

# Predicting Multiplex Networks from Embraces in Spider Monkeys: Computational Tools for Quantifying Social Bonds

## Introduction

The emerging field of network science has demonstrated that social relationships emerge from structural connections known as a social network. Relationships emerge from social bonds across multiple behavior types, and are represented using a multiplex network. In using a multiplex approach, social bonds across and within behavior types may be examined. Spider monkeys show a phenotype that is opposite to many species in which grooming is not utilized to regulate social relationships. Instead, embraces are thought to regulate relationships in spider monkeys. Previous studies have investigated embracing and grooming, however no study has investigated the predictive power of any monoplex network behavior and how it corresponds to a multiplex network. Here we investigated the hypothesis that embraces, but not grooming, hold predictive power of social bonds in the multiplex network by calculating edge weights between dyads.

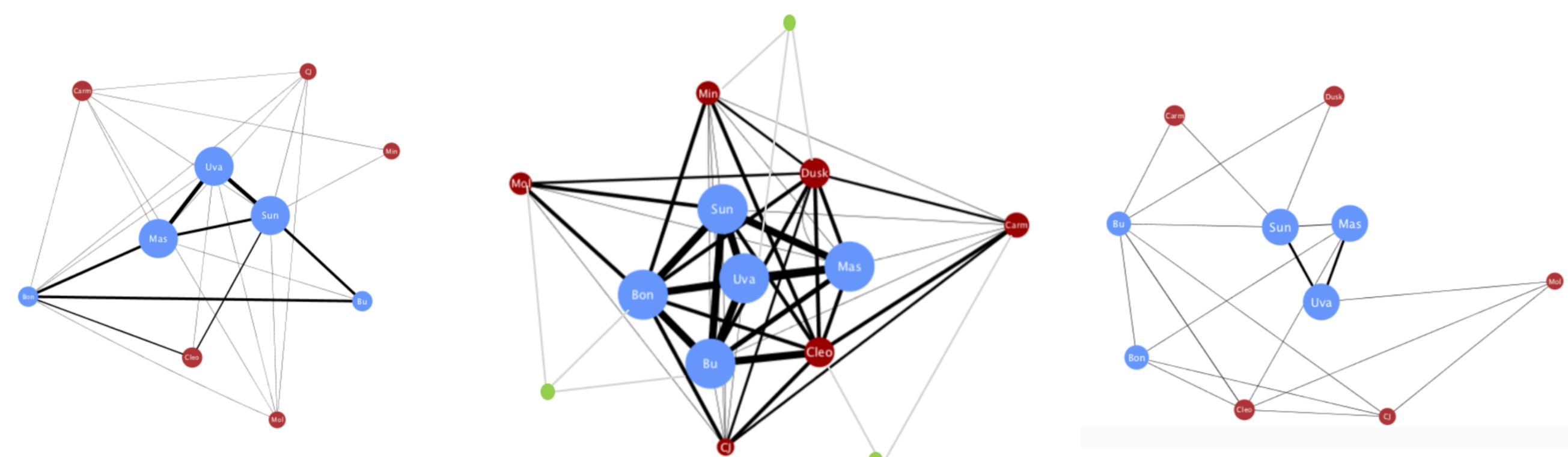


Fig 1. Monoplex Network for separate social interactions

## Methods

186 hours of observation data were collected from 15 Colombian spider monkeys (*Ateles fusciceps rufiventris*) at Monkey Jungle in Miami, FL. Social interactive data were pooled as a global matrix and exported to Excel and uploaded to Cytoscape (Shannon et al., 2003) for multiplex network analyses. Edge weights, which represent strength of social bonds, were calculated for each embrace and grooming dyad. The Pearson correlation examined if embracing or grooming dyads were correlated with multiplex edge weights.

