

User Innovations Through Online Communities From the Perspective of Social Network Analysis

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Abstract—Organizations have begun to leverage both internal and external sources for innovation. Specifically, organizations are increasingly relying on end users that engage via user innovation communities to identify potentially valuable ideas for an organization to adopt. However, research has shown that organizational success in leveraging these communities relies on a thorough understanding of how users behave within the community. The purpose of this manuscript is to provide further analysis and develop a richer understanding of user behavior in the Dell IdeaStorm user innovation community. Findings illustrate different patterns of user behaviors when they comments or rate posted ideas.

Keywords—user innovation; open innovation; online community; social network analysis.

I. INTRODUCTION

Organizations have widely acknowledged the role of innovation in economic growth. However, not all firms are successful when appropriating returns from innovations. Consequently, research is needed to understand the innovation process and how organizations can increase the likelihood of positive gains from innovation. According to [1], there are three building blocks which explain this phenomenon: 1) the appropriability regime, 2) the complementary assets, and 3) the dominant design paradigm. These building blocks are still central to the analysis of innovation in the 21st century.

Innovation can be divided into two primary types: product and process innovations. Both of them have traditionally taken place within the boundaries of a firm, and have been seen as the primary source of competitive advantage for organizations. This suggests the need for control of critical aspects of the innovation process in order to protect their competitive advantage. [2]. However, a new form of business innovation, called open innovation, has strongly emerged during the last years [3]. Open innovation means a firm opens up its boundaries to identify and capture innovative external ideas and knowledge to create value beyond the firm's limited resources and capabilities [4], [5].

Commercial firms, unlike individuals, face the additional problem that free revealing of its innovation process will benefit their competitors [6]. However, there are two conditions that explain why firms would expose

themselves to such risk [7]. First, sharing may provide firms with valuable selective benefits, that are unavailable to free-riders [8], and which could be classified into economic (reduced production cost or enhanced value of complementary assets), social (improved reputation and image), and technological (increased network externalities and exploration of new technologies) [9]. Second, the potential negative impact of sharing may be quite low compared to the expected private gains. The act of revealing source code via the Internet is nearly costless, suggesting that even the prospect of minor benefits is sufficient to induce community participation [8]. Recent developments along the open innovation paradigm [4] suggest that firms need to reject the idea that control implies ownership and open themselves up to the broad array of resources available to the firm. To do this, managers must find new ways to conceptualize the 'post-Chandlerian firm, where innovation proceeds along less hierarchical lines [10] since "the network of relationships between the firm and its external environment can play an important role in shaping performance" [11].

Based on virtual world technology and using open innovation mechanisms, consumers and manufacturers jointly develop innovations in a media-rich and interactive environment. The idea of involving customers and end-users as co-innovators has become highly popular [12]. For example, Osram, a light manufacturer, started an idea contest and invited Second Life residents to contribute ideas on the topic of lightning; Toyota Scion launched a virtual car model and encouraged participants to modify and customize their cars. Before Aloft, a new hotel concept from Starwood Hotels was built, a virtual mockup was discussed, evaluated, modified, and further developed in Second Life, resulting in several changes to the overall design [13].

Prior research has focused on identifying the factors that influence an organization's adoption decision when innovations come from outside the organization's formal boundaries [14]. More specifically, [15] and [16] have examined how participation in open innovation communities influences the innovative and financial performance of the services sector and firms commercializing open source software, respectively, revealing that participation is more strongly related to performance for firms that also exhibit high levels of

social participation, for firms of larger size, and for firms with high R&D intensities [15].

The aim of this paper is to increase our understanding of the social interactions that occur within a user innovation community. Using Social Network Analysis (SNA), we propose that insights into member roles and the nature of interactions among individuals and the organization can provide additional guidance to organizations that utilize these communities. Moreover, SNA can be considered an appropriate tool for identifying lead users that can help an organization identify promising ideas and/or users to adopt or follow.

This paper is structured as follows. First, the importance of user innovation communities is highlighted. Then, the methodology of our research is shown. Section 4 introduces to our case of study. Results are shown in section 5. And finally, Section 6 stands for our conclusions.

