Structural balance in social network of Harry Potter

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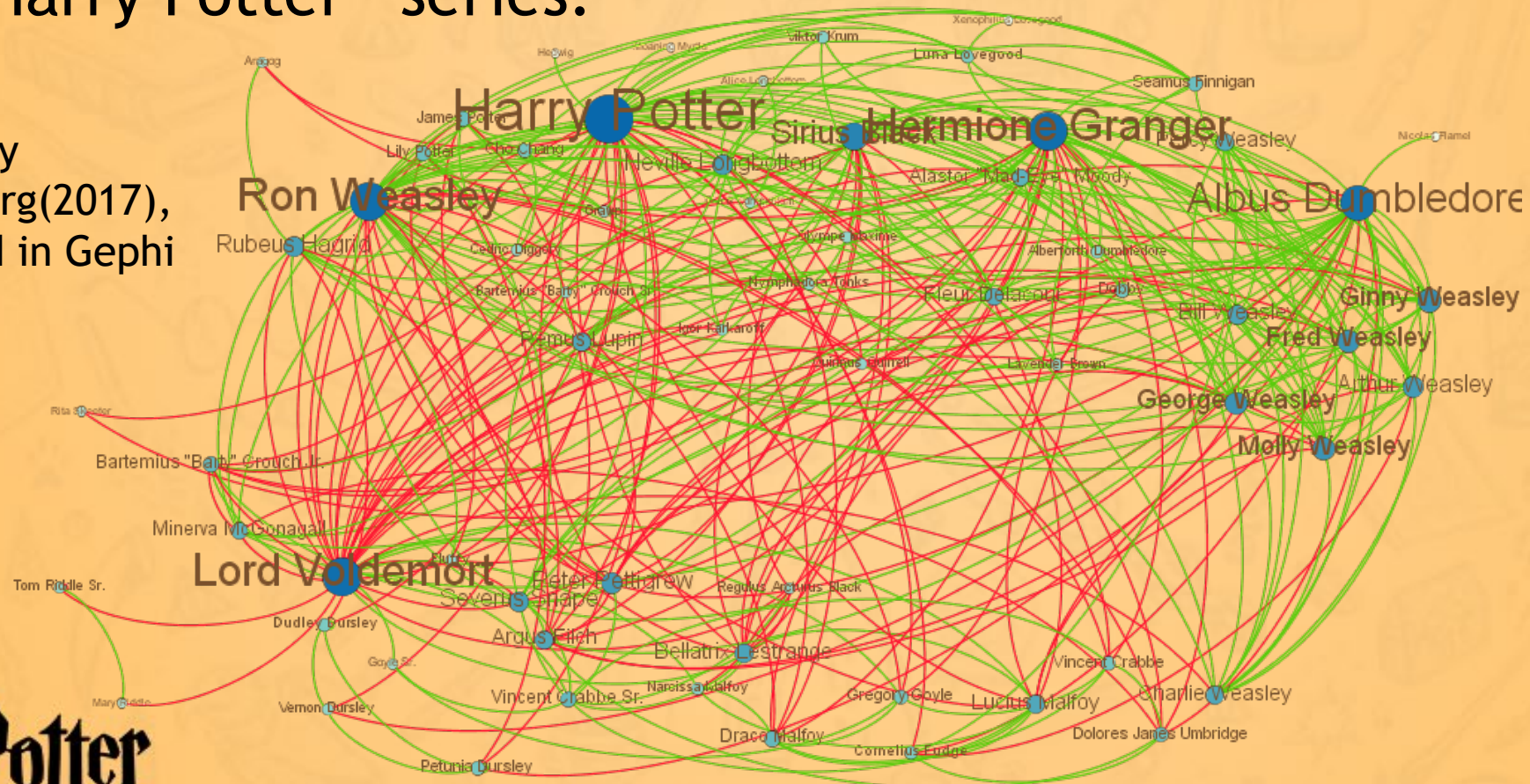
Introduction

- Balance analysis on the relationship between characters in “Harry Potter” series.

Dataset by
Harish Garg(2017),
Visualised in Gephi



Harry Potter

Concepts

- Structural balance theory - Heider (1946)

Balance is a state of equilibrium, and that individuals in networks strive to move towards and maintaining that equilibrium or balance.

