The role of online neighborhood forums in creating self-organized and resilient communities

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Abstract.

Cities have co-evolutionary and dynamic behavior (Purtugalli, 2012), and to deal with such dynamics we need self-organized systems that are adaptive and can coevolve with these uncertain situations (Gert de roo, 2010; Batty, 2007). Networks can enhance systems' adaptability and resiliency through creating powerful linkages and augmenting information sharing and dialogue on local issues (Innes and Booher, 2010). In this paper, we examine ways in which information technology affects creation of self-organized networks by exploring three Facebook neighborhood groups in California, U.S., Cambridgeshire, UK, and British Columbia, Canada. Building on system and graph theory, we explore two questions: (a) how do online neighborhood forums affect self-organization capacity of communities by providing opportunities for information sharing, and (b) how can network analysis explain self-organizing capacity of online communities? A web-based close-ended survey to understand the capacity of information sharing in neighborhood forums. Using NetVizz, a Facebook data scraping tool, user interactions are extracted from the Facebook groups in order to explore members' connections and interactions. SPSS and Gephi software are used to visualize and statistically analyze the survey responses and Facebook graph data. The findings show that neighborhood online forums can enhance self-organization capacity of online communities by providing opportunities for communities to discuss local issues and arrange face to face meetings as needed. Network analysis can be a valuable method for exploring self-organizing behavior of online communities.

Introduction:

Cities have co-evolutionary behavior; they can adapt and change dynamically (Purtugalli, 2012; p.63). In order to deal with this dynamic environment, we need systems that are adaptive and can coevolve with changing situations. Complex adaptive systems are systems which can adapt their behavior to the new environment (Batty & Marshall, 2012, 56). The ability of these systems to move between stable and unstable situations makes them more adaptive and provides them capacities to evolve (Gert de roo, 2010, 31). These systems can also facilitate knowledge circulation through the system; therefore increase system's intelligence (Huys and Van Gils, 2012, 150).

Cities deal with uncertainties on a regular basis, whether it be due to disasters such hurricanes, wildfires, and floods or to economic crisis. It is crucial to find ways in which local communities can work as self-organized systems that can deal with the uncertain situations. This paper explores ways in which social networks can affect self-organization of the neighborhoods. We also examine how network analysis can enhance exploring self-organization capacity of communities.

1- Self-organization in complex systems:

The idea of self-organization has been discussed in cybernetics, thermodynamics, mathematics, information theory and the related fields (Gershenson and Heylighen, 2003, 606). In planning some scholars have also explored cities through the lens of self-organizing systems theory, focusing on the idea of bottom up planning (i.e.Batty, 2010), and trying to simulate interactions in cities (Batty, 2007, Portugali, 1999, Gershenson, 2012). Self-organization is usually characterized with enhancement of order which is not caused by external agents or structures (Gershenson and Heylighen, 2003, 607).

An important aspect of such systems is about their ability of co-evolution. Kauffman (1993) argues that complex adaptive systems co-evolve through time. Mitleton-Kelly (2003) describes this co-evolution as the way that each agent or element influences the other agents and therefore is itself influenced by all other related agents or elements in the system. In this environment the nature of the relationships among agents will change when the context or the environment changes and the agents are constantly changing and adapting the environment

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(Huys and Van Gils, 2010, 146). All these actions and interactions can make prediction of systems' behavior difficult.

