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Abstract

The notion of "community" has often been caught between concrete social relationships and imagined sets of people perceived to be similar. The rise of the Internet has refocused our attention on this ongoing tension. The Internet has enabled people who know each other to use social media, from e-mail to Facebook, to interact without meeting physically. Into this mix came Twitter, an asymmetric microblogging service: If you follow me, I do not have to follow you. This means that connections on Twitter depend less on in-person contact, as many users have more followers than they know. Yet there is a possibility that Twitter can form the basis of interlinked personal communities—and even of a sense of community. This analysis of one person's Twitter network shows that it is the basis for a real community, even though Twitter was not designed to support the development of online communities. Studying Twitter is useful for understanding how people use new communication technologies to form new social connections and maintain existing ones.

Keywords

online communities, social networks, scholarly communication, knowledge dissemination, information and communication technology, Internet

1. Introduction

Barry and Beverly Wellman moved to Toronto more than 40 years ago. Not being able to get a public school job at first, Beverly went to teach English-language subjects at a Jewish day school. She lived downtown and commuted to the suburbs. One day the principal asked her,

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"When are you moving to be among your own kind?"
"Where do the academics live?" Beverly replied.

The principal imagined Beverly to be part of the "Jewish community of Toronto," a set of all the Jews living in the city, not realizing that Beverly has multiple social identities and networks (Wellman [1971, 1979, 2001] discusses multiple social identities and networks). The principal's usage was similar to the imagined community that politicians use when talking about "the Italian community," "the gay community," and so on. In Toronto, in efforts to make their imaginations concrete, they often post street signs telling people that they are in "Little Italy" or "Chinatown" even though few Italian and Chinese Canadians live there—they are relics of past concentrations. But people seem to need to imagine that they—or others—belong to a community: a set of people who share sociability, support, and a sense of identity. Indeed, even when people are in loosely bounded networks, they will often identify themselves as part of a more defined group or community (Freeman, Freeman, & Michaelson, 1989).

The notion of "community" has often had a tension between concrete social relationships and imagined sets of people perceived to be similar (see Hillery's [1955] 94 definitions of community). Until the 1970s, almost all relational definitions of community were locally constrained, treating neighborhoods and communities as almost synonymous (Wellman & Leighton, 1979). From the 1970s onward, the proliferation of long-distance relationships led some community scholars to expand their purview to nonlocal ties among friends, relatives, and workmates (Wellman, 2001; Wellman & Leighton, 1979).

A bigger challenge has come with the rise of the Internet because it has enabled people to interact communally without ever meeting. Are Internet-based relations community? Community sociologists, computer scientists, and pundits have not been sure. For years, Wellman had to convince fellow community sociologists to allow such relations into their conferences. A key step came in the early 2000s when the new American Sociological Association journal, *City & Community*, explicitly incorporated "virtual community" into its scope conditions. Some community scholars have also analyzed "portable communities" that physically and intermittently gather, such as "Deadheads" traveling to Grateful Dead concerts (Adams & Sardiello, 2000), artistic geeks at the annual Burning Man gatherings in the Nevada desert (Chen, 2009; Doherty, 2004)—and to be un-presentist, tradesmen in itinerant medieval fairs (Duby, 1985).

While community sociologists were struggling to get beyond the neighborhood, computer scientists studying human-computer interaction had other issues. Some wrote of online community as if it functioned without any in-person contact (see Wellman & Gulia's [1999] review). One early influential article stretched the evidence to contend that the Internet pulled people away from their in-person ties (Kraut et al., 1998). For years, the media and some pundits made much of this—how could you have community without any physical contact? (see the review in Wellman & Gulia, 1999). For years, social scientists have responded by systematically showing that almost all people who interact communally online also see each other in person. They

have found that the Internet and in-person contact extend and enhance each other, rather than replace each other (see the reviews by Boase & Wellman, 2006; Chua, Madej, & Wellman, 2010). That has been true for most modern forms of electronic communication services such as e-mails, listservs, and instant messages, as well as social media such as Facebook and MySpace. They are all structured to allow people who know each other—now or in the past—to keep in contact.

Into this mix came Twitter (http://twitter.com), founded in 2006, gaining some public notice in 2007, and explosively growing in 2009—with much media attention. Twitter is a social networking and microblogging service that allows its users to send and read short (140-character-long) messages known as "tweets." Unlike other social media, Twitter is asymmetric: If you follow us, we do not have to follow you. Indeed, the norm for those following more than 100 people is to have many more people following them. This means that these networks of followers of a person and those whom a person is following (which we call "sources") have less dependence on in-person contact or local proximity (Takhteyev, Gruzd, & Wellman, 2010). For example, Barry Wellman's Twitter network—the source of data for this article—contains 114 people whom he is following (i.e., sources) and 652 who are following him (as of August 2, 2009, 10:00 EDT).

As Twitter nomenclature can be confusing, please note that we call those that Wellman follows "sources," and we call "mutuals" those whom both he follows and who follow him back. Sources and followers do not have to be persons—CNN is followed by almost 1 million Twitter users (aka "tweeps")—but all of the sources Wellman follows are real persons.

If we rely on the traditional definition of community—as a spatially compact set of people with a high frequency of interaction, interconnections, and a sense of solidarity (Wellman & Leighton, 1979)—Twitter could not be considered a community; nor, we dare say, could most of the personal networks of tweeps. And even if we fall back to the Internet-era definition of community that suspends the requirement for spatial compactness, it is still unlikely that there are many traditional communities on Twitter. Although a high frequency of contact is there for some, Twitter interactions are asymptotically J-curved, with many tweeps just lurking or intermittently tweeting. Yet despite the asymmetric and sparse nature of personal connections on Twitter (Cheng & Evans, 2009), there is a possibility that Twitter can host sets of interlinked "personal communities" (Wellman, 1979). However, this networked definition of Twitter raises a wide variety of interesting questions about the kinds of communities these Twitter networks form. To what extent:

- Do they consist of tweeps who see each other in person, regularly, intermittently, or latently?
- Do they consist of interconnected clusters of persons who are sources or followers of each other?
- Do they cluster by focus (for example, fans of J. Lo, or scholars of the Internet)?
- Does information diffuse among these networks, using the Twitter facility of retweeting a source's message?

