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The Impact of Culture On Smart Community Technology: The Case of 13 Wikipedia Instances

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Abstract Smart communities provide technologies for monitoring social behaviors inside communities. The technologies that support knowledge building should consider the cultural background of community members. The studies of the influence of the culture on knowledge building is limited. Just a few works consider digital traces of individuals that they explain using cultural values and beliefs. In this work, we analyze 13 Wikipedia instances where users with different cultural background build knowledge in different ways. We compare edits of users. Using social network analysis we build and analyze co-authorship networks and watch the networks evolution. We explain the differences we have found using Hofstede dimensions and Schwartz cultural values and discuss implications for the design of smart community technologies. Our findings provide insights in requirements for technologies used for smart communities in different cultures.

Keywords: Social network analysis, Wikipedia communities, Hofstede dimensions, Schwartz cultural values

1 Introduction

People prefer to leave in *smart cities* where their needs are satisfied [1]. The development of smart cities depends on the collaboration of individuals. The investigation of the flow [1] of knowledge created by the individuals allows the monitoring of city *smartness*. One of the dimensions devoted to the smartness is connected with culture, the cultural background of individuals and places where cities are located [1].

Due to the use of media technology, social and individual behaviors are captured as digital traces. The monitoring of these traces reveal characteristics for *smartness* [1]. Digital traces of users in Wikipedia origin from 287 instances with different languages that are connected with different countries or regions and cultures. The data from the Wikipedia is freely available as any bottom-up technology [2]. The

extraction and interpretation of useful data is challenging. In our paper we investigate Wikipedia data for evaluating smartness of Wikipedia instances. The other challenge we consider in the study is the comparison of social behavior of Wikipedia users that have different cultural backgrounds.

Participants and collaborations are pivotal for smart knowledge building communities as well as technology that enable monitoring and providing feedback to maintain the context the communities. Wikipedia instances include numerous numbers of participants that collaboratively create and revise articles. Wikipedia data is freely available in the Web. Since then a plenty of tools and papers exists that are monitoring Wikipedians' activities and provide information, e.g. for fostering fights with vandalism. Even though few research pays attention to cultural values of Wikipedia participants and examine differences of Wikipedia instances focusing on the cultural background of their participants. While cultural studies [3–9] define differences in ways of thinking, ways of collaboration and learning from cultural backgrounds.

Our work is investigating a culture-dependent dimension that characterizes a context of a smart city [1]. In our case study we define differences of representatives of cultures while they are building knowledge collaboratively in Wikipedia. In the next section we refer to studies that examine cultural backgrounds, apply these findings for Wikipedia and analyze Wikipedia networks. After that, in section 3, we describe how we crawl and analyze data from 13 Wikipedia instances by examining editing behaviors of Wikipedians of different cultures. In section 4 we visualize co-authorship networks of the Wikipedia instances, compare them and watch the changes in the networks over a period of time. Later we discuss the results with findings from Hofstede [6] and Schwartz [3] cultural dimensions and values. We discuss usage of these finding for interaction design and architectures of knowledge building technologies. At last, we finish our paper with conclusions.

2 Related Work

2.1 Cultural Theories

Representatives of different cultures were characterized by beliefs and values [4–6, 8, 10] that were extracted based on surveys of the representatives.

The seminal work of Hofstede [6] proposed cultural dimensions estimated by surveying IBM workers in over 50 countries. *Power distance* (PD) dimension ranks a relation to social inequality. The acceptability and expectancy of the power of members within societal institutions like family, school, or a community at work defines PD. Another dimension identifies if everyone is responsible for him/herself (individualistic cultures) or groups are responsible for their members (collectivistic cultures). *Individualism* describes the situation when a person thinks about her own interests first while in *collectivism* a person thinks about group interests first.