o-evolution is principally discussed in biology, environmental sciences and evolutionary economics (Kauffman, 1993); however, we have seen the application of this idea in social sciences and planning as interdisciplinary works are being more common every day. Co-evolution can make systems more self-organized, therefore, more resilient. Fuchs (2003, 1) argues that "Self-organizing systems involve certain degrees of freedom, chance, unreducibility, unpredictability, and indeterminacy … . Social self-organization is a self-referential, mutual process where structural media and human actions produce each other". He believes that bottom up processes generate relationships, therefore generates a structure which is different from the individual level actions and interactions. He calls this process "emergence" which is to some extent unpredictable, and cannot be forecasted through exploring at the individual level. Fochs argues that based on his notion, interaction of the agents can result to creation of structures and social qualities which is different from each agent's interaction (5). Therefore, the agents' interaction together and with their environment share the structure of the system, (Gershenson and Heylighen, 2003, 612). Fuchs (2003, 5) also argues that systems have a top-down effect which is about the effect of the whole system on the individuals. He calls this whole process "systematic societal self-organization" or "recreation" which enables the system to maintain and "re-produce" itself and adapt itself to the new situation.
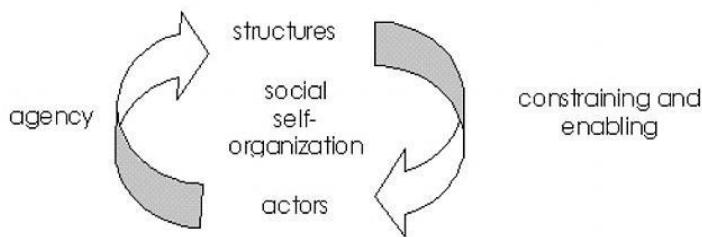
Fig 1. Self-organization of Social Systems (Fuchs, 2003, 6)

Zellner, Hoch, and Eric Welch (2012, 41) also support this idea by arguing that Interactions among large number of components in complex systems foster the systems' self-organization capability and make the systems adaptable to the changes. However, these interactions may also lead to unpredictability of its behavior. Giddens (1984, 2) also emphasizes

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on the importance of recreation by arguing that "Human social activities, like some self-reproducing items in nature, are recursive… they are not brought into being by social actors but continually recreated by them via the very means whereby they express themselves as actors".

The notion of self-organizing systems is rooted in the ideas of complexity theory and collaborative planning advocating for a bottom-up process which can lead to an organized system which is able to some extent regulate agents' bottom up actions, therefore, producing a process which takes care of itself without being required to have extensive interactions with the external environment. Self-organizing system is not a new idea; however, practical approaches of creating and supporting systems are still required to be studied.

In this study we focus on the importance of network power, which can be considered as a "flow of power in which participants all share" (Innes & Booher, 2010) in creation of self-organized systems. The network concept is based on the idea that the ties link nodes or link peoples, organizations, and communities (Wellman, 1983). In the next section, we precisely explore the preliminary concepts of graph theory as a method for analyzing social networks.

2- Graph theory and the study of online neighborhood forums:

Graph theory help us explore which networks are the most well-organized, well-connected or cost-effective (Linehan, Grossa, & Finnb, 1995). Graph theory has been used in various fields including information science, computer science, economics, management, sociology, architecture, and recently in emergency management, and landscape and ecological planning (See Foulds, 1992; Linehan, Grossa, & Finnb, 1995; Minor & Urban, 2008; Wilson, 1976; YAMADA, 1996; Zetterberg, Mörtberg, & Balfors, 2010).

As Linehan et al. (1995, 183) argues "Graph theory provides a useful approach for analyzing networks, as it allows the analyst to optimize a given flow-related objective … .The parameters that determine network connectivity are (a) the number of separate networks within the region, (b) the number of links within the network, and (c) the number of nodes within the network" Network analysis is a method for exploring graph or network characteristics. Wellman (1983) argues that it is the core of studying social structures. It more focuses on the "structural concerns" to peoples' acts than why they act so (156). He clarifies that it is about analyzing "social patterns of ties" that connect members and studying "deep structures". It focuses on

exploring these patterns to understand how they affect certain behaviors. Precisely, it explores how patterns of relationships in a network influence access to resources including power, information, and wealth (157).

The table 1 summarizes and defines the common terms and definitions of graph components. In addition, it also summarizes connotations of each definition in online neighborhood groups as social networks. It provides a framework to apply the concepts of graph theory in analyzing self-organization capacity of online neighborhood forums.