To answer these questions, we chose the Twitter network of one community scholar, Barry Wellman, to explore a personal community on Twitter. We studied Wellman's Twitter network because he is an active Twitter user and because he is one of the authors of this article, thus making it easier to interpret and validate the discovered personal network. As part of this study, we collected a plethora of information from Twitter about inter-tweep connectivity such as who is connected to whom, who replies to whom, are the relationships mutual, which tweets are passed on, and so forth. We use this information to study this new form of community, one in which spatial proximity seems to play a minimal role.

2. Imagining Twitter as a Community

To begin, let us look at two of Wellman's Twitter friends—"steve3034" and "cyberpsy." Both have Twitter home pages that give their real names, but as we use pseudonyms here, they cannot be traced from this article. Steve3034 in Korea follows Wellman, whereas cyberpsy in England is a mutual with Wellman: They follow each other. Clicking on steve3034's home page shows his place of work, that he is following more than 200 people (including Wellman), and that he has more than 1,000 followers himself. His Twitter page even gives his picture and his personal website. cyberpsy's home page provides similar information. Both provide pictures, a common Twitter norm. Steve3034's picture is a straightforward portrait, whereas cyberpsy's is more metaphoric.

Although Wellman and cyberpsy are colleagues and friends, Wellman and steve3034 have neither met nor corresponded. Steve3034 is a member of Wellman's information-diffusion network. But is he a part of Wellman's community, real or imagined? Wellman has 114 sources and has met about 50 other followers whom he only checks intermittently (he calls them "light sources"). Who else is in his set of 652 followers? He is talking to friends and colleagues who "reply" to or "retweet" him (so he knows they are reading him), addressing others he knows who do not reply or retweet (and so he is unsure about whether they are paying attention), and broadcasting to hundreds of strangers whom he has never met. Are they part of a community, real or imagined? Or are there multiple communities here, given Wellman's diverse interests in Internet society, social network analysis, and community sociology?

To help stimulate our thinking about these questions, we turn to Benedict Anderson's *Imagined Communities* (1983). In this book, Anderson was dealing with societies forging a new social identity by emphasizing a common—somewhat artificially constructed—community. He focused on such developing societies as Indonesia, where the authorities have tried to construct a common identity out of thousands of islands and ethnic groups. But although Anderson focuses on the then-keen concern for state-building in the face of communist attractions, his concept of imagined community is a useful starting point for thinking about Twitter. In Anderson's imagined communities, "the members of even the smallest nation will never know most of their fellow-members, meet them, or even hear of them, yet in the minds of each lives

the image of their communion" (p. 6). This seems to be what is happening on Twitter. Users could never know everyone on Twitter, but they are certainly aware of other users' presence, especially in their "neighborhood" of sources. When users sign in to Twitter, they see a live stream of messages coming from all of their sources, and when the users write a message, they are writing for their intended audience of tweeps who follow them. Thus, whether people are primarily on Twitter to follow others, to promote their ideas, or to broadcast what they are doing (Naaman, Boase, & Lai, 2010), it is impossible for them to be on Twitter and not to be aware of other residents of this virtual place, just as in Anderson's concept of imagined community.

We also want to go beyond looking at Twitter as an imagined community. We want to see if Twitter can sustain and provide grounds for development of an online community that is not simply imagined by each user but that is built on the shared sense of community. Therefore, in addition to relying on Anderson's work, we also apply two other notions of online communities: Jones's (1997) notion of "virtual settlement" and McMillan and Chavis's (1986) compilation of what constitutes a "sense of community" (SoC). Both of these works build on Wellman's fundamental insight (1979, 2001) that community is based on sociable and supportive social relations, and not on physical locality.

Jones (1997) argued that the prerequisite for an online community is the presence of a "virtual settlement" that meets four conditions:

- interactivity,
- more than two communicators,
- common-public-place where members can meet and interact, and
- sustained membership over time.

A strength of Jones's notion is that it is grounded in the combination of computer-mediated communication, cyber-archaeology, and virtual communities. (We also note with amusement that even when studying an online community, Jones reverts to the locality-based language of earlier generations of neighborhood-focused community scholars.) To apply Jones's notion, researchers need to examine the "artifacts" that community members create (in the case of Twitter, artifacts are source-follow relationships and their postings) and, based on these artifacts, quantify each of the four conditions described above (e.g., Blanchard, 2004; Blanchard & Markus, 2004; Efimova & Hendrick, 2005; Gruzd, 2009a; Koh & Kim, 2004).

However, the presence of a virtual settlement does not necessarily guarantee the presence of a community. In other words, the fact that there is a system like Twitter that allows people to get together and exchange messages does not necessarily make people feel as if they belong to a community. For that, they need a sense of community.

According to McMillan and Chavis's SoC (1986), community members experience a sense of community if they feel that they belong to the community (**membership**); they can make a difference to the community (**influence**); they provide support and are supported by other members (**integration and fulfillment of needs**); and they share

history, common places, time together, and similar experiences (**shared emotional connection**). Blanchard's review (2004) shows the importance of these four characteristics for the presence of a SoC. The main advantage of using McMillan and Chavis's SoC is that it "strengthen[s] some of the connections that Anderson's phrase, 'imagined community,' implies but leaves rather vague" (Haesly, 2005, p. 9). As Haesly (2005) explains, this is because McMillan and Chavis's SoC "illuminates both the social and psychological mechanisms that serve to link individuals to their community—even if that community is an imagined community" (p. 9). But heretofore these concepts have not been applied to the kinds of personal communities that Twitter might support.

