Social Network Analysis of Video Bloggers' Community

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Abstract

Vidoe blogs (or vlogs) have become increasingly popular in recent years. As the main motivation for vlogging is to interact with other vloggers, it is important to investigate the structure of the videobloggers' community and the interactions among vloggers. This research conducted a quantitative analysis using social network analysis. A list of personal vloggers was identified from VlogDIR and linking patters of vlogs were analyzed. The results suggest that videobloggers' community is highly decentralized and exhibits a core/periphery structure.

1. Introduction

Blogs are journal based web sites that typically use content management tools to allow the authors to post contents on the websites (Gordon, 2006). The number of blogs has increased significantly in the last few years. According to Technorati (2007), a blog tracking website, there are approximately 74.4 million blogs nowadays (Technorati, 2007). Blogs are intrinsically social, as they reveal the blogger's personality, interests, and points of view(Nardi et al., 2004); they also provide a platform for the bloggers to interact with their readers and other bloggers. Therefore, blogs that share similar interests, views, or opinions are usually inter-connected, which form a virtual community among the bloggers.

Vlogs are similar to blogs, but instead of using text to convey messages, they post short videos. The use of videos provides more freedom for bloggers to express their opinions/views and interact with their viewers more directly and interactively. As stated by Miles (2003), "[vlogs] are less about consumption (watching others' content) than exploring models for authorship and production, ...it is the ability to participate as communicative peers that is much more significant and viable for distributed networks than our reconstitution into new consumers"(Miles, 2003). Most vloggers look to other vloggers and friends for feedback and support(Luers, 2007). Luers (2007) also identified a few social needs fulfilled by vlogging: being connected, finding validation for one's experience and ideas, and being a producer as well as a consumer(Luers, 2007). Each vlogger's interactions with other vloggers are the foundation of the vlogger community.

Despite the increasing importance of vlogs, little academic research has been done to study the structure of the vloggers' community, or the interactions among vloggers. As the main motivation for vlogging is to interact with other vloggers(Miles, 2003; Luers, 2007), it is very important to study the social network of this new type of virtual community and identify the structure of the community.

2. Literature Review

Virtual communities have been defined many ways. One of the first and more general definitions is that they are "social aggregations that emerge from the Net when enough people carry on public discussion long enough, with sufficient human feeling, to form webs of personal relationships in cyberspace"(Rheingold, 1993). Other researchers such as Preece (2000) have defined virtual communities as follows: social interaction, a shared purpose, a common set of expected behaviors, some form of computer system which both mediates and facilitates communication (Preece, 2000).

Various forms of virtual communities exist. Based on consumer needs that are fulfilled by virtual communities, virtual communities can be categorized into four types: communities of transaction, communities of interest, communities of fantasy, and communities of relationships (Armstrong and Hagel, 1996).

Blogs are journal based web sites that typically use content management tools(Gordon, 2006). These software tools allow their authors to quickly post new content to their blogs in what has been described as "pushbutton publishing for the people."(Schiano et al., 2004). Blogs are all based upon similar content management software and bloggers usually have common goals and interests. Based on Armstrong and Hagel' (1996) categorization, blogs can be viewed as communities of interests. Rheingold(1993) found out that the primary motivation of virtual communities is to meet people and possibly expand circles of friends(Rheingold, 1993). Comparing to physical communities, blogs provide a way to socialize with others but also maintain a distance from others. Kiesler(1986) observed that unlike physical

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communities, virtual communities can break down societal and organizational barriers(Kiesler, 1986). She found that people ignore traditional hierarchical organizational boundaries if there is strong mutual interest in a particular subject. Once people get to know each other on the basis of their communication within the virtual community, people can broaden the relationships or move them offline.

Not all blogs are text based. Bloggers can create audio files typically called blogcasts(Wikipedia, 2007a). These posts have a text portion that describes the audio file and the file can be downloaded and played on a portable MP3 player such as Apple Inc's Ipod. This type of blog is the videoblog or vlog.