Terms	Definition	Online neighborhood networks
Node	The main component of a graph	The main component of a forum. (e.g. members of a forum or the posts that members provide in a forum)
Edge	Identifies connectivity between nodes	Friendships or other types of connectivity between the nodes
Path	A sequence of consecutive edges in a network that joins two or more nodes. Average length path demonstrates the average path	Represents a possible connectivity rout between members
Degree	The number of edges or neighbors that are joined to a node	The number of friends, posts or other features that present connectivity of a node
Graph Density	The ratio of the number of edges and the probable number of edges	The ratio of the number of friendships, posts or other features and the probable number of friendships
Modularity	A measure of network structure. The power of division of a network into different modules	A measure that demonstrates structure of online neighborhood forums by dividing it into separated communities or groups.
Number of communities	One of the results of modularity measure. The number of different modules in a network.	The number of different community of friendships or group of posts in an online neighborhood forum.

Table 1. Graph components and the connotations in online neighborhood networks (See Minor & Urban, 2007; Wilson, 1979)

Wellman (1983, 172-174) introduces specific characteristics of networks by arguing that (a) ties or edges are usually inter-related and different in terms of their intensity and content, (b) ties connect the members of the network both directly and indirectly, (c) the structure of social ties among members builds "nonrandom networks" and causes the creation of boundaries and clusters, (d) clusters can also be working as nodes and linkages between clusters can connect both individuals and communities, (e) scarce resources are distirbuted unevenly in complex networks, and (f) collaborative activities are organized in the networks to achieve scarce resources.

3- Online neighborhood networks: fostering social ties and allowing face to face interaction

Several researchers have examined the role of neighborhood-based online forums in fostering local social ties and community participation (Foth, 2006; K Hampton & Wellman, 2003; KN Hampton, 2003). These forums can facilitate face to face interaction (Hampton and Wellman, 2003). Their member can meet each other if needed, since they are living in a same geographical area (Foth, 2006). These forums can also facilitate building trust (Rhoads, 2010), and can foster social capital (Hampton, 2003) in communities. Hampton and Wellman (2003) also clarify that place-based online forums facilitate communication around local issues. These forums can also enhance peoples' interactions by providing more flexibility for their members to communicate (Evans-Cowley & Hollander, 2010; Evans-Cowley, 2011; Mandarano, Meenar, & Steins, 2010)

On the other hand, place-based online forums can bring several challenges. Foth (2006) argues the importance of considering various issues such as privacy, control, and security that these forums can bring.

4- Research context:

This study focuses on the role of online neighborhood groups and ways in which they can work as self-organized systems. More precisely, it focuses on ways in which Facebook neighborhood groups can facilitate local information sharing for communities.

We found and joined a total of thirty two English speaking neighborhood groups in Facebook by using Facebook search using the terms neighborhood. Twenty six of these groups accepted our request to join them. We randomly selected three different groups in Cambridgeshire, England; California, USA; and Calgary, Canada for more detailed study. Below is a profile of each of the three neighborhoods:

Hinchingbrooke Neighbourhood: This neighborhood is located in Cambridgeshire, England. The Hinchingbrooke Neighbourhood group has 208 members. This note demonstrates how the group administrator defines it: "We have decided, that we want a Hinchingbrooke Neighbourhood Group to share information about events, random questions we have or maybe just meet people who live in Hinchingbrooke."
(https://www.facebook.com/groups/300047226735440/members/)

West End neighborhood: West End neighborhood is located in Santa Rosa, California, USA. West End neighborhood group has 555 members. Here is how the group administrator defines it: "This group is dedicated to the all things West End. The West End is located in Downtown Santa Rosa Ca. and is one of the few neighborhoods in Sonoma County that has an Urban feel. The neighborhood is just up the tracks from Railroad Square. The web site listed below is a great resource."

(https://www.facebook.com/groups/srwestend/members/)

Provinceton Neighbourhood: Provinceton neighborhood is located in Cloverdale, British Columbia, Canada. The group has a total number of 220 members. This is how this group is described: "For owners and residents of the Provinceton Neighbourhood in Cloverdale, BC to digitally congregate and discuss items related to our community. Also, a great place to get to know fellow neighbours!" (https://www.facebook.com/groups/262014890475375/members/)

5- Research framework and Method

In this study, we evaluate self-organizing capacity of networks by exploring the extent in which online groups facilitate information sharing among participants and create powerful networks. In addition, it examines how the graph information retrieved from a place-based online network can explain it self-organizing capacity.