Schwartz's cultural values were grounded on requirements needed for people while collaborating with each other [11]. The values we pay attention to are *egalitarism*, *hierarchy*, *embeddedness* and *autonomy*. *Egalitarism* states for the desire to cooperate

with others avoiding negative outcomes and enhancing the welfare of all people; while *hierarchy* advocates the respect for the social power and authority. *Embeddedness* states for the respect of social relationships associating people as parts of a group while *autonomy* emphasizes self-direction, creativity and exciting life.

Cultural differences were studied in distance learning [12]. The studies emphasized differences in learning depending on countries learners are coming from. McLounghlin and Oliver, Gunawardena et al. [7, 13] used results of their studies to propose instructional design rules for creating culture-sensitive online learning courses.

Studies of cultural differences between Wikipedia collaborators motivate to investigate correlations of activities in Wikipedia and Hofstedes' dimensions [14]. Hara et al. [14] analyzed only four Wikipedia of various sizes and different cultures, two Wikipedia belong to eastern culture (Japanese and Malay) and two belong to western culture (English and Hebrew). Courtesy behaviors in the Wikipedia of eastern countries were explained by greater respect of hierarchical structure in society and preferences of working collectively [6]. While authors from Wikipedia of western countries disagree more often that is supported through smaller power distances in the countries.

The activities around the article "game" in four different Wikipedia were measured as well using Hofstede dimensions. Pfeil at al. [15] analyzed the article from French, German, Japanese and Dutch Wikipedia. The authors finded correlations between some dimensions and activities and therefore proved that Wikipedia is a culturally dependent place.

The described studies in Wikipedia analyze just the article [15] or several Wikipedia [14]. Both works indicated the need for the further research with the use of many Wikipedia instances. Pfeil et al. [15] highlighted the need for more cross-cultural analysis of non-Western countries. The studies made a use of Hofstede dimensions that are criticized as they were collected only from people working at IBM and thus sharing same identity. Other works like from [3] included samples of individuals that do not work in one company.

2.2 Wikipedia Network Analysis

Voss [16] was the first who analyzed Wikipedia networks. He mainly investigated the German Wikipedia and its network of articles. Articles as nodes are connected if they have links to others. Voss showed that the Wikipedia network is scale-free [17]. Moreover, Voss compared namespaces of the German, Japanese, Danish and Croatian Wikipedia. He found similar structures in the German and Japanese Wikipedia that have much more media talk pages comparing to the Danish and Croatian Wikipedia. But Voss concentrated on precise investigation of the German Wikipedia and omit further explanations of differences or similarities that he observed in the namespaces.

Zlatic et al. [18] examined precisely 11 Wikipedia networks of articles. The authors found that most of Wikipedia instances are complex networks and their network measures are close to each other. Even though, some networks like Korean and Bulgarian are different but the explanation of differences was not included.

Nemoto and Gloor [19] examined the English, Japanese, German, Korean, and Finish networks in Wikipedia user talks. Their approach was based on 3-month sliding windows networks. The number of edges and nodes in the networks were stable for the English and German Wikipedia and were fluctuating for the Japanese and Korean. The authors detected similarities in clustering coefficients in networks of different Wikipedia while group degree centrality was the highest for the Japanese Wikipedia. They explained it through hierarchical culture of the Japanese.

Klamma and Haasler [20] created the Wikiwatcher tool that can be used for retrieving Wikipedia dumps, visualize their networks and perform simple social network analysis. Using the Wikiwatcher [21] they visualized different Wiki projects (Berlin Wiki, Google Wiki, Aachen Wiki) and observed their changes in time. They observed that registered users often serve as connectors in networks of anonymous users. Moreover, they showed that a tiny number of Wikipedia contributors have created or edited the majority of articles.

Related works investigate author and article networks in Wikipedia [16, 18–21], geographical location of authors [22], and their editing behavior [14, 15] but just a few explain findings using theories about cultures. In the following we present the case study of 13 Wikipedia instances where we explain the finding using cultural theories.

3 Monitoring Wikipedia Editions

Using the WikiWatcher (WW) [20] we extract author networks from Wikipedia data dumps. WW extracts data from XML dumps where wikis' data is usually stored. In this case study we use WW as well to visualize author networks.

