202 (0.8846)
  7. frc192 (0.8654)
  8. frc2077 (0.8654)
  9. frc2358 (0.8654)
  10. frc2530 (0.8654)
----------------------
Getting Projection: default
eigenvector centrality
----------------------
  1. frc2574 (0.1493)
  2. frc2194 (0.1463)
  3. frc1259 (0.1461)
  4. frc1306 (0.1461)
  5. frc2202 (0.1458)
  6. frc5003 (0.1457)
  7. frc2530 (0.1431)
  8. frc192 (0.1430)
  9. frc5855 (0.1429)
  10. frc2077 (0.1429)
----------------------
Getting Projection: default
katz centrality
----------------------
  1. frc2574 (0.1894)
  2. frc2194 (0.1777)
  3. frc1259 (0.1756)
  4. frc1306 (0.1739)
  5. frc2202 (0.1696)
  6. frc5003 (0.1665)
  7. frc2530 (0.1634)
  8. frc192 (0.1596)
  9. frc5855 (0.1591)
  10. frc2077 (0.1583)
----------------------
```

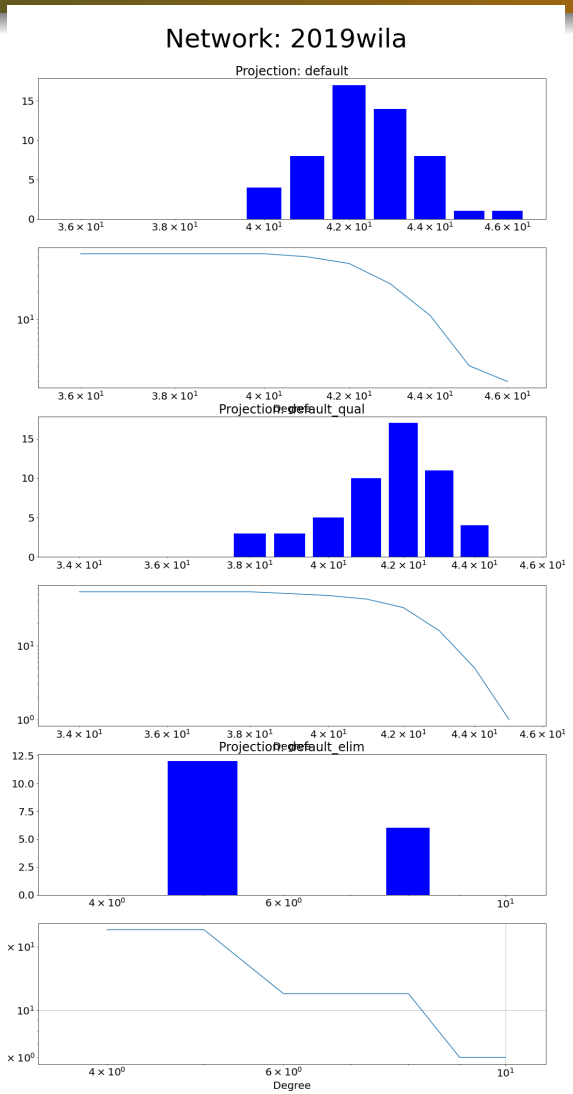


