A Small World of Ice and Fire

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1. Abstract

Starting in 2011 the HBO hit series Game of Thrones, based on GRR Martin's epic fantasy series A Song of Ice and Fire, captivated an entire generation for eight seasons. While the television series has ended, the author is still working on the final two books of the seven-book series. Martin's works have been praised for their realism, as the novels include complex interpersonal relationships. Martin does not shy away from complex ethics and allows the readers to feel real suspense about the characters' fates.

Perhaps due to its popularity, the social networks within both the books and the television series have been studied from several different angles. Liu and Albergante (2017) performed network analysis on the television series to analyze the character relationships from a structural balance perspective and used this to predict audience reaction. Stavanja and Klemen (2019) used link prediction to attempt to predict the next kills between victim and murderer (though with limited success). One particularly in-depth analysis of both the books and the television series successfully used network centrality measures and how they change over time to model plot lines (Beveridge & Chemers, 2018).

For our research, we wanted to take it a step beyond past research and look for evidence that that fantasy social network GRR Martin created exhibits small world characteristics.

A small world network described in Watts and Strogatz's seminal paper (1998) describes the characteristics of a network that lies somewhere between a completely regular network and a completely random network. Small world networks have a degree of clustering, like a regular network, but also exhibit some random weak ties which help to shorten paths between some nodes. The phenomenon is commonly observed in real life social networks and is useful for the dissemination of information.

We were curious if the realism of A Song of Ice and Fire extended to the network structure as well. Of course, this is not the first time that a social network in a fictional work has been examined for its realness (Waumans, Nicodème, & Bersini 2015) but this is the first application to small world networks specifically. The implications of the results could lead to another tool for literary analysis.

This leads us to our hypothesis that the social network within A Song of Ice and Fire exhibits the same small world phenomenon commonly witnessed in real social networks. We will test this by comparing the clustering coefficient and characteristic path length of the series network to a similar, artificially created random network. If the clustering coefficient is higher than the random

network, while the path lengths stay relatively the same, we can conclude there is evidence of a small world network.

2. Data Description

We obtained the dataset from mathbeveridge's Github repository (Andrew Beveridge, 2017). This dataset contains character interaction networks for George R.R. Martin's "A Song of Ice and Fire" series of epic fantasy novels. There were 2823 edges and 796 nodes. These interaction networks were created by connecting two characters whenever their names appeared within 15 words of each other in the books of the series.

The dataset contains five attributes/features:

- Source and Target: These represent the two connected characters.
- Type: Undirected
- ID: Every connection is assigned an ID from 0 to 2822.
- Weight: The edges have variable weights which correspond to the number of interactions between the characters.

3. Key Findings

3.1 Community Description (Game of Thrones Wiki)**:**

According to the Spinglass Community detection algorithm, the network appears to be divided into 17 clusters with sizes as shown in Table 1.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
189	16	7	70	2	9	24	166	92	19	123	2	46	7	7	11	6

Table 1: Cluster Sizes

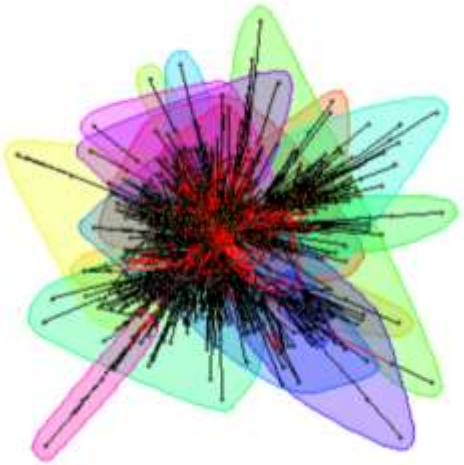

Figure 1: Clusters using the Spinglass Community Detection Algorithm

Cluster 1, the biggest of them all containing 189 nodes appears to have some influential members of the Seven Kingdoms. The people in this cluster have one thing in common: “King’s Landing; the capital city”. Some of the more notable names include:

- Cersei, Jaime, Tywin and Tyrion of the Lannister Family;
- Joffrey, Tommen, Robert, and Renly of the Baratheon Family
- Sansa, Eddard, Lyanna,and Brandon of the Stark Family
- Aemon, Aerys I, Aerys II, Baelor I of the Targaryen Family
- Margery, Loras, Garth, Willas of the Tyrell Family
- Petry Baelish, Brienne of Tarth, Varys, Podrick Payne, Bronn, Gregor Clegane, High-Sparrow and Shae are some of the other noteworthy people who played an important part in King's Landing.

The second biggest cluster is Cluster 8 containing 166 nodes. These people appear to be connected through “The Wall”. The more noteworthy names are:

- Jon Snow, Samwell Tarly, Maester Aemon, Allister Thorne, Qhorin Halfhand and Benjen Stark of the Night’s Watch.
- Melisandre, Stannis Baratheon, Shireen Baratheon and Davos Seaworth of the people campaigning for Stannis as the rightful King.
- Ygritte, Mance Rayder, Craster, Gilly and Tormund of the Wildlings.

Cluster 9 appears to contain people who are connected through the “Free Cities”. The free cities include Braavos, Lorath, Lys, Myr, Norvos, Pentos, Qohor, Tyrosh and Volantis. Some of the influential people include: Daenerys Targaryen, Viserys Targaryen, Jorah Mormont, Daario Naharis, Drogo, Xaro Xhoan Daxos and Missandei, all of whom also appear to be connected through Daenerys Targaryen because she wandered the Free Cities in her quest to sit on the Iron Throne.