We collected data by conducting web-based surveys and data harvesting methods. Focusing on the Facebook group members as our target population, we sent out surveys using three different methods: (a) first, we introduced a link to the survey on the group wall, (b) then, we sent a direct massage to all the members introducing a survey link, (c) at last, we created a Facebook event and asked for the members' participation in our survey. We surveyed the total of 983 members of three different online neighborhood groups. We then used SPSS software for analyzing the survey data.

To harvest the graph information for each group (e.g. number of nodes and edges, density, and modularity measures), we used Netvizz, which is an application for scraping Facebook graph. data. Gephi, a social network analysis software, was used to analyze the Facebook graph data.

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6- Analysis:

6-1- Exploring the effect of online social networks on communities' self-organizing capacity

The results below are based on the total of 145 responses (15% response rate) that we received from the members of the three online neighborhood groups who filled out the surveys.

How often the members check their Facebook group wall? Most of the members check their group wall regularly. About half of the respondents (51.7%) check their neighborhood group wall five times per week or more. 19.3% of them check their group wall three or four times a week. 28.9% of the members check their group wall two or less than two times a week.

How often the members have used their forum to inform the other members about issues related to their neighborhood? Most of the members do not use Facebook for informing each other about the issues relevant to their neighborhood. Sixty-two percent of the participants mentioned that they rarely use their neighborhood groups to inform others about a neighborhood issue. Less than one-quarter, 23.4%, the total respondents mentioned that they have not ever posted anything on the group wall related to their neighborhood, while about half of them have joined their groups more than a year ago. Only about 5% of the group members are new to their group (joined less than a month ago).

To what extent the members believe that they can rely on each other's help in the need time? About one third of the group members (36.6%) can rely on help of their other group members (seven or more) in a time of need, while 30.3% of them can hardly trust other network members' if they needed help in a time of need.

How common it is for the group members to use their online forum to arrange face to face meetings? Members rarely use their Facebook neighborhood group to arrange face to face meetings. 82.1% of the respondents have used the group for arranging face to face meetings 2 times or less. Among these respondents, 68.3% mentioned that they have not ever used the group for doing so. 13.8% of them used the group for arranging face to face meetings once or twice. However, a few of the member have used the forum for arranging face to face meeting. 10.4% of them used it five times or more, 6.9% used it two or three times for this purpose.

To what extent do the members believe that their online forum has a capacity of informing the other members about a neighborhood issue? The majority of the participants (78.5%) believe that their online forum has a strong capacity in informing the members about an issue in their

neighborhood. Approximately 20% of the participants believe that their group has a moderate capacity in doing so. Only 2.2% of the participants believe that their group is very ineffective in informing the members about an issue relevant to their neighborhood.

To what extent do the members have social contact with their neighbors who are not part of their Facebook group? The majority of the group members also have social contact with their neighbors who are not a member of their Facebook group. Approximately 30% of the participants have social interactions with a lot of their neighbors (five or more) who are not part of the forum, comparing to 26.2% of the members that are in contact with some of their neighbors (three or four) who are not part of their group, and 33.1% of the participants that are in contact with just one or two non- group members in their neighborhood. 11% of the group members do not have social interaction with their neighbors who are not part of their Facebook forum.

How did members learn about their Facebook group? About half of the members (53.1%) have learned about the Facebook group through their neighborhood community, while 36% of them have been invited to their group by an online invitation.

Summary of the results

Although most of the forum members believe that their online neighborhood group has the capacity to inform the other members about their neighborhood issues, they rarely use it for this purpose. Their communication with their neighbors in the neighborhood forum is usually not related to their neighborhood issues. On the other hand, since most of the group members have social contact with their neighbors outside of their online group, information sharing in the online network may be extended to inform those who are not a member of the online forum.

Furthermore, the level of trust among participants is not low, since about half of the group members can easily rely on the help of their other group members' in the need time.

Although the majority of the members have not ever used their online forum for arranging a face to face meeting, their forum still provide this opportunity for them to do so.