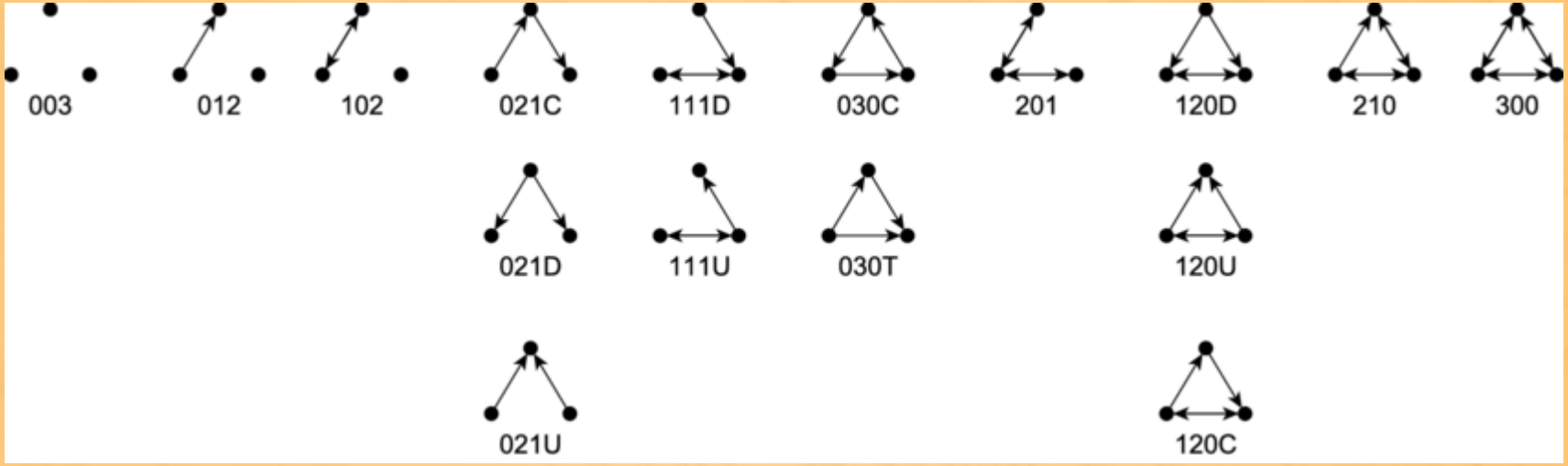
- Balance theory in signed network - Cartwright and Harary (1956)

A triad within a network is balanced if the product of the signs of its edges is positive.

Concepts

- Triad: group of three nodes

***Leinhardt not Leinchard*



Triadic census and their names, by Holland and Leinhardt (1978)

Figure adapted from: Cugmas et al (2017)