3. Data Collection

We used Twitter's application programming interface (API; http://apiwiki.twitter.com) to retrieve automatically a list of Barry Wellman's followers and sources. Then using the same API, for each pair of Wellman's followers and sources, we determined who follows whom.

For the purposes of this research we restrict Wellman's personal network on Twitter to only those individuals who share a mutual (reciprocal) relationship with Wellman, i.e., follow Wellman and are also followed by Wellman, and are also mutually connected to at least one more person in Wellman's personal network of mutual followers. We decided to focus on members with mutual relationships because we wanted to emphasize the importance of reciprocal connections as a core of community, while being cognizant of how asymmetrical connections interlink communities and facilitate the flow of information and support. If two individuals are mutually connected, then it indicates that they are interested in knowing what the other has to say and also that valuable resources in this network, such as information and support, can flow between these two members. Thus, if we are unable to find a community among Wellman's mutual followers, it would most likely mean that a community is equally unlikely to exist in Wellman's broader Twitter community that includes people with asymmetrical connections. (The reverse is not necessary true.) Therefore, in our data, we removed any follower or source that does not have at least one mutual connection to Wellman's mutual followers.

To trace changes in Wellman's Twitter network of mutual followers, we collected these data twice: in August 2009 and February 2010. The resulting network for each time period is shown in Figures 1 and 2, respectively. The August network has 56 mutual followers and 140 connections or ties among the followers, whereas the February network has 72 mutual followers and 285 connections. (A few Twitter usernames were replaced with anonymous, but gender appropriate, pseudonyms per user's request.)

To process, analyze, and visualize this network data, we relied on two different packages. First, we used ORA (http://www.casos.cs.cmu.edu/projects/ora), a social network analysis (SNA) software package, for basic manipulations and visualization of the network data. We also used UCINET (http://www.analytictech.com/ucinet),

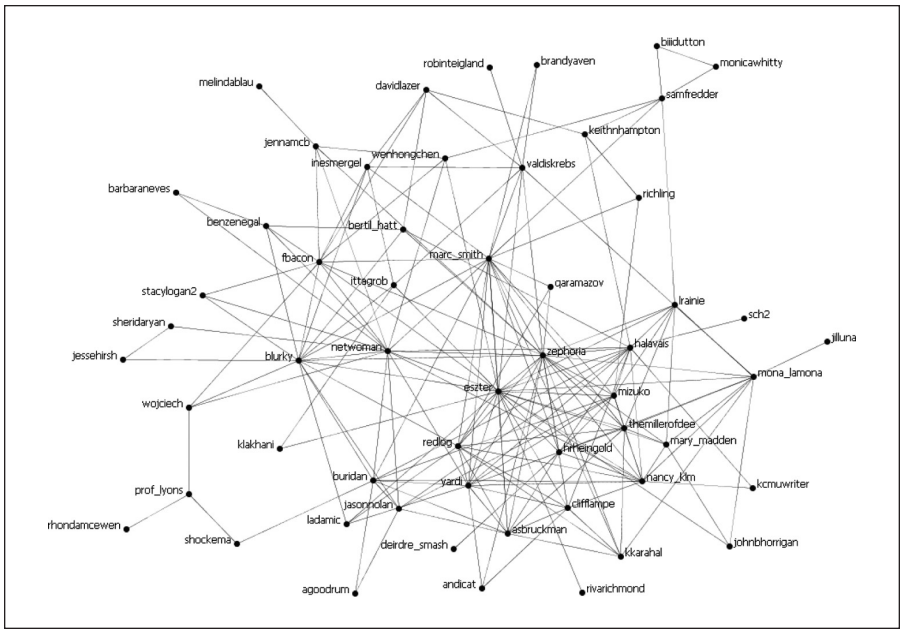

Figure 1. Wellman's network of mutual followers (as of August 2, 2009)

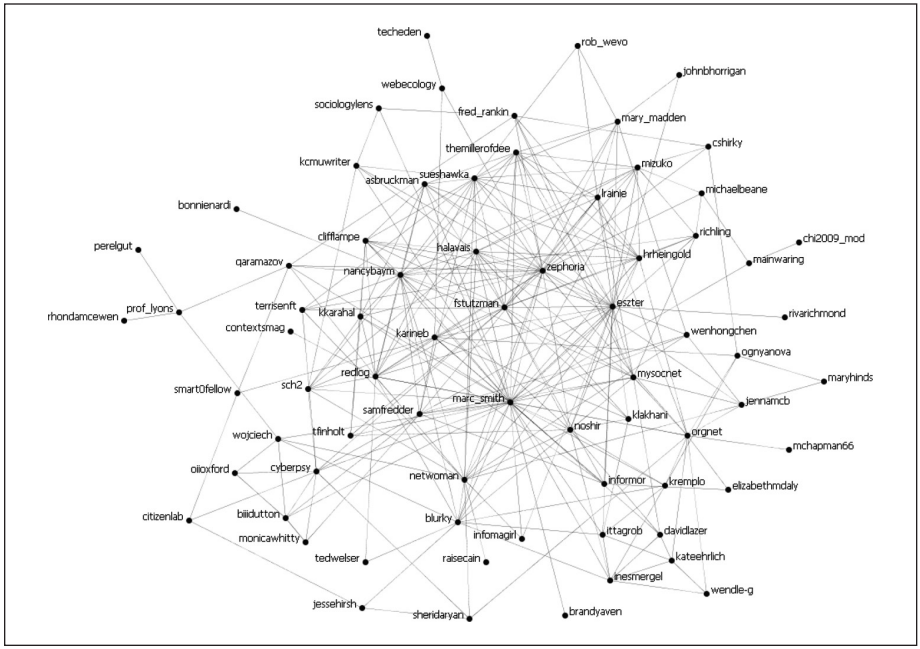

Figure 2. Wellman's network of mutual followers (as of February 2, 2010)

another popular SNA software package, to calculate different SNA measures and run statistical tests on the network data.

