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An Analysis of the Shi Clan Connections in the Wei-Jin and North-South Dynasties Based on the Character Network of Shishuoxinyu

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Abstract

Shishuoxinyu is a collection of anecdotal stories about the words and deeds of Wei and Jin characters. In this paper, we build a complex network with characters in Shishuoxinyu to analyze the scholarly connections in the Wei-Jin and North-South dynasties. The ER random graph, WS small-world network, BA scale-free network, and experimental network are constructed for comparison. The network properties of the experimental network were analyzed using the average degree, average clustering coefficient, and average path length. Degree centrality, mesoscopic centrality, and proximity centrality were selected to understand the importance of the experimental network nodes, and it was found that the king guide had the highest importance in the whole experimental network. Then, through the observation of network degree distribution, this experimental network is considered as a scale-free network with robustness and vulnerability, which is in line with the political characteristics of the Wei-Jin and Northern Dynasties. Finally, ten larger-scale Shi clans are selected to construct a new network for inter-clan linkage analysis. This study helps to uncover the reasons for the rise and fall of the Shi clans during the Wei-Jin and North-South dynasties.

Keywords

Complex Network, Shishuoxinyu, Wei, Jin, North and South Dynasties, Scale-Free Network, Scholarly Gatekeepers

1. Introduction

The Wei-Jin and North-South Dynasties were a turbulent and chaotic era. It is mainly divided into the Three Kingdoms (Cao Wei, Shu Han, and Dong Wu), Western Jin, Eastern Jin, and Northern and Southern Dynasties periods. The

Wei, Jin, and North-South Dynasties connected the unified Qin and Han dynasties with the enlightened and powerful Sui and Tang dynasties. During these centuries, wars broke out, lands were divided, and regimes changed frequently, with more than thirty large and small secessionist regimes arising from the old and the new. Such a period of disintegration was the darkest and most painful time for the common people, but it was a fertile ground for literature, religion, music, painting, calligraphy, and so on. Cultural diversity and national integration reached an unprecedented level. The political landscape of this period was also unlike any other in history, as the imperial power weakened and the scholarly gentry took control of the dynasty, presenting a special kind of gentry politics [1] [2] [3] [4]. Many strange events took place as a result of the cooperation and struggle between these scholarly families. Shishuoxinyu [5] is a collection of literary novels written by Liu Yiqing and others in the Southern Song Dynasty and is a representative work of notebook novels in the Wei-Jin and North-South Dynasties. The content of Shishuoxinyu mainly includes virtue, speech, politics, and literature. Each category has several stories, and there are more than 1200 stories in the whole book. These stories link most of the Wei-Jin and North-South dynasties scholars together, forming a network of characters. Constructing a character network has become an important tool to analyze literature and film works. In [6], Bonato *et al.* study the character networks of multiple film and television novels through complex networks. In [7], Kubis *et al.* summarized and quantitatively analyzed the character networks in Polish novels through complex networks. Tang *et al.* [8] mined the relationships between characters in the novel by constructing complex networks. The relationship between characters in Shishuoxinyu is complicated. This paper uses complex networks to analyze the text content of this book. It mainly starts from the basic topological properties of the network, the importance index of network nodes, the distribution of network degree, and the establishment of the gentry sub-network. It is expected to dig to understand the connection between gentries.

2. Data Acquisition and Processing

The empirical data in this paper come from the book Shishuoxinyu written by Liu Yiqing and others during the Southern Song Dynasty. Step 1: Use Python crawler technology to obtain the text content and later annotated content of Shishuoxinyu. Step 2: Obtain the original names, aliases, and font names of most characters in Shishuoxinyu by searching the introduction of characters in the notes of the book. Information on 376 historical figures was obtained. Step 3: Match the names with the characters mentioned in each anecdote of words and deeds in the text of the book to build connections between the characters. For example, one of the anecdotes in Shishuoxinyu is “谢太傅寒雪日内集，与儿女讲论文义。俄而雪骤，公欣然曰：’白雪纷纷何所似’，兄子胡儿曰：’撒盐空中差可拟。’兄女曰：’未若柳絮因风起。’公大笑乐。即公大兄无奕女，左将军王凝之妻也。”This paragraph tells an interesting story about several people in the Xie family enjoying the snow. It mentions Xie Anshi, Xie Daoxuan, Xie

Hu'er, Xie Wu Yi, and Wang Ning Zhi. In the end, these people are connected on the web. Using the above method, the final data on the degree of association of the characters in Shishuoxinyu was compiled and a total of 1711 edges were created.