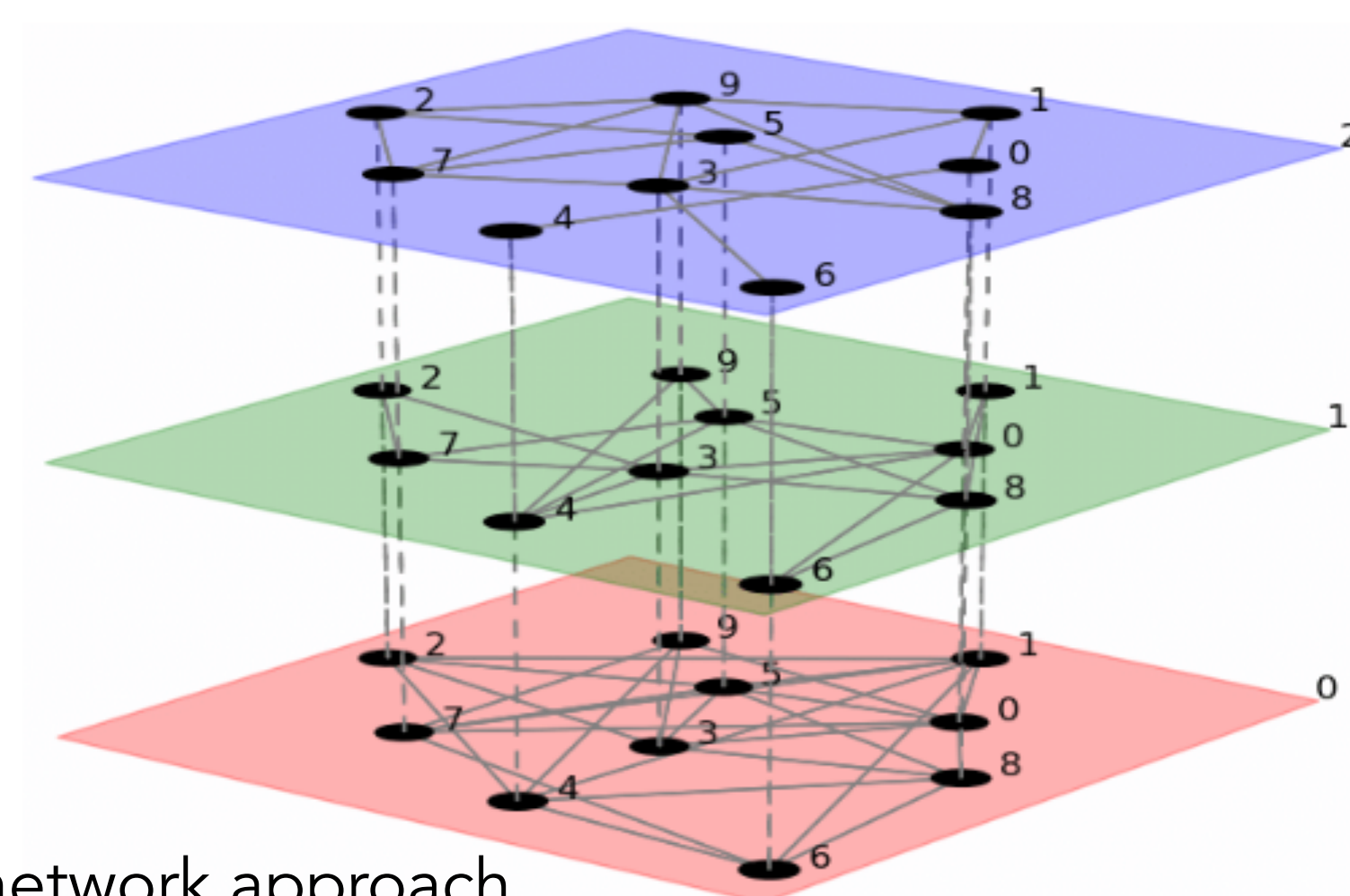


Fig 3. Multi-layered network approach

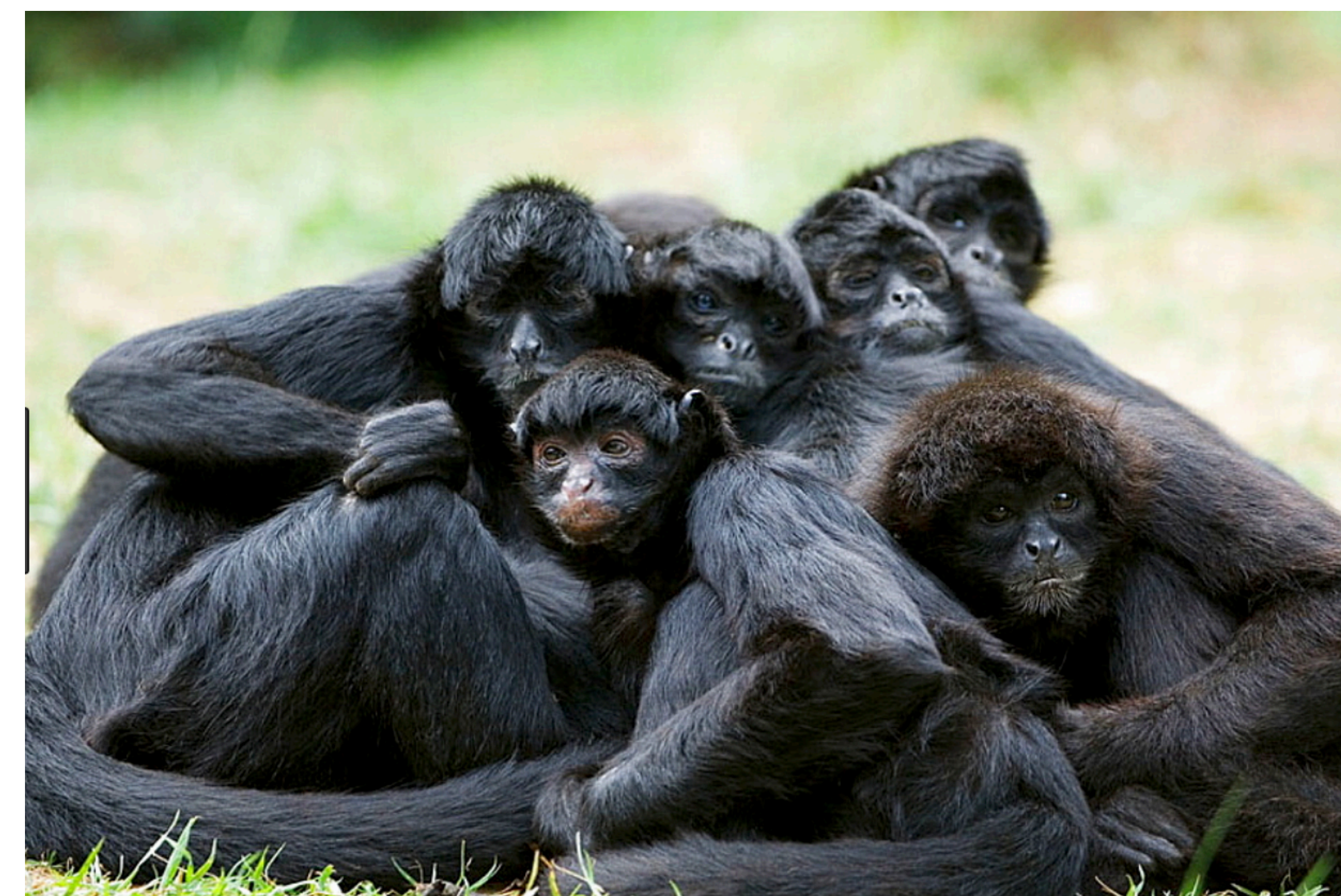


Fig 2. Social group of Colombian spider monkeys (critically endangered)

## Results

Embrace Edge Rank Dyads	Grooming Edge Rank Dyads	Multiplex Edge Rank Dyads
Uva - Mas	Cleo - Cary	Uva - Mas
Uva - Sun	Cleo - Carm	Uva - Sun
Mas - Bu	Cleo - Mol	Mas - Bu
Sun - Mas	Mol - Bu	Sun - Mas
Cleo - Bu	Bu - Bon	Cleo - Bu
Bu - Bon	Dusk - Sun	Bu - Bon

- Network edge weights for embracing were correlated to multiplex edge weights ( $r(4) = 0.93$ ,  $p = 0.007$ ).
- Network edge weights for grooming were not correlated to multiplex edge weights ( $r(4) = 0.0046$ ,  $p = 0.994$ ).
- We discuss these results in light of spider monkey ecology with social network analysis as a unique tool for elucidating the structure and dimension of social behavior.