Concepts

- Semicycles in a triad

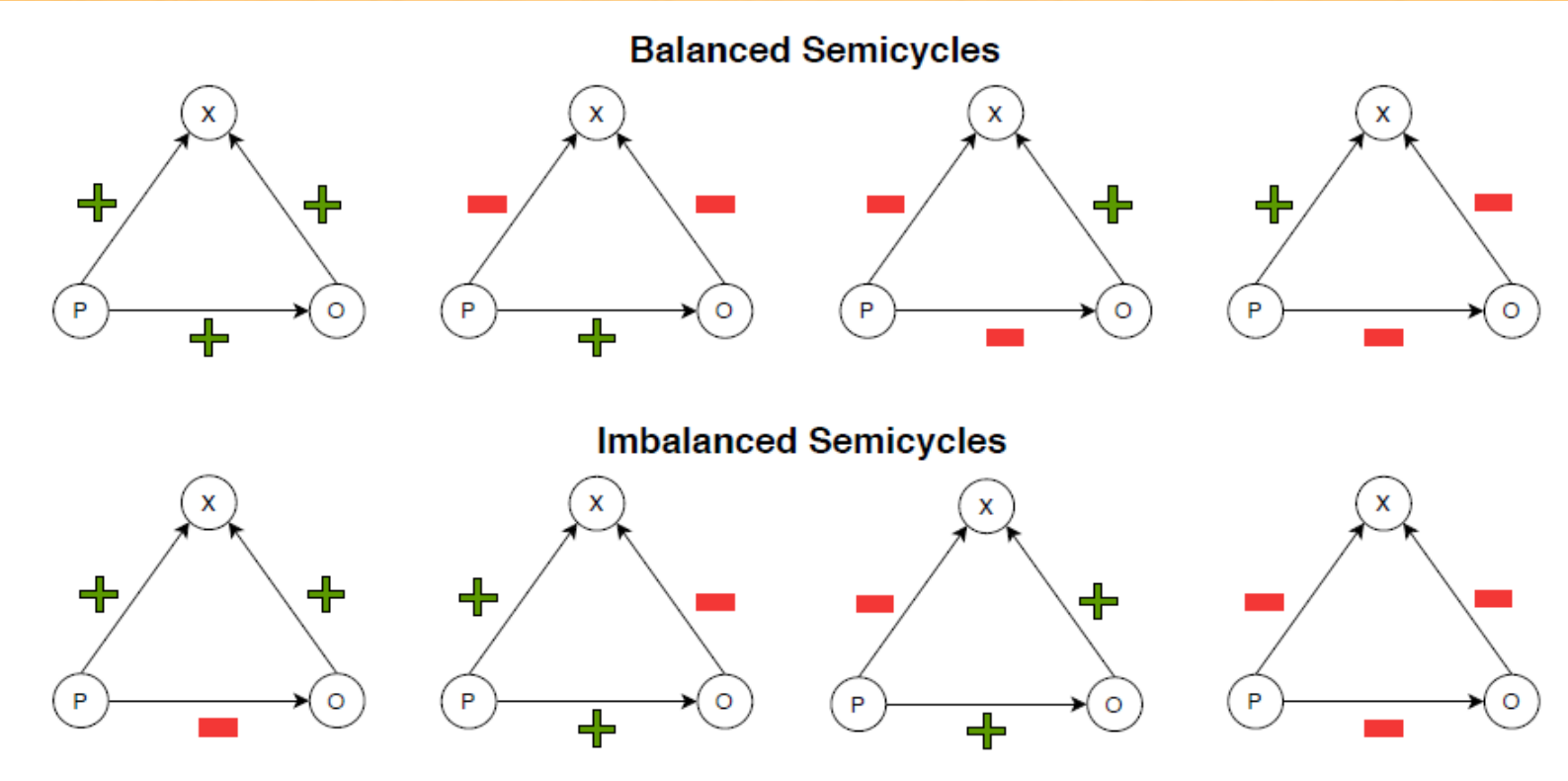


Figure adapted from: Lindh et al (2020)

Motivation

- Considering the signs and direction of ties, how can I measure the structural balance of a network?