3.1 Data Set

We analyze the Wikipedia data starting from June, 30th 2001 till January, 1 2009 and divide it into 16 time windows, half a year each. They include data from the Spanish, Russian, Turkish, Japanese, Danish, Bulgarian, Greek, Ukrainian, Korean and Macedonian Wikipedia. We choose both European and Asian Wikipedia. The instances were selected according to their size: large European Wikipedia (Spanish and Russian), large Asian Wikipedia (Japanese and Turkish), small European Wikipedia (Bulgarian, Catalan, Danish, Greek, Macedonian, and Ukrainian) and small Asian Wikipedia (Arabic, Hindi, and Korean). The set of small European Wikipedia instances includes Wikipedia of different Slavic languages (Bulgarian, Macedonian, and Ukrainian) and the Catalan Wikipedia, the Wikipedia instances of a minority language group in Spain.

Selecting different Wikipedia instances we consider *power distance* (from high respect for the hierarchy in Russia to relations based on equality in society in Denmark) [6]. In our data set we have the Danish Wikipedia with high individualism and the Korean with high collectivism score. Moreover in our research set we operate with Wikipedia instances that belong to cultures with high *embeddedness* values like

in Slavic and Eastern countries or high *egalitarism* like in countries of Western Europe.

3.2 Assumptions and Limitations

The inducted study includes representative samples for many countries that include any kind of users that contribute in Wikipedia instance. Thus the samples are limited only by users of Wikipedia and not by their occupation or gender as it was in many studies [12]. The samples are comparable as 1) participants are using same technology; 2) the number of registered participants is from 0,09% to 0,3% of Internet users of a country[1]. In many previous studies surveys include small samples and just a few of them estimate culture differences not only based on surveys but as well based on interactions [12].

Wikipedia authors decide to be registered or anonymous. Registered authors use names for their identification while anonymous users use Internet Protocol (IP) addresses for the identification purpose.

- We operate with geographical location for anonymous users while geographical location of registered users is unknown.
- It is possible that one person has several accounts (registered and anonymous). The Internet Provider address (IP) for an anonymous user can not serve as an identification of an anonymous user as most IPs change by Internet Service Providers continuously and using a different pattern. Therefore we assume that 1) if one person has a registered account, it is an only account she has; and 2) we are talking not about anonymous contributors but about anonymous contributions.
- Each of the Wikipedia instances have a language that connects the instances to countries the languages are spoken (Spanish and Arabic are exceptions). We assume that contributors that are involved in Wikipedia from other countries not connected to Wikipedia instances are native speakers.
- Arabic and Spanish languages are native in many countries of the world. Cultural values of Arabic countries are close [3] while cultural values of Spanish-speaking countries like Latin, Central America and Spain are different. The Spanish and Arabic Wikipedia are edited a lot from many different parts of the world [31]. Investigating both Wikipedia, we have to consider the difference of contributors' culture.

3.3 Users and Edits

The ratio of registered users to all users in many Wikipedia instances is very low. In many Wikipedia from our set in the beginning the number of anonymous users is lower than after some time, e.g. in the Turkish Wikipedia in Figure 1. In some other Wikipedia instances the number of anonymous users is high from the beginning of the

[1] except of the Hindi Wikipedia, where at most 1/10000 of internet users contribute to the Wikipedia in 2009

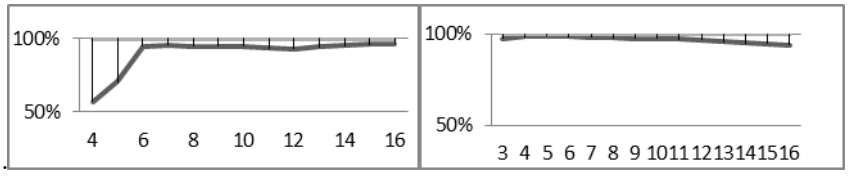

Fig. 1. The ratio of contributors in Turkish (left) and Danish (right) Wikipedia. The area above the line stands for registered users and the area below the line for anonymous users.

