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**Kenna, R., Yose, J., Holovatch, Y., Sarkanych, P., MacCarron, P.  
& Holovatch, Y**

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## NETWORK ANALYSIS OF THE KYIV BYLYNY CYCLE — EAST SLAVIC EPIC NARRATIVES

PETRO SARKANYCH

*Institute for Condensed Matter Physics,  
National Academy of Sciences of Ukraine,  
Lviv 79011, Ukraine*

*L<sup>4</sup> Collaboration & Doctoral College  
for the Statistical Physics of Complex Systems,  
Leipzig–Lorraine–Lviv–Coventry, Europe  
petrosark@gmail.com*

NAZAR FEDORAK

*Ivan Franko National University of Lviv,  
Lviv 79000, Ukraine*

*Ukrainian Catholic University, Lviv 79011, Ukraine*

YURIJ HOLOVATCH

*Institute for Condensed Matter Physics,  
National Academy of Sciences of Ukraine, Lviv 79011, Ukraine*

*L<sup>4</sup> Collaboration & Doctoral College  
for the Statistical Physics of Complex Systems,  
Leipzig–Lorraine–Lviv–Coventry, Europe*

*Center for Fluid and Complex Systems,  
Coventry University, Coventry CV1 5FB, UK  
Complexity Science Hub Vienna, 1080 Vienna, Austria*

PÁDRAIG MACCARRON

*MACSI, Department of Mathematics and Statistics,  
University of Limerick,  
Limerick V94 T9PX, Ireland*

JOSEPH YOSE and RALPH KENNA

*Center for Fluid and Complex Systems,  
Coventry University, Coventry CV1 5FB, UK*

*L<sup>4</sup> Collaboration & Doctoral College  
for the Statistical Physics of Complex Systems,  
Leipzig–Lorraine–Lviv–Coventry, Europe*

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In recent times, the advent of network science permitted new quantitative approaches to literary studies. Here, we bring the Kyiv bylyny cycle into the field — East Slavic epic narratives originating in modern-day Ukraine. By comparing them to other prominent European epics, we identify universal and distinguishing properties of the social networks in bylyny. We analyze community structures and rank most important characters. The method allows to bolster hypotheses from humanities literature — such as the position of Prince Volodymyr — and to generate new ones. We show how the Kyiv cycle of bylyny fits very well with narrative networks from other nations — especially heroic ones. We anticipate that, besides delivering new narratological insights, this study will aid future scholars and interested public to navigate their way through Ukraine’s epic story and identify its heroes.

*Keywords:* Digital humanities; comparative mythology; bylyny; Ukraine; Kyiv cycle; Volodymyr; complex networks; social networks; comparative literature; heroes.

## 1. Introduction

Over the past decade, quantitative methods have been developed to compare social networks depicted in mythological narratives. In [35] and other studies [31], these have been applied to prominent European epics<sup>a</sup> such as in early Irish literature; the Anglo-Saxon Beowulf; the ancient Greek Iliad; as well as a collection of sagas of the Icelanders [36]. Here, we bring bylyny — heroic epics of eastern Slavs — into the fold of network narratology. We consider epics from the heyday of Kyivan Rus’ — the end of the ninth century to the middle of the eleventh century. While narrative analysis is traditionally the prerogative of the humanities [7], and while societal-structure analysis is traditionally the subject of social sciences, the involvement of methods and concepts imported from the natural sciences is now broadly accepted in academia [18].

Actually, applications of quantitative methods to folklore and classical literature have a long tradition. Historic-geographical approaches have been used to identify different types of folk tales, depending on topics, events and characters [30]. The famous Aarne–Thompson–Uther catalogue includes more than 2000 such categories [10]. A very different approach is the usage of principal-component analysis. This allows each text to be presented in the form of a vector, with elements representing certain motifs [6]. Identification of similarity between texts is reduced to the measurement of similarities of vectors. Another different, but equally innovative approach, is that of phylogenetics. This was developed for the study of evolutionary relationships between biological species and adapted to search for connections

<sup>a</sup>For comparative purposes, by “epic” in this paper, we loosely mean an extensive narrative, that appears to describe events that happened far in the past, without demanding all scholastic hallmarks of epic (e.g. poetic form, formulaic composition, attested as an oral tradition, etc.) are met. For the reader interested in authoritative explanations of the traditional oral epic, we refer to John Miles Foley’s [17] and related literature.

between various narratives [14, 60]. A popular quantitative approach is to involve complex networks. For example, in an analysis of the Egils saga [59], allowed sub-classifications of internodal relationships include genealogy, friendship, enmity interactions, gifts and inheritance. Another approach analyses how adjectives are used with certain body parts in classic fairy tales [65]. Network approaches can also be used to categorize tales [1] and a review of applications of networks to analyze fictional texts can be found in [32].

In the comparative approach used here, social networks are quantified by a set of observables such as node-degree distribution, clustering coefficients, assortativity, and other standard measures. Each of these is not unique to social network, but can be used to characterize and compare them [44]. By using these measures, it is by now well established that social networks, in the main, have a number of common characteristics: they are mostly small-world [3, 38, 40, 64]; have heavy-tailed (right skewed) nodal degree distributions [3, 5, 45]; and their clustering coefficients are higher than would be expected for other (such as randomly constructed) network types [44]. The social-balance hypothesis often holds for such networks too (“the enemy of my enemy is my friend”) [21, 22, 58]; they have hierarchical structures [52]; and are assortatively mixed by node degree [42, 44]. The program set up in [34–36, 54, 66] quantifies the extent to which networks of characters of mythological narratives that belong to different cultures exhibit these and other unifying and distinguishing features. Here, we analyze bylyny — the heroic epic of Eastern Slavs. Continuing our studies initiated in Refs. 24, 55, our goal is to find universal quantitative characteristics and to place bylyny in a larger context of mythological narratives of other cultures. We also wish to identify the most important characters and their placement in the narrative, both amongst their immediate community and the broader society — “the secrets to their success”, so to speak. The rest of the paper is organized as follows. In Sec. 2, we briefly discuss bylyny, their content, as well as the period and place of their origins. We present the complex network of bylyny society in Sec. 3, and rank most prominent characters. We discuss network properties in Sec. 4, where we compare bylyny with network properties of other mythological narratives. Section 5 concludes.

## 2. Bylyny

Bylyny (or staryny, as they are sometimes called) are short, melodious, recitative epic songs of the Eastern Slavs. (The word “bylyny” is plural and its singular form is “bylyna”). One of the first researchers of bylyny in the context of the Ukrainian medieval tradition was prominent historian and literary critic Mykhailo Hrushevsky who proposed the division of bylyny into heroic-epic and religious-legendary parts [25]. The first of these are older and are associated primarily with areas around Kyiv and Halych in modern-day Ukraine. They center on characters such as Dobrynya, Illya Muromets’, and Oleksiy (Oleshko, Alyosha) Popovych, as well as the so-called

bylyny of the “Halych-and-Volhynian group” [25]. These bylyny form the main focus of this paper.

The second group was created later are associated with Novgorod and Moscow. These are social (not heroic) bylyny. Plots of the Novgorod cycle are grouped around ordinary people: merchants, moneylenders, musicians, etc. Novgorod was an important (primarily naval) trade center and, due to its geographical remoteness from land-based military and commercial routes, it evaded the Tatar-Mongol invasion in the 13th century. In contrast, Moscow was rapidly subordinated into the Golden Horde and for several centuries the city was one of the western Mongolian ulus. These historical and geographical details are reflected in bylyny local to different areas [25].