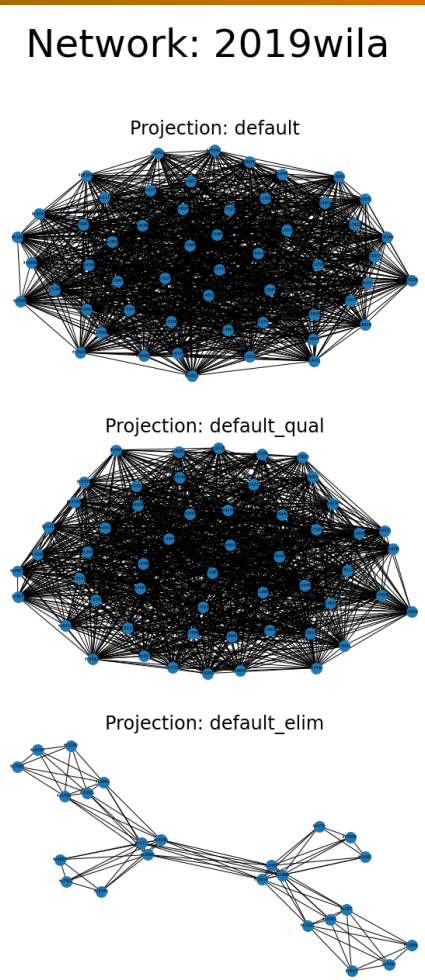


2019 Seven-Rivers Regional Analysis

La Crosse, WI

```
Getting Projection: default
Diameter =  2
-----------------------------------------------
Getting Projection: default
degree centrality
----------------------
  1. frc2081 (0.8868)
  2. frc4296 (0.8679)
  3. frc1986 (0.8491)
  4. frc3928 (0.8302)
  5. frc4786 (0.8302)
  6. frc6381 (0.8302)
  7. frc6420 (0.8302)
  8. frc7048 (0.8302)
  9. frc7596 (0.8302)
  10. frc2194 (0.8302)
----------------------
Getting Projection: default
eigenvector centrality
----------------------
  1. frc2081 (0.1502)
  2. frc4296 (0.1475)
  3. frc1986 (0.1436)
  4. frc3928 (0.1411)
  5. frc7596 (0.1411)
  6. frc6381 (0.1410)
  7. frc2194 (0.1409)
  8. frc648 (0.1407)
  9. frc4786 (0.1407)
  10. frc6420 (0.1406)
----------------------
Getting Projection: default