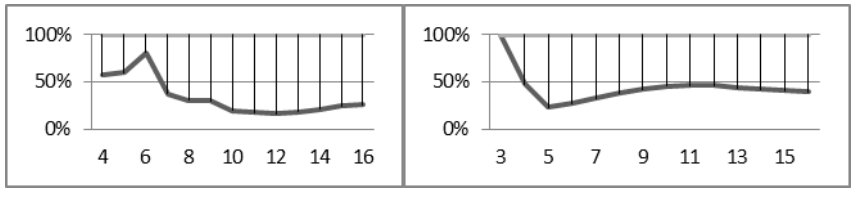

Fig. 2. Ratio of edits done by registered and anonymous users in Turkish (left) and Japanese (right) Wikipedia.

instances existence, e.g., in the Danish Wikipedia in Figure 1.

In spite of the huge number of anonymous users, they make less than 20% edits in Wikipedia articles. The exception is the Spanish, Turkish and Japanese Wikipedia instances (Figure 2). We count the low number of contributions from anonymous users because the users do not have appropriate identifications. Therefore many contributions of one unregistered user are counted as contributors from many anonymous users. The contributions usually include high quality content [23] that ensures involvement in knowledge sharing in Wikipedia.

We compare the ratio of involvement between anonymous and registered users by capturing ratios of pages that registered and anonymous users contribute to. In most of the cases anonymous users contribute to the most of articles in the beginning. But later the ratio of pages edited by registered users increase tremendously up to 100%.

Users in Japanese and Ukrainian Wikipedia show different behavior. Many active Japanese users stay anonymous. Therefore about 50% of Wikipedia pages are edited by anonymous users. In Ukrainian Wikipedia most of articles are edited by registered users. Only 10% of articles are of interest of anonymous users.

From the Table 1 we find following peculiarities of Wikipedia instances.

- The Turkish Wikipedia has twice as much edits per an article in average than in the Arabic Wikipedia. The number of registered users in the Turkish Wikipedia is twice as much as well.
- The Bulgarian Wikipedia has the highest average number of page edits between small and middle Slavic countries and bigger amount of registered users comparing to Wikipedia instances of other Slavic countries like Ukraine.
- 1) Korean and Danish and 2) Korean and Bulgarian Wikipedia instances have comparable number of registered users. In the first case, the Korean Wikipedia has 9K while the Danish Wikipedia 15K registered users but the

average number of edits are nearly similar in both Wikipedia instances. In the second case, the Bulgarian Wikipedia includes 7K registered users and it has even higher average number of edits per article than the Korean Wikipedia.

Table 1. Statistics of Wikipedia instances. The number of anonymous and registered contributors, revisions, pages are rounded.

Wikipedia	Anonymous contributors, K	Registered contributors, K	Revisions, M in 2009	Edits per article in average	Number of pages, K in 2009
Arabic	320	16	2,4	3,5	384
Ukrainian	110	5	2,1	3,89	338
Macedonian	26	1	0,5	4,25	65
Catalan	260	8	3	4,53	361
Hindi	22	1	0,3	4,52	50
Turkish	1.054	30	4,2	5,18	492
Russian	1.520	42	10,9	6,15	1,239
Danish	305	15	2,7	6,54	253
Korean	248	9	2,6	6,58	227
Greek	190	6	1,2	7,07	94
Bulgarian	265	7	2	7,33	155
Spanish	5.178	158	19	8,46	1,439
Japanese	8.869	106	21	10,04	1,398

4 Dynamic Analysis of Wikipedia Co-authorship Networks Across Cultures

With the help of the Wikiwatcher we analyze networks of Wikipedia instances that emerge in previously defined 16 time windows. Firstly we visualize networks of registered contributors. We define authors as nodes and their connections describe if authors revise the same articles. Nearly all networks' visualizations from our Wikipedia set have the same look. Most of registered users belong to a strongly connected component of a network that is the biggest group of nodes in the network where a node can reach any other node from the group. Authors working on popular articles are usually connected.