6-2- **Using network analysis as a method for exploring self-organization capacity in neighborhoods**

Learning about characteristics of networks is important in exploring their self-organizing capacity. To explore how and if the graph characteristics of each online neighborhood group affect its self-organization capacity, we compare the data that we retrieved from the three

networks (Facebook groups) with the survey findings. We first analyzed the graph attributes of each group, and then examined how those characteristics are related with their capacity of information sharing.

Analyzing and visualizing neighborhoods as social networks, provides information about their characteristics and behaviors of participants. Considering neighborhood groups as graphs, we used Gephi, an open source network visualization and analysis software. Gephi is a powerful tool for visualizing simple and complex graphs. In the following pages, we explore the characteristics of each neighborhood visually and statistically.

6-2-1- Visual exploration of the network characteristics
Network visualization is a method for qualitative analysis of network characteristics.
The diagrams below show how the friendships among members of each Facebook neighborhood group shape the network. The dots demonstrate group members and the line between them shows friendships. The black dots represent the most connected members in the group.


Fig 1. Friendships network in Hinchingbrooke neighbourhood group
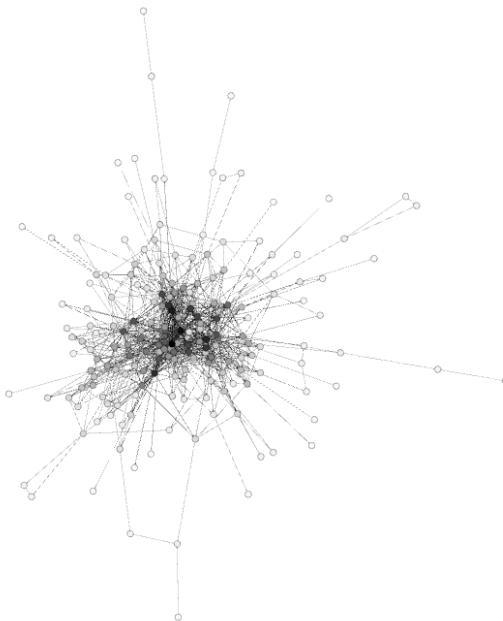
Fig 2. Friendships network in West End neighborhood group
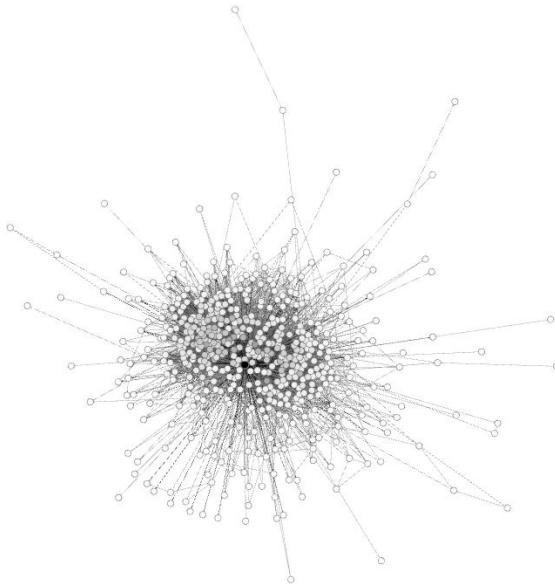
Fig 3. Friendships network in the Provinceton neighborhood group
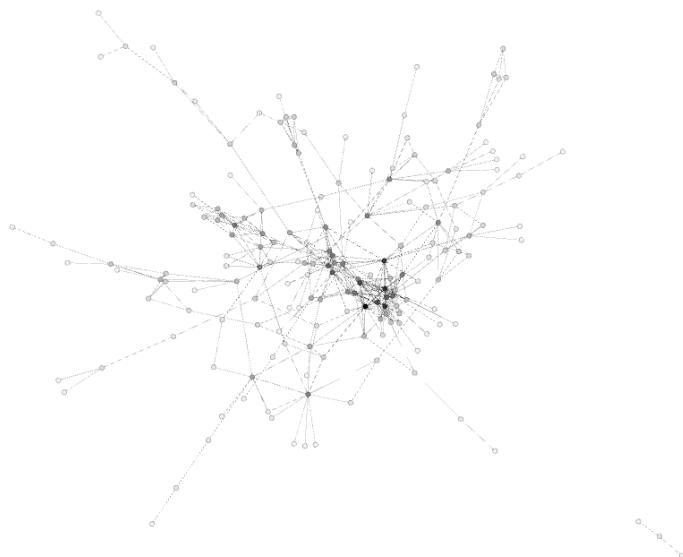
The friendship connectivity in West End neighborhood looks denser and stronger than Hinchingbrooke and Provinceton neighbourhoods. This indicates that more of the people in the West End Neighborhood group are more interconnected with people within the group being connected as friends on Facebook. While the Provinceton neighborhood group illustrates that