katz centrality
----------------------
  1. frc2081 (0.1922)
  2. frc4296 (0.1890)
  3. frc1986 (0.1613)
  4. frc6381 (0.1608)
  5. frc3928 (0.1607)
  6. frc7596 (0.1589)
  7. frc2194 (0.1572)
  8. frc648 (0.1554)
  9. frc4786 (0.1549)
  10. frc6420 (0.1520)
----------------------
```





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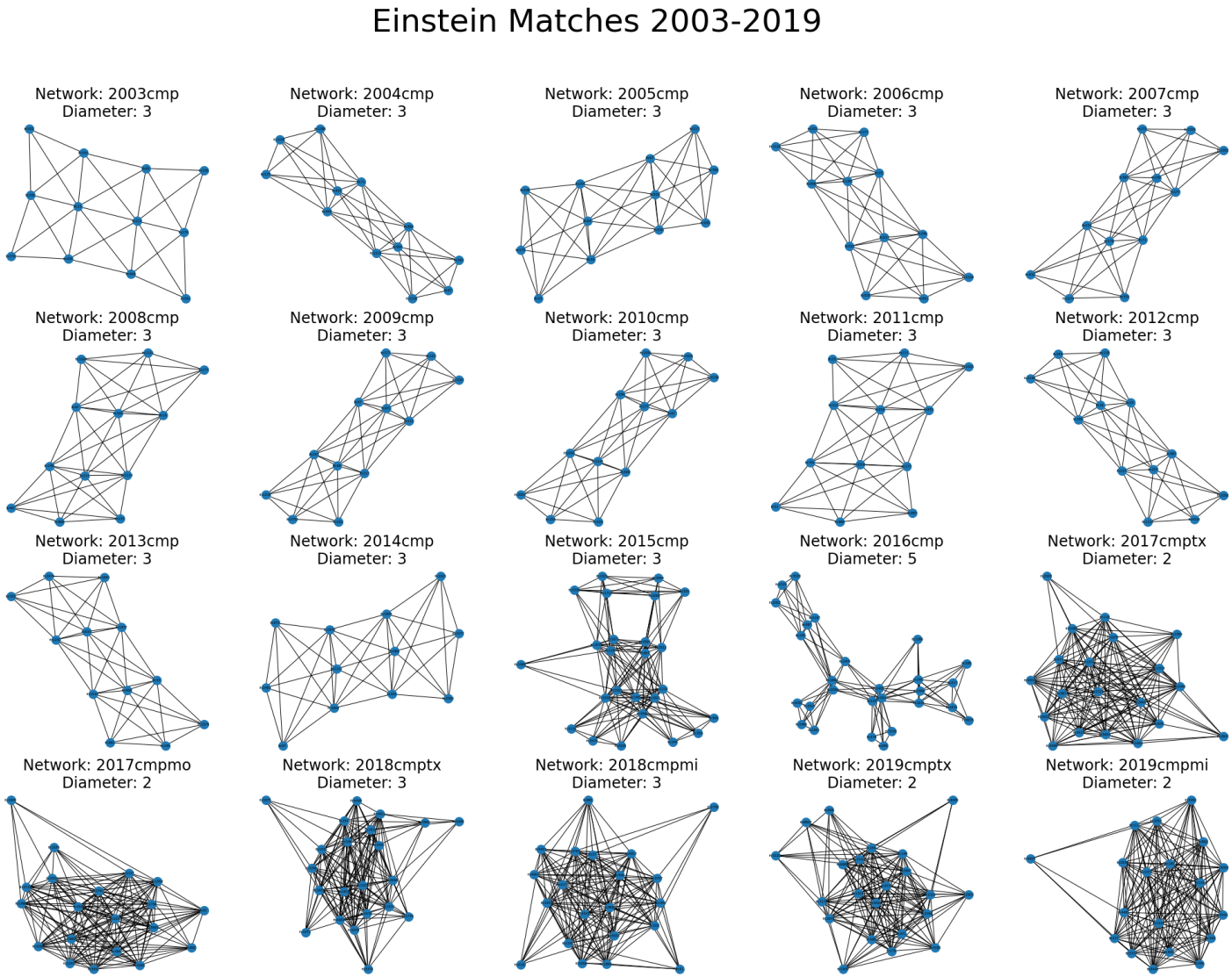
Einstein (Championship) Matches



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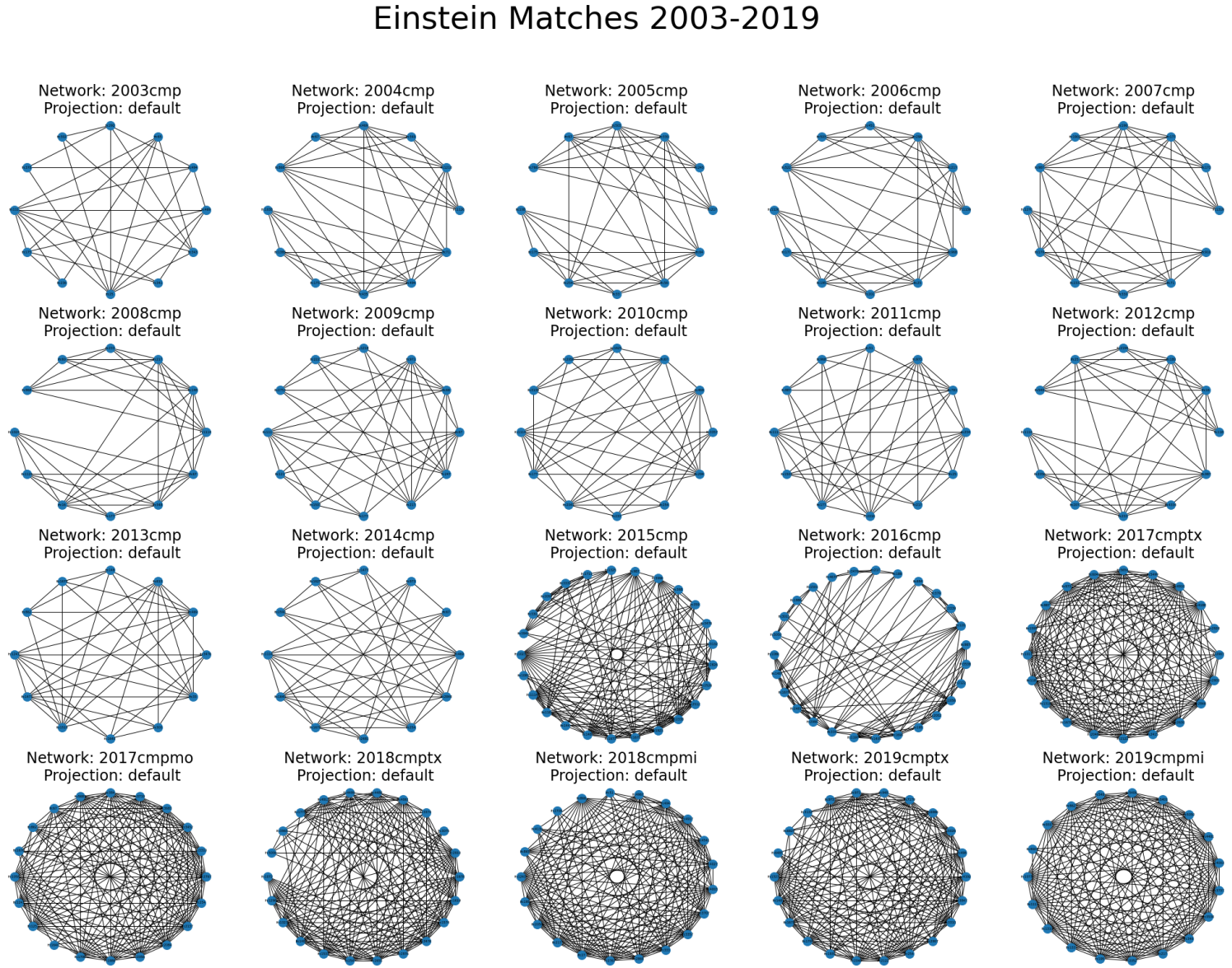
Einstein (Championship) Matches



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Ending

Thanks for listening...
I hope it was was interesting...
Any Questions?

Bibliography I

Bibliography isn't showing up????

- The Blue Alliance: https://www.thebluealliance.com/
- networkx

[1]