Given the thematic heterogeneity and striking differences in the geographic and political orientation of bylyny, it is not sensible to analyze the whole corpus as one here. We focus our attention only on the Kyiv cycle, which covers the period of the highest prosperity of Kyivan Rus’ (the end of the 9th to the middle of the 11th century). Part of this epic tradition includes the songs of *skomorokhs* (a typological analog of Western European singer-minstrels) and the story of matchmaking. These epic works are not heroic, and therefore we also omit them from our analysis. The subject of our study is therefore 39 texts of epic tradition which we take from [50].

Bylyny were passed from generation to generation in oral form. Although the first recording was of the Moscow cycle by Englishman Richard James, for his diary, in 1619 [33], it is believed that Kirsha Danilov was the first to publish a collection of bylyny in the middle of 18th century [13].<sup>b</sup> These describe events that happened in Kyiv, but they had been transmitted and migrated by oral tradition, and were collected and documented in the northern eastern Slavic lands in the 18–19th centuries. Vasyl Avenarius explained this by the fact that, at that time, the majority of the population of Ukraine (south-western Eastern Slavic territory) was already literate, in contrast to the inhabitants of the remote villages of the empire. In Ukraine, therefore, knowledge and testimony of historical memory were passed in writing [4]. Also, for Ukrainians at that time, more recent (originating in the 15–18th centuries) recitative lyric epics about Cossacks (the so-called *dumas*) became popular [56]. Also, the characters of bylyny in Ukraine “migrated” to other folklore genres, such as folk tales or folk songs. Interestingly, there are *dumas* about Illya Muromets’, one of the most popular of the bylyny characters.

Approximately 100 years after Danilov’s collection, the topic of bylyny was brought to attention of scholars again. This was due to the fact that Pavel Rybnikov discovered an active bylyny tradition in the Olonets region of northern Russia [53]. At first, this was received with a fair share of skepticism similar of that shown towards Ossian [67]. However, subsequent expeditions verified its authenticity [47].<sup>c</sup>

<sup>b</sup>This collection shows signs of edits and corrections from the collector [47].

<sup>c</sup>As it was pointed by Oinas, during the Soviet time, folklore research was heavily affected by ideology and propaganda [48]. His work on *Kalevipoeg* [46], the Estonian epic cycle, is a good example of epic poetry in which the bylyny are considered part of the broader traditional genre.

Despite temporal, geographic and thematic differences, bylyny have a lot in common and different stories have common characters. Bylyny of the Kyiv cycle include a series of works related to the exploits of the most famous heroes: Illya Muromets', Dobrynya and Oleksiy Popovych. It is this feature of bylyny that allows us to interpret the characters of this epic tradition as a social network. The main character of bylyny of the Kyivan cycle is Prince Volodymyr, who performs the classical function of "epic king" in the manner of many medieval heroic epics (like Charlemagne in the so-called "royal cycle" of the French "chansons de geste"). His wife is Opraksiya (Apraksiya, Eupraxia) and she never appears in the epics separately from her husband. Three main battle heroes are Illya Muromets', Dobrynya and Oleksiy Popovych. Each are vassals of Prince Volodymyr and are in military service to him. The main antagonists of the three heroes are the Soloviy The Robber, the Tatars and various bandits. In addition to concrete historical references, the words "Tatar" or "Tatars" may refer to an enemy in a more general sense.

A most interesting "epic hero" from a literary point of view is Illya, an old experienced warrior who does not always blindly perform the orders of Prince Volodymyr and sometimes transforms them or even resists them. In contrast, Oleksiy is young and hot-tempered. This pair are reminiscent of the characters of the German epic "Hildebrandslied", only there the old hero Hildebrand was the father of his young antagonist Gadubranda. Dobrynya is the guardian (perhaps an uncle) of Grand Prince Volodymyr-Vasyl the Great, the baptist of Rus', and in bylyny he is depicted as Volodymyr's nephew [25]. According to some scholars, Dobrynya may have been the main protagonist of the whole epic cycle in the period when it started to be created [25]. We give some more information about the character(s) of Dobrynya in Appendix A.

Bylyny feature the usual epic hyperbole. For example, characters may show superhuman abilities: Illya, Dobrynya, or Oleksiy is able to defeat several thousand troops alone; Soloviy The Robber is able to demolish houses with his piercing whistle, and so on (compare Cuchulain from Táin Bó Cúailnge and the Ulster cycle in Ireland, for example). An interesting and controversial issue is the link between characters of bylyny and their likely historical prototypes.

Historians, folklorists and literary scholars tried to get past distortion in the tales to a historical basis, especially for the Kyiv cycle [25, 29, 49, 62]. The key character is Prince Volodymyr himself. His mental, ideological and geographical connection with the Baptist of the Kyivan Rus' Volodymyr-Vasyl the Great (958-1015) is indisputable. Historical sources are primarily medieval works such as "The Tale of Bygone Years" [12], "The Lives of SS. Borys and Hlib" [2], as well as the life of Volodymyr the Great himself [61]. The life of Prince Volodymyr the Great gradually idealized in the memory of people and became an example of the Christian way of life in the context of the ancient Ukrainian chronicle tradition. Later rulers of Rus' — mostly Volodymyr's descendants — were compared to his example. It can be assumed that the gradual transition from the oral to the written transfer of the most important events in the history of people — that is, the gradual transition from folklorization

to fiction of history — began with the Kyiv chronicles. This transition became systematic after 988, when, through baptism, Rus' was adsorbed into other European states and cultures. Chronicle history knows many glorious princes, but after the death of the Baptist of Rus', the name "Volodymyr" bore a special royal responsibility giving rise to special expectations of his actions. Examples of the "worthy Volodymyrs", whose images are detailed and vividly written in the chronicle tradition and in memory, are Volodymyr Monomakh (1053-1125, initially the Prince of Chernihiv and Pereyaslavl, later — the Grand Prince of Kyiv, the great-grandson of Volodymyr the Great) and Volodymyr Vasylykovich (1249–1288, Prince of Volhyn', the great-grandson of the Grand Prince of Kyiv Mstyslav Izyaslavych, who himself was the great-grandson of Volodymyr Monomakh).

Each of these two princes — Volodymyr Monomakh and Volodymyr Vasylykovich — is depicted only positively in the Ukrainian chronicle tradition. The first, besides becoming a positive character of the Tale of Bygone Years [12], the Kyiv Chronicle (12th century) [23] and even the Halych-and-Volhynian Chronicle (13th century) [63], was the only Ukrainian prince-writer. His works ("Testament of Volodymyr Monomakh", a fragment "Letter to Prince Oleh" and "Prayer") were placed in the Laurentian edition of the Tale of Bygone Years under the annalistic year 1096 (the year according to the chronicles) [12]. The main human characteristics of Volodymyr Monomakh in literary and national memory were justice, Christian zeal, enlightenment, wisdom, charity and he is also remembered for tireless and invincible military campaigns, political strength and statesmanly thinking, aimed at uniting the Rus' lands and their rulers. As for Volodymyr Vasylykovich, the Halych-and-Volhynian chronicle presents an extremely touching portrait of this prince — "a philosopher never seen in the land of Rus' and who suffered an incurable illness [37]. Volodymyr Vasylykovich did not have children, but took care of his people as a father. He distributed much of his property to churches and monasteries, and was the embodiment of wisdom, humility and mercy. According to the chronicles, when, four months after his death, his tomb was opened (at the command of his widow), Volodymyr Vasylykovich's body was found uncorrupted: "the fragrance was from the grave, and the smell is similar to the expensive scents" [37].