there are fewer people who are interconnected as friends on Facebook. Many members of this group are only friends with one, two, or three other network members.

6-2-2- Exploring the network characteristics for each Facebook group

Table 2 below demonstrate graph characteristics of each neighborhood group, by considering two scenarios based on friendships and interactions. In the friendship scenario, nodes are members of a group and edges are friendships among members. In the interaction scenario, nodes are members' post and edges are likes or comments on that post. Table 2 summarizes the characteristics of each network.

Character istics	West End		Hinchingbrooke		Provinceton	
	Friendships	Interactions	Friendships	Interactions	Friendships	Interactions
Nodes	555	170	208	137	220	145
Edges	8516	482	1029	535	395	534
average degree	15.344	2.835	4.947	3.905	1.795	3.683
graph density	0.028	0.017	0.024	0.029	0.008	0.026
modularity	0.342		0.347		0.66	

Table 2. Characteristics of the three online forums based on network analysis

In West End neighborhood, each member is friends with 15 other people in the group on average. Each post has been replied to or liked 2.8 times on average. In Hinchingbrooke Neighbourhood group each member is friends with on average five other people in the group. Each post has been replied to or liked 3.9 times on average. In Provinceton neighborhood group, each member has less than two friends in the neighborhood group. Each post has been replied to or liked 3.683 on average.

Friendship density: Friendship density in West End neighborhood is the highest (0.028). It is much higher than the friendship density in Provinceton group (0.008); however, it is close to the friendship density in Hichingbrooke group (0.024).

Friendship connectivity: Members of West End group have more friendships comparing to the other two. Average friendship among West End Group is 15.344 comparing to 4.947 for

Hinchingbrooke and 1.795 for Provinceton. However, it is noteworthy to consider that the number of the group members in West End is about 2.5 times more than the other two.

The number of communities within each group, based on the friendships among members: Higher modularity correlates with higher number of communities in each group and less homogeneity within the group. Modularity in West End group is less than the other two ones, followed by Hinchingbrooke and Provinceton. Although the difference of modularity indicator between West End and Hinchingbrooke is not very high, we conclude that West End group is the most homogenous one considering the communities of friendships.

Interaction Density: Interaction density is about the density of interaction based on the number of replies or likes that each post has received. Based on analysis of the groups' interaction, Hinchingbrook has the highest density (0.029), followed by Provinceton neighborhood (0.026) and West End (0.017). This finding is not correlated with the analysis of friendship density.

Summary of the results:

Friendship among the members of the West End group is stronger compared to the other two groups. West End is also the most homogeneous group in terms of communities of friends.

On the other hand, the members of Hinchingbrooke neighborhood are more supportive in terms of liking or commenting each other's posts. Although friendship density is the highest in West End group among the other groups, its interaction density is the lowest.

These findings are based on analyzing the online network characteristics. To measure self-organization of each network, we also need to explore the qualitative capacities of these networks in facilitating information sharing and empowering communities. In the next section, we first explore characteristics of each neighborhood based on the survey results, then compare the information that we retrieved from network analysis with the survey data.

6-2-3- Exploring the information capacity of each online neighborhood forum

This table summarizes the forum characteristics based on the survey findings.