II. USER INNOVATION COMMUNITIES

Technology is enabling new forms of producer-consumer collaboration in an organization's innovation process. As opposed to the traditional models, the development work in the open innovation model is based on the needs and co-creation activities of a community of users that interact with one another and the organization [4]. User innovation communities can be defined as "distributed groups of individuals focused on solving a general problem and/or developing a new solution supported by computer mediated communication" [14]. It is a customer-centric innovation process, where new products and/or services are co-created together. Open innovation characterizes an innovation process where the customer is involved as a source for ideas, technical solutions, design or even first prototypes [17]. Instead of the firm creating innovations and exchanging it with their customers, during open innovation consumers take an active role and co-create these innovations together with the company [18]. For virtual co-creation the participation of engaged customers is crucial. Customers' actual experiences and their beliefs about the expected benefits significantly influence their actual continued participation in such forums.

This creates a context that is highly different from traditional Internet applications. To co-create value, the firm and its customers representing the open innovation community must reconcile their objectives and define both the role and effort required from each party and an equitable division of the returns [4]. In fact, changing the focus from ownership to the concept of openness in projects requires a reconsideration of the processes that underlie value creation [19]. The process of co-creation is mainly influenced by the user, and therefore also the experience largely depends on the users [17].

Firms participate in user communities because they feel that they can influence the direction of development, gain legitimacy to use the innovation, and benefit from the expertise of a large base of skilled users [2]. Strong ties to the developer communities allow firms to access important

complementary assets [1] such as technological know-how and information on emerging user needs or interests that facilitate the appropriation of rents from internally developed innovations [2], [20]. Thus, the work developed in the user community can be used in conjunction with the firm's internal expertise to develop competitive products and/or services. Firms that engage in these communities, therefore, have a certain type of business model [21], [4], which works as a cognitive script and shapes the mindset of the firm towards looking for ideas in the community. Although this engagement in the community creates value for the firm, it is more difficult to appropriate because competitors may interfere. Firms with a strong knowledge base are in a better position to generate unique configurations of internal and external resources, which support their capacity to generate and appropriate returns from innovations [2], [22]. The presence of such "complementarities" [23] thus suggests that a firm's access to community resources is conditioned by its internal R&D activities. As firms with technological know-how can make more valuable contributions to the communities, they are also more likely to obtain valuable resources in return that contribute to higher performance. Firms with strong technical know-how have the absorptive capacity to recognize, assimilate, and apply the knowledge resources that are available in the community [24]. Similarly, community engagement stimulates the discovery of new opportunities that may redirect a firm's internal R&D towards more lucrative business activities [16].

III. METHODOLOGY

Social Network Analysis has been frequently used to analyze the behavior of online communities. The idea consists of representing communities as a graph $G = (N, E)$ where N denotes a finite set of nodes and E denotes a finite set of edges or arcs such that $E \subseteq V \times V$ [25]. In the case of online communities, nodes represent users, while arcs represent possible interactions among users. The number of vertices represents the number of community members and the arcs represent the interactions among them.

Density is defined as the number of lines in a simple network, expressed as a proportion of the maximum possible number of lines. However, this definition does not take into account valued lines higher than 1 and it depends on the network size. A different measure of density is based on the idea of the degree of a node, which is the number of lines incident with it [26]. A higher degree of nodes yields a denser network, because nodes entertain more ties, and the average degree is a non-size dependent measure of density.

IV. CASE STUDY: DELLIDEASTORM

Dell IdeaStorm [27] is a user innovation community where end users freely reveal innovative ideas with community members and Dell [14]. This website represents a new way to listen to customers on how to build the best products and services. Through IdeaStorm, customers can post their ideas about existing or new Dell

products, services and operations [28]. Moreover, users have the option of voting for the best or the worst ideas as well as discussing the ideas with other users. Using this information, Dell shares the ideas with top management, department managers, and key employees that work within relevant subject domains.

Users can comment on ideas by other (identified by an alias) as well as promote or demote ideas using the IdeaStorm vote feature. Promotion means adding ten points to the current rating of the idea while demotion means subtracting ten points. Dell takes part in the community commenting ideas through the user with alias *bill_b*.

