Online Community Influence: A Study Using the Hirsch Metric and Social Network Analysis

Research-in-Progress

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ABSTRACT

This study looks at small to medium sized online community (OC) and tries to identify ways to measure impact of the contributions of the users of the OC. OC's are dependent on contributions of their users to maintain the health of the OC. Measuring the health of an OC by identifying those users that have most influence and thus create more activity and finally more people the visit the OC is an important activity to the stakeholders in the OC. In order to measure these high end users we are extending previous research to include a two part measure. First, using the Hirsch metrics to measure the productivity and impact of user contributions and second, using social network analysis to see those users that have high centrality measures in the network of posters and readers of the OC. This study looks at one University sports fan site to measure the influence of their users and found some correlation between the Hirsch measures and the centrality measures.

Keywords

Hirsch Index, Influence, Online Community, Online Identity, Replies, Threads, User Status, Views, Virtual Community.

INTRODUCTION

Online communities have become a driving force in many shared interest websites. The OC or sometimes referred to as the virtual community, is defined as an "aggregation of individuals or business partners who interact around a shared interest, where interaction is at least partially supported and/or mediated by technology and guided by some protocols or norms" (Porter, 2004). For OC's the health of the OC is measured not by sales of a product but by the amount of visitors, which in turn is dependent on the amount of relevant and new content in the OC. While some OC's may have content that is primarily developed by paid staff writers, many OC's are dependent on the users for content. One of the problems with OC's is they tend to fall out of fashion after a lively, vibrant period. For owners of these OC's, trying to keep the vibrancy period continuous remains a constant challenge. Our research has been concerned with trying to find ways for owners of OC's to identify how to maintain the health of an OC.

Our previous research has identified the Hirsch index (h-index) as a possible way to measure the 'high level' contributor (Cuellar et al., 2012). The h-index is an important measure that takes into account the author of a research paper and measures both the productivity, in the number of publications of the author, and the influence of the author, using the number of citations their publications garner (Hirsch, 2005). There has been a plethora of research on the subject of the h-index and it's validity, which seems to confirm that the h-index is a valid measure of influence. While the h-index seems to measure influence the consensus is that with any measure the h-index still has some exceptional cases in which the measure tends to breakdown. For example those researchers that publish little but publish only a few highly influential papers, such as Einstien, have a low h-index. In order to combat this problem, the h-index should be used as one measure out of a family of measures to paint the whole picture of a researcher. As a result, spin-off metrics such as the g-index, gc-index, and hc-indices have been created. There has also been many studies in the business academic publishing area using the h-index.

While the use of the Hirsch index is an important step to integrate a bibliometric measure that takes contribution and influence as a measure, in the same sense that the h-index alone does not measure the true researcher, we believe the h-index alone cannot be used to measure the 'high-level' contributor. We still need to continue to improve on this measure of influence by the individual user of the OC. In this research study we propose to add social network analysis (SNA) in order to improve on the measure of the 'high-level' contributor.

Another area of measure of a community can come from SNA. SNA has been used in several past IS research and while using 'digital trace data' is somewhat new in the IS arena (Howison et al., 2011), we feel that using the postings to determine the social network is valid for this exploratory research. As a step towards creating and improving an aggregate measure of influence of a contribution to an OC we are adding a SNA to our measure. We are proposing the creation of the social network and the analysis using centrality measures to improve on our aggregate measure of the influence of users in an OC.

Our overall research question is: How can an OC continue to foster growth and relevance? In order to find the answer to this question we are first tasked to find those individuals that contribute to the OC that improve the health and interaction of the OC members. So our current research objective is to find a measure or measures that allow us to identify these individuals who stir up interaction in the OC. One caveat in this stream is that we have not started to address and purposefully so the questions of measuring 'quality'. We are merely looking at influence and the ability of an OC member to cause interaction.

This study examines a university sports-fan community OC. The OC is comprised of users who have interest in the university sports teams and their success. Since this OC's scope is not global in nature and is localized to one geographic region in the US, we find that this is at best a medium sized OC. The OC provides a forum for users to share information, debate, and comment on each other's postings. The owners of this OC understand the importance of the member's contributions because the majority of users come to the OC to socialize and exchange ideas and thoughts about their beloved team. The OC, typical to those of this type of OC, rely heavily on users traffic to the OC in order to generate revenue through the visibility and use of their advertisers ad and links.

The rest of the paper is structured as follows. We look at background information including past studies on OC, the use of h-indices in OC user influence measurement, and social network analysis. We then look at our research question and hypotheses. We then look at the OC that we used in this study and some characteristics of the OC. We then present the data collection process and results. We finish the paper with a summary, including weaknesses and possible future studies, and conclusions.