Thus, Volodymyr the Great, Volodymyr Monomakh, and Volodymyr Vasylykovich together carry a whole complex of positive features. These were implicitly approved in the public consciousness and merged into an epic manifestation as the unified "epic ruler", Volodymyr. Still, local temporal and thematic differences in bylyny of different cycles suggest corresponding temporal, territorial and ideological personifications. Volodymyr the Great is associated with bylyny of the 10–11th centuries; Volodymyr Monomakh with stories of the 12–13th centuries; and Volodymyr Vasylykovich for the stories in the 13–14th centuries (especially of Halych-and-Volhynian cycle). One of the schemes outlined below for the distribution of the epicenter of bylyny suggests this triple division of Prince Volodymyr. Whether Prince Volodymyr is part-amalgam of these historic characters or not is an interesting question, and one that has been addressed exhaustively using traditional

philological and historical methods. Complex networks cannot resolve such issues, of course. Still, very similar roles of “superheroes” are interesting to explore in network terms, not least to gain insight into how people in medieval times sought to present their heroic icons, real or imaginary [18, 35].

### 3. The Kyiv Bylyny Network

The extraction and analysis of networks of interacting characters from epic narratives is a recent quantitative approach to comparative narratology; see [31] for an extensive survey up to 2019 and [18] for more recent developments. In it, individual characters in a text are represented by nodes and interactions between them are represented by edges. In the approach introduced in [35], and in subsequent literature [27, 36], two characters are deemed linked if they know or interact with each other in some way. Multiple meticulous human readings are required to construct a reliable network — e.g. to infer whether characters have met before and or whether they present together in a small group or, indeed, if the interactions between them are hostile or not. The manual method of [35] and attempts at automation form two (of four) focal points for extraction and analysis of character networks in [31]. In [15] the authors suggest a method to construct a network of characters automatically by allowing a computer to detect points in the text where two characters communicate directly. Despite this method showing good precision, it captures only one of our conditions for a friendship connection to be made — namely when two characters are in conversation. There are other methods to analyze the text with the help of modern data science approaches, like the one presented in [26] where the ranked list of characters is obtained automatically using named entity recognition. Despite this method showing high accuracy, it does not allow to extract the interactions between the characters. Thus, it is not yet possible to extract the full, nuanced network using automated means and we use the manual approach here. Therefore, we use human reading to construct a friendly link between two characters if they talk to each other, from the text it is obvious that they have met before or they are present in a small group. In contrast, the hostile link is added if two characters either fight each other or are in a state of war.

From the 39 bylyny texts that form the basis of this study, we extracted a dataset comprising 153 individual characters connected by friendly and hostile links. This social network is depicted in Fig. 1. Each character there is represented by a number and some of the most important ones in network terms are listed in Table 1. The most prominent of these have already been mentioned and we encounter others in the sequel as well as in Appendix A where we provide more background information to the Kyiv bylyny. Isolated nodes are omitted as they do not form part of a network. The terms used to rank characters are explained in the following section.

In Fig. 1, friendly and hostile links are represented by solid blue lines and dotted red lines, respectively. Of the 320 edges, 223 are friendly and 105 hostile. The aggregate amount of friendly and hostile bonds is larger than the total number of edges



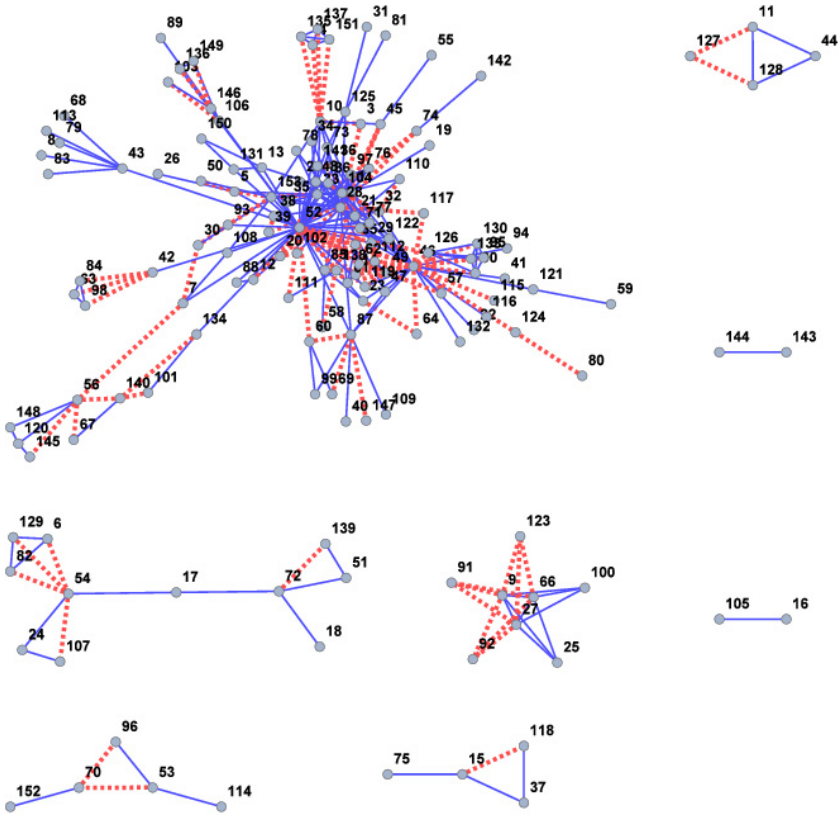


Fig. 1. (Color online) Social network of characters of Kyiv cycle byliny. Red dashed lines corresponds to the hostile links, while blue solid to the friendly ones. Each node has its own code number. The most important characters and the corresponding numbers are listed in Table 2. The largest connected component is in the left top corner of the figure. Smaller graphs represent characters of separate stories. For example, graph consisting of nodes 143 and 144 is two bulls observing troops who do not interact with other characters. The star shaped graph in the second row from the bottom describes story about Vavilo (node number 9). Characters of this part of the epics do not appear in any other story.

because the same characters can interact in different ways (friendly and hostile) in different byliny — and even within the same text [36].

The network in Fig. 1 consists of several separate pieces. The top left cluster is called the giant connected component. No individual bylyna has these many characters with some 10–20 characters in the biggest individual bylyna. Similar “subtle narrational tricks” were used in modern narratives to mirror natural social networks [18]. The size of the giant component reflects the spread of characters across different tales. This is not least because in the Kyiv epic cycle byliny are united by the presence of hero-protagonist, Prince Volodymyr. He is identified in the network as node number 52 (we henceforth refer to node numbers using the symbol #, so that Prince Volodymyr is identified as #52). In relative terms, the giant component

Table 1. List of most important characters of bylyny, ranked by three commonly used network measures. Character names are listed in the first column and their numeric identifiers (using the symbol # in the text) are listed in the second. These numbers are sorted by the Cyrillic alphabet and used to locate the corresponding character in Fig. 1. The three remaining columns give how each character is ranked in terms of node degree ( $R_k$ ), closeness ( $R_C$ ) and betweenness ( $R_B$ ) centralities.