Harry Potter

Problem Statement

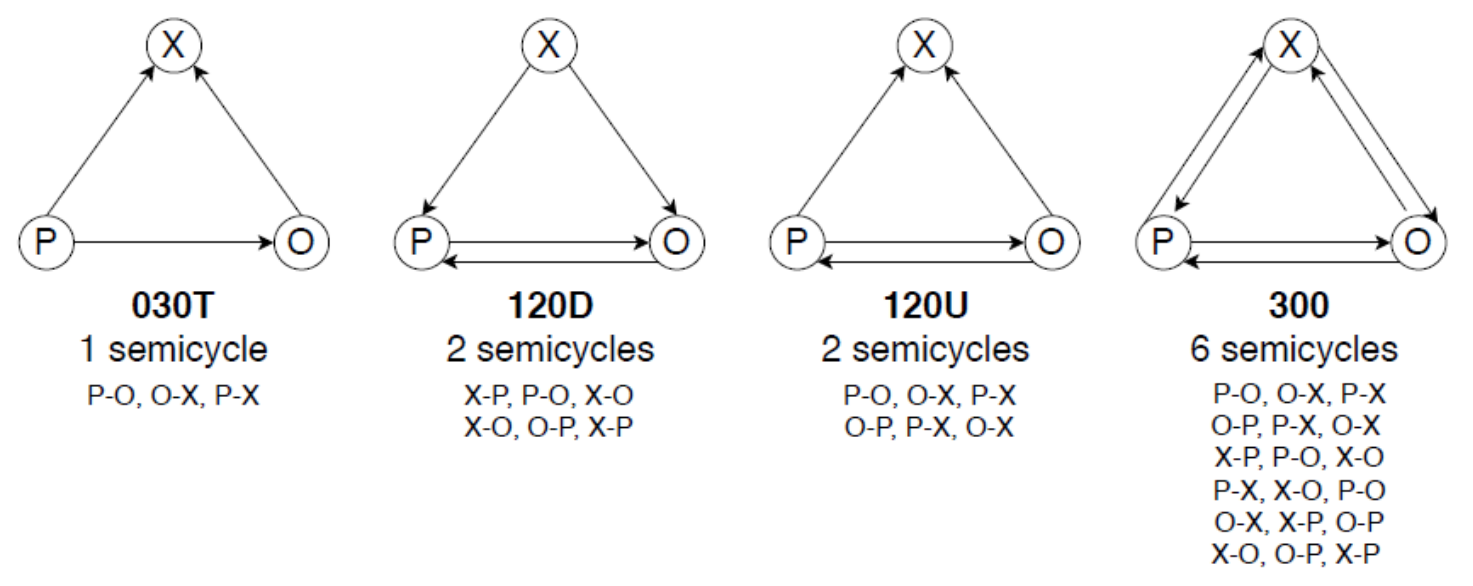
For the signed & directed social network of Harry Potter, is the structure balanced? What is the balance score of the network?