The character association degree data used for the complex network analysis in this paper is an undirected entitled network in which the weights of the edges are the number of simultaneous occurrences between two characters in an anecdote of speech or action. Some of the experimental network data are shown below.

First, the network data is organized into a triadic form, and **Table 1** shows some of the triadic data for this network.

Source and Target represent the two nodes of the concatenated edge, and Weight represents the weight of the concatenated edge.

The network data is then organized into the form of an adjacency matrix, and **Table 2** shows some of the adjacency matrix data for this network.

In **Table 2**, the horizontal and vertical axes represent the node numbers respectively, while the middle value represents the edge weight of two nodes, and a value of 0 means there is no edge between two points. As shown in **Table 2**, the matrix is sparse and there are few connecting edges between the first 10 nodes.

Table 1. Partial triad data.

Source	Target	Weight	Source	Target	Weight
1	39	1	3	103	1
1	127	1	3	111	1
1	142	2	3	127	1
1	216	1	3	175	1
2	121	1	3	215	1
2	197	1	4	163	1
3	18	1	4	333	1
3	81	1	5	6	1

Table 2. Partial adjacency matrix data.

	1	2	3	4	5	6	7	8	9	10
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	1	0	0	0	0
6	0	0	0	0	1	0	1	0	0	0
7	0	0	0	0	0	1	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0

Based on the web data compiled above, it is visualized to represent the connections between characters.

In this paper, we use Gephi to visualize the network data of characters in Shishuoxinyu, and the visualization results are shown in Figure 1. The visualization process first used the Fruchterman-Reingold algorithm to unfold the layout of this network data. Then, the size of each character node was ranked in terms of degree. In the figure, the character names of Xie Anshi (Chen County Xie Clan), Wang Mao Hong (Langya Wang Clan), and Huan Wen (Longchamp Huan Clan) are more conspicuous, indicating that these three nodes have larger degrees. Similarly, based on the weight of the edge visualization, even for the edge, the greater the weight of even the edge, the darker color and thicker lines, and vice versa. From the figure, Huan Wen and Xie Anshi are two nodes even though the edge weight is greater, the two people in this book are strongly associated.