Using the proposed methodology, the community can be modeled as a graph considering users as nodes and arcs as interactions among users. Using comments, promotions and demotions to set arcs among nodes, up to three graphs can be obtained for representing the community: 1) comment, 2) promotion, and 3) demotion. The analysis of obtained graphs can illustrate different pattern of user behavior when commenting or voting on ideas.

V. RESULTS

An automatic tool has been programmed for extracting reported ideas in IdeaStorm one year beginning January 2010. A total of 1482 ideas have been processed, obtaining the data for each idea detailed in Table I.

TABLE I. DATA EXTRACTED FROM IDEASTORM

• Idea name
• Author
• Date
• Comments <ul style="list-style-type: none"> ○ Number of comments ○ Authors who posted these comments
• Promotions <ul style="list-style-type: none"> ○ Number of received promotions ○ Authors who suggested promotions of the idea
• Demotions <ul style="list-style-type: none"> ○ Number of received demotions ○ Authors who suggested demotions of the idea

A. Comment network

The comment network is built as follows: nodes are users and arcs are set between users commenting an idea and the author who posted this idea. Thus, ideas represent the basic unit of analysis. This step is repeated through the 1482 extracted ideas. The obtained graph is a valued directed graph, where incoming links means comments received by a user. **Figure 1** shows the obtained network. The total number of users (nodes in the network) is 1361. These users can be categorized as:

- Users who have posted at least one idea ($n = 1153$)

- Users who have commented ideas but they have never posted an idea ($n = 208$)

In-degree means the number of arcs that a node receives. In our comment network, in-degree of a node represents those users whose ideas are most commented. Actually, nodes of **Figure 1** have been represented with an area proportional to their in-degree. 808 users exhibit an in-degree value of 0 (the 208 user who have never posted an idea plus those users who posted an idea but never received a comment). The number of users with an in-degree higher than 1 is 24. Obviously, user with alias “*bill_b*” shows an in-degree of 0, as the role of this employee from Dell is commenting ideas, not posting them. Table II details the in-degree partition, showing only those authors with low and high in-degree value.

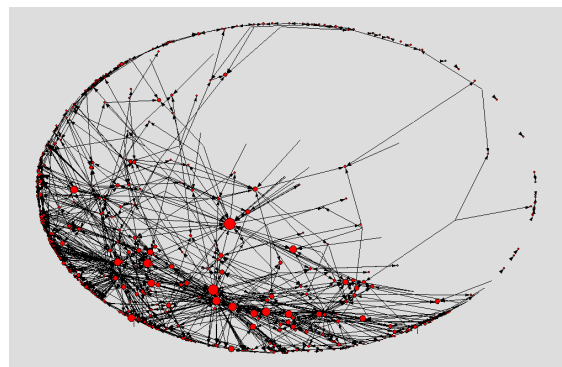


Figure 1. In-degree 2010 comments network.

TABLE II. IN-DEGREE PARTITION.

Partition	Freq	Representative Alias
0	808	<i>bill_b</i>
1	258	<i>2tall</i>
2	132	<i>ARMADILLO</i>
3	50	<i>Allie</i>
...
38	1	<i>winoffice</i>
50	1	<i>Rebel333</i>

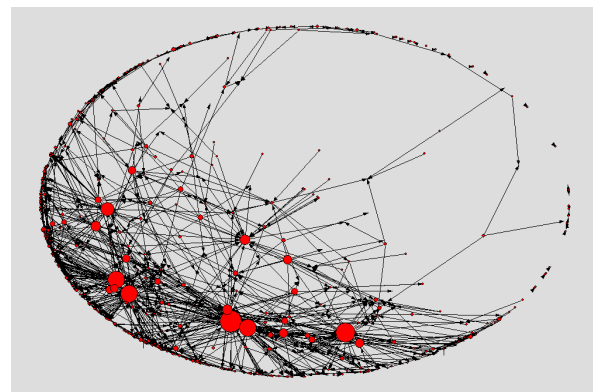


Figure 2. Out-degree 2010 comment network.