In addition to collecting purely network data, we also collected 3,112 messages that Wellman either originally posted or "retweeted" others' messages between April 2009 and February 2010. These messages were used during the content analysis part of our methodology to support and validate some of our network-based observations. We also used this sample of 3,112 messages to build another type of social networks called the "name network," developed and validated in different online communities by Gruzd (2009a, 2009b, 2009c). In the name network built from Twitter interactions, people are connected based on how many times their names co-appear in the same messages. To build the name network, we relied on a web tool, the Internet Community Text Analyzer (ICTA; http://textanalytics.net; see also Gruzd & Haythornthwaite, 2008).

4. Wellman's Twitter Network Under a *Microscope*

4.1. Twitter's "Imagined" Community

1. Common language. We first relate our data to Anderson's discussion of imagined communities. He posits that a key element of community formation is the development of a common language. Just as every country has developed a set of protocols for using the telephone—such as "Hello/Goodbye" in North America, "Pronto/Ciao" in Italy, and "Moshi Moshi" in Japan—there is "Twitterspeak," our term for a set of linguistic conventions constructed by Twitter participants. For example, computer programmer Chris Messina propagated the use of hashtags (#) to label intrinsic topics. Thus, if you are interested in the discussion of the 2010 Olympic Winter Games in Vancouver, a search with the hashtag #van2010 will find many tweets on this topic. Technically, #van2010 is part of a folksonomy, a user-created naming system, which is quite distinct from a taxonomy, a centrally created naming system.

Other key linguistic conventions (and folksonomies) in English-speaking Twitter include "RT"—to signify a "retweeted" or forwarded message, "via" to signify a highly edited message, and @name to identify the username of whom you are talking about. @name also sends the message to that Twitter user.

Take this typical Twitter message, sent on December 30, 2009, 11:35 EST, which is difficult to decode without knowing Twitterspeak:

> steve3034 RT @barrywellman: accusing Twitter of what it's not: "The trouble with Twitter" James Harkin http://bit.ly/8luIrq via @cyberpsy

The message gets richer when translated from Twitterspeak.

Translation: Wellman's follower *"*steve3034*"* is forwarding (*"RT"*) Wellman's message to his own Twitter followers and using the @ sign to give Wellman credit (and fortuitously, it gives us the ability to check the path of information diffusion). Wellman's message says that James Harkin's article "The Trouble With Twitter"

accuses Twitter of being something it is not (a common problem with Twilliterate media pundits). Wellman, in turn, acknowledges he got the post from one of his Twitter sources: *"via cyberpsy."* The web address in the tweet is for those who want to read Harkin's article for themselves: *http://bit.ly/8luIrq*. As in almost all tweets giving references, it uses a shorter web application (in this case, *bit.ly*) because there is rarely enough space in a (140-character max) tweet to provide a full URL. Clicking on the shortened address takes readers to the longer real version.

In addition to language conventions that are widely accepted in Twitterspeak, there are also a few conventions that are characteristic of Wellman's communities. These specific conventions were introduced by either Wellman or his followers and were adopted by others in his personal community. A few most characteristic conventions are described below.

The first convention is that when a user replies to somebody else's message, he or she often uses initials (e.g., "Wellman") or "Me" followed by colon (:) to indicate where the answer begins. For instance, in the following message, Barry Wellman replies to a user with a username redlog: "*RT @redlog does the ASA have an official twitter stream? Wellman: Yup, @asanews*." Out of 3,112 messages posted by Wellman in the period between April 2009 and February 2010, there were 204 messages (6.5%) containing "Wellman:" or "Me:".

An interesting convention is when a message exceeds the allowed 140 characters. In such a case, a user splits it into two or more shorter parts and includes "(X of Y)" or "(X/Y)" at the end of each part, where X indicates the part number and Y the total number of parts that complete the message. Another convention was also introduced to address the message length limitation. Every time a message is being retweeted (forwarded) by somebody, her or his username is automatically added to the message to preserve information about who retweeted a message after whom. For example, the following message has been posted by iMedicalApps and retweeted two times (first by jasonnolan and then by mysocnet): "*mysocnet: RT @jasonnolan: RT @iMedicalApps: First lady launches contest for healthy kids game iPhone apps, with $40,000 prize http://bit.ly/avBozv*." However, at some point if a message is retweeted many times, there is no space to preserve the full chain of "who retweeted after whom." A norm for Wellman's community is to remove the middle part of the retweeting chain to preserve information about the original poster and the most recent poster.

Due to the large size of the Twitter population—estimated at 175 million users—and the viral spread of 65 million tweets per day, it is easy for a convention to be adopted by many tweeps within a short time. As a result, it is difficult to determine if any of the conventions that are characteristic to the Wellman's community were initiated within the community or came from outside. Nevertheless, the persistent use of these conventions by members of Wellman's community suggests the existence of a particular script-language offered privileged access to Wellman's community.

In sum, the examples described above demonstrate how Twitter communities have adopted and extended their own unique linguistic conventions. Although it is not necessary for newcomers to speak Twitter—just as young toddlers can make themselves

understood—Twitterspeak is important for facilitating productive conversations and identifying oneself as part of the overall Twitter community, and specifically Wellman's community and his mutual followers.

2. *Temporality*. Another factor that Anderson associated with the formation of "imagined" communities is the presence of the "homogeneous" time, in which a community is "moving" through history together by sharing "a consciousness of a shared temporal dimension in which they co-exist" (see also Lo, 2000). Do Twitter users also have "a consciousness of a shared temporal dimension"?