Secondly, we visualize a network of anonymous contributors (Figure 3). The contributors form isolated groups since the very beginning of the observation. The groups are growing but most of them stay isolated from each other. Considering limitations of the study, isolated groups of nodes in a anonymous users' network can represent one user that logged under different Internet Protocol (IP) addresses and changes one article only. As well connections between nodes of two isolated groups can be caused by the nodes denoting one unregistered user that edits articles. One article is interesting for one group while the other article for the other group. Later we

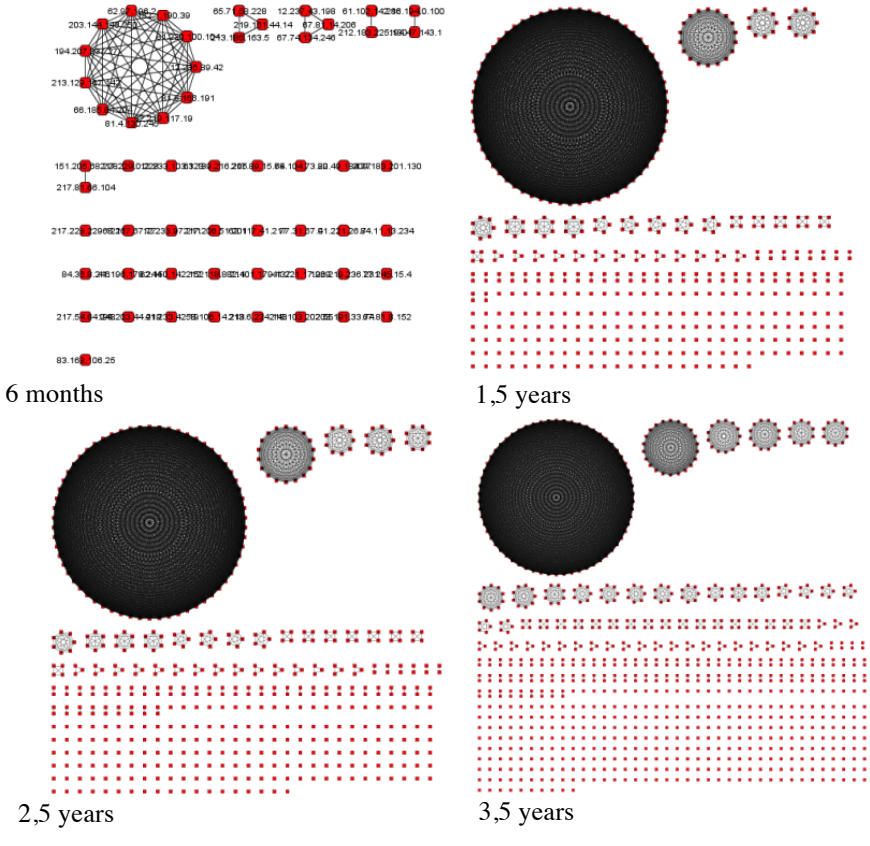

Fig. 3.. Evolving of a Wikipedia network of anonymous contributors.

construct a network with both anonymous and registered users (Figure 4). Most of nodes belong to a strongly connected component and a minor amount of nodes are isolated or appear in isolated groups. Registered users are bridges that make a network of anonymous users connected as [21] define for small Wiki projects. Though registered users in Greek and Catalan Wikipedia behave differently.

Catalan Wikipedia registered authors have been forming a network with one large and small groups unrelated to each other. It seems that isolated groups consist of authors that are interested in particular topics. Ribé and Rodríguez [24] defined that many Catalan Wikipedians miss to refer to any other article from the Catalan Wikipedia while Catalan Wikipedians operate only with a closed set of articles. The references can evoke an interest of contributors to other kind of articles while the absence of the references gives a reason for a low density of the Catalan Wikipedia network comparing with other networks.