Figure 2 shows the out-degree network. Size of nodes is now proportional to the number of arcs a node sends (posted comments). As expected, 953 users of **Figure 2** have an out-degree of 0 while just 408 users have posted at least one comment, following the typical participation inequality of online communities (the majority of contributions are posted by small fraction of the community) [29]. The number of users with an in-degree higher than 10 is 25 (nodes with a bigger area in **Figure 2**). The user in the second position of out-degree ranking is “bill_b” (from Dell), with an out-degree value of 111. Table III details the out-degree partition, showing only those authors with low and high out-degree value.

TABLE III. OUT-DEGREE PARTITION.

Cluster	Freq	Alias
0	953	000hmy
1	238	A..J..
2	70	BlinneOrlaith
3	33	Air2Ground
...
111	1	bill_b
131	1	jervis961

B. Promotion network

The promotion network is built considering users as nodes and arcs as the links between users promoting an idea and the author who posted this idea. In this case, the network size is 2151. Again, it can be distinguished among users who have posted at least one idea at IdeaStorm 1153, and users who have promoted ideas but they have never posted an idea, 998.

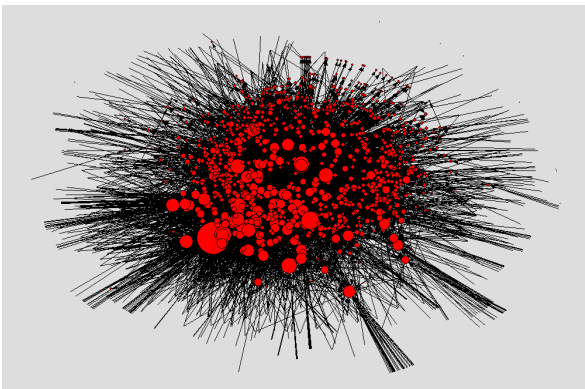


Figure 3. In-degree 2010 promotions network.

The in-degree network allows discovering those users who have posted ideas which have been most promoted (**Figure 3**). However, this network does not distinguish how many ideas have been posted by each author. Therefore, it is possible a node with a high in-degree due to posting a lot of ideas (for instance with a medium number of promotions). Regardless, it is clear that in general, ideas are receiving more promotions than comments if we compare this network with the in-degree comment network. The number of users with an in-degree

higher than 1 is 1153, and the number of users with an in-degree higher than 10 is 341.

Figure 4 shows the out-degree promotion network. Nodes are overlapping, but we have maintained the same area scale for nodes' areas to highlight the high out-degree values of certain nodes as compared with the in-degree of **Figure 3**. There are five nodes with an out-degree higher than 500. It is also interesting to mention that there are just 6 nodes with an out-degree of 0, and 1281 nodes with an out-degree of 1. That means that the majority of users have at least promoted one idea. The high value of users with an out-degree of 1 could be explained if we assume that new users usually engage in exploratory behavior prior to full engagement. Therefore, they promote an idea to see how the site functions.

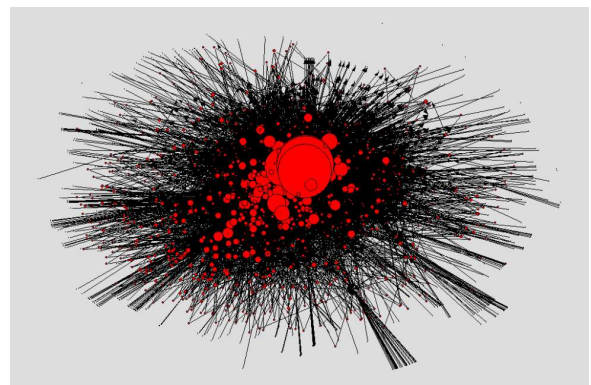


Figure 4. Out-degree 2010 promotions network.

C. Demotion network

Demotion network is built in a similar way to the previous network but using demotions instead of promotions. Network size is 1459 (users who have posted at least one idea at IdeaStorm 1153, and users who have demoted ideas but have never posted an idea, 306). The meaning of the demotion network is the same as the promotion network, but using the idea of demotion instead of promotion.