Twitter is very much a stream of many consciousnesses uttering messages. "It is a river of data rushing past that I dip a cup into every once in a while," says *New York Times* columnist David Carr (2010). This is likely because Twitter exaggerates "presentism": the belief that only things that are happening now are what matters (Wellman & Gulia, 1999). Two hours ago is normal reading time; a day ago is a long time; a month ago is ancient history. Nevertheless, Twitter users do exhibit a continued imagined consciousness of a shared temporal dimension. This is demonstrated through their use of Twitter as a global platform for raising awareness and organizing prodemocracy protests in countries such as Iran and Moldova; organizing donation drives and supporting victims of recent earthquakes in Haiti, Chile, and Taiwan; or helping with Hawaii's tsunami evacuation (e.g., Hughes & Palen, 2009). In fact, according to some estimates, more than 85% of popular topics mentioned on Twitter are headline news (Kwak, Lee, Park, & Moon, 2010).

3. *"High centers."* Finally, Anderson suggested that community formation is associated with the decline of the conception that "society is naturally organized around and under high centers." This was true for Indonesian rulers in Anderson's times, but is it true for Twitter now?

At first glance, Twitter represents a decentralized structure where anyone is free to follow anyone else (except for the few tweeps who keep their messages privately accessible by permission only) and free to restrict access to their account by blocking "outsiders." Wellman, for example, blocks spammers and pornsters. As a result, almost all Twitter users have the same user privileges and can access the same set of features on the website. From this purely system-oriented perspective, almost all Twitter users are equal.

However, if instead of sacred and state ruling elites, we adopt a more network-oriented view of "high centers," the picture is different. Less than 1% of all Twitter users (0.9%) follow more than 1,000 tweeps (Cheng & Evans, 2009), suggesting that high centers in Twitter are popular individuals or organizations who are followed by many others. Many are celebrities or media companies. For example, the popular news channel CNN uses Twitter to share news and get feedback from their viewers: As of March 1, 2010, it had nearly 1 million followers.

Even a less popular Twitter user can be a high center of his or her unique personal network—a distinct set of sources and followers. This is different from the traditional group-centered community, of which preindustrial villages are the exemplars. It is not even the place-to-place community that scholars started thinking about in the

Table 1. Node Centrality of Top 10 Users in Wellman's Network

User	Rank, degree centrality	Rank, betweenness centrality	Followers	Following
eszter	1	1	1,774	472
zephoria	2	4	23,110	620
marc_smith	3	2	967	441
netwoman	4	3	442	202
blurky	5	5	342	91
halavais	6	6	629	458
yardi	7	17	256	476
nancy_klm	8	14	830	256
redlog	9	22	353	180
buridan	14	7	390	387
samfredder	23	8	143	166
valdiskrebs	18	9	3,174	406
jephu	10	10	33	35

1970s, when they realized that most households connected over a distance, rather than walking door to door within the neighborhood. Rather, it is person-to-person connectivity—a ramifying, sparsely knit network of individuals—a community of networked individuals (Rainie & Wellman, 2011; Wellman, 1979, 2001).

To see if there are high centers in Wellman's network, we used UCINET social network analysis software to calculate different centrality measures for all 56 of Wellman's mutuals. There are many reasons why a user can be considered central in a network. As a result, there are different centrality measures available. For our analysis, we use the two popular measures of "degree" and "betweenness." Degree centrality represents the number of direct connections to others in the Wellman's network. People who are high in degree centrality are well-connected individuals, and they can directly reach many people in the network. Betweenness centrality represents how many times an individual appears on the shortest path between all possible pairs of people in the network. Individuals with high betweenness centrality tend to be influential because they are well informed and can affect the flow of information in a network. As a result, they are often information gatekeepers.

Table 1 shows the top mutuals for both measures. Interestingly, the top six users are the same for both degree and betweenness. But it is not surprising that people with the highest degree and betweenness centralities in Wellman's mutual network are the same people who also have many outside followers, ranging from 256 to 23,110. This suggests that people who are central in Wellman's network are also likely to have some centrality in the overall network of Twitter users: The local and overall high centers overlap to some extent.

Beyond the top six users, there are some differences in the rankings that degree centrality and betweenness centrality show. To investigate these differences, we use

UCINET to measure the network centralization index (NCI) for both degree and betweenness. NCI describes whether centrality is concentrated in the hands of a few individuals or equally distributed among network members. Higher values of network centralization represent more variability and more inequality in centrality among members. In Wellman's network, the NCI for degree centrality is 32.5%, twice as large as the NCI for betweenness centrality (15.7%). This means that the degree centrality of the people in Wellman's network varies more than their betweenness centrality. This means that in Wellman's network, degree centrality is concentrated in the hands of fewer people than betweenness centrality. And if we view centrality as a form of individual "power" (in the sense of being able to directly reach many others in this network or to control the flow of information), then people with high degree centrality are more "powerful" than people with high betweenness centrality simply because there are fewer of them to share this "power" with each other.

On the other hand, due to their higher overall awareness of what is going on in different social circles, people with high betweenness centrality may be more important for community building than those who are simply well-connected individuals. This supposition is indirectly supported by the fact that people with high betweenness centrality are more likely to be Wellman's friends than people with high degree centrality. This is because Wellman's friends are more likely to maintain better awareness of his network than those who are just following him.

Regression analysis confirmed the link between people with high betweenness centrality and Wellman's friends. Before conducting the regression analysis, Wellman first evaluated each person in his network on the scale from 1 to 4, where 1 represents a stranger and 4 a close friend. For simplicity, we then dichotomized Wellman's responses into two groups: strangers & acquaintances (rated 1-2) and friends & close friends (rated 3-4). Then, using these rankings and the centrality values for each person, we performed the regression analysis.

There is a weak (but statistically significant) association between betweenness centrality and friendship. We found that 8.5% of the total variance in betweenness centrality can be explained by the friendship relationship. However, there was no statistically significant association between degree centrality and friendship.