Forum characteristics based on the survey	West End	Hinchingbrooke	Provinceton

The percentage of the forum members that joined the group more than six months ago	75%	80.8%	64%
The percentage of the forum members that have posted an issue related to their neighborhood several times (5 times or more)	29.5%	21.2%	12%
The percentage of the forum members that check their wall forum regularly (5 times a week or more)	20.5	65.4%	64%
The percentage of the forum members that have had face to face interactions with other forum members (have seen at least 5 members)	75%	76.7%	64%
The percentage of the forum members that can rely on the other members in the need time (can rely on at least 7 other group members)	20.5%	53.8%	32%
The percentage of the forum members that have used their forum to arranged face to face meetings several times (5 times or more)	18.1%	9.6%	4%
The percentage of the forum members that believe that their forum have a great capacity to inform the members about their neighborhood issues.	75.1%	75%	84%
The ratio of the group members that have interactions with couple of their neighbors (5 or more) who are not part of the online forum.	36.3%	34.7%	18%

The members of West End forum are the most active in terms of posting issues related to their neighborhood. West End is also the most active group in terms of arranging face to face meetings. The members of Hichingbrooke forum are far more active than the other two groups in checking their wall page. Furthermore, the level of trust among them is the highest. It is easier for them to rely on the help of the other group members in the need time compared to the other two group members. In both Hichingbrooke and West End forums, around one third of the members have interactions with couple of their neighbors who are not a member of their Facebook group; however, this type of interaction is much lower in Provinceton neighborhood group.

In all of these groups, the level of face to face interaction among the group members and the belief that the Facebook group has a great capacity in informing the members about their neighborhood issues, are high.

6-2-4- Comparing the results of the network analysis and survey

The interaction density in Hichingbrooke is the highest, and in West End is the lowest. This trend is similar to the extent in which members of each group rely on each other's help. West End members have been far more active comparing to the other members in arranging Face to Face meetings, followed by Hichingbrooke and Provinceton, This trend is similar to friendship density among participants.

Although the friendship and interaction density differs in these three groups, in all of these cases, a lot of members have face to face interactions outside of their network, and believe in great capacity of their networks in informing members about their neighborhood issues.

The number of posts is not necessarily related to the number of posts that are related to neighborhood issues. The percentage of the neighborhood-related posts in West End neighborhood is the highest among the other forums; however, the interaction density in this forum is the lowest.

Summary of the results:

Interaction density in a group can be related to the level of trust among its members. Friendship density can be also related to the encouragement of the group members in arranging face to face meetings with members. Furthermore, high friendship density in a network can be related to the members' interactions with those of their neighbors that are not part of the network.

In addition, face to face interaction among the group members is not necessarily related with network density or friendship density.

7-   Concluding points:

This study finds various ways in which place-based online forums can enhance self-organization capacity of communities. Online neighborhood forums can enhance self-organizing capacity of communities by facilitating local information sharing among the group members. In addition, since most of the group members have social contact with their neighbors who are not part of their online group, information sharing in a place-based online network may be extended to outside of the network and may inform those who are not a member of the online forum. However, although most of the forum members believe that their online neighborhood group has a great capacity to inform the group members about their neighborhood issues; they rarely use it for this purpose. Their communication with their neighbors in the neighborhood forum is usually not related to their neighborhood issues. There are also other factors that can enhance the quality of information sharing among participants, including the moderate to high level of trust among the group members and also the opportunity of using forum for arranging face to face meetings and continuing dialogue outside of the online forum.

Analysis of friendship and interaction density in networks provides opportunities for preliminary analyzing and hypothesizing about networks' behavior. However, this type of analysis cannot be solely used for the deep evaluation of self-organization capacity of online networks. We also need to analyze details of members' behavior as well. For example, we need to analyze the role of key members in arranging face to face activities or posting attractive local news.

More than forty years ago Friedmann and Hudson (1977) argued that planning cannot sustain by applying the current body of theories and we need new theoretical propositions. Echoing their word, we also believe that urban planners, designers, and policy makers need to incorporate new theoretical perspectives in their research. Graph theory provides a valuable framework for analyzing communities as the core of self-organized urban systems.

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