Character name	#	$R_k$	$R_C$	$R_B$
Prince Volodymyr	52	1	1	1
Illya Muromets'	46	2	2	2
Dobrynya	28	3	3	3
Oleksiy Popovych	1	5	4	10
Mykhailo Potyk	87	9	7	5
Princess Opraksiya	104	4	5	13
Duke	33	7	6	15
Vasyl	8	10	13	7
Churylo	153	6	12	16
Soloviy the Robber	126	11	15	23
Tatar	138	15	14	24
Kudrevanko	65	10	8	37
Dunai	32	18	11	31
Ivan Hostynyi Syn	43	19	37	4
Mykhailo	85	16	25	28
Kalyn	49	17	16	36
Matviy	77	12	9	49
Luka	71	13	10	50
Hoten	146	24	40	11
Soloviy	125	25	42	14

comprises 76.5% of the bylyny network. This is smaller than for the epics of many other nations, but similar to that of the Old English epic poem Beowulf. This comparison is not to suggest there is a connection between bylyny and Beowulf. Rather it is but one measure to position the complexity of bylyny relative to other epics. Our aim here is to quantify and document network features of bylyny and we do this using standard network indices — precisely in order to compare to other epic narratives from other nations. The results are gathered in Table 2 where giant components are represented by  $G_c$  in the penultimate column.

The other components of Fig. 1 correspond to individual or smaller groups of stories. These also belong to Kyiv cycle, but they don't share characters with the largest connected component. For example the star shaped cluster in the second. row from the bottom comes from the story about Vavilo (#9). That tale relates how Vavilo overwhelms an antagonist king and takes his place (hence the high degree of hostility represented by dotted red edges). Characters in this story do not appear anywhere else, so they form isolated fragment of the full social network. Thus, besides illustrating the cohesion and fragmentation of bylyny, Fig. 1 also offers an aide to navigating one's way through the complex world it depicts.

Table 2. Characteristics of the social network of bylyny compared to those of other epics (from [27, 35, 36]). Here,  $N$  and  $L$  indicate the number of characters and edges, respectively. Other measures are the average and maximum degrees ( $\langle k \rangle$  and  $k_{\max}$ ); the average shortest path length of the complex network ( $l$ ) and the counterpart for random graphs of the same size ( $l_{\text{rand}}$ ); the diameter of the giant component ( $l_{\max}$ ); the average clustering coefficient of the complex network and that of the corresponding random graphs ( $C$  and  $C_{\text{rand}}$ ); the size of the largest connected component ( $G_c$ ); and the assortativity by degree ( $r_k$ ). Identifiers in brackets (“all”, “hostile”, “friendly”) specify types of relationships used to construct the network.

Network	$N$	$L$	$\langle k \rangle$	$k_{\max}$	$l$	$l_{\text{rand}}$	$l_{\max}$	$C$	$C_{\text{rand}}$	$G_c$	$r_k$
Bylyny (all)	153	320	4.18	52	2.9	3.61	6	0.57	0.03	76.5	-0.15
Bylyny (hostile)	98	102	2.14	17	3.63	5.76	8	0.06	0.022	51	-0.11
Bylyny (friendly)	142	223	3.16	41	2.76	4.33	6	0.42	0.022	57	-0.11
Beowulf (all)	72	167	4.45	27	2.38	2.91	6	0.7	0.06	67.5	-0.10
Beowulf (hostile)	31	26	1.67	—	2.08	3.25	4	0	0.05	32.2	-0.20
Beowulf (friendly)	68	141	4.12	—	2.45	2.98	6	0.69	0.06	66.1	-0.03
Táin (all)	422	1200	6.10	168	2.8	3.3	7	0.8	0.02	98.5	-0.33
Táin (hostile)	144	168	2.33	—	2.93	5.88	7	0.17	0.02	90.9	-0.36
Táin (friendly)	385	1091	5.67	—	2.84	3.43	7	0.84	0.01	90.9	-0.32
Iliad (all)	716	2084	7.40	106	3.5	3.3	11	0.6	0.01	98.7	-0.08
Iliad (hostile)	321	361	2.25	—	4.10	7.12	9	0	0.01	89.4	-0.39
Iliad (friendly)	664	2317	6.98	—	3.83	3.34	12	0.62	0.01	82.3	0.10
Odyssey	301	1019	6.77	112	3.29	3.18	8	0.45	0.02	98.3	-0.08
Gísla Saga	103	254	4.9	44	3.4	2.9	11	0.6	0.05	98	-0.15
Egils Saga	293	769	5.3	59	4.2	3.4	12	0.6	0.02	97	-0.07
Laxdæla Saga	332	894	5.4	45	5.0	3.5	16	0.5	0.02	99	0.19
Njáls Saga	575	1612	5.6	83	5.1	3.7	24	0.4	0.01	100	0.01
Mabinogion	666	2427	7.29	135	3.83	3.48	11	0.48	0.01	76	0.19

The number of vertices is denoted by  $N$  in Table 2 and the number of edges is  $L$ . We explain the meaning of the other indices in Sec. 4 where we use them for comparative purposes. The first row of the table contains statistics for the full social network of bylyny and results for the friendly and hostile networks are listed in the second and third rows. The hostile network has 98 nodes 51% (50) of which are in the largest connected component. Bylyny have a higher proportion of hostile edges than the other narrative networks, data for which are also listed in Table 2. Hostility for most epic tales tends to be between 10% and 20% in terms of edge count. The difference between bylyny and other tales can be explained by the fact that bylyny are 39 individual stories about heroes. Each of the stories describes heroic exploits, they require an antagonist or even a couple of them for the hero to defeat. And with heroes being common for most of the stories, one may expect the portion of hostile links to be greater than in many other epics.

Different regions of the Kyivan Rus’ had their own heroes, and these are not necessarily connected to the giant component. For example, the connected component involving Vasyl’ Okulovych (#11), in a right upper corner of Fig. 1, has a large proportion of hostility.

For comparative purposes, Table 2 also contains network statistics for epics from other nations. Besides Ireland’s Táin Bó Cuailnge and the Anglo-Saxon Beowulf,

mentioned previously, these include the Iliad and Odyssey from Greece and the Icelandic Gísli Saga, Egils Saga, Njáls Saga, Laxdæla Saga and the Welsh Mabinogion. The data for these texts come from previous publications [34]. When the information is available, we present data separately for friendly and hostile links as well as for the full networks. Comparison of the quantitative characteristics of social network of bylyny with those listed above enables a search for universal and differentiating characteristics of societal aspects of epic narratives.

In [34], different categories of networks are identified for different genres based on the shape of their degree distributions and their assortativity. There it is observed that stories centered on a single protagonist that travels to many locations, such as Beowulf, the Odyssey or Gísli saga all are disassortative and the main characters having exceptionally high degrees (relative to both system size and the rest of the characters). On the other hand, narratives, such as Laxdæla saga, Njáls saga and the Mabinogion (which, after the first four chapters mostly deals with Arthurian Romances) are set in one location, and while they have protagonists, they are still stories of a people. These have faster decaying degree distributions and are assortative. (We present a plot the cumulative degree distribution in Appendix B.) Between these extremes we find the Iliad and Egils saga, both of these have a few protagonists who are highly active in the hostile network, these networks have assortative friendly networks. Similar to these is the Táin Bó Cuailnge, however in this case we identify 6 characters with extremely large degrees in both hostile and freindly networks (for further discussion see [35]) placing it between these first and last categories. From the network measures in Table 1, we see that bylyny is more similar to that of Beowulf, the Odyssey and Gísli saga. We discuss its individual properties and this result in more detail over the following sections.