Vlog, as mentioned before, is a type of blog that consists of videos posted to a blog. The use of videos allows for expanded possibilities and thus provides new and different motivations to vloggers. Videos posted on the blogs are typically no longer than five or ten minutes in length(Luers, 2007). Vlogging became popular due to the decreasing barriers of entry to Internet video publishing. Much of the initial success of vlogs comes from video hosting websites such as blip.tv at http://blip.tv which offer free hosting. These video hosting sites allowed vloggers to combine current blogging technology with hosted videos to create vlogs. The videos posted to the vlog usually start with a title card that lets the viewer know what they are watching. Some vlogs use a format very similar to television shows. Since vlogs use existing blog technology, they still usually have text comments that the viewers can leave.

Vlogging has become increasingly popular over the recent years. In January of 2005 Mefeedia, a web site that is a directory of video bloggers (vloggers) had 617 vlogs. As of January 2007, Mefeedia.com lists 20,913 vlogs(Mefeedia.com, 2007).

Unlike traditional media such as broadcast television, the major motivation for vlogging is to receive feedback and support from other vloggers and find friendships in vloggers' community (Luers, 2007). Vlogging helps to fulfill some social needs of the vloggers, such as feeling connected, finding validation for one's experience and ideas, and being a producer as well as a consumer(Luers, 2007). Therefore, each vlogger's interactions with other vloggers are the foundation of the vloggers' community.

There are many different forms of vlogs. Some vlog genres are diary, experimental, documentary, and mash-up(Luers, 2007). There are three main types of vlogs: personal vlogs, news shows, and entertainment orientated. Personal vloggers talk about or even share their life experiences captured by a video camera and are thus more of a personal media than a television show. Besides personal vlogs about the vlogger's life, there are news shows which are informal newscasts on a wide variety of topics. An example of a news show is Rocketboom found at www.rocketboom.com. These shows are somewhat similar to a newscast found on TV, but are informal. Also there are vlogs that exist for purely entertainment reasons such as AskANinja at askaninja.com, or a sitcom format such as the Carol and Steve at show at http://www.stevegarfield.blogs.com/videoblog/carol_and_steve_show/index.html (Clayfield, 2007).

3. Social Network Analysis

Social network theory was first attributed to J. Barnes in 1954(Wasserman & Faust, 1994). It focuses on the interactions between social entities such as people, corporations, or other organizations so as to form a complete network (Wasserman & Faust, 1994).

The main components of a social network are nodes and links. Networks are made up of nodes, which are the social entities mentioned before. The nodes are connected by links which are the relationships between nodes. These networks allow researchers to understand the structure of the relationships among the actors(Wasserman & Faust, 1994) as an individual's relationship with others has a large effect on social resources and many other important things about them.

Social network analysis allows researchers to visualize and conduct mathematical analysis on the network. Social network analysis allows for the identification of central nodes, which can have roles such as leaders, hubs, or gatekeepers. It also allows identification of subgroups in a network where nodes are strongly connected to each other. Visualization helps to identify the overall structure of a network.

3.1. Centrality and Centralization

Measurements are used in social network analysis to determine the important actors in the network(Wasserman & Faust, 1994). The most common measure of importance is centrality.

Centrality refers to the importance of an individual actor; and centralization refers to the network as a whole. Centrality is based on the concept that "actors who are most important or the most prominent are usually located in strategic locations within the network"(Wasserman & Faust, 1994).

The most centralized network exhibits a star structure. A star structure can also be called a hub-and-spoke network. A star has one or two nodes in the center surrounded by many nodes with few or no other connections connected to the center nodes(Kumar et al., 2006).

In the star network depicted in figure 1, Node A is more central than the other nodes and the other nodes

have equal centrality. Therefore, a star network exemplifies the ideal of a centralized network.

Ahuja and Carley (1999) noted that a centralized network such as the star network may reflect an uneven distribution of knowledge such that knowledge is concentrated in the focal points of the network. They also found that centralized organizations are more efficient for routine tasks. However, as Krebs and Holley (2004) pointed out, a star network leads to a single point of failure if the node linking every other together is removed(Krebs & Holley, 2004).