## Conclusion

- Here we provide evidence that the embrace network predicts the multiplex network in spider monkeys.
- In other words, relationships, which emerge across multiple behaviors and not just one, are best predicted by embracing but not grooming.
- This information may particularly useful for captive management staff seeking tools to predict and increase cohesion in captive groups.
- This network analytic approach enabled empirical testing of field-dominated hypotheses regarding the regulation of social bonds.
- Those wanting to examine social bonds should capture data on embraces to accurately quantify social bonds in spider monkeys.

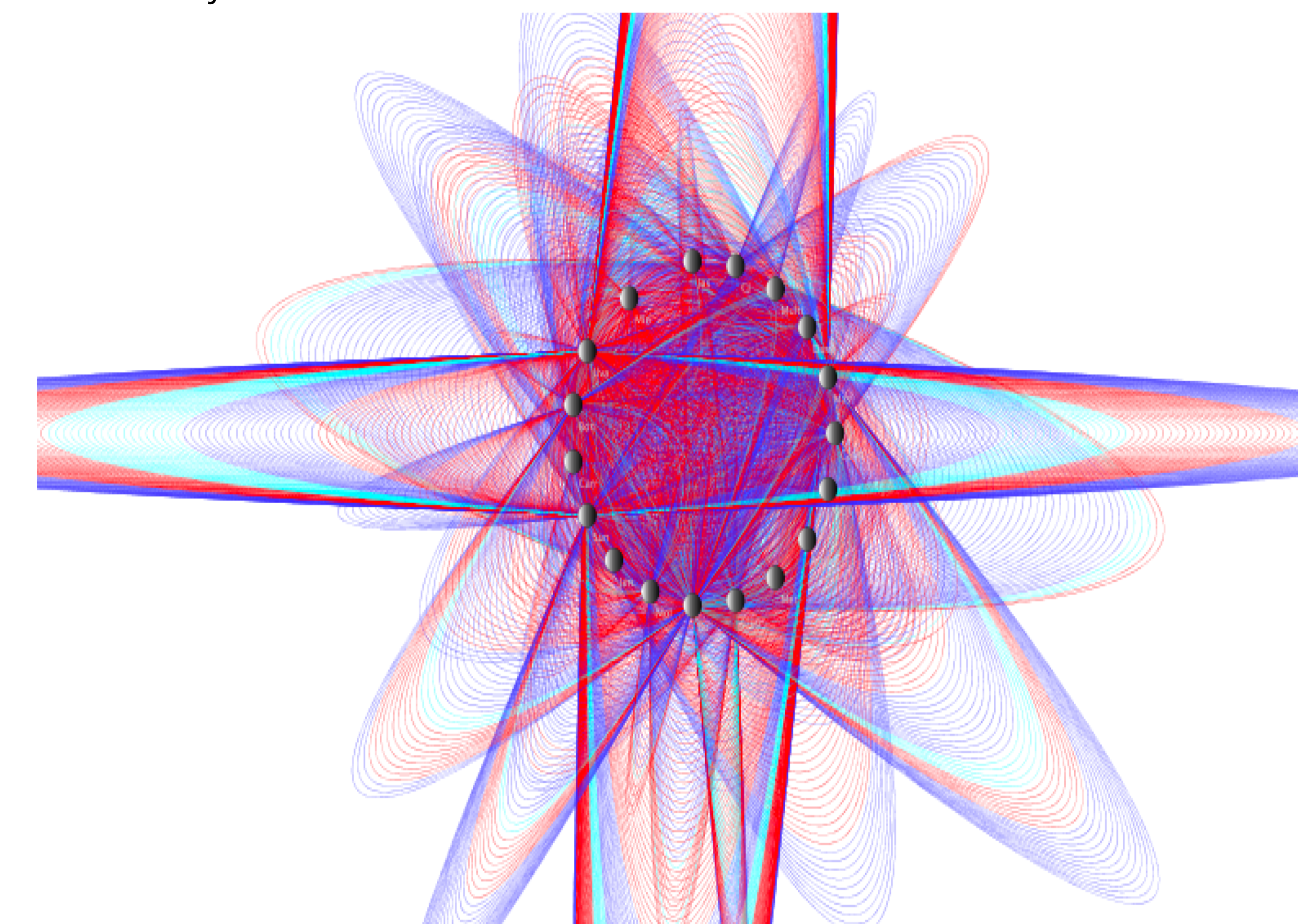


Fig 3. Multiplex Network

## References

Available upon request.