## 4. Network Statistics

### 4.1. Node degree

The degree of a node is the number of connections it has and, as such, it is one measure of a character's importance for the story. The node with the largest degree is Prince Volodymyr (#52) who, mentioned in almost every bylyna, is connected to roughly half of all other characters. At  $k_{\max} = 52$ , his degree is much higher than the average degree  $\langle k \rangle = 4.18$ . These maximal and average values are entered in Table 1 to give a feeling for how the central hero compares with central heroes of other texts. These include Ireland's Cuchulain, England's Beowulf and Greece's Achilles. While absolute values (of degree) are not meaningful comparative measures across different texts, rankings are, and Prince Volodymyr is highest ranked in Ukraine in the same way as Cuchulain is in Ireland and other national heroes are in their respective countries. But Prince Volodymyr is not the only hero in Ukraine and Illya Muromets' (#46), Dobrynya (#28) and Oleksiy Popovych (#1) are also prominent (see Appendix A) and ranked accordingly. In Appendix A we present the giant

component of Fig. 1 with nodes sized proportionate to node degrees. Like Fig. 1, this is similar to a star graph, or rather to several star graphs fused together; it draws out how leaders are directly linked to each other and also attached to greater numbers of low degree characters. (We also present a plot of the degree distribution in Appendix B).

As discussed in Sec. 2, some researchers believe Prince Volodymyr to be a collective character — a fusion of three distinct entities. We will return to this issue in Sec. 4.6 where we discuss the assortativity of the network [11, 56].

#### 4.2. Distances between characters

Real social networks — even those with large numbers of nodes — are characterized by small average distances between them. This is the famous small-world effect [38]. Since the 1960’s the term “six degrees of separation” or “six handshakes” entered the public domain [20] and it is widely known that the average distance between randomly selected members of society is about six. More recently, it was established that a similar value occurs in an equivalently sized Erdős-Rényi random graph [64]. Distance, in this sense, is the shortest length of a path or sequence of edges, which have to be traversed to get from one node to another. We denote it by  $l$  and refer to such paths as geodesics. The longest geodesic is called the diameter of a network and represented by  $l_{\max}$ . We now check the typical distances (paths) between nodes in bylyny social network and compare to other stories from other countries. In the case of disconnected graphs like that of bylyny, we use only the giant connected component to determine diameters.

In order to find the average shortest path  $l$  and diameter  $l_{\max}$ , all geodesics in all connected components are taken into account and the resulting values of  $l$  and  $l_{\max}$  are listed in Table 2. For bylyny, the average path length is  $l = 2.9$ . Again this is most similar to the Irish Táin Bó Cuailnge, for which  $l = 2.8$ . The same can be said about the diameter of the network; for bylyny the maximum path length between characters is 6 (for all and friendly networks) while for the Táin Bó Cuailnge it is 7. The value of the diameter  $l_{\max} = 8$  for the hostile network of bylyny is higher, which means that this network is “stretched” relative to the friendly one. A similar feature is observed for other epics in Table 2.

It is usual to compare the average geodesic length  $l$  to the corresponding value  $l_{\text{rand}}$  calculated for an Erdős-Rényi random graph [16] of the same size. An Erdős-Rényi graph is an example of the small world network for which average path length grows logarithmically with the number of nodes [8]. Average values of  $l_{\text{rand}}$  are given in Table 2 for random networks of appropriate sizes. As one can see from the table, the average shortest distance for bylyny networks are lower than for random graphs with relevant number of edges and nodes. This is similar to the Irish Táin Bó Cuailnge and the Anglo-Saxon Beowulf interestingly, however, the Icelandic sagas and Greek classics, do not share this quality.

### 4.3. Closeness centrality

We are also interested in the concept of distance between characters. One relevant measure is the closeness centrality [9, 39]. For each node, this is the inverse of the sum of the distances to all the other nodes within the connected component. Therefore, the higher the closeness centrality  $C_C$  is, the closer the given node is to all other nodes. See Appendix B for a visual depiction of the giant component weighted according to this measure. The top five characters ranked according to closeness centrality are Prince Volodymyr (#52); Illya Muromets' (#46); Dobrynya (#28); Oleksiy Popovich (#1) and Princess Opraksiya (#104).

Immediately after these are Duke (#33) and Mykhailo Potyk (#87). “Duke” here is a name and not a title. The famous Ukrainian historian Mykhailo Hrushevsky, who specialized in the history of literature, identified them as part of the Halicia–Vолhynia character group [25]. According to bylyny, Duke is a Halician prince and Mykhailo Potyk is considered to be borrowed from Western Ukraine, where he, in turn, came from Bulgaria, with a history of St. Michael from Potuka [25]. In the texts, he is a hero fighting on the side of Prince Volodymyr and against King Lya-hetskiy (#60). We find it interesting that closeness centrality has identified the importance of characters of the Halych-and-Vолhynian region, which once was a successor of the Kyivan Rus'. These characters have relatively low degrees. It is also interesting that, without Volodymyr and Opraksiya, the highest ranked character by closeness centrality is Dobrynya who outranks Illya Muromets'. This may be a reflection of the fact that in several texts Illya opposes Prince Volodymyr, while Dobrynya is always on the side of the ruler, and, therefore, closer to him.

Thus, besides a simple ranking of network nodes, individual metrics may inspire us to look deeper into individual characters, questioning the roles they play in the story and how they are represented. We continue in this vein with other measures of centrality.

### 4.4. Betweenness centrality

Another local characteristic that can give an insight onto the importance of individual nodes is the betweenness centrality  $C_B$ . This measures how important the node is in maintaining communications between other nodes. Betweenness centrality is the fraction of geodesics passing through a given node. Like the closeness centrality, betweenness makes sense only within connected components. Accordingly, a value  $C_B = 1$  corresponds to the case when all the geodesics of the network pass through the given node. The lead characters according to in betweenness terms are again Prince Volodymyr (#52), Illya Muromets' (#46) and Dobrynya (#28). Oleksiy Popovich (#1) is ranked significantly lower according to this measure. Interestingly, Ivan Hostynyi Syn (#43) is ranked fourth although he appears just once, in a story which only has five unique characters. However, because Ivan has a direct connection to Prince Volodymyr (Fig. 1) these five unique characters are connected to the rest of the network.

In ways like this, nodes with high betweenness centrality are important for maintaining the integrity of the network. For example, if one removes the three characters of byllyn social network with the highest values of  $C_B$ , the network splits into 24 pieces, the largest of which contains only 72 nodes.

#### 4.5. Clustering coefficient

The clustering coefficient measures the probability that neighbors of a particular node in a network are themselves connected [64]. In a fully connected graph, the clustering coefficient of a node is equal to 1. In a tree graph (one without loops) it is 0. For byllyn, and in complex networks in general [52], nodes with high degree tend to have small clustering coefficients; the larger the degree of the node is, the less likely that its neighbors are connected to each other. This is due to the fact that heroes [Ilyya (#46), Dobrynya (#28), Oleksiy Popovych (#1)] each have several different enemies independent of each other.

While clustering coefficient is a local (nodal) characteristic, its average value tells us something about the nature of the whole network. In contrast to the manner in which complex networks tend to have similar average path lengths to that of Erdős–Rényi graph, their average clustering coefficients tend to not to be so aligned. We denote the clustering coefficient of random counterparts as  $C_{\text{rand}}$ . For epic narratives, clustering coefficient for friendly and full networks can be an order of magnitude greater than those of random graphs of the same size and this is not the case for hostile network. Byllyn social networks are no different and values are given in Table 2. These observations may serve as an evidence of the structural balance hypothesis for epics social networks: if two characters are connected through friendly links with a third one, it is likely that the first two are positively linked. Likewise, if two characters are connected through hostile links with a third, it is unlikely that they are also hostile to each other.