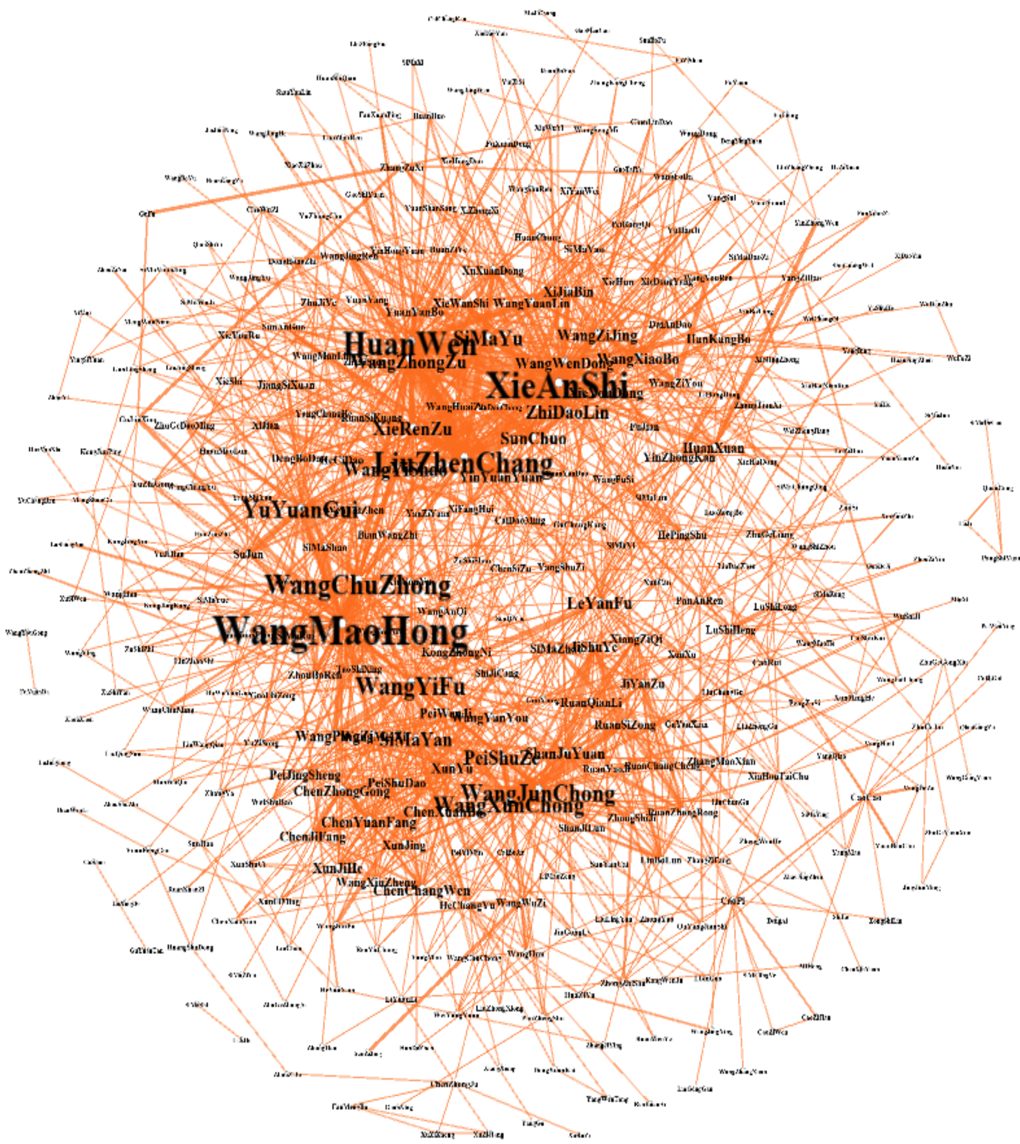

Figure 1. Visualization of the network.

3. Basic Topological Properties of Networks

The experimental network properties are analyzed by three basic topological properties of the network: the average degree, the average clustering coefficient, and the average path length. Concerning the scale of the experimental network (the number of nodes is 376 and the number of connected edges is 7111), ER random network, WS small-world network, and BA scale-free network of similar scale are generated to assist in analyzing the properties of the experimental network in this paper. The specific parameter settings of these three network models are shown in Table 3.

The number of edges of the three generated network models is 1634, 1880, 1855, and is closer to 1711 connected edges of the experimental network, and the nodes are all 376. First, the three generated network models are visualized by distributing the nodes on concentric circles. The distribution of the edges of the ER random graph is more uniform, while the edges of the WS small-world network are mostly distributed at the edges, which indicates that each node is mostly connected to the nodes adjacent to itself.

The experimental network is visualized as above, and Figure 2 is obtained. It can be seen that the network visualization graph is similar to the WS small-world network and the BA scale-free network. Some of the nodes are more inclined to connect neighboring points, resulting in sparse edges in the middle of Figure 3, similar to the WS small-world network. On the other hand, some nodes actively interact with the rest of the nodes and have more connected edges, similar to the BA scale-free network. It can be interpreted that some of the characters in the clan communicate more within their clan, while some of the clan leaders are not only closely associated with their clan, but also with other clans and independent characters.

The basic topological properties of the four networks are further analyzed. This paper mainly analyzes the average degree, average clustering coefficient, and average path length.

1) Average degree

The average degree denoted as $\langle k \rangle$, which is defined as follows:

$$\langle k \rangle = \frac{1}{N}\sum_{i,j}^{N} a_{ij} \quad (1)$$

Table 3. Parameters for generating the network.