There are some very popular individuals with many followers who can be considered to be high centers in Twitter. These individuals can be found by measuring degree centrality. However, from the community building perspective, people with higher betweenness centrality can be more useful high centers because they have a better awareness of a local community. They serve as the same sort of connectors between different social circles that social scientists have found in studying communities (Merton, 1957), organizations (Burt, 1992) and the web (Watts, 2003).

In sum, although abandoning high centers was associated with community formation in Anderson's times, high centers play important roles in Twitter as community builders and information sources. This underlines an important difference between Twitter as an imagined community and the imagined communities studied by Anderson in the physical world. To see the sort of person-to-person Twitter community in which

Wellman is immersed, we examined it through the lenses of Jones's concept of virtual settlement and McMillan and Chavis's concept of SoC (sense of community).

4.2. Virtual Settlement

Following Jones's four requirements of "virtual settlement" (a prerequisite to online community), this section will examine Wellman's network to determine whether it can be classified as a "virtual settlement," and if yes, what kind of "virtual settlement" it is.

1. Interactivity. To evaluate the level of interactivity among Twitter users in Wellman's network, we collected all messages that were posted or retweeted by Wellman between April 2009 and February 2010. The total message count was 3,112. Three-fifths (60%) of these messages (tweets) included the @ sign that indicates their conversational nature: They were directed at one or more tweeps. This means that the level of replying and retweeting by members of Wellman's network is more than twice as frequent as compared to the average Twitter user according to Huberman, Romero, and Wu's (2009) estimate (24.5%) and almost more than five times according to Java, Song, Finn, and Tseng's (2006) estimate (12.5%). This suggests that Wellman is more than just an active poster; he is also an active conversationalist. Due to the high percentage of retweeted and conversational-type messages (with @), this collection of tweets is a great source of "who retweets whom" or "who talks to whom" information. This is because people who tend to retweet or reply to each other's messages also tend to coappear in the same tweets. For example, in the following tweet, Wellman replies to "yardi" and "klakhani," demonstrating that all three of them are part of the same conversation:

> @yardi @klakhani My partial solution is to call on students a lot, instead of banning laptops. Sometimes asking what I just said.

Using information about co-occurrence of usernames, such as "yardi" and "klakhani," we can find who interacts with whom within Wellman's network and how they interact with each other. To discover who retweets or replies to whom, we used the ICTA program to analyze all of the 3,112 tweet messages that were posted or retweeted by Wellman between April 2009 and February 2010. The resulting network included 512 users and 1,448 ties among them. As the focus of this study is on Wellman's 56 mutual followers, we removed everyone else from this network. The revised network included 101 ties connecting mutuals whose usernames tend to coappear in the same tweets. Because co-occurrence of usernames often represents various interactions between Wellman's followers, we will refer to this network as Wellman's interaction network.

To find out if there are more interactions within Wellman's network of 56 mutuals as compared to the larger interaction network that includes all 512 RTers and @ers, we measured and compared densities for the interaction network of 512 versus the subset mutual network of 56. We found that the mutual network of 56 users was 6 times

denser than the larger interaction network of 512 users (0.07 versus 0.011). This suggests a high level of interaction among the 56 mutual followers relative to the low interaction on the overall Twitter network. This satisfies one requirement for community.

2. A variety of communicators. This requirement is easy to confirm because there are more than two people in Wellman's mutual network—56 people to be exact. Yet there is disproportionate concentration in only two of Wellman's interests: Internet society and social network analysis (e.g., only a few mutuals focus on community sociology). It appears that Twitter, itself a manifestation of the intersection of the Internet with society (currently called "social media"), especially attracts Wellman's friends who are in this area, and in a few cases has led him to make new mutual friends on Twitter.

3. A common public place where members can meet and interact. Twitter provides a set of features for its users to communicate and stay in touch with each other. In addition to sending and reading personal updates or tweets, users can also exchange private messages via its "Direct Message" feature.

Moreover, in addition to using Twitter as a common interaction and communication platform, Wellman uses other computer-mediated technologies—such as e-mail, listservs, texting, and Skype—to stay in touch with some of his followers. This is especially true for the 29 people in his network whom he identifies as his "friends" or "close friends," including 12 of his coauthors and six of his former students.

Furthermore, because most of his mutual followers share the same research interests, they sometimes meet each other in person at conferences. Wellman also sees in person those mutuals who live in Toronto (who also have in-person contact with each other), just as most North Americans routinely integrate their online and offline contact (Boase, Horrigan, Wellman, & Rainie, 2006; Wang & Wellman, 2010; Wellman, Hogan, et al., 2006).

Based on these observations, we can conclude that the common public place requirement is true for much of Wellman's Twitter network.

4. Sustained membership over time. To check if there is a sustained membership over time, we took two snapshots of Wellman's mutual network: one in August 2009 and another in February 2010. The network had grown from 56 members in August 2009 to 72 members, of which two-thirds (64%, 36) were carried over from the August 2009 network. (This number is actually slightly higher, but because a few mutuals made their profiles private, we were not able to capture their data with the computer program that we used to collect our network data.)

We found a sustained membership over time in Wellman's mutual network, with 36 members constituting a continuing core. In comparison to other emerging online communities, Wellman's community membership sustainability rate of 64% is probably above average. For instance, another "imagined" community of weblog readers with similar characteristics (e.g., similar in size, use of nicknames, etc.) to Wellman's community had a sustainability rate of just below 50% during a slightly shorter time period of four months (Gruzd, 2009a). In the case of Wellman's mutuals, someone could

leave this network because either Wellman or the other party decided not to follow one another: One—but not both—would continue to be a follower.