Examples of existing measure

- Fraction of balanced triangles (Zheng et al, 2015)
- Walk-based: Eigenvalues (Estrada, 2019)
- Frustration index (Aref & Mark, 2018)

Methodology

- Algorithm proposed by Lindh et al (2020) - Expansion of balance theory using transitivity and direction of edges



Transitive and balanced triads, with their semicycles

Figure adapted from: Lindh et al (2020)

The algorithm

for each type of triad, i = 1,2,3,4:

for each triad set, Tj, j = 1,…,Nj:

for each semicycle:

Sign of semicycle = product of sign of all edges

Let S_j^+= # of positive semicycles

S_j= # of all semicycles

Balance ratio of triad set, $B_{Tj} = S_j^+ / S_j$

Let N_T= Total # of triad sets with B_{tj} not equal to 0

$T^{(i)}$ = Total # of triad sets

Balance ratio of triad class, $B_T^{(i)} = N_T / T^{(i)}$

Average balance ratio of the graph, $B_{avg(G)}$= sum of $B_T^{(i)}$ / 4

Results & Discussions

- Descriptive network measures:

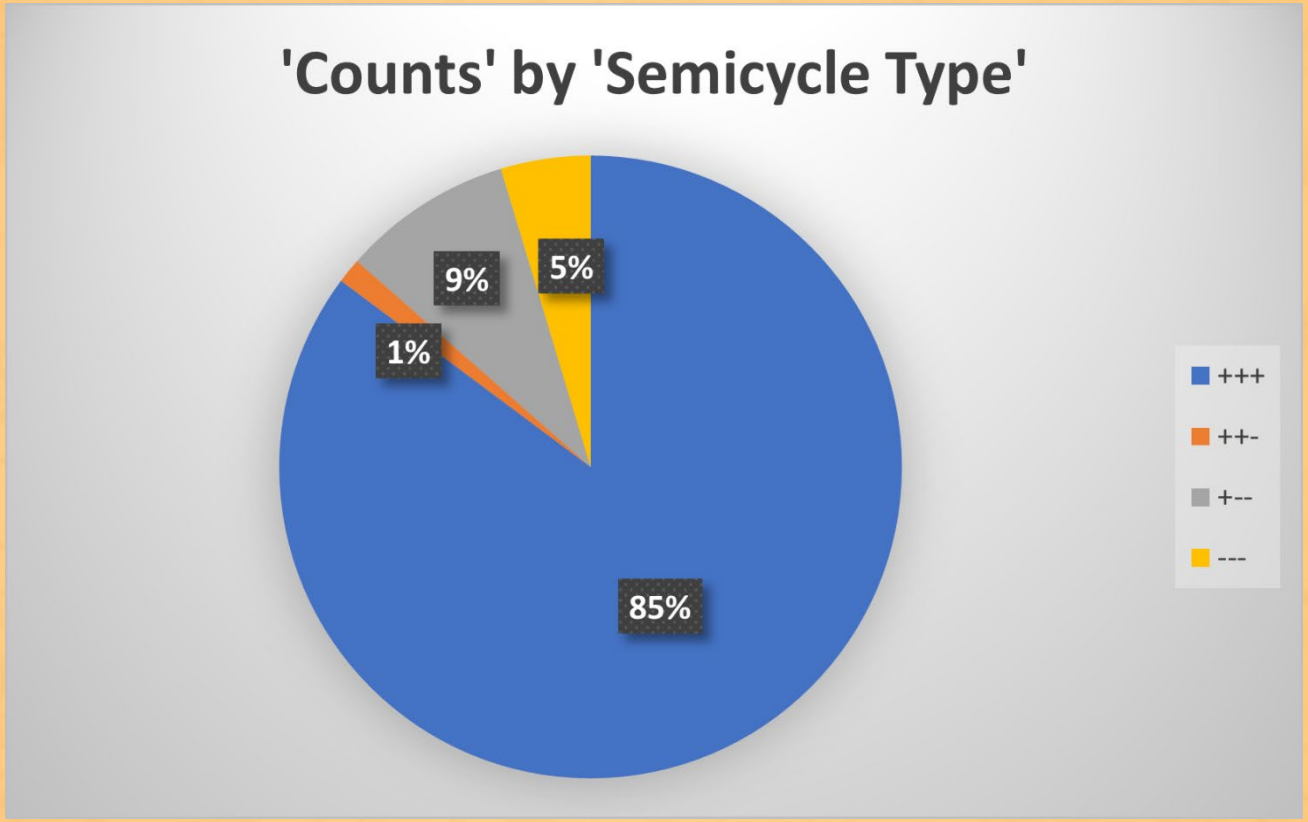
Descriptive network measures	Harry Potter network
# of nodes	65
# of edges	456
Average degree	14.0308
Transitivity	0.3825
Average clustering	0.4151
Density	0.1096
Average shortest path length	2.375

***There are a lot of CLOSED triads found*

Results & Discussions

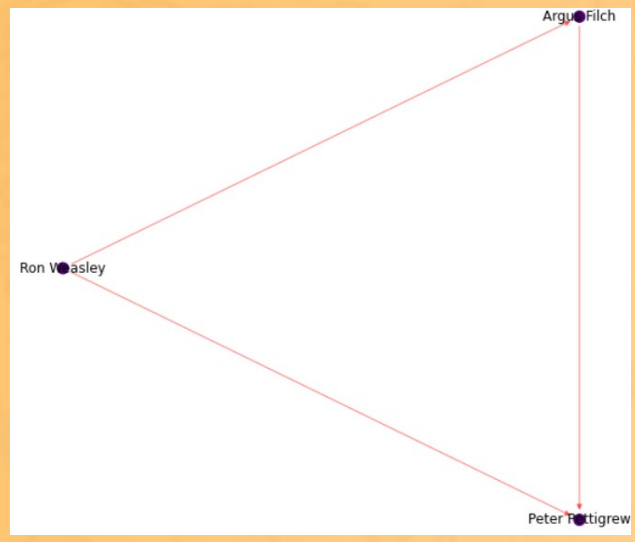
Transitive triads type	Count	Completely Balanced	Partially Balanced	Completely Imbalanced	Balance Ratio, B_T(%)
030T	211	190	0	21	90.050
120D	131	115	0	16	87.790
120U	167	158	2	7	95.810
300	84	82	1	1	98.810
Total	593	545	3	45	B_Avg(G)= 93.11