Background

OC's are vibrant due to contributions from members of the OC. An OC's health is directly tied to the contributions made by the community of users (Assmann et al., 2009; Cothrel et al., 1999). OC's tend to die out as they start to have a stagnant user community. There tends to be a distinct life-cycle of OC's where they have a word-of-mouth maturation period of gaining relevance and improved activity, a saturation point where activity plateaus out, and finally a declining period where the OC's tends to fall out of relevancy (Iriberri et al., 2009). The challenge for OC owners is to continue the initial growth period as long as possible and try to avoid the declining period. A healthy OC will continue to grow or at the very least be relevant and have continued postings and interactions. While there is many research on popular very large social networking sites, which have national or global scope, there has been a lack of work done one smaller OC's (Shen et al., 2006) this paper is one such study.

Assessing OC's based on User Status

We have found there has been a lack of studies to identify how to assess the health of an OC. We feel one way to study the health of the OC is by looking at the contribution levels of users. OC's typically create a status level for their users and this is used to indicate how much a user has contributed to the OC. There have been some studies that have looked into this user status (Chen et al., 2011; Spring et al., 2008; Stewart, 2005) and how user status can be used as an incentive to participation in the OC (Cheng et al., 2006). User status can be seen as a direct quantitative measure of the user's contribution if levels are tied to the amount of contribution users make to the OC.

Assessing Vibrancy of the OC

We have found many studies on OC tend to rely on more indirect 'opinion' measures using surveys (Law et al., 2008; Marett et al., 2009; Schaedel et al., 2010; Shen et al., 2008; Shen et al., 2009; Zheng et al., 2007). Most OC's have a ranking system where the user gets some level when they achieve a certain number of posts. This is basically a posting count which we feel is not a true measure of who is influencing others. The survey studies typically focus on smaller OC's and target the users and/or owners of the OC. While these studies are valid, they still suffer from the fact that surveys are reliant on the expertise of the users. Thus, they are not an exact measure of the status of the current OC. The data collected is dependent on the opinions, feelings, and bias of the survey respondents. Since surveys typically use Likert scale like measures, there is 'wiggle' room for the respondents and the responses are not exact. They may be thinking their feeling is between a 3 and a 4 but since there is no 3.5 they are forced to choose one or the other.

Instead we use a more exact measure that is dependent on the previous behaviors of the users of the OC. We use a measure that is a pseudo-measure of the Hirsch index (h-index) which uses previous postings and their popularity by looking at the

'reads' and 'replies' to these postings (Takeda et al., 2012). The h-index is a measure in bibliometrics that is defined as "A scientist has index h if h of his/her Np papers have at least h citations each, and the other (Np – h) papers have no more than h citations each" (Hirsch, 2005). In order for a researcher to gain a high h-index they must do two things. First they must publish enough research papers to gain a sufficiently high h-index. One can only get a maximum of h equal to the number of publications that they publish. So the h-index is partly a measure of productivity. Second, the researchers publications must garner citations. The second part of the h-index measures the relevance of the researchers publications. In order to get a high h-index, a researcher must publish many papers and those many papers must all get many citations.

The h-index has gained some momentum for use in the bibliometric fields, but has been the subject of some criticism which in turn has produced a cottage of extended measures of the h-indices. There was criticism that the h-index is time sensitive. A researcher requires some time to reach enough publications to even get citations. The hc-index address this issue with a time aspect giving citations to younger publications more relevance (Sidiropoulos et al., 2006). Another problem was that there were some research papers that garnered unusually large numbers of citations that would essentially get the same treatment as papers with lesser number of citations. Once you get past a certain number, the more citations you get did not matter. So the g-index addressed this issue by adding up all the top research paper citations for a given author (Egghe, 2006). We feel that these two issues are somewhat minimized with our target OC. The OC vibrancy is based on current measures of interaction and the data captures interaction up to the last second to when the data is pulled, so there is less of a time issue with the dataset. Also the larger individual posts, while important, do not garner more current interaction. There has been an increase in the use of the h-index in other areas of research outside of bibliometrics such as chemistry, physics, economics, and IS (Truex III et al., 2009; Truex III et al., 2011).

Our past study looked into the use of the h-index and identified this as a valid measure (Takeda et al. 2012). The study identified a major difference between the use of the h-index in the OC versus academic publishing. With OC's there is the ability to see those that replied to a posting and those that read a posting (via the display of the posting on their computer screen).