Network	Parameters
ER Random Network	$N = 376, p_1 = 0.024$
WS Small World Network	$N = 376, k = 10, p_2 = 0.1$
BA scale-free network	$N = 376, m = 5$

*N is the number of nodes in the network, and p_1 is the probability of connected edges, and k is the number of neighboring nodes connected to each node, and p_2 is the probability of randomly reconnecting each original edge in the network, and m is the number of edges connected from a new node to an existing node.

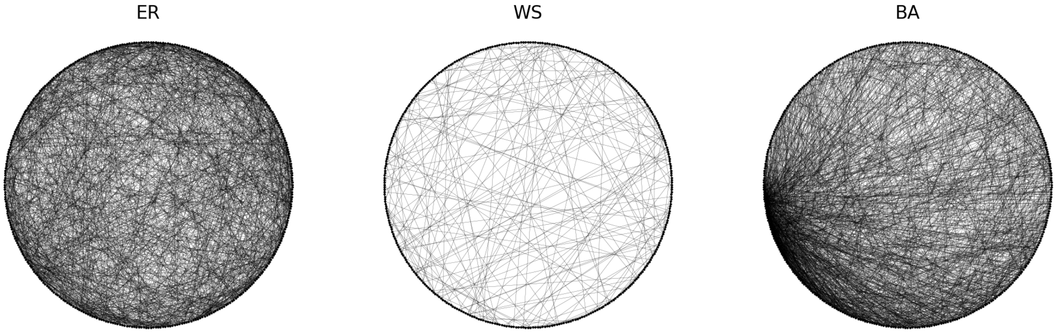

Figure 2. Visualization of generated networks.

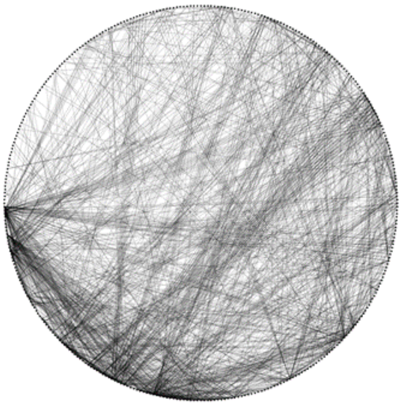

Figure 3. Visualization of the experimental network.

where N is the number of nodes in the network, a_{ij} is the element of the i row and j column of the adjacency matrix of the network.

2) Average clustering coefficient

The clustering coefficient of node i denoted as C_i:

$$C_i = \frac{1}{k_i\left(k_i - 1\right)} \sum_{j,k=1}^{N} a_{ij} a_{jk} a_{ki} \tag{2}$$

The average clustering coefficient of the network is defined as C:

$$C = \frac{1}{N} \sum_{i=1}^{N} C_i \tag{3}$$

3) Average path length

The average path length of the network L is defined as the average distance between any two nodes:

$$L = \frac{1}{\frac{1}{2} N\left(N-1\right)} \sum_{i \geq j} d_{ij} \tag{4}$$

where N is the number of nodes in the network, d_{ij} is the distance between any two nodes.

The average degree, average clustering coefficient, and average path length of the four networks are shown in **Table 4**.

Table 4. Basic topological properties of the four networks.

Network	Average degree	Average clustering coefficient	Average path length
Experimental Network	9.51	0.49	3.09
ER Random Network	8.69	0.02	2.97
WS Small World Network	10.0	0.48	3.68
BA scale-free network	9.87	0.08	2.67

Observing Table 4, we found that the average degree of the experimental network is closest to that of the BA scale-free network, and the average degree of both networks is smaller than that of the WS small-world network and larger than that of the ER random network. The average degree of the network can indicate the degree of direct association of each node of a network to a certain extent. Therefore, the degree of direct association of the nodes in the experimental network is closer to that of the BA scale-free network. As for the average clustering coefficient of the network, the experimental network is closer to the WS small-world network, and the average clustering coefficients of both are much larger than those of the ER random network and the BA scale-free network. The average clustering coefficient can analyze the aggregation of the network, and the value of the average clustering coefficient ranges from 0 to 1. The closer to 1, the stronger the denseness of the network is. This shows that the experimental and WS small-world network denseness in this paper is stronger than the other two networks. Finally, observing the average path length, we can see that the average path lengths of the experimental network and the ER random network are close to each other, and both are larger than the scale-free network and smaller than the WS small-world network. The average path length is another important feature metric in the network, and it is the average shortest distance between all node pairs in the network. Here the distance between nodes refers to the minimum number of edges to be experienced from a node. The average path length measures the transmission performance and efficiency of the network. From Table 4, it can be seen that the WS small-world network has the lowest transmission efficiency, and the experimental network and ER random network are closer to each other.