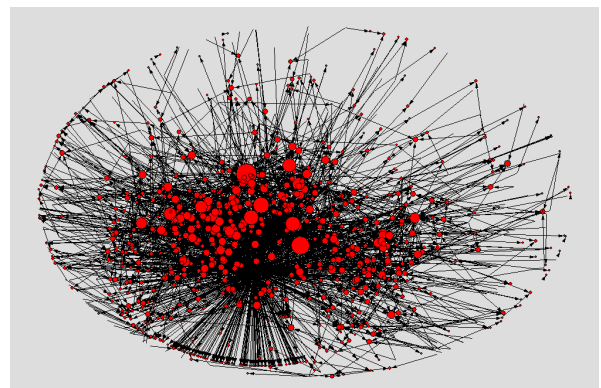


Figure 5. In-degree 2010 demotions network.

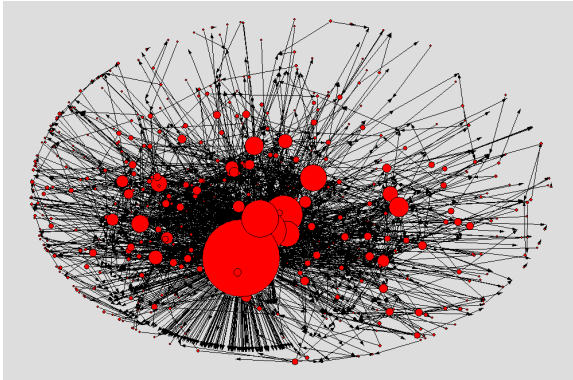


Figure 6. Out-degree 2010 demotion network.

Figure 5 illustrates the in-degree demotions network. 22 users exhibit an in-degree demotion value higher than 10. Figure 6 is the out-degree demotion network. In this case, it can be easily noticed the presence of a very active “demoter” user with an out-degree of 795!

D. User behavior

The obtained partitions of the three referred networks have been correlated to analyze to what extent the patterns of behavior in one network are similar to the rest of networks. Table IV details the obtained Spearman's rank-order correlations for the 1153 who have posted at least one idea. IN and OUT-COM refers to the in and out degree partition of the comment network, and a similar notation is used for the rest of rows and columns of Table IV. The Spearman's rank-order correlation is the nonparametric version of the Pearson product-moment correlation, and measures the strength of the association between ranked variables, that is, how closely several sets of rankings agree with each other [30].

TABLE IV. CORRELATION MATRIX.

	IN-COM	OUT-COM	IN-PROM	OUT-PROM	IN-DEM	OUT-DEM
IN-COM	1,000	,363**	,274**	,190**	,196**	,146**
OUT-COM	,363**	1,000	,315**	,461**	,144**	,434**
IN-PROM	,274**	,315**	1,000	,402**	-,079**	,276**
OUT-PROM	,190**	,461**	,402**	1,000	,170**	,588**
IN-DEM	,196**	,144**	-,079**	,170**	1,000	,134**
OUT-DEM	,146**	,434**	,276**	,588**	,134**	1,000

** Correlation is significant at the 0,01 level (2-tailed).

In-degree partition of the comment network is positively correlated with the in-degree partitions of promotion and demotion networks. However, the low value of correlation coefficients means that authors of most commented ideas are not always the ones who receive most promotions and demotions. Perhaps, a large number of comments signals controversy and

disagreement among users making popularity of the idea ambiguous. The correlation coefficient of IN-PROM and IN-DEM is almost zero meaning there is no clear relationship among users receiving promotions and demotions.

In the case of out-degree partitions, correlation coefficients are also positive but higher meaning people frequently commenting on ideas are usually the same people who promote and demote most ideas. In fact, the correlation coefficient of OUT-PROM and OUT-DEM is the higher of Table IV.

In general, the participation inequality pattern can be distinguished in the three obtained networks, and most active users comment *and* vote on ideas.

VI. CONCLUSIONS AND FUTURE WORK

This paper deals with the concept of open innovation from a social network analysis perspective. For this purpose, the open innovation community from Dell has been modeled as a graph, considering three networks attending to the interaction possibilities offered through this web. More specifically, the in-degree and the out-degree distributions for these networks have been analyzed, obtaining several patterns of behavior of community members. A possible extension of this work would consist of identifying lead users, which represent the most important subset of the community from the organization perspective.

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