One important distinction is that we are not making a connection between the users with high h-indices and the health of the OC. While the number of users with high h-indices may not translate directly with the health of the OC, those with high h-indices are creating more users to log into the OC, view posts, and ultimately view advertisements. At this stage of the research stream we want to identify ways to measure high h-indices users to see if their activity actually turns into a healty OC. We are trying to find ways for the OC developer to identify those users that have high h-indices so that they can cultivate their talent, or try to encourage users with lower h-indices to create posts that will result in higher h-indices.

Social Network Analysis

Centrality in a social network refers to the notion that the group revolves around a certain individual. If an individual is more central that means there are more people connected to that individual, if they are less central that means there are less connections to that individual. There are several measures of centrality, three which we use are degree, closeness, and betweeness centrality. Degree centrality is a simple count of the connections an individual has with others in the network. Degree refers to the number of edges a node in the network has, or the number of connections that an individual has with the others in the network. In theory an individual can have at most n-1 connections when there are n individuals in the social network. This is because the individual cannot have a connection with themselves, but can have connections with everyone else in the social network. When one individual has every possible connection, the distance between that individual and all other persons in the social network is one (Acedo et al., 2006; Eaton et al., 1999; Henry et al., 2007; Otto et al., 2002; Polites et al., 2008; Vidgen et al., 2007).

Closeness centrality is a mean measure of how close an individual is to the rest of the network. The distance between two individuals is measured by number of connections between the two individuals taking the closest connection between the two. For example, if I knew a guy (individual A) who knows a guy (individual B), then the distance between me and A is one and the distance between me and B is two. The closeness centrality takes the minimum distances between an individual and all others in the network and gives the mean of this number. (Polites et al., 2008; Vidgen et al., 2007).

Finally the betweeness centrality is a measure of how an individual is used in the minimum distance connections between any two other individuals in the network. The betweeness centrality of an individual is found by the summing all the shortest distances that go through an individual and dividing by (n-2)(n-1) where n is the number of distinct individuals in the social network (Vidgen et al., 2007).

Theoretical Framework and hypothesis development

Using the hr and hv indices we were able to identify those users that were influential from the citations point of view. By adding a social network perspective we were able to look at those individuals that are central to the network of communication between the users of the OC or the social network of the OC. While we expect that both h-indices and all three centrality measures that we use to be correlated, we do expect some differences in the strengths. For the h-indices there is much more of a chance of interaction in the social network when someone replies to your posting as opposed to just reading your postings. With a read, there is no chance for the author to actually reply and make a connection to the reader. While when a reader posts a reply, there is acknowledgement of the read and confirmation sent back to the author, which in turn can spark a reply to the reply and thus a connection in the social network. So we expect the hr numbers to correlate more highly with the centrality measures.

For degree centrality, this is a sort of 'who you know'. Closeness centrality is a kind of 'how close is anyone in the network to you'. Finally, for betweeness centrality, this is a measure of 'how well do you know any two people in the network'. We expect that direct connections are made from replies, so we should find that degree centrality to be more closely correlated with the h-indices. This brings us to our set of hypotheses:

H1a: Users that have high replies (hr) will have higher degree centrality in the social network.
H1b: Users that have high replies (hr) will have higher closeness centrality in the social network.
H1c: Users that have high replies (hr) will have higher betweeness centrality in the social network.
H2a: Users that have high views (hv) will have higher degree centrality in the social network.
H2b: Users that have high views (hv) will have higher closeness centrality in the social network.
H2c: Users that have high views (hv) will have higher betweeness centrality in the social network.

Research context

BigUFans.com is a OC website for the school Big University (one of the authors is an alumni of Big U. and the owner of BigUFans.com). Big U. is a large tier I research institution in the south-eastern US. Big U. is a public state university that has been around for 150 years with over 30,000 students. The OC is in particular geared towards the athletic teams of Big U. where football is the major sport. Big U competes in the NCAA Division I in many athletic disciplines including the major sports of football, basketball, and baseball.

Currently BigUFans.com has four major competitors. BigUFans.com was created in 1999 and is the largest free OC. The OC makes revenue by advertising sales. Thus gaining activity on BigUFans.com is an important activity. The other competitor sites have some aspect of paid areas in their OC. BigUFans.com is the only completely free OC for Big U. Anyone may anonymously browse the contents of BigUFans.com but in order to post to forums a user must register.

There are six administrators and 17 moderators of BigUFans.com that work to keep the topics on the forum of BigUFans.com relevant and free of spam and incendiary comments. Registered members can become moderators as they become more active in the community but only at the invitations of the owner of the site. Because of the work of the staff, one of the major advantages of BigUFans.com over their competitors is that the community feels the OC has more positive messages that are free of advertising, spam, flame wars, and off-topic postings.