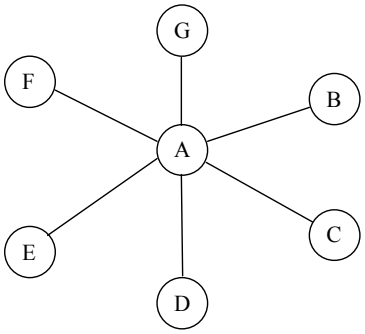

Figure 1 - Freeman's Star Network

The most decentralized network structure is the network depicted in figure 2. The nodes in this network have equal centrality. Therefore, no node has an advantage over other nodes.

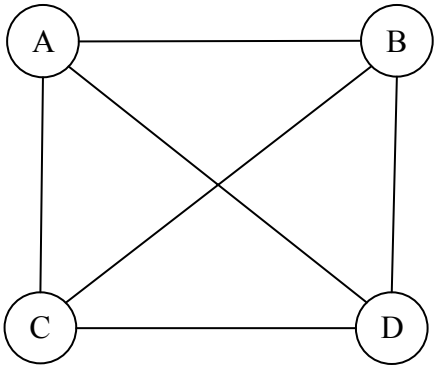

Figure 2 - A Decentralized Network

3.2. Core/Periphery Structure

Another social network structure is a core/periphery network. The ideal core/periphery structure is a dense, connected core surrounded by a sparse, loosely connected periphery(Borgatti & Everett, 1999; Long, 2006). This structure is somewhere in between a highly central star network and a fully decentralized network(Borgatti & Everett, 2006).

One unique feature of this structure is that it cannot be subdivided into exclusive cohesive subgroups, although some actors are connected more than others(Borgatti & Everett, 1999). Also, nodes in the core are very close to each other, but are also close to the periphery. However, nodes in the periphery are relatively close to only the core. Krebs and Holley (2004) described the periphery as an open, porous boundary of the community network. They classified nodes in the periphery in three ways: 1) New to the community and with time will join the core; 2) Bridges to other communities; 3) Resources that are unique and may span other communities

Figure 3 shows an example where the dark nodes are the core and the lighter nodes are the periphery.

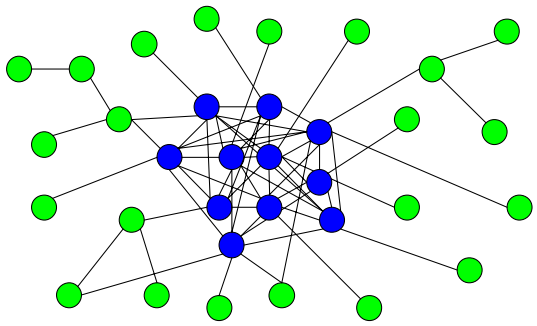

Figure 3 - A Core/Periphery Network

Krebs and Holley (2004) noted that this arrangement allows information to move the fastest through the network. In addition, the network becomes more robust and stable. They also noted that organizations move from a scattered structure to a core/periphery network over time. They concluded that core/periphery structure is the most efficient and sustainable network(Krebs & Holley, 2004). They warned though that too dense of a core can lead to rigidity and activity overload.

3.3. Relevant Applications of Social Network Analysis

Social network analysis has been widely used to study many networks from biological networks to virtual workgroups. It has also been used to study virtual communities. A study by Long (2006) showed that open source software development teams go from a centralized hub to a core/periphery structure over time, which decreases the overall centralization of the group (Long, 2006). Chau & Xu (2006) used social network analysis to analyze the structure of online hate group blogs. Another study identified virtual communities in blogs using social network analysis measures(Chin & Chignell, 2006). Ahuja et al. (2001)

and Sparrowe et al. (2001) studied performance in workgroups and found that centrality was a strong predictor of individual performance in the group(Ahuja et al., 2003; Sparrowe et al., 2001). Another study of the online social networks Yahoo! 360 and Flickr suggested that these communities consist of singletons, a sparse middle region, and a giant component(Kumar et al., 2006).

4. Research Methods

In many prior studies using social network analysis, centrality measures and core/periphery fitness were used as key structural analysis. These measures are relevant to this research as the focus of this research is to study the structure of the vloggers' community. Many centrality measures exist, but most studies choose to use simple measures created by Freeman. These measures are degree centrality, closeness, and betweenness.

