Empirical Research on User Relationship Network for Product Innovation Community

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Abstract. The 'social network' which is formed by user behavior and its interact relation, could link user wisdom quickly, gather huge amounts of information, accelerate the sharing of knowledge and creation. Xiaomi community using grasping user comments or response data on community BBS section of typical products has been proven a typical product innovation platform that can be used to build the user relationship network. Typical social network properties have been discovered by using the social network analysis method. But high clustering core - edge structure in the network makes the majority of user behavior have certain limitation about focus on more themes' content of products at the same time. Core users tend to talk more to periphery users in the user relationship network, then, the core users almost no communication between themselves, and their intermediary effect are not obvious. Obtained the empirical results show that impact on analyzing user interaction and its relationship building, which could spread information aggregation and quickly generate iteration to promote the product innovation design.

1.   Introduction

The 'social network' formed by the aggregation of several 'interactive relationships' changes information requirements and behavior pattern of users, aggregates user wisdom ability and huge information, and gives full play to the value of resources with wide application of Web2.0. Many traditional manufacturing enterprises have transformed to the Internet as a result, and built an open product innovation community based on user social network relationship. Users are directly involved in the process of product innovation design, thereby driving information resource iteration with user requirements, and promoting product innovation. Xiaomi Technology has the most prominent performance among domestic product innovation enterprises. It utilizes Xiaomi community and forum to gather fans. Information is interacted through posts, comments and other community user behaviors. Users fully participate in the product innovation design. A lot of practices show that the relationship network built by user interactive behaviors in product innovation community can accelerate and inspire the sharing and creation of knowledge resource among users, thereby promoting the innovation design of products.

2.   Research Methods and Status

2.1 Research Methods

It is generally believed that 'network' is a collection composed of certain relationship among nodes. 'Social network' is a collection composed of social actors as nodes and their relationship thereof. A social network is a collection composed of many users and link-line among all user relations, wherein the user relationship represented by the 'edge' can be directed or undirected [1]. Social Network

Analysis be used for quantitative research on the relationship among users in social network. Graphs in graph theory can be used for describing social network as social network graph more intuitively.

2.2 Literature Review

Complex network theory method is utilized to analyze social network and user behavior with the development of Internet technology and social network site, which has become a hot field of research at home and abroad.

Teutte [2] etc. apply complex network and network dynamics theory in the research on Twitter, Flickr and other related social network site product fields, thereby analyzing basic parameters and network features of user relationship network. It is discovered that the relationship network among users have characteristics of free scale, small world and other complex networks. Sun Meng [3], etc. regard microblog product as an example to study the user relationship in social network. Reveal the general rule of user relationship.However, the research on product innovation design field is relatively scarce. Mark Fuge [4] uses the network analysis method to describe network features of online collaborative design community Open IDEO, the incentive mechanism to coordinated distribution design team is discussed and analyzed.

In the paper, Xiaomi community is adopted as an example based on social network analysis method. A community user relationship network is constructed through grabbing relevant data. Scholars strive to reveal the function rules of relationship network on product innovation design through analyzing network structural properties.

3. Data Acquisition and Processing

In 2014, Xiaomi community user and information are involved and active highly. Hadoop is utilized to collect the theme posts and related comment data published by Xiaomi community from June 2014 to January 2015 for analysis.

3.1 Data Sample Processing

74,214 pieces of original data are collected in the product section of Xiaomi community. The user network relationship is constructed with review and reply among users. After unrelated data are deleted, 1824 pieces of valid data are finally selected for analyzing user relationship network.

3.2 Establishment of User Relationship Matrix

Users in Xiaomi community are set as network nodes. It is defined that the relationship of mutual comment and reply between user A and user B forms user relationship network if user A comments on user B. In the paper, the relationship among nodes and relationship direction are considered only for establishment of user relationship matrix. 1 is concluded if A and B have relationship, and 0 is concluded if they have no relationship.

4. Structural Properties of Xiaomi Community User Relationship Network

4.1 Analysis on Small World Network Characteristics

In social network, average path is used for describing the transmission efficiency of information, clustering coefficient is local characteristics of networks. The analysis results show that the average path of Xiaomi community user relationship network is 4 (as shown in figure 1). It indicates that any two users in the network can establish a relationship through four people. However, the network clustering coefficient is only 0.003 (as shown in figure 2). Thought it is larger than the random network (0.00004), stronger aggregation is not manifested. The network density state should be further considered in order to analyze the reasons for lower clustering of the network. The network density is only 0.0006 (as shown in figure 3) according to data analysis. The network density is low, there are few actual relationships in the network, establishment of effective relationship linkage is deficient among users, thereby leading to lower network clustering. However, Xiaomi community user relationship network still has small world characteristics.