4.3. Sense of Community

So far, we have established that Twitter users form what we can call an "imagined community" and that Wellman's personal Twitter network exhibits the characteristics of what Jones has called a "virtual settlement." Our next step is to see if members of Wellman's network have a sense of community (SoC), as this would solidify the claim that Wellman's personal Twitter network is something of an online community.

1. Membership. Without conducting a survey, it is difficult to determine whether a member of Wellman's community has a sense of membership or belonging to this network. Therefore, we rely on a measure of network structure to test an opposing hypothesis: There is no real sense of belonging among members of Wellman's mutual network. If that were the case, then we should see many isolated nodes and multiple social circles that are poorly interconnected.

Because we are only interested in strong relationships among Wellman's followers during our data collection, there are no isolates in this network: Each node has at least one connection to somebody else in the network, including Wellman. Therefore, we checked a related question: Are peripheral network members capable of sensing Wellman's community? Because peripheral network members usually have only a few connections to others in Wellman's mutual network, it is likely that their mental images of this community depend on tweets and retweets that reach them from these few connections with the mutuals. Moreover, because Wellman is connected to everybody else in this network by definition, his tweets are the most important representation of people and their connections in his personal Twitter network. To test if a peripheral member can imagine the whole network by just observing Wellman's tweets, we measured the similarity between Wellman's interaction network ("who talks to whom" among mutual followers) and the mutual (source-follow) network.

For this test, we relied on QAP correlation, a commonly used measure in social network analysis to compare matrices of relational data (Krackhardt, 1987, 1992). We found the moderate QAP correlation of .27 ($p < .05$) between the mutual and interaction networks. Because in the interaction network people are connected based on co-occurrence of their usernames in Wellman's tweets, the moderate correlation suggests that people who are mentioned in the same tweets are also likely to be Wellman's mutual followers. And because Wellman's tweets are visible to everyone in this community, we concluded that even Twitter users who are on the periphery of Wellman's network of mutual followers would be able to build some sense or awareness of Wellman's community from reading Wellman's messages and observing names of other mutuals and their connections to each other.

The next step was to examine the mutual network for connected components and groups. The network has only one connected component: Everyone in the network is

Table 2. Group Level E-I Index

Field	Number of network members	Internal connections	External connections	E-I index
Internet—society	26	98	88	–.05
Social network analysis	17	66	56	–.08
Organizational studies	4	4	10	.43
Human computer interaction	3	2	33	.89
Pew Internet Research	3	2	9	.64
Computer science	3	2	10	.67

connected to everyone else, either directly or indirectly without going through Wellman. This is a common feature in social networks.

Next we used the overall clustering coefficient (the mean of the densities for all the nodes weighted by the number of their direct connections) to make our conclusion regarding the strength and interconnectivity of possible groups in this network. The clustering coefficient is relatively high—.40—suggesting that there are some nodes that tend to form densely knit groups. To confirm this independently, we applied Girvan and Newman's (2002) clustering algorithm to discover these densely knit groups in the network. The algorithm suggested six different groups. We showed these groups to Wellman to see if they really represent real groups or are simply artifacts of automated clustering. After reviewing these groups, Wellman confirmed that except for a few inconsistencies, each identified group does connect mutuals who are interested in one of six broad research areas: social network analysis, Internet society, Pew Internet Research, organizational studies, human computer interaction, and computer science (Table 2).

This suggests that people in Wellman's network tend to cluster around specific interest areas. This clustering does not go against the notion of a community because social networks may contain densely knit groups (Watts & Strogatz, 1998; Wellman, 1988). But it does raise the question: Does the presence of smaller groups within Wellman's larger network really hurt the overall sense of membership or belonging in it?

To continue this line of inquiry, we measured the extent to which members from each group are connected to other groups. Specifically, we wanted to know if each group has more internal (within-group) connections than external connections to other groups. To test this, we relied on Krackhardt and Stern's (1988) External-Internal index (E-I index), defined as the number of ties external to the groups minus the number of ties that are internal to the group divided by the total number of ties. Essentially, the E-I index measures the group embeddedness on a scale from –1 (all ties are within

the group) to +1 (all ties are with external members of the group). We used UCINET to calculate the E-I index for Wellman's network.

We found that for the two largest groups, Internet society and social network analysis, their group-level E-I indexes are close to 0, indicating that there are almost as many external connections as internal (see Table 2). This suggests a considerable overlap between the groups. As for the four smaller groups, their E-I indexes approach 1, which means that their members have substantially more external connections than internal ones—a clear sign of a significant overlap between these groups.

In sum, Wellman's mutuals are clustered based on their research interests. However, the E-I indexes show a considerable overlap between the clusters. These intergroup connections are partially explained both by the ease of communicating with others on Twitter and by the close relationships between the research areas in which Wellman's mutuals are interested. As a result, people who are interested in one area are also likely to be interested in another, creating a favorable environment for many intergroup connections.

2. *Influence*. The next step is to confirm that online participants in this community can and do influence each other. And because it has been shown that strict counting of followers by itself is not a good indicator of user's influence on others in terms of engaging the audience (Cha, Haddadi, Benevenuto, & Gummadi, 2010), we decided to use retweeting behavior as an indicator of influence in this community and count how many tweets are being retweeted by other members of this community.

In Section 4.2, we showed that there is a high percentage of retweeted and conversational-type messages being exchanged within this group, suggesting that the participants do influence each other. To investigate the retweeting behavior of this community even further, we collected and manually evaluated a small sample of tweets that were first posted by Wellman and were then retweeted by others. The sample consisted of 52 messages posted between February 16 and March 16, 2010. In total, Wellman's messages were retweeted 76 times. Although most of the messages were retweeted just once, 21% (11) messages were retweeted at least twice.

Out of the 52 retweeted messages in the sample set, about one-quarter (13) came from people that Wellman was following, with many of those messages (9) originating from one of Wellman's mutuals. Although this is a relatively small sample, it does suggest that Wellman's followers do influence what he—and subsequently others in his community—read and find interesting.