4. Network Node Importance Metrics

In this paper, the importance of the nodes of the experimental network is observed by calculating degree centrality, mediator centrality, and proximity centrality. Table 5 shows the centrality metrics for the four networks above.

First, the degree of centrality of the four networks is compared, and the average degree of centrality of these four networks is relatively close. The mean degree centrality of the experimental network is 0.026, which indicates that each node in this network is connected to an average of 2.6% of the nodes in the whole network. The maximum degree centrality of the experimental network and the BA scale-free network are both about 23%, which means that the nodes

Table 5. Centrality indicators for the four networks.

Network	Category	Degree Centrality	Median Centrality	Proximity to centrality
Experimental Network	Average value	0.026	0.006	0.315
	The maximum value (node serial number)	0.226 (127)	0.121 (127)	0.467 (127)
ER Random Network	Average value	0.023	0.005	0.337
	The maximum value (node serial number)	0.051 (280)	0.021 (280)	0.385 (135)
WS Small World Network	Average value	0.027	0.007	0.272
	The maximum value (node serial number)	0.035 (273)	0.029 (68)	0.315 (273)
BA scale-free network	Average value	0.026	0.004	0.377
	The maximum value (node serial number)	0.232 (7)	0.147 (7)	0.554 (7)

with the maximum degree in the network are connected to 23% of the nodes in the network. Then observe the mesoscopic centrality, the mean values of mesoscopic centrality of all four networks are small, while the maximum values of mesoscopic centrality of the four networks differ widely. The maximum values of the mesoscopic centrality of the experimental network and the BA scale-free network far exceed those of the other two networks. Since the node memo number is the number of shortest paths through a node in a network, the memo number centrality can be used to measure the importance of the node to other nodes. It can be seen that the 127th node in the experimental network plays a very critical role in the character connection. Finally, proximity centrality is studied, which is the reciprocal of the average distance from the node to the rest of the nodes in the network. The mean and maximum values of the proximity centrality of WS small worlds are slightly smaller than those of the other networks. With the three centrality calculations, it can be seen that the character Wang Mao Hong (Wang Guiding) corresponding to the 127th node in the experimental network has the highest importance in the whole experimental network.

5. Network Degree Distribution

The concept of degree distribution is from the perspective of probability, the degree of k of the nodes in the whole network as a proportion of the number of nodes p_k can be considered as a randomly selected node in the network with degree k of the network. In this paper, we first count the degree distribution of the four networks by using the degree_histogram() function in the networkx package of python and then draw the scatter plot of the four network graphs by Matlab and fit them. The fitted function curves are shown in **Table 6**.

Table 6. Four network degree distribution fits.

Network	Fitting method	Fitting the distribution	Fitting function	R^2
ER Random Chart	least squares	Normal distribution	$f(x)=55.75\exp\left(-\left(\frac{x-9.44}{3.79}\right)^2\right)$	0.93
WS Small World	least squares	Normal distribution	$f(x)=168.30\exp\left(-\left(\frac{x-10.94}{1.24}\right)^2\right)$	1.00
BA without scale	Weighted least squares	Power law distribution	$f(x)=7404x^{-2.59}$	0.96
Experimental Network	Weighted least squares	Power law distribution	$f(x)=398.70x^{-1.57}$	0.96

Figure 4 shows the fitted degree distributions of the four networks. It can be seen that the degree distributions of ER random network and WS small-world network both show a bell-shaped curve with normal distribution, which is consistent with the network characteristics of both. And the BA scale-free network and the experimental network both show a long tail phenomenon, which is consistent with the power-law distribution characteristics. Therefore, the power exponential function is used to fit these two networks. And because the absolute value of the power exponent of the experimental network is less than 3, the experimental network is considered a scale-free network.