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Average distance (among reachable pairs)   = 4.001
Distance-based cohesion ("Compactness")    = 0.003
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Figure 1. Network average path

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Overall graph clustering coefficient: 0.003
Weighted Overall graph clustering coefficient: 0.001
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Figure 2. Network clustering coefficient

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Density (matrix average) = 0.0006
Standard deviation = 0.0249
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Figure 3. Network density

4.2 Centrality Analysis

'Centrality' is of great significance for the study on information transmission and influence role in network. The centrality analysis is based on node degree in the network. The importance and rights of nodes in the social network or the judgement in the center position are evaluated.

4.3 Degree Centrality

Xiaomi community user relationship network is defined as follows: 'comment by others' is the node incoming degree, and 'commend on others' is the node outgoing degree. The degree centrality of the node is higher, the node is closer to the center position of the network, namely the direct condition between the user and other users is more, the power of the user in the network is larger, which is the core figure among users in the network.

```
                         1           2
                     OutDegree    InDegree
                    ----------- -----------
    1333    远方雪菲儿    26.000      66.000
    430     sse002        9.000       0.000
    629     橙子比你拽     9.000       0.000
    596     北极大大熊     8.000       1.000
    286     lianglianglala 8.000      1.000
    102     billzhang1989  6.000      4.000
    19      108949936      6.000      0.000
    576     啊木哥哥       5.000      23.000
```

Figure 4. Analysis on incoming degree and outgoing degree of network node (partial)

```
                    1           2           3           4
                OutDegree    InDegree    NrmOutDeg    NrmInDeg
               ----------- ----------- ----------- -----------
1    Mean        0.849       0.849       0.031       0.031
2  Std Dev       1.115       4.471       0.041       0.163
3    Sum       1168.000    1168.000     42.504      42.504
4 Variance       1.244      19.993       0.002       0.026
5    SSQ       2702.000   28482.000      3.578      37.717
6   MCSSQ      1709.837   27489.838      2.264      36.403
7 Euc Norm      51.981     168.766       1.892       6.141
8  Minimum       0.000       0.000       0.000       0.000
9  Maximum      26.000      97.000       0.946       3.530

Network Centralization (Outdegree) = 0.916%
Network Centralization (Indegree) = 3.501%
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Figure 5. Statistical description of incoming degree and outgoing degree of user relationship network nodes

The analysis results are shown in figure 4 and figure 5. The average outgoing degree and incoming degree are less than 1 respectively, which indicates that most users only give comment to 1 person, and only comment on 1 person is obtained, or there is no comment. Only very few users have higher centrality, which should be at the core in network users. Ucinet software is utilized to describe outgoing degree figure and incoming degree figure of user relationship network more intuitively (as shown in figure 6).
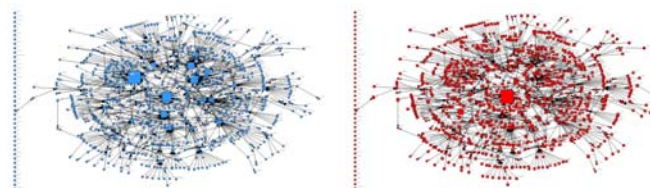

Figure 6. Incoming degree figure (left) and outgoing degree figure (right) of user relationship network node

The figure shows thatmost users send out reviews or replies rarely in Xiaomi community. Most users only comment single theme, and few users comment on multiple themes. It indicates that users have less attention on multiple themes at the same time with obvious attention limitations.

4.4 Betweenness Centrality

Betweenness centrality reflects the degree that one node can control node interaction of other users, and the node influence and function are embodied.

```
                                   1            2
                           Betweenness nBetweenness
                           ------------ ------------
      1333    远方雪菲儿       9150.417        0.485
      1240         鑫酱       4597.500        0.244
      576       啊木哥哥       2811.333        0.149
      634       楚意朦胧       2371.083        0.126
      893       龙江春晓       2277.000        0.121
      897         陆国明       2211.500        0.117
      1228        邪灵羽       1869.500        0.099
      569    阿丹--是圣女       1581.500        0.084
```

Figure 7. Network node betweenness centrality (partial)

```
                              1            2
                      Betweenness nBetweenness
                      ------------ ------------
      1    Mean           37.193        0.002
      2  Std Dev         328.407        0.017
      3     Sum        51141.000        2.711
      4 Variance      107851.055        0.000
      5    SSQ    150197312.000        0.422
      6   MCSSQ    148295200.000        0.417
      7 Euc Norm       12255.501        0.650
      8  Minimum           0.000        0.000
      9  Maximum        9150.417        0.485

      Network Centralization Index = 0.48%
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Figure 8. Statistical description of network node betweenness centrality

Figure 7 and figure 8 show that a few users in Xiaomi community user relationship network have higher betweenness centrality, but the network centralization index is only 0.48%, thereby indicating that most nodes in the network does not depend on the transitive relation with high betweenness centrality node, the clustering effect is not ideal. The results show that the mediating effect of user nodes in the whole network is not prominent Users with higher betweenness centrality does not play the linking role as intermediary bridge well, namely the information resource in the network are not diffused widely.