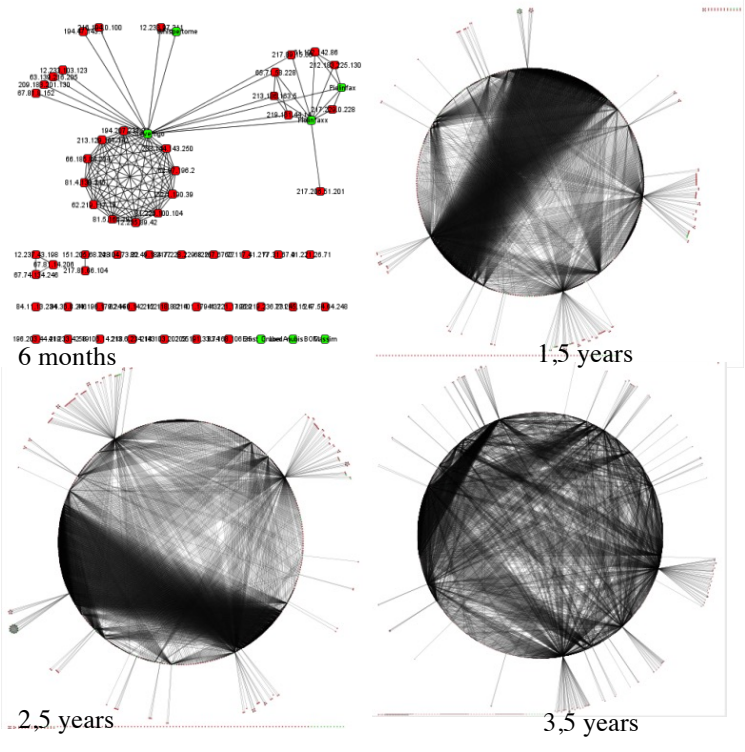

Fig. 4.. Evolving of a Wikipedia network of all contributors.

The network of registered authors in Greek Wikipedia (Figure 5) include many groups isolated from each other. Registered users in the Greek Wikipedia do not serve as bridges between isolated groups of anonymous users as it works for other Wikipedia author networks.

4 Discussions

4.1 Cultural Perspective

Previous work argues that due to democratic relations in digital world the cultures with high power distance do not notice its influence in digital environment [13]. The average revisions per article are different for the Arabic and Turkish Wikipedia. The Turkish Wikipedia has a higher number of registered users (Table 1).

The influence of differences in the average revisions can be caused by the *embeddedness* value of [3] or *power distance* dimension (PD) of [6]. Turkish culture