The majority of activity on BigUFans.com comes from discussion about the football program. During the 2011-2012 season monthly activity saw an average of 2.9 million page views, 1075 new posts, 167,000 unique visitors, and 89 topics started. Daily activity included 1,017 signed in users and 5 new users. A typical visit consisted of 5.2 page views. The demographics were typically male (92%), college graduate (72%), and of middle to upper income (71%). During the offseason prior to the 2011-2012 season, there were 2 million page views a month. Currently BigUFans.com gives different level user status automatically to users that post a certain amount, regardless of how many users read their messages.

Methodology

For the measure of the h-indices data was collected over the period that encompassed the football season period of August 2012 until February, 2012. We collected data for the h-indices over a longer period of time than the social network due to the fact that the h-indices take a longer period of time to achieve a spread and to get high h-indices one needs more time for replies and views to become recorded. This data collection resulted in 911 distinct authors and over 500,000 distinct thread creation.

The social network data was taken over a two-month period between December 2012 to January 2013 to give a more snap shot of the social network. Given the amount of data to process for this preliminary study we felt that taking the social network data over a shorter period of time was better. This resulted in over 200,000 reads of the postings by over 1600 unique individuals.

Data for each of the threads includes a user identification (userID), the number of replies the thread received, the userID's of those that replied to the threads, the number of views to the thread, and the userID's of those that viewed the thread. A Java program written by the authors was used to calculate the h-indices and UCINET was used to calculate the centrality measures. The data was then imported into SPSS to calculate the correlation values to evaluate the hypothesis.

Measures

For data collection in this OC it was possible to find the reads or 'views' of posts as well as the 'replies' to posts. This means there was an additional h-index available compared to the bibliometric version. For a researcher to find out how many people is impossible in the OC we are able to measure how many people clicked on a posting and actually had displayed the post on their computer screen for a 'view'. While a 'view' may not necessarily be a 'read' by the user, we assumed the topic had caused enough interest by the user to prompt the action of actually clicking on the link and displaying the posting on their computer. We call this measure the hv-index

The second aspect of the OC is that there is the possibility of a user to respond or 'reply' to a users post. This is equivalent to the citation in the bibliometric sense. The OC user is prompted by the posting so much that they actually type our a reply to the posting. We found this required more action by the responder compared to the 'view' therefore this number was always lower than the hv-index. We called the the h-index of the reply the hr-index.

We also collected the 'view' activity of the users on the OC. We were able to identify the posts and the unique readers of these posts. This allowed us to created the social network of influence in the OC. We were also able to create a directional network as we knew userID of the poster and the userID of the readers. One can argue that the flow of data is going form the posters to the reader. Another argument is that the flow should go in the other direction as the citation of the poster is being received from the reader. We created two networks using both directions for this study. Each is labeled either Rp (for reader to poster) or Pr (for poster to reader)

Findings and hypotheses

The results of the study included the measure of degree centrality, closeness centrality, and betweeness centrality of both networks. We also found the hr-index and hv-index of each of the posters. We took these measures and ran correlation analysis on the measures in SPSS, the result is in figure 1. We are looking for correlation between the H numbers and the centrality numbers (degree, closeness, and betweeness). Some variables have been shortened in the figure in order to display the items to be read easier. Also the two different directional networks are listed with Rp (reader to poster) and Pr (poster to reader). First we find the highest correlation between hr and hv, which is expected as those that get more replies are bound to be getting high number of views from the OC community.

For the individual hypothesis we find that the hr-index had correlation numbers of (.200, -.401, .416) with Rp and (.442, .015, .416) with Pr (these are listed Degree, Closeness, and Betweeness Centralities). We also see that the hv-index had correlation numbers of (.394, -.529, .577) with Rp and (.649, .001, and .577) with Pr. Taking a look back at the hypotheses:

H1a: replies (hr) to degree centrality – Not supported for Rp, strong support for Pr.
H1b: replies (hr) to closeness centrality – Negative correlation for Rp. Not supported for Pr.
H1c: replies (hr) to betweeness centrality – Support for both Rp, Pr.
H2a: views (hv) to degree centrality – Some support for Rp, stronger support for Pr.
H2b: views (hv) to closeness centrality – Negative correlation for Rp. Not suppoted for Pr.
H2c: views (hv) to betweeness centrality – Strong support for both Rp, Pr.