Due to the extremely uneven degree distribution of the network, the scale-free network is highly robust to random node failures, but also because of the uneven degree distribution, the scale-free network is extremely vulnerable to deliberate attacks. The experimental network in this paper is a scale-free network, so it also has the above robustness and vulnerability. So, it can be seen that the politics controlled by the scholarly gatekeepers had a certain vulnerability, and a change of an important person could have a very serious impact. This may also be a reason for the political turmoil in the Wei-Jin and North-South dynasties.

6. Inter-Clan Connections

Some of the major scholar clans in the network were extracted, including the Yu Clan of Xinye, the Sima Clan of Wen County, the Yang Clan of Taishan, the Wang Clan of Taiyuan, the Huan Clan of Longchamp, the Wang Clan of Langfeng, the Xi Clan of Gaoping, the Ruan Clan of Chenliu, the Yin Clan of Chen County, and the Xie Clan of Chen County. A new sub-network was constructed by re-establishing the nodes of these clans to specifically analyze the connections among these clans. Figure 5 is generated based on the sub-network data. Different node colors represent different clans. And the characters of each Shi clan are clustered.

Observing Figure 5, we can see that the Xie clan of Chen County on the right had more frequent exchanges with various other scholarly clans, especially with the Wang clan of Langya and the Huan clan of Longchamp. Among them, the