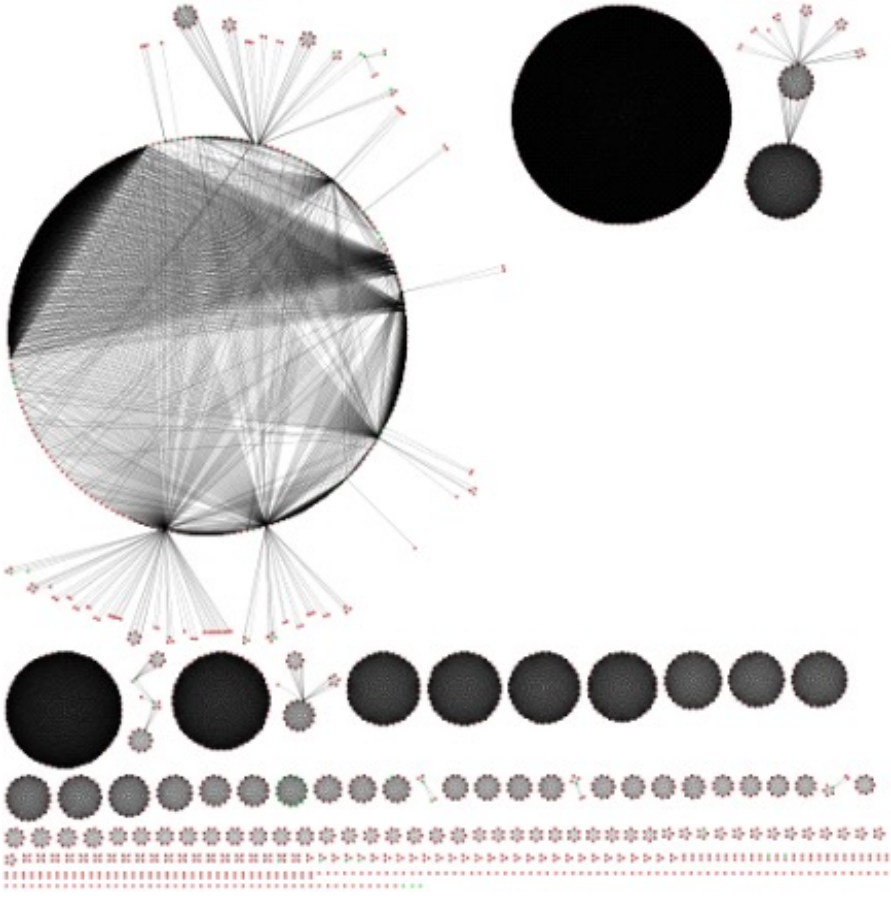

Fig. 5.. The network of all authors in the Greek Wikipedia after nearly 3,5 years.

representatives have less *embeddedness* and higher affective and intellectual *autonomy* than Arabic culture representatives while Arabic people have high *power distance* value.

Russian and Turkish Wikipedia are different in size (Table 1) and the average edits per article are higher in Russian Wikipedia. But their embeddedness values are similar and PD is much higher in Russian culture. Therefore, we find no correlation between the average of revisions per article and *embeddedness* or PD supporting [13].

The PD does not correlate with the average of edits per article in other cases as well. The Korean and Danish Wikipedia have similar values of the average although their PD are totally different. Moreover, the Korean Wikipedia has smaller number of registered contributors than the Danish Wikipedia (Table 1). Zlatic et al. [18] show that Korean Wikipedia has one of the highest clustering coefficients in article networks comparing to other 29 Wikipedia instances examined in their study. While

editing many articles authors ”connect” articles with each other so that article networks are dense. Therefore we can assume that author networks have high clustering coefficient as well as authors are connected due to articles they collaboratively edited. Although both Wikipedia instances are similar in the average edits per article, their cultures support opposite values like *egalitarism* (Danish) and *hierarchy* (Korean).

The Bulgarian and Korean Wikipedia can be compared as well based on the size of registered users (Table 1). The Bulgarian Wikipedia has the higher average of edits per article. According to Schwartz [3] both cultures has a high respect for *hierarchy* and *embeddedness*. Moreover, Zlatic et al. [18] detect peculiarities of Bulgarian Wikipedia that make the Wikipedia exceptional, e.g. the directed article network in the Wikipedia is highly disassortiative (nodes of different degrees are connected with a high probability)..

Representatives of Slavic countries like Ukraine and Macedonia admire *embeddedness* and *hierarchy* values [3]. Edits per article in their Wikipedia instances are much lower than those in the Greek and Danish Wikipedia that belong to cultures with much more respect to opposite values like *egalitarism* and *autonomy*. The Russian Wikipedia has a higher value of the average edits per article. The reason for this can lie in the number of contributions. The Bulgarian Wikipedia is exceptional in our case: it has the highest number of edits per article between Slavic cultures although Schwartz [3] states about similarities of Slavic countries.

Most Wikipedia users from our dataset are anonymous. Even so, articles are created and edited mostly by registered users (more than 80 % of content). The finding from the Japanese Wikipedia contradicts the behavioral pattern of anonymous users; they create or edit 45 % of articles. Ishii and Ogasahara [25] find as well that Japanese prefer to stay anonymous. Anonymous users in the Japanese Wikipedia are much more active then anonymous users in other Wikipedia.