Results & Discussions

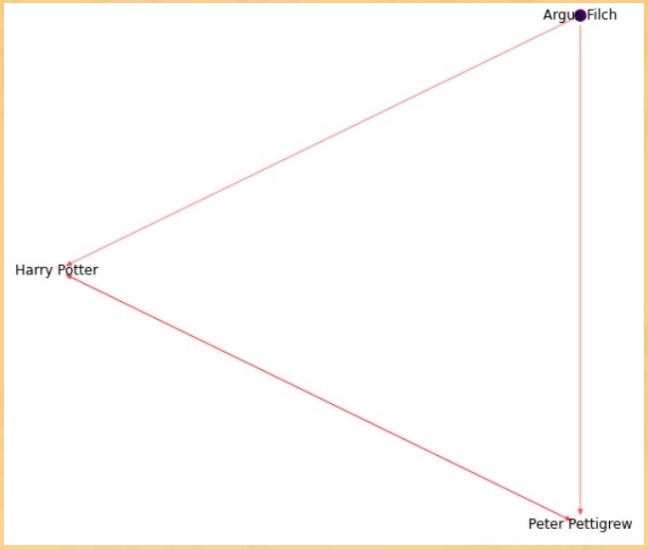


Examples of imbalanced semicycles

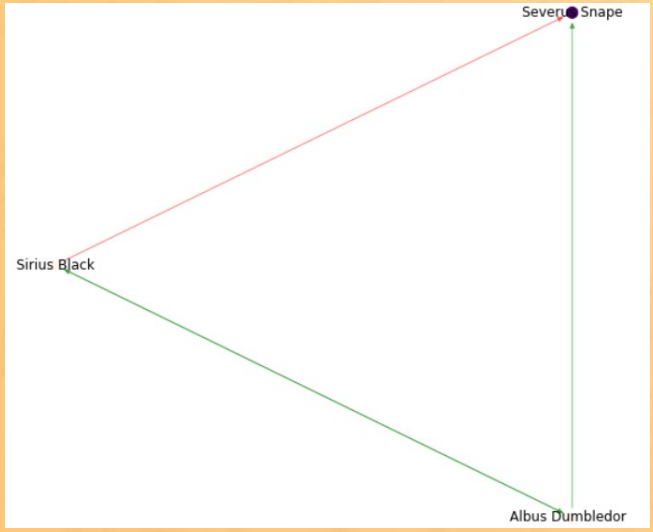
030T



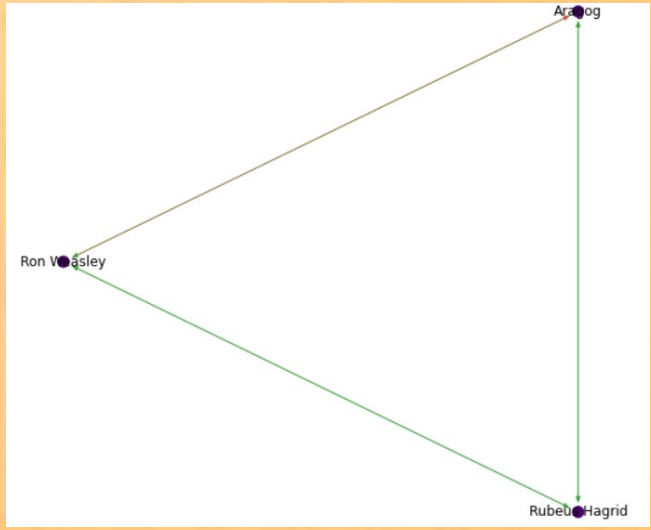
120D



120U



300



Conclusion

Harry Potter characters network is 93.11% balanced.

Limitation:

Not comparable – only one result

Next step/future work:

Apply – generalisation by BFS approach

There are 6 books in the series – dynamic network

References

- Dataset:

https://data.world/harishkgarg/harry-potter-universe

- Papers/ studies:

- Dinh, Ly & Rezapour, Rezvaneh -Shadi & Jiang, Lan & Diesner, Jana. (2020). Structural balance in signed digraphs: considering transitivity to measure balance in graphs constructed by using different link signing methods.
- Zheng, X., Zeng, D., and Wang, FY. 2015 Social balance in signed networks. *Inf Syst Front* **17,** 1077–1095
- Aref, Samin, and Mark C. Wilson. 2018. "Measuring Partial Balance in Signed Networks." Journal of Complex Networks 6 (4): 566–95
- Estrada, Ernesto. 2019. "Rethinking Structural Balance in Signed Social Networks." Discrete Applied Mathematics

- PPT templates:

https://prezentr.com/templates/harry-potter-powerpoint-template/

https://slidesmania.com/a-harry-potter-inspired-template-for-matt-meyer/