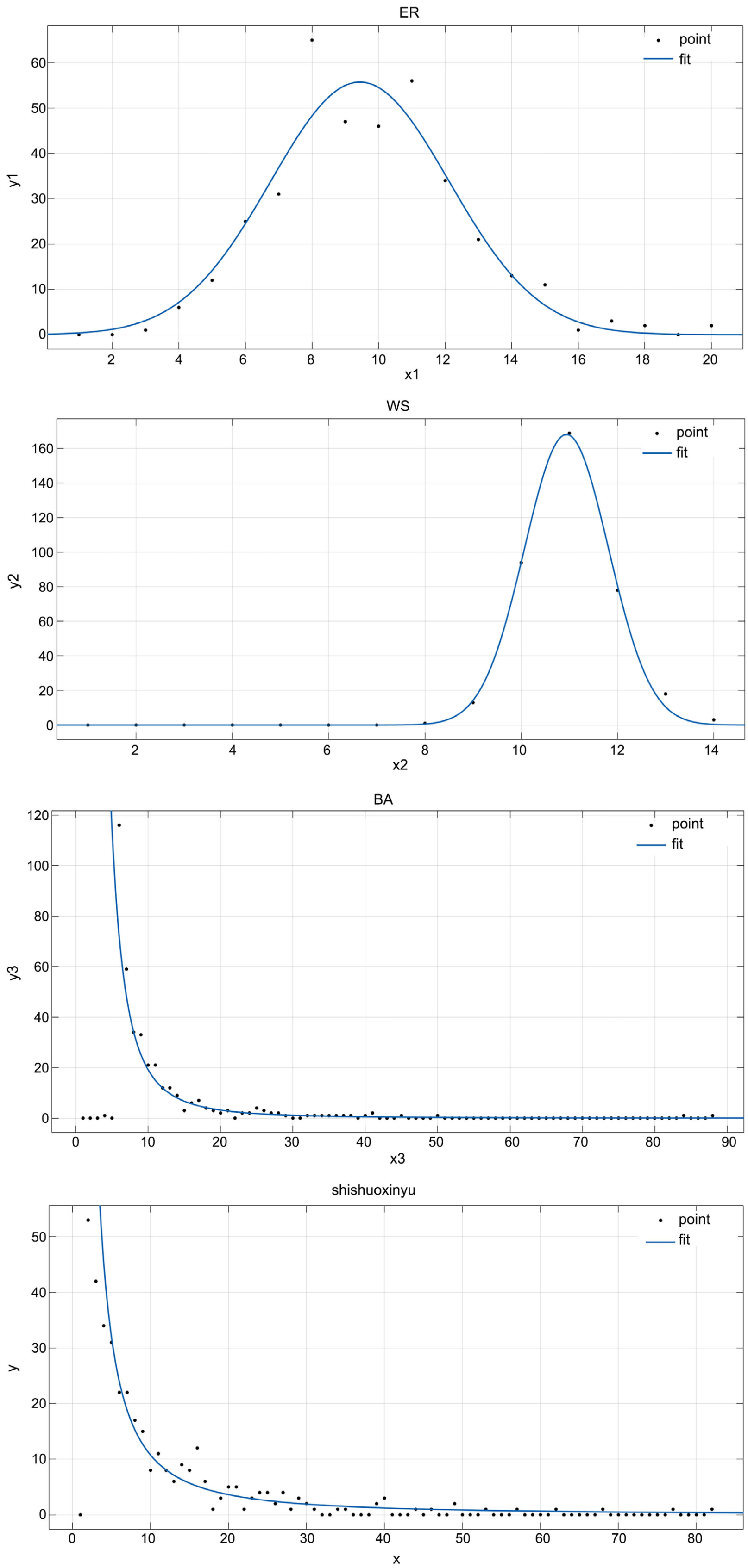

Figure 4. Fitted graph of the degree distribution of four networks.

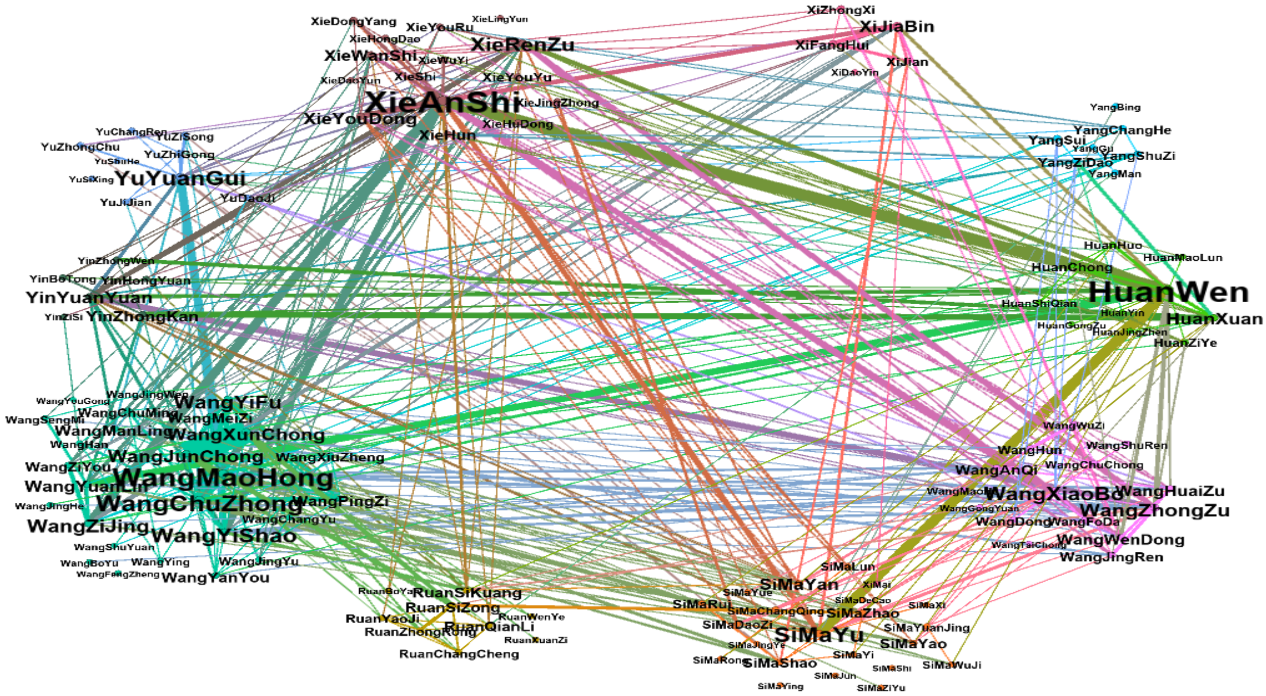

Figure 5. Visualization of clan clustering.