4.1. Degree Centrality

Degree centrality measures who is the most active in a network(Wasserman & Faust, 1994). This is done by measuring the number of ties to other actors within the network(Wasserman & Faust, 1994). An individual's centrality is the extent to which an individual is linked to others in the group (Ahuja et al., 2003). Ahuja et al (2003) noted that a node is central if it has a higher degree than others in the network. Therefore, individual centrality can serve as a measurement of how closely an individual belongs to a group.

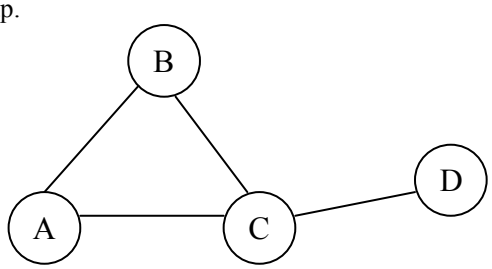

Figure 4 - Example Social Network

In Figure 4, node C has the highest degree centrality and is thus the most central because it is connected to three other nodes. Node D is peripheral and has a low degree because it is adjacent to only one other node.

According to social network theory, a large amount of interaction by an individual will not only change that individual's relative position in the network, but will also affect others positions as well. Most importantly, individuals with high centrality have higher influence and cognition in the network. Being linked to a large number of people in a network enables an individual to be more likely connected to other powerful individuals in the network. Another way of looking at degree centrality is the degree to which an individual can communicate with others directly or quickly(Borgatti, 2005). This is important in this research as degree centrality identifies those with a high number of connections with others that are likely leaders or hubs.

The major limitation of this degree centrality is that it should only be used to compare centrality scores within a single network. However, this limitation was overcome by using scores standardized for network size.

4.2. Closeness

The next centrality measure is closeness. It is based upon distance between one actor to all other actors in a network. This measures how easy it is for one actor to be able to communicate with others in the network(Wasserman & Faust, 1994). The fewer actors an actor has to go through to get to any other actors, the closer the actor is(Wasserman & Faust, 1994).

Borgatti(2005) noted that nodes with low closeness scores have short distances from others, and so tend to receive information sooner, assuming that what flows originates from all other nodes with equal probability, and also assuming that whatever is flowing manages to travel along shortest paths. In the case of information traveling through a network, normally nodes with low closeness scores are well-positioned to obtain novel information early, when it has the most value(Borgatti, 2005).

Closeness is important to this study because it allows us to measure the efficiency of communication in the network and identify actors that can receive information from others quickly.

4. 3. Betweenness

The last measure of centrality is betweenness. It measures how important an actor is at bridging the gap between other actors in the network(Wasserman & Faust, 1994). If a network is set up in such a way that there are no other paths that these other actors can take to communicate with each other, this actor in the middle has high importance(Wasserman & Faust, 1994). Removing a node with high betweenness can disrupt the flow of information through the network and introduce fragmentation(Borgatti & Everett, 2006).

Therefore, betweenness measures the amount of network flow that a given node "controls" in the sense of being able to shut it down if necessary(Borgatti, 2005) and can show whether an individual plays the role of a broker or gatekeeper(J.-C. Wang & Chen,

2004). A broker exchanges information between two other nodes and a gatekeeper withholds information from passing between nodes.

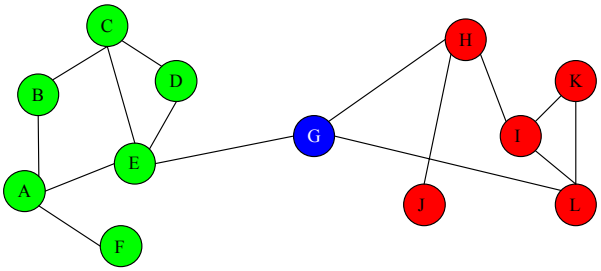

Figure 5 - Example of Betweenness: A Node Bridging Two Clusters of Nodes.

Notice in Figure 5, the "G" node has high betweenness centrality and is connecting the ABCDEF and HIJKL networks together into one big network.

4.4. Network Centralization

Network Centralization looks at the centrality measures at a network wide level and determines the extent to which the network exhibits a star structure. For each of Freeman's centrality measures, a network centralization score can be calculated which indicates how centralized the network is. Network centralization is important to this research because it shows overall how centralized or decentralized the network of vloggers may be.