Summary

This research continues the stream of research to find ways to measure user influence in an OC. Previous studies introduced the use of the Hirsch metric to measure the user contributions to the OC. We are trying to create a basket a measures to help identify different influence measures of a user of an OC. This study extended this measure by trying to include SNA measures to the mix of measures. We were able to confirm some support in some measures in this exploratory study.

We found that betweeness centrality was highly correlated with the hr and hv indices. This may be explained by the fact that there might be a cluster of high influence users in the middle of the social network. We also found negative correlation between Rp closeness centrality and the hr and hv-indices. While Pr closeness centrality was of no correlation. Finally we found stronger correlation between Pr degree centrality than Rp degree centrality. This is probably because of the reads going in the same direction as the measure of hv.

There are a few possible challenges in the use of the h-index in this study. First the use of the h-index can be problematic. The h-index for the OC is inherently higher than those of the bibliometric kind. The hv-index is measuring the display of the text to screen and not really a 'read'. The content of replies are not read by the study so a reply may not even be relevant to the original topic. A reply may actually be a reply to a subsequent poster and not the original thread creator so the influence may be measured incorrectly. While the administrators do filter out off-topic postings so this weakness may be minimized. We also realize that the h-indices take time to garner a number so only veteran users are going to show up on the high h lists.

		RpDegree	RpClose	RpBetwn	PrDegree	PrClose	PrBetwn	Hr	HV
RpDegree	Pearson Correlation	1	-.266**	.412**	.297**	-.162**	.412**	.299**	.394**
	Sig. (2-tailed)	.	.000	.000	.000	.000	.000	.000	.000
	N	1641	1641	1641	1640	1641	1641	1641	1641
RpClose	Pearson Correlation	-.266**	1	-.356**	-.389**	-.154**	-.356**	-.401**	-.529**
	Sig. (2-tailed)	.000	.	.000	.000	.000	.000	.000	.000
	N	1641	1641	1641	1640	1641	1641	1641	1641
RpBetwn	Pearson Correlation	.412**	-.356**	1	.827**	-.039	1.000**	.416**	.577**
	Sig. (2-tailed)	.000	.000	.	.000	.113	.	.000	.000
	N	1641	1641	1641	1640	1641	1641	1641	1641
PrDegree	Pearson Correlation	.297**	-.389**	.827**	1	-.027	.827**	.442**	.649**
	Sig. (2-tailed)	.000	.000	.000	.	.283	.000	.000	.000
	N	1640	1640	1640	1640	1640	1640	1640	1640
PrClose	Pearson Correlation	-.162**	-.154**	-.039	-.027	1	-.039	.015	.001
	Sig. (2-tailed)	.000	.000	.113	.283	.	.113	.555	.979
	N	1641	1641	1641	1640	1641	1641	1641	1641
PrBetwn	Pearson Correlation	.412**	-.356**	1.000**	.827**	-.039	1	.416**	.577**
	Sig. (2-tailed)	.000	.000	.	.000	.113	.	.000	.000
	N	1641	1641	1641	1640	1641	1641	1641	1641
Hr	Pearson Correlation	.299**	-.401**	.416**	.442**	.015	.416**	1	.672**
	Sig. (2-tailed)	.000	.000	.000	.000	.555	.000	.	.000
	N	1641	1641	1641	1640	1641	1641	1641	1641
HV	Pearson Correlation	.394**	-.529**	.577**	.649**	.001	.577**	.672**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.979	.000	.000	.
	N	1641	1641	1641	1640	1641	1641	1641	1641

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 2. The Correlation Matrix

The calculation of the hv-index and the social network of reads are algebraically related. This may account for high correlations between the SNA numbers and the hv-index. Another challenge is the use of a response network may not be suitable for analysis. The use of digital trace data collected from OC's has generated some caution as to how this data might be used and analyzed using SNA techniques (Howison et al. 2011).

We also realize this a really specific type of OC, and therefore cannot generalize to other OC's. We do believe the methodology of using both h-index and SNA measures can be a benefit to OC's in general. We also realize the data was taken over a short period of time and that more data over more seasons might show us better and more insightful results.

Some possible future research areas for this study include (1) the use of other SNA measures. (2) The addition of more seasons of data points. (3) Exploring if this methodology can be used on other similar type of OC's and other completely different types of OCs.

Conclusion

The current study is a part of a stream of research in examining how to measure the influence of user contribution in an OC. This is important for the stakeholders of the OC including the users, administrators, moderators, and owner of the OC. We added the social network measures to previously introduced measures of h-indices to measure the influence of OC users. We were able to show some correlation between these measures.

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