Out of the 62 people who retweeted Wellman, only 17% (11) were also mutual followers. This means that nonmutual followers are about 6 times more likely to retweet Wellman's messages than are his mutuals. At first glance, this seems to go against our previous observation about within-community influences. But the 6:1 ratio does not contradict our previous observation. This is because there are 12 times as many nonmutual followers in Wellman's network as there are mutuals. So, this means that if there are absolutely no differences in influences between nonmutual and mutual followers, then nonmutual followers should have been 12 times more likely to retweet Wellman's messages than his mutual followers. But this is not the case: They are only

6 times as likely. This means that per capita, Wellman's messages are twice as likely to influence the mutual members of his personal Twitter community.

3. Integration and fulfillment of needs. To check for whether Twitter fulfills needs and provides social cohesion, we conducted a content analysis of 600 tweets, a subset of our larger sample of Wellman's tweets described in Section 4.2 that covers messages posted between April and August 2009. Specifically, we looked for instances where network members provided support or were supported by other members. We found many messages that volunteer useful information to others, often in the form of URLs to external sites or articles. For example, 35% (195) of 600 tweets in the sample included a URL. This suggests that people rely on Twitter not only to connect to other people, but also to connect to information. This is in line with previous research on online communities (e.g., Burnett & Buerkle, 2004; Wellman et al., 1996) that demonstrated how access to information is one of the most important reasons for people to join and stay in an online community. As Ridings and Gefen (2004) pointed out, information can be seen as "a valuable currency or social resource in virtual communities" (n.p.), just as in any other community. But given the nonphysical nature of virtual communities, for some, the "primary significance of virtual communities is the fact that they function for their members not only as social settings, but as 'information neighborhoods'" (Burnett, 2000, n.p.).

Another common example of messages when a user provided or asked for help is a question-answer type of tweets. In our sample of 600 tweets, we found that 11% (68) of tweets were questions and that 12% (74) were replies.

A relatively high saturation of question-answer type tweets in a medium that was not originally designed for such interactions clearly demonstrates that members of Wellman's community are comfortable with asking for and providing help, confirming McMillan and Chavis's third requirement.

4. Shared emotional connection. In addition to offering information access and exchange, online communities establish emotional connections among members (see, for example, Bastani, 2001; Hiltz & Wellman, 1997). According to McMillan and Chavis (1986), having shared emotional connections means having shared common places, spending time together, and having similar experiences.

Based on the content analysis of the 600 tweets described above, we conclude that this community exhibits instances of shared emotional connections among the members.

Humorous exchanges (more than 5% of all messages) are also important in forming stronger social connections (Braithwaite, Waldron, & Finn, 1999; Maloney-Krichmar & Preece, 2005). For example, Baym (1995) showed that humor helps to create group identity and solidarity. Below is an example of a humorous tweet:

> RT @jessehirsh Saw Google Street View car breaking the Highway Traffic Act going the wrong way on a 1-way street. Wellman: [Google's motto is:] Do no harm, except . . .

Finally, there were many tweets suggesting that two or more members visited common places and spent time together, mostly when attending a conference. For example, the following message posted by Wellman indicates that four people from Wellman's community attended the same conference (#ir10—refers to the 10th conference on Internet Research):

> Sounds like #ir10 was a great vector for the flu @GERALD @STACY @NICK @JOE

The three examples above strongly suggest the presence or development of shared emotional connections in this group. This can be explained by the fact that many members had already known each other prior to joining Twitter. Some of them are friends or coauthors in the real world. As a result, Twitter connections in Wellman's community often represent preexisting relationships between people.

This is supported by our finding that Wellman's self-reported friends are more likely to be connected to each other than to nonfriends. We confirmed this using a standard statistical test. For this test we used Wellman's manual ranking to divide 56 members in two groups: 29 friends and 27 nonfriends. Then we used UCINET to calculate the E-I index described above for these two groups.

The resulting index of –.13 shows that there are more connections within the groups than across the groups. This is statistically significantly at less than .02. Furthermore, when we calculated the group level E-I indexes, the value for friends dropped to –.25 and the value for nonfriends went up to .04. This indicates that Wellman's friends tend to be connected to other friends within groups, but for nonfriends, the number of internal and external connections remains about the same.

Our findings here are important in two ways. First, because Wellman's friends are more likely to be connected to other friends, their relationships are more likely to contain preexisting shared emotional context, thereby confirming the fourth requirement of shared emotional connection. But this fact does not seem to make "nonfriends" feel more isolated because they are as equally connected to Wellman's friends as they are to his nonfriends. From our perspective, this is a good model to follow when organizing an online community: Identify a core-set of more closely related individuals who are holding the community together but are also linked to others, so that newcomers both feel welcome and feel they can easily create connections to members in the core.

5. Conclusions

An "imagined" community on Twitter is dual-faceted. It is at once both collective and personal. It is collective in the sense that all tweeps belong to the worldwide set of tweeps who understand Twitter's norms, language, techniques, and governing structure. Moreover, almost all tweeps' pages and messages are reachable—and hence readable—except for a small number of partially locked private pages. Yet community

on Twitter is also personal because tweeps imagine they are following and talking to unique and identifiable tweeps.

The collective Twitter community forms around high centers that are popular individuals, celebrities, or organizations such as media companies. Yet even less popular individuals on Twitter can play the role of local high centers of predominantly mutual networks. The high centers in personal Twitter networks are often characterized by high betweenness centrality: a social network analysis measure that indicates how many times an individual appears on the shortest path between all possible pairs of people in the network. Because tweeps with high betweenness centrality link different social circles, they play a critical role in community building and information gatekeeping on Twitter.

The analysis of one of these personal Twitter networks—Barry Wellman's personal network of mutual followers—reveals that such a personal