4.5. Core/Periphery

Core/Periphery is a hybrid structure that exhibits some form of centralization as a core, but also has a less centralized periphery. This structure has been found to have important implications to the communication effectiveness of networks such as online hate groups or open source software development. Thus, it is useful to include this measure in this research as vloggers may follow a similar structure. The presence of core/periphery structure is determined by fitting a social network to a mathematical model. A fit of .5 (50%) or greater is considered a good fit(Long & Siau, 2006).

5. Data Collection

5.1. Sample Selection

The focus of this study is to understand the network structure of vloggers' community. This study used a sample of vloggers who identified themselves as personal vloggers from VlogDIR. VlogDIR was chosen for this study due to the fact that it is a popular and reputable directory of thousands of vloggers. Vloggers voluntarily add themselves to the directory and can specify what category they fit into.

A list of personal bloggers who have registered at VlogDir was used in this study for social network analysis. The reasons for choosing personal bloggers for this study are two fold. First, using a list avoids the snowball approach in which data collection begins at one blog. Starting at one point results in an ego-centric network where the starting point is in the middle of the network and the rest of the nodes as done in some other studies(Chin & Chignell, 2006; Efimova & Hendrick, 2005). Second, similar studies have used lists of blogs as a basis sampling (Chau & Xu, 2006; Kumar et al., 2004).

5.2. Data Collection

The data collection for this study was done in a five-step process.

1) Obtaining list from VlogDIR. This involved collecting all of the URLs of the personal vloggers listed on VlogDIR into a file. This was done by using a computer program typically known as a spider to capture the URLs of the personal vlogger's vlogs from VlogDIR. 244 of these URLs were captured from VlogDIR's personal vlogger list.

2) These URLs were then manually cleaned to ensure they met criteria for being active vlogs. This study focuses on active personal vlogs for social network analysis, therefore, the URLs collected must meet the following criteria: 1) The URL had to be a personal vlog. This means that the vlog clearly indicates that it is about someone's life or describes its contents as personal. If these were not found, a content analysis of a video would quickly determine the subject matter of the vlog as personal or not. 2) If a URL was found to be a personal vlog, it had to have three video postings within the last three months of the time of this study. This second criteria was chosen to ensure that the personal vloggers in this study were representative of currently active vloggers that had a history of video postings.

After the data cleaning, only 74 of the original 244 URLs remained in the list.

3) The cleaned URLs were used as input to Technorati, a blog tracking website, to obtain URLs of other blogs that linked to the vlogs. After the URLs from VlogDIR were cleaned with the criteria mentioned before, the URLs were entered into Technorati. Technorati collects linking interactions between bloggers. Technorati keeps track of what are known as "inbound links" or links to a blog URL. It also tracks outbound links to other blogs as one blog's inbound link is an outbound link on the other blog. For each personal vlogger's URL, all other URLs that

linked to the vlogger's URL were captured. A computer program was used to automate the collection of these inbound links to each vlogger's vlog URL and store them in a database. This method of link collection proves to be much efficient than traditional methods which rely on content analysis of each vlogger's vlog to determine the outgoing links to other pages manually. Also, Technorati only keeps track of links to other blogs, whereas a web spider would have to capture all links on a webpage whether it was a blog or not.

4) A socialmatrix was build based on the links between the vlogs that are collected. A sociomatrix is a mathematical representation of a social network that uses data placed in rows and columns to signify relationships between individuals in the network. Table 1 is a theoretical example of a sociomatrix that represents linking relationships for 4 individuals.

Table 1 - A Sociomatrix

0	A	B	C	D
A	0	1	1	1
B	1	0	0	1
C	1	0	0	0
D	1	1	0	0

In this example, a link exists between A&B, B&D, A&C, and D&A. Notice that self relationships, known as reflexive ties, are usually ignored and result in a blank diagonal line in the sociomatrix(Wasserman & Faust, 1994).