4.2 Implications for Collaborative Technologies

These findings can be used for organizing culturally sensitive collaborative technologies. The first attempts from McLounghlin and Oliver, Gunawardena et al. [7, 13] provide rules for constructing distance learning courses. Using our study we can provide recommendations to the design of knowledge building communities – smart communities [2] - to make their environment more culture-sensitive and thus smart. We provide some implications for technologies that support smartness of the cities with the focus to cultural background of people in the cities.

In the case of the Danish and Korean Wikipedia instances Hofstede [6] and Schwartz [3] find significant differences between cultures while both the Danish and the Korean are active in Wikipedia contributions. Due to Wikipedia policies, the Korean who usually have a respectful attitude to authorities, feel more comfortable in Wikipedia environment where everybody can contribute and most of contributors have same roles. From studies of online learners we know that the Korean students appreciate working in groups [12] and therefore the Korean Wikipedians contribute a lot to many articles thus organize a dense web of connections between authors and

articles [18]. Therefore Wikipedia way of collaboration is appropriate to engage a lot of Internet users from countries with collectivistic cultures like in Korea.

The Danish have one of the lowest power distance values between investigated countries [6]. Therefore communication with other peers and critical opinions is usual for such countries. Anyway smaller amount of the Korean revise more often Wikipedia articles than the Danish. But Korean contributions is highly probable to be not so critical as it is usual to Western countries [14]. Danish Wikipedians and other culture representatives that value intellectual autonomy [3] can benefit from the system of awards and roles. The system should be based not on the number of contributions – criticized in many crowdsourcing websites, e.g. stackoverflow - but on the quality of contributions as it partially responsible for welfare of others important for the Danish.

The similar implications can be applied for the Greek Wikipedia. The absence of brokers that connect isolated groups of authors and therefore provide bridges between information [26] can be caused by no awards in contributing and spreading knowledge over different topics. Users that connect different topics and groups should be honored by a special badge visible for others.

Based on examinations of Wikipedia instances belonging to Slavic countries, the instances include a huge number of pages that is not edited or has a few editions while the Neutral Point of View can be achieved if several editors contribute qualitative information. The Bulgarian Wikipedians manage to concentrate on existing articles and editing them while the Ukrainian and Macedonian Wikipedians edits rarely exisiting articles while more often creating new ones. The Russian Wikipedia has a higher number of edits per article in average but anyway the number is still low comparing to other Wikipedia instances with similar number of pages like the Spanish or Japanese. For Slavic countries, the Wikipedians need a clear instructions about further steps that can be performed in the Wikipedia instances. It will reflect than the respect of Slavic countries before an authority that provides the instructions. The similar implications can be done for the Arabic Wikipedia that have even higher respect for the authority [3].

Japanese culture is unique and Schwartz [3] has difficulties to find a position on a map of values for Japan. The Japanese share contradicting cultural beliefs like harmony and mastery. Moreover, the Japanese prefer to stay anonymous that is perfectly realized in Wikipedia. The success of the Japanese Wikipedia lies in possibility for contributors to stay anonymous. Japanese anonymous users are extremely active and perform contributions in 50% of pages in the Wikipedia. The need for the anonymity is needed be considered by designing other collaborative technologies where Japanese take part.

5 Conclusions

In this paper we analyze Wikipedia editors and their networks as smart communities where we pay attention to one of the dimension of the *smartness* – culture. We compare social behaviors of Wikipedia users by analyzing their activities in revising articles. Moreover we visualize networks authors create by editing same articles. We

find differences in ratios of registered and anonymous users (Turkish, Japanese), ratios of edits the users have done (Korean, Bulgarian, Russian, Japanese) and differences in visualization of networks (Greek, Catalan). We explain these differences using cultural-dependent values and beliefs. Moreover we discuss the implications for design of knowledge building communities environment.

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