Xie clan and various parties contact mainly established by Xie Anshi (Xie An) as the center, the rest of the internal characters communicate less with each other. Then focus on the lower-left corner of the Langya Wang clan. There are more figures of the Langya Wang Clan appearing in the Shishuoxinyu, and the Langya Wang Clan not only had exchanges with other scholarly clans, but also very frequent exchanges within the scholarly clan. The Huan clan was not particularly large among the ten clans, but the breadth and depth of communication with other clans were even greater than that of the same size. Huan Wen and Wang Xie, two of the top clans, were frequently associated with each other and were closely related to Sima Yu, the Emperor of Jin. The Longchamp Huan clan was not prestigious in the Western Jin Dynasty, but thanks to the efforts of Huan Wen, the Longchamp Huan clan greatly increased its status in the court. In his later years, Huan Wen was very ambitious but was constrained by Wang and Xie, not further. Despite this, it also provided a certain basis for the later usurpation of the throne by Huan Xuan, Huan Wen's son. The close relationship between the clans always affected the development of the court situation. A change in a key figure, a shift in the scholar clan, is very likely to affect the political stability of the time. It is for these reasons that gatekeeper politics was eventually replaced and the scholarly clan gradually declined.

7. Conclusions

In this paper, we analyze the basic topological properties of the character network of Shishuoxinyu in terms of average degree, average clustering coefficient, and average path length, and construct ER random network, WS small-world network, and BA scale-free network of similar size to compare with the experimental network. The results show that the average degree of the experimental network is close to that of the BA scale-free network, and the average association degree of the nodes is lower. In contrast, the average clustering coefficient of the experimental network is close to that of the WS small-world network, the average clustering coefficient is higher and the network is denser. In addition, the average path length of the experimental network is close to the average path length of the ER random network, and the network transmission efficiency is average.

In this paper, the mean and maximum values of degree centrality, mesoscopic centrality, and near-centrality are used to observe the importance of the nodes in the experimental networks. The mean values of each importance metric for the four networks do not differ significantly, while the maximum values differ more significantly. The maximum value of degree centrality of the experimental network and the maximum value of degree centrality of the BA scale-free network are both around 23%, indicating that the nodes with the maximum degree in these two networks are associated with 23% of the nodes in the network. The maxima of Meso-centrality of the experimental network and BA scale-free network far exceed the other two networks, indicating that the maxima nodes are very important to other nodes. With the three measures of node importance of degree centrality, mesoscopic centrality, and proximity centrality, it is found that the node corresponding to the character Wang Mao Hong (Wang Gui) has the highest importance in the entire network of characters of the Shishuoxinyu.

The analysis of the degree distribution of the experimental network reveals that the experimental network degree distribution graph shows a long-tail phenomenon, which is consistent with the power-law distribution characteristics, and the experimental network is considered as a scale-free network. The uneven degree distribution of the scale-free network has high robustness to random node failures and high vulnerability to deliberate attacks. The network of characters of Shishuoxinyu also has robustness and vulnerability, so politics controlled by the scholarly gentry has a certain degree of vulnerability, and a shift of an important person may have very serious effects.

Finally, ten larger clans were selected, and the characters in the ten clans were re-established as nodes to construct a new sub-network for inter-clan linkage analysis. Among them, the Chen County Xie clan interacted more frequently with each of the other scholar clans. The main connection is established through the key figure Xie Anshi (Xie An) and other scholar clans. Then observe the larger scale of characters, the Langya Wang Clan, which not only had exchanges with other scholarly clans, but also very frequent exchanges within the scholarly clan. It is worth noting that in the Huan clan of Longchamp, Huan's characters are not large, but the exchange with other clans is much more than the same size of the clan, similar to the Chen County Xie clan, Huan clan and the clan links mainly to Huan Wen as the center of the establishment. Longchamp Huan clan relys on Huan Wen in the dynasty status greatly improved, for Huan Xuan usurped the throne to provide a certain basis. There was cooperation and confrontation between the scholarly clans, and the network of characters was more complex. Changes in key figures could easily lead to shifts in the scholarly clans and the subversion of the regime. These unstable conditions led to the turbulence of the Wei-Jin and Northern Dynasties, and such a form of rule was eventually replaced.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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