4.5 Closeness Centrality

The closeness centrality refers that the node is not controlled by other nodes, and the value is the sum of the shortcut distances between the node and all other points. The closeness centrality value is higher, the node has further distance from the core of power. The information and influence are limited. Conversely, the distance to the core is shorter, it is more convenient to obtain various information resources. Figure 9 shows that the closeness centrality value of most users in the Xiaomi community is larger, it is on the edge position.

```
                          1            2            3            4
                    inFarness   outFarness  inCloseness outCloseness
                    ------------ ------------ ------------ ------------
    534  yuanlove小米 1154608.000  1889250.000       0.119        0.073
    403    sanjianglu 1167068.000  1889250.000       0.118        0.073
    1087      天空静静 1167916.000  1885128.000       0.118        0.073
    1200 小米电视工程师 1168441.000  1885130.000       0.118        0.073
    526       xzclong 1230701.000  1889250.000       0.112        0.073
    1260        雅鲁江 1249481.000  1887876.000       0.110        0.073
    748      浩子同学 1302538.000  1889250.000       0.105        0.073
    182     friendmean 1325938.000  1889250.000       0.104        0.073
```

Figure 9.Network node closeness centrality (partial)

4.6 Core - Edge Analysis

Core-edge structure is a special structure, which consists of several interrelated elements, wherein the centers are closely related, and the surrounding areas are sparsely distributed [18]. Core-edge structure analysis can reveal the community structure of community users. The core and edges of the user communities as well as expression forms thereof are defined.

Figure 10 show that the final fitness value is larger, the core - edge structure model of actual data is more significant. In the paper, the final correlation coefficient is 0.082. It can be believed that Xiaomi community user relationship matrix has a core - edge structure finally through calculating two fitting correlation coefficients in the results and density information of all blocks (as shown in figure 11).

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Starting fitness: 0.000
Final fitness: 0.082
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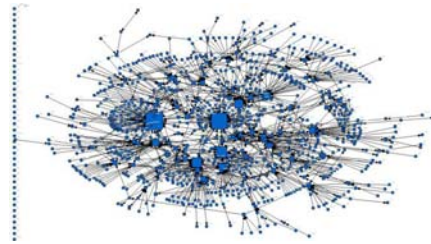Figure 10. Analysis on network core - edge (partial)

Figure 11. User relationship network core - edge structure diagram (node square area is larger, the centrality is higher).

The analysis shows that the users with high centrality in the core position tend to exchange with users with low centrality on the edge. There is nearly no exchange among users with high centrality. The core - edge structure is stable, which can stabilize the network structure and promote the communication and interaction of information. However, users are prone to focus on theme due to too much clustering. They are lack of attention to many theme contents at the same time.

5. Conclusion

Currently, domestic product innovation community has huge value potential. Though a series of achievements have been obtained, they are still in the development stage, and there are still more realistic problems. In the paper, structural properties of user relationship network in Xiaomi community are empirically analyzed, and it is discovered that

(1) There are few effective links between users. It shows that the network does not aggregate users better on the basis of interests, hobbies and common cognition, thereby hindering knowledge sharing behavior. It can' not t stimulate user's creativity in product innovation.

(2) Since users don't play the role as an intermediary bridge, limitation of information resource transmission in the network is caused. The focus attention has more obvious limitations. If sufficient user feedback information cannot be obtained for the product, the product innovation iteration will not be utilized.

(3) The whole network presents a core - edge structure. The non-core users concentrated on the core users cannot obtain other product associated knowledge due to the limited attention and sharing behaviors of core users. It is manifested as inactive heterogeneity behavior activities of core and edge users among different product sections, and the innovation ability of users cannot be fully exerted.

Therefore, analyze on product innovation community user relationship network characteristics and construct a user relationship network can provide research basis for clustering users, dividing roles, and describing user role requirements and behavioral characteristics effectively and subsequently based on complex network theory method. The incentive mechanism and interference measures are implemented for product innovation community on the basis of characteristics of user relationship network. Users can fully participate in product design process and user experience feedback, thereby driving community development and product innovation design.

Acknowledgments

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