In this study, the relationships between nodes signify that one vlog is linked to another vlog. The links gathered from Technorati were examined to see if any personal vloggers from the sample (the cleaned URL list from VlogDir) had linked to other personal vloggers from the sample. If so, an indication of the link was placed into a sociomatrix. Another computer program was used to automate the generation of the sociomatrix. This sociomatrix was 74 rows by 74 columns. Links between vlogs were represented by placing 1s in the respective rows and columns of both vlogs. A social network formed this way is known as an undirected network since the direction of the link was not considered. Since we were only interested in the interactions of personal vloggers, this social network is appropriate for this study.

5) The sociomatrix was then used as the dataset for UCINET, a social network analysis software package. UCINET created the visualization of the network as well as calculated the social network measures of centrality and core/periphery fitness.

UCINET is commonly used for social network research. For example, it has been used by Chau & Xu(2006) to analyze online hate groups as well as by Long(2006) to analyze open source software development. UCINET was used in this study to calculate the centrality and network centralization measures as well as calculate core/periphery fitness. The same calculations were performed by Chau & Xu and Long in their studies.

6. Results

6.1. Social Network Graph

Figure 6 shows the social network of vloggers' community. The dots are the nodes that represent the vloggers and the arrows are the links between the nodes. Nodes with no links were removed from the graph. There are thirty four active nodes in this network.

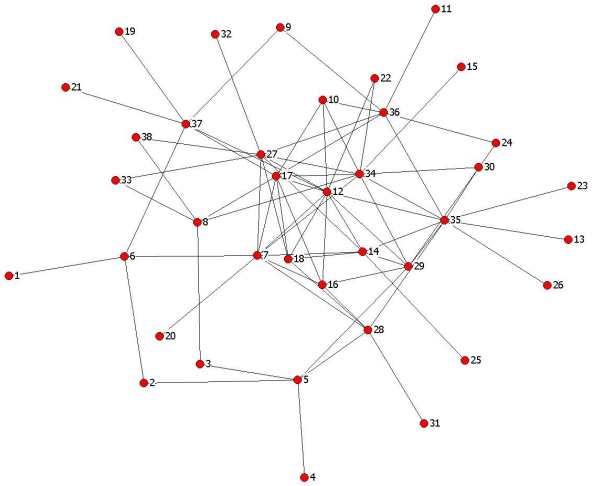

Figure 6 – Social Network of vloggers' community

6.2. Individual Centrality Scores

Results of centrality measurement are presented in Table 2.

At the individual level, nodes 12, 34, 35, 27, 17, and 7 had the highest degree centrality. These nodes had a degree of 9 or higher. All of these nodes were part of the core. The core's density is rather low, resulting in a loose core. Nodes 35, 7, 34, 12, 27, and 37 had the highest betweenness centrality. These nodes had a normalized between of 13 or higher. These nodes served as bridges and connected most of the loose core together. Nodes 12, 34, 7, 17, 35, and 27 had the highest closeness centrality. These nodes had a normalize closeness of 48 or higher. These nodes were also in the core. It makes sense that degree and closeness centrality would be so high for those in the core. This same result was observed by Kumar and Chin. While I thought that those with high betweenness would connect those in the periphery to

the core, they actually served to connect the core together.

Table 2 - Individual Centrality Measures

Node	Degree	Normalized Degree	Normalized Closeness	Normalized Betweenness
1	1	2.703	28.030	0.0
2	2	5.405	32.456	1.491
3	2	5.405	33.636	1.294
4	1	2.703	28.244	0.0
5	5	13.514	38.947	10.259
6	4	10.811	38.542	8.747
7	9	24.324	49.333	15.883
8	5	13.514	41.111	5.709
9	2	5.405	35.238	0.824
10	4	10.811	40.217	0.403
11	1	2.703	31.092	0.0
12	11	29.730	52.857	15.051
13	1	2.703	33.036	0.0
14	7	18.919	47.436	7.433
15	1	2.703	33.945	0.0
16	5	13.514	43.023	1.077
17	9	24.324	48.684	10.077
18	5	13.514	43.023	1.718
19	1	2.703	30.081	0.0
20	1	2.703	33.333	0.0
21	1	2.703	30.081	0.0
22	2	5.405	37.374	0.043
23	1	2.703	33.036	0.0
24	2	5.405	35.922	0.503
25	1	2.703	32.456	0.0
26	1	2.703	33.036	0.0
27	9	24.324	48.052	14.698
28	6	16.216	43.529	9.942
29	7	18.919	46.835	9.798
30	2	5.405	38.144	0.0
31	1	2.703	30.579	0.0
32	1	2.703	32.743	0.0
33	2	5.405	34.906	0.234
34	1	27.027	50.685	15.099
35	1	27.027	48.684	21.681
36	7	18.919	44.578	11.737
37	6	16.216	42.529	13.993
38	2	5.405	34.906	0.234

6.3. Network Centrality Scores

The network centrality is presented in Table 3.