The third biggest cluster, Cluster 11 containing 123 nodes. The people in this cluster appear to be connected through “The North” and through “House Frey” due to the Red Wedding. The notable names include:

- Catelyn, Bran, Rickon, Robb and Rickard of House Stark
- Walder, Walda, Roslin, Petyr, Emmon, Edwyn and Elmar of House Frey.
- Ramsay Snow, Theon Greyjoy and Roose Bolton of the people who sacked Winterfell.
- Rickard Karstark, Jon Umber and Hother Umber who held fealty to House Bolton during the Battle of the Bastards.
- Maege Mormont, Halys Hornwood and Donella Hornwood who held fealty to House Stark during the Battle of the Bastards.
- Meera Reed and Jojen Reed because of their friendship with Bran Stark.
- Edmure, Hoster and Brynden of House Tully because of their allegiance to House Stark.

We also observed that there are 268 cross community edges (i.e., edges connecting two different communities). The most notable of which are:

- Arya Stark and Sandor Clegane; Clegane saves Arya from the troops of “Lord of the Light”.
- Brienne of Tarth and Catelyn Stark; Brienne swears an oath to Catelyn, becoming her sworn sword.
- Catelyn Stark and Joffrey Baratheon; Joffrey executes Catelyn’s husband Eddard Stark at King’s Landing.
- Aegon Targaryen (Jon Snow) and Tyrion Lannister; Jon and Tyrion become friends before Tyrion leaves The Wall and they reunite later when Jon arrives at Dragonstone to meet Daenerys.

3.2 Betweenness Centrality:

We calculated the betweenness centrality for each of the edges. An edge with high betweenness shows that the edge is part of the shortest path for most nodes. The top 10 edges with the highest betweenness scores that we found are:

1. Jaime Lannister – Jon Snow
2. Theon Greyjoy – Tyrion Lannister
3. Theon Greyjoy – Victarion Greyjoy
4. Cersei Lannister – Daenerys Targaryen
5. Theon Greyjoy – Tywin Lannister
6. Jory Cassel – Theon Greyjoy
7. Asha Greyhoy – Robert Baratheon
8. Drogo – Robert Baratheon
9. Jon Snow – Jory Cassel
10. Barristan Selmy – Tyrion Lannister

The edges between Jaime Lannister, Jon Snow and Cersei Lannister, Daenerys Targaryen tie in with their importance in the books, but we were surprised to find as many Greyjoys as we did on the list. It probably makes sense as the House Greyjoy is one of the Great Houses of Westeros and because of Theon Greyjoy’s close connection to House Stark.

Local bridges also tend to have high betweenness scores because they provide the shortest path for several nodes. When removed, the average path lengths become larger and the graph may break into separate components.

We systematically removed the top edges to evaluate any changes in the graph. By removing the edge with the highest betweenness, the transitivity for the graph changed to 0.6350316 and the average shortest path length changed to 15.78. Even after the removal of all the top ten of the edges with high betweenness, the network did not change much. We obtained a transitivity of 0.6345626 and average shortest path length of 16.33. This is probably not surprising considering the fact that there are over 2000 edges and many interlaced connections between the characters that the removal of the top 10 edges does not significantly affect the network parameters.

3.3 Closeness Centrality:

A measure of importance within the social network based on the inverse of the number of steps needed to reach from one character to another. These are the characters who are closest to the shortest path which characterize a small-world network. The top 10 nodes with the highest closeness centrality measure that we found are:

1. Tyrion Lannister
2. Jon Snow
3. Jaime Lannister
4. Cersei Lannister
5. Stannis Baratheon
6. Arya Stark
7. Catelyn Stark
8. Sansa Stark
9. Eddard Stark
10. Robb Stark

All the characters on the list are highly influential people on the show with a lot of connections. At first it was surprising to not find Daenerys Targaryen on the list. However upon further analysis, it makes sense because she was not in Westeros for the major part in the books and therefore was probably unable to form as many direct connections with characters on the mainland as the other characters on the list.

3.4 Small-world Phenomenon:

The small world theory is based on the observation that the world is linked by short chains of acquaintances, popularly known as the “six degrees of separation” (Easley and Kleinberg, 2010).

According to Watts-Strogatz, the small world network satisfies two properties: small average shortest path (global) and high clustering coefficient (local).

We calculated the clustering coefficient and average shortest path length for the graph and the values were:
Clustering coefficient (Local) = **0.6350514**
Average shortest path length = **15.7104**

In the context of the asoiaf (A Song of Ice and Fire) network, the path length indicates how fast information could spread from one house to another. Although two houses would not have a common member, they often have indirect ties to each other through intermediary houses.

A random graph was generated using erdos.reyni.game algorithm in R where we specified the same number of nodes and edges. Similar weights were assigned to the edges.
Clustering coefficient (Local) = **0.009181137**
Average shortest path length = **17.81689**

We can see the average clustering coefficient of the asoiaf network is considerably higher than that of the random graph generated.
The graphs have approximately the same average shortest path length.

Therefore, we can conclude that the asoiaf network exhibits small world phenomena.

4. Insights and Conclusions

Like other research, our analysis found parallels between network science results and the overall story and character relationships. Neighborhood analysis separated important groups within the story. Important characters have higher measures of centrality. More importantly, this analysis presented evidence that the fantasy social network in A Song of Ice and Fire does show strong evidence of being a small world network.

This result is interesting as it shows that the author, likely unintentionally, created a social network that is like reality on a network structure level. This opens more questions in terms of psychology as well as literary analysis. Could the popularity of the series be tied to some inherent and possibly subconscious recognition of a social network that resembles what we experience in our day to day lives? Could an author use this knowledge to write better stories, and network science could be a valid tool of literary analysis? The latter seems to be true, but the former remains to be tried. In any case, our results demonstrate that a fictional network can resemble a real small-world network.

5. References:

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