#### 4.6. Degree assortativity

In real social networks, individual nodes tend to be connected to vertices of similar degree; (“birds of a feather flock together”) [44]. In fictional social networks (such as the Marvel universe [19]), however, high-degree vertices are mostly connected to low-degree ones (“not everyone can be a superhero”). Social networks of epic narratives tend to occupy an intermediate position. A measure for correlation between neighboring nodes is the degree assortativity  $r_k$  [41, 44]. By definition, degree assortativity is bounded so that  $-1 < r_k < 1$ . Positive values characterize assortative networks whereby high-degree nodes connect to each other and nodes with low degrees are interconnected as well. Negative values, on the other hand, indicate that the network is disassortative, i.e. that high-degree nodes are joined to nodes with a low degree and vice versa.

Assortativity values for bylyny social networks are listed in Table 1, along with those of other epics. For the full network, a value  $r_k = -0.15$  indicates that the network is disassortative. This result is consistent with the fact that bylyny are epic tales about heroes: parts of networks are star-shaped structures (Fig. 1) where heroes associate with less significant characters. A different behavior is found for some Icelandic sagas; they are stories about people and for them the assortativity is positive. In a previous network study of the Icelandic sagas, we concluded that network analysis allows to quantitatively compare societies from epic narratives with a real-world social networks [36].

In epic networks, the hero is sometimes brought into contact with lower-degree characters through conflict. This results in a greater degree of negativity in the degree assortativity of the hostile networks than the friendly one. This tendency is evident in Beowulf and the Iliad. It does not occur in bylyny, however — or in Ireland’s Táin Bó Cúailnge. In this sense, again, bylyny find similarities with Ireland’s iconic tale. It should be noted, however, that the negativity of assortativity can sometimes be caused by the structure of the story itself. For example, events described in the epic Beowulf occur in two different places and are also divided by time intervals. They are connected only through a common protagonist. As shown in [27, 35], removal of the protagonist changes the nature of network connections from disassortative to (weakly) assortative. A similar effect is present in the bylyny social network. Removal of the node corresponding to Prince Volodymyr increases the degree assortativity to  $r_k = 0.01$ , which is indeed a positive value, albeit a very small one.

As discussed in Sec. 2, many researchers believe that Prince Volodymyr is a collective character [56] — an amalgamation of historical figures Volodymyr the Great, Yaroslav the Wise, and Volodymyr Monomakh [11]. We split Prince Volodymyr’s node into three distinct vertices and randomly distributed his edges amongst them. We did this multiple times and find that the bylyny network assortativity increases assortativity to  $r_k = 0.004$ . In this way, the network becomes more similar to a real-world social networks. Division into four makes the network even more assortative with  $r_k = 0.03$ . Thus, we see that dividing the superheroic main character into more “human” (less connected) individuals makes the network more akin to a real social network. Of course, disassortativity is necessarily driven by high-degree characters interacting with low degree ones and reducing the degree of the most connected characters necessarily increases the value of  $r_k$ . In a sense, this procedure “de-mythicalises” the hero, so it is up to the reader to make what they will of it. Certainly, and as always, we advise that any conclusion cannot be drawn from a single metric and has to involve holistic input from humanities.

#### 4.7. Communities

Even from Fig. 1, it is obvious that the bylyny network comprises distinct communities. While this visualization depicts interacting characters, it hides a more subtle community structure — for, even in the giant component many vertices are more



heavily connected certain others than with the rest of the network. The standard approach to detecting communities uses a specially tailored algorithm created by Girvan and Newman [43]. Application to the bylyny social network (taking into account both types of links) yields an interesting result: the largest connected components is divided into 15 communities. We depict these in Fig. 2. The largest such community has 36 nodes (colored red in the center of the figure). These include Prince Volodymyr (#52), his wife Opraksiya (#104), Oleksiy Popovych (#1) and Dobrynya (#28). The second largest community has 22 characters. This is the large group of yellow nodes concentrated around Illya Muromets' (#46) to the right side of the figure. This demonstrates that Illya Muromets' (#46) and Dobrynya (#28) with Oleksiy Popovych (#1) represent a different generations of heroes [4, 50]. Illya is from the older heroes, whereas Oleksiy and Dobrynya are from the younger ones.

The analysis also identifies a community concentrated around Churylo (#153) and another around Mykhailo Potyk (#87). Both of these characters, along with Duke (#33) are associated with Halicia-Volhynia [25]. This Principality or Kingdom was a medieval state and vassal of the Golden Horde that existed from 1199 to 1349. The appearance of these characters in the epic describing the Kyivan Rus', can be explained by the fact that after the destruction of Kyiv by the Mongols, cultural heritage passed to Western land in the Halicia-Volhynia kingdom and it has absorbed part of the local heritage. As one can see, the quantitative analysis of

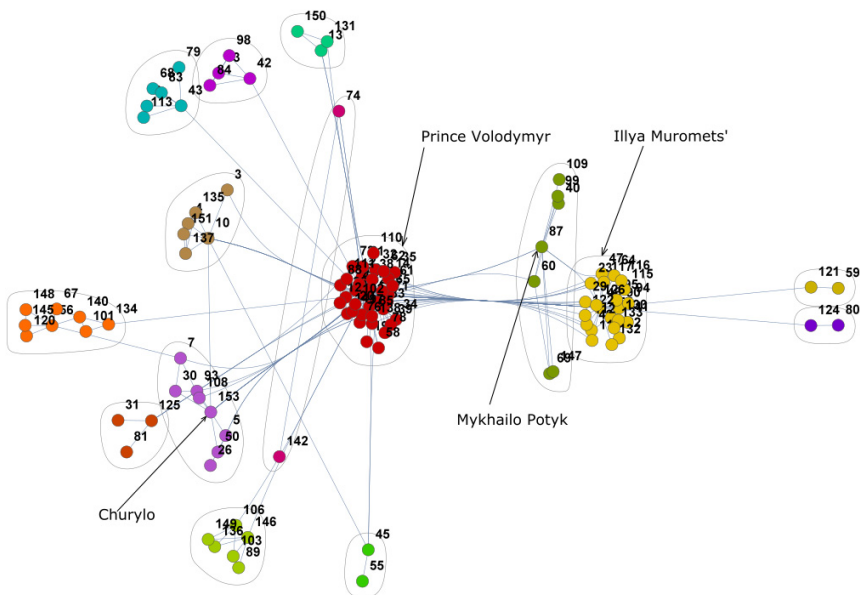


Fig. 2. Community structure of the bylyny social network (with both hostile and friendly links). The largest of 15 communities is centered around Prince Volodymyr (#52 in the center of the picture), while that around Illya Muromets' is second biggest (#46 on the right side of the figure). The next two communities by size are concentrated around Churylo (#153) and Mykhailo Potyk (#87).

bylyny social network also provides separate communities centered around these characters, as shown in Fig. 2.

## 5. Conclusions and Outlook for the Future

To what extent do epic narratives belonging to different cultures share common and differentiating characteristics, and to what extent can we quantify them? This was the question asked 10 years ago in [35]. In the interim years, the approach has been developed, extended, improved and applied to an increasing corpus of (mostly medieval) literature [27, 34–36, 67]. This paper brings the approach to bylyny – the heroic epics of Eastern Slavs.

Table 1 captures some network properties of the societies in this and other epic and mythological narratives. All full and friendly networks are small world in that average path lengths are similar to random average path length and they have high clustering coefficient. Additionally, their maximum degrees are much greater than the average, indicating the degree distributions all have right skew. These are unifying characteristics — placing bylyny firmly in the category of other European and world narratives.

It is the assortativity that shows the key differences between these networks — but even these differences unite. As discussed in [34], the social networks properties often reflect the type of story. For example, Iceland’s *Njáls saga* and *Laxdæla Saga* are stories mostly of a people and set in a single location. *Beowulf* and the *Odyssey*, for example, are focused on a protagonist who travels between locations. Narratives like the *Iliad* and *Egils saga* lie between these two in that they have protagonists with relatively large degrees (decreasing the value of  $r_k$ ) and their friendly networks are assortative. Bylyny are mostly focused on a single node making it more similar to these heroic epics than the other two types of story. It also shares many network properties with Ireland’s *Táin Bó Cúailnge* and the Ulster cycle of Irish mythology.

Vasyl Avenarius in the introduction to his book [4] notes that Prince Volodymyr is called “the sun” because all the characters orbit around him like the planets orbit around the sun. Our results support this opinion. Prince Volodymyr is the most important node by degree, closeness and betweenness centralities. Bylyny social networks are disassortative by nodes degree, a property that is shared with most of the epics in Table 2. As with the character *Beowulf* in the eponymous tale, by removing him we see the rest of the social network is assortative [35], Prince Volodymyr therefore drives the disassortativity and the previous suggestion that he is an amalgamation (a suggestion similar to one made previously for the Irish *Táin Bó Cúailnge* [35]), reduces his degree and therefore the assortativity, making the network more like that of the *Iliad* and *Egils saga*. Indeed, the friendly network with Prince Volodymyr node removed, becomes slightly assortative.

Thus the Kyiv bylyny cycle of east Slavic epic narratives falls nicely within the European tradition in network terms — it is in many ways like Ireland’s heroic tradition and Iceland’s social ones.

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**Special Note:** National epics like the ones discussed in this paper are important elements of national identity. Many countries use representations of iconic characters from the mythological or historical past in identity documents, iconography and coinage. In his recent essay, “On the Historical Unity of Russians and Ukrainians”, Vladimir Putin invoked the distant past when he said [51] “The spiritual choice made by St. Vladimir, who was both Prince of Novgorod and Grand Prince of Kiev, still largely determines our affinity today.”<sup>d</sup> This is a basis for his view that “the idea of Ukrainian people as a nation separate from the Russians [has] no historical basis – and could not have been any.” Putin’s erroneous view of culture and history has been roundly refuted in multiple authoritative quarters. In his subsequent interview, author and historian Timothy Snyder says of Putin [57]: “He considers himself the second Volodymyr the Great, and sees his task as completing his work, which began more than a 1000 years ago.”

However, as we see in this paper, Prince Volodymyr is a character strongly connected with people of different opinions — people such as Illya, “who does not always blindly perform the orders of prince Volodymyr and sometimes transforms them or even resists them.” In the future, the narrative of the current political situation will be written by historians and other academics, and not by autocrats or sycophants. As for the heroic Kyiv cycle of Ukrainian bylyny, we expect that that story will be of heroes again embracing freedom of thought and dissenting opinions; and will centered on a free and peaceful Kyiv.

## Appendix A. Dobrynya in Epics and in Chronicles

In humanities literature, the correspondence between the epic Dobrynya and the chronicle Dobrynya (from the Tale of Bygone Years) is frequently studied, in attempts to determine the extent to which the former is drawn from the latter. In the chronicles, Dobrynya is a brother of Malusha (the wife of Prince Svyatoslav, who

<sup>d</sup>The Kyivan Rus’ name “Volodymyr” transform to “Vladimir” in the Russian language. Likewise “Kiev” is the Russian spelling for “Kyiv”.

himself is the father of Volodymyr the Great). He was a member of the old aristocracy (a “boyar”), a warlord (“vojevoda”) of Kyiv and a representative (“posadnyk”) of Volodymyr the Great in Novgorod. “In the year 6478 [970] Svyatoslav sent Yaropolk to Kyiv, and Oleh to Derevlyans as his princes. At the same time, people of Novgorod came, asking the prince for themselves: “If you do not go to us, then we will find the prince by ourselves”. Svyatoslav replied that he will find them a prince. Yaropolk and Oleh refused, so Dobrynya suggested: ‘You should ask Volodymyr’ — because Volodymyr was son of Malusha, sister of Dobrynya. Therefore, Dobrynya was an uncle of Volodymyr. The people of Novgorod were happy with Svyatoslav sending Volodymyr to them. In the end, Volodymyr was sent to Novgorod together with his uncle Dobrynya, and Svyatoslav was sent to Per-eyaslavets’ ” [37].

Ten years later, in the year 980 according to the chronicles, Volodymyr started a campaign in Novgorod, where, at that time, Prince Yaropolk already was ruling. Here is the beginning of this story [the translation is ours]:

“Volodymyr came with the Varangians [Vikings] to Novgorod and said to Yaropolk’s prince: ‘Go and tell my brother: “Volodymyr is going against you, prepare to fight.”’ He then sat in Novgorod, and sent a [young] messenger to Rogvolod the prince of Polotsk, saying: ‘I want to take your daughter Rognida as a wife.’ Rogvolod then asked his daughter: ‘Do you want to marry Volodymyr?’ She replied: ‘I do not want to take off Volodymyr’s shoes, but Yaropolk’s.’ Rogvolod came from across the sea and had his volost’ in Polotsk.<sup>e</sup> . . .

The messenger came back to Volodymyr, and told him the full answer of Rognida, the daughter of Rogvolod the Prince of Polotsk. Volodymyr gathered a huge army including Varangians, Slavs, Chood’ and Kryvychi — and went against Rogvolod. At the same time Rognida was preparing to be sent to meet Yaropolk. But Volodymyr came to Polotsk, and killed Rogvolod and his two sons. He also took Rognida for the wife and continued his campaign against Yaropolk” [37].

In the same year, according to the Tale of Bygone Years, Volodymyr, having defeated Yaropolk and finally becoming established in Novgorod, sat on the princely throne in Kyiv.

“Volodymyr began to reign in Kyiv alone. He set his idols on a hill outside the palace courtyard: the Perun<sup>f</sup> of the wood, and the head was silver, and the mustache of gold; Hors, and Dazhbog, and Strybog, and Simargal, and Mokosh. People were bringing human sacrifices to these idols, calling them gods, but sacrificing to demons. The land of the Rus’ and the hill

<sup>e</sup> A Volost’ was a traditional administrative subdivision in the Kyivan Rus’, usually ruled by a local prince.

<sup>f</sup> Here and below follow names of principal pagan deities of the Slavs: Perun, Khors, Dazhboh, Striboh, Simargal, and Mokosh.

were defiled by their sacrifices. But the precious god does not want death of sinners; on this hill there is now the Church of St. Vasyl the Great<sup>§</sup>...” [37].

Meanwhile,

“Volodymyr has sent Dobrynya, his uncle, to Novgorod. Dobrynya, having come to Novgorod, placed the idol of Perun on the Volkhov River, and brought sacrifices of the Novgorod people as to this idol as God” [37].

Here, we see “uncle Dobrynya” as the most trusted person of Grand Prince Volodymyr; he is trusted both politically and religiously — even in a pagan sphere.

The next mention of Dobrynya comes five years later:

“In the year 6493 [985] Volodymyr started a campaign to Bulgaria with Dobrynya, his uncle, in boats, while Torks traveled by horses. After defeating the Bulgarians, Dobrynya said to Volodymyr: ‘I looked at the prisoners, and they all were in boots. We will not take these as a tribute, we both go to look for those in the carbatinas’ ” [37].

This mentioning is interesting to us because Dobrynya is not only a close proxy, but also Volodymyr’s counsellor, endowed with observation and ability to make non-obvious conclusions.

The chronicle does not cover the death of Dobrynya. Together with the death of Grand Prince Volodymyr-Vasyl the Great in the year 1015, his uncle also disappears from the pages of the Tale of Bygone Years. But already in 1018 we read about Dobrynya’s son named Constantin. Here is this episode where the sons of Prince Volodymyr (Yaroslav, later named “the Wise”) and Dobrynya met each other:

“When Yaroslav came to Novgorod, he wanted to flee the sea. Local prince Constantin, son of Dobrynya, with the Novgorodians destroyed the boats and said to Yaroslav: ‘We can still fight for you with Boleslav and Svyatopolk’. Novgorodians began to collect money: from a man — four coins; from an elder — 10 hryvnias; and from a boyar — 80 hryvnias. This allowed Yaroslav to hire Varganians and to gather big army [37]”.

Dobrynya son’s Christian name draws attention here — it indicates that Dobrynya himself was baptized with Volodymyr in 988. Afterwards he gave his son not a pagan Slavic name but a Christian one.

For completeness of the picture, we should mention another character with the name Dobrynya from the “Tale of Bygone Years”. This is Dobrynya Raguilovych another prince of Novgorod, but in the year of 1096.

<sup>§</sup>Named after Prince Volodymyr second name Vasyl he got after baptismation.

“Oleh sent his brother Yaroslav [Svyatoslavych] to the vanguard. He stood on the field near Rostov. Mstyslav in the meantime consulted with Novgorodians. They sent in front of him Dobrynya Raguilovych, and Dobrynya first of all captured the collectors of the tribute. When Yaroslav heard that collectors were captured, because Yaroslav stood at the guard on the river, he ran away that night and ran to Oleh and told him that Mstyslav was coming, There was also a message to Oleh that his watchmen were captured, so he moved to Rostov [37].”

Not going deep into the historical details of this message, it is worth noting that Dobrynya Raguilovych mentioned here is also obviously a brave and smart man (judging by the description of his deeds) and that he was a contemporary of another well-known Prince Volodymyr–Volodymyr Monomakh. So different Dobrynyas might have followed the same path as different Volodymyrs and became a single character. We will endeavour to investigate these possibilities in a further study.

### Appendix B. Bylyny Giant Component

In Fig. B.1 we present the largest connected component of the bylyny network (including both friendly and hostile links) with vertices sized proportionate to node degree  $k$ . Prince Volodymyr (#52) and Illya Muromets’ (#46) have the highest

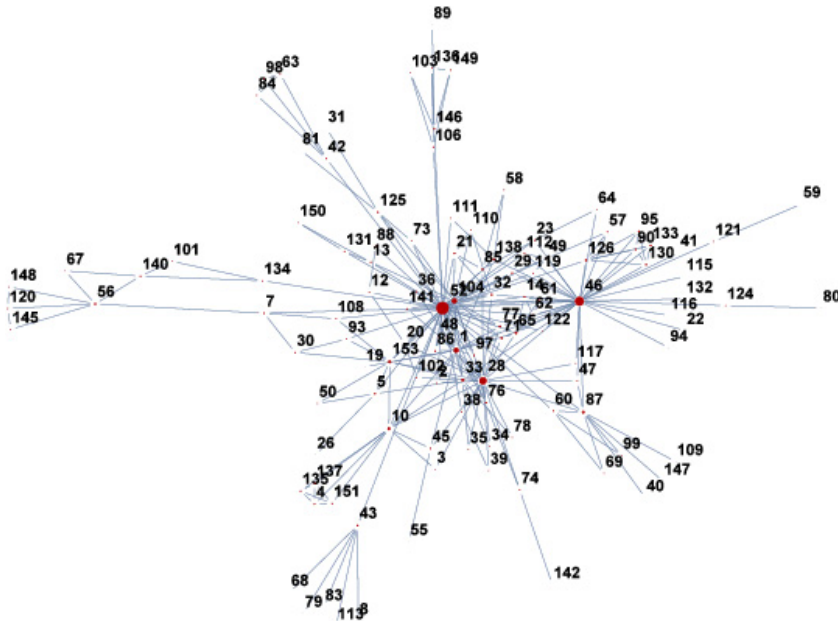


Fig. B.1. The largest connected component of the bylyny network with vertices sized proportionate to node degree  $k$ .

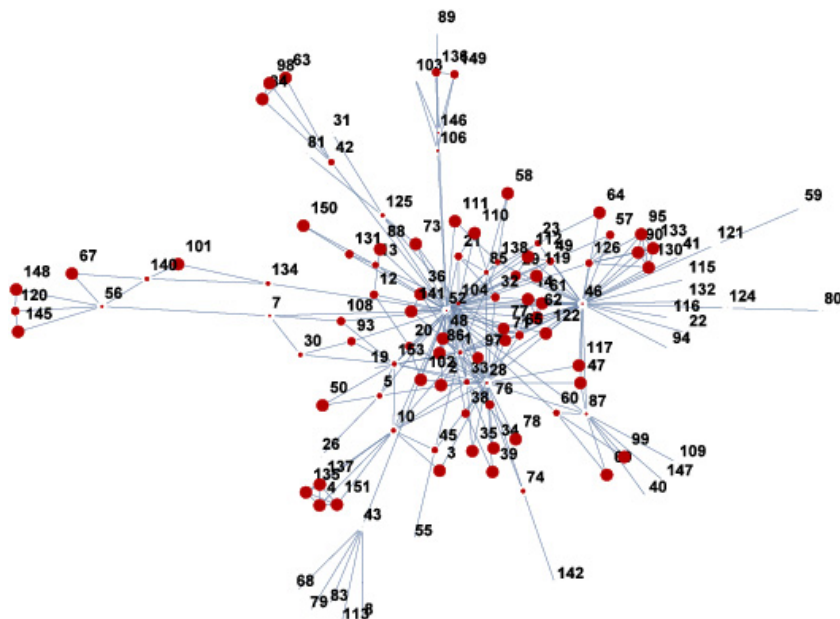


Fig. B.2. The giant component with nodes weighted by clustering coefficient  $C$ .

degrees and corresponding nodes are largest. They also have highest closeness and betweenness centralities ( $C_C$  and  $C_B$ , respectively) and similar plots for these measures can be constructed. Their clustering coefficients are small, however and counterpart plot for this measure is given in Fig. B.2. Likewise Ivan Hostynyj Syn (#43) has a relatively high centrality values but low node degree and clustering coefficient.

Finally, in Fig. B.3, we give a plot of the cumulative degree distribution plotted against node degree. The fit is a power-law, suggestive of a scale-free properties of the

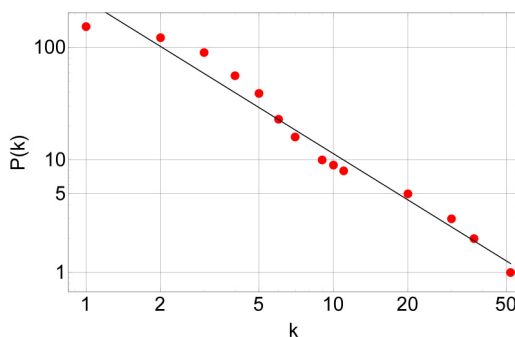


Fig. B.3. Cumulative degree distribution  $P(k)$  as a function of a node degree in a double logarithmic scale. Straight black line shows a fit to a power-law suggesting a scale-free property of the network.

bylyny character network. We refer the reader to the literature for similar plots for other epic tales [28].

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