Table 3- Network Centrality Measures

Network Degree	Normalized Network Degree	Network Betweenness	Network Closeness
20.27%	1.80%	17.46%	30.05%

According to Long and Siau (2006), the centrality measures are relatively low. All of the centrality measures were less than 50% which is the midpoint between a centralized and decentralized network. The highest level of centralization was exhibited when calculated using closeness. This means that overall nodes had a higher level of closeness than degree or betweenness.

6.4. Core/Periphery Analysis

Results of core/periphery analysis are shown in Table 4.

Table 4 - Core/Periphery Analysis Results

Nodes in Core	Nodes in Periphery
7 12 14 16 17 18 27 28 29 34 35 36	1 2 3 4 5 6 8 9 10 11 13 15 19 20 21 22 23 24 25 26 30 31 32 33 37 38

Final Core/Periphery Fitness: 0.544

Nodes 7,12,14,16,17,18,27,28,29,34,35, and 36 were in the core. The rest of the nodes were in the periphery. These determinations were derived by shifting the nodes between the core and periphery until the maximum Pearson's correlation between the observed data and an ideal core/periphery network was achieved. Overall, this network exhibits a core/periphery structure since a fitness score over .50 indicates a good fit of the core/periphery model.

7. Discussions and Implications

The results of social network analysis on personal bloggers in VlogDIR suggest that vloggers' community has a core/periphery structure. This network structure is similar to those found by Long, Chin, and Efimova & Hendricks(Chin & Chignell, 2006; Efimova & Hendrick, 2005; Kumar et al., 2006; Long, 2006). The core/periphery structure indicates that no individual or small group of individuals has a communication advantage over everyone else. Also the network is highly decentralized with a highest network centrality score of 30.5%.

The results of this research help us to better understand vloggers' community and how vloggers interact with each other in the community. Since the vlogger community is a core/periphery structure, one can utilize this structure by identifying and reaching the core group of vloggers. This can generate network wide awareness much faster than reaching someone in the periphery.

As vlogs are becoming increasingly popular, they have also shown tremendous potentials and promises for business applications. Businesses could use vlogs also to communicate with consumers. They could also use vlogs to better their customer service. Although businesses already use text blogs, they can be much more personal and interactive using video to make vlogs to raise awareness of their products. Robert Scoble, for example, interviewed Microsoft employees while he worked there and posted the videos online as a vlog(Wikipedia, 2007b). As vloggers' community exhibit core/peripheral structure, business that are targeting vloggers can better serve their customers and generating product awareness by first identifying core groups in the community.

Since vlogs provide a more personal, realistic experience, individuals may be able to use vlogs to gain a cross-cultural understanding and thus be more empathetic to other cultures. Vlogs also allow communication at a more personal level. Thus, vlogs can serve as a new way for people to interact. Individuals can also use vlogs to raise awareness about themselves or other issues. For example, people such as politicians can communicate to voters more directly than television advertisements and even respond to comments left on their vlogs.

8. Conclusions

This research is one of the first studies to investigate the structure of vloggers' community. The results of this research provide better understanding of vlogging and can serve as a foundation for future research. Further research can explore the similarities and differences between vlogs and other forms of virtual communities in more detail, to provide additional insight into vloggers. For example, it would be interesting to compare peoples' response to video to their response to text, to see which one is more engaging. Perhaps further studies could use a larger sample of vloggers and include other types of vlogs besides personal vlogs. Other resources for lists of vloggers also exist, such as mefeedia.com and the yahoo group of vloggers. Finally, a longitudinal study could be performed when the vloggers' community is more mature, to better understand how the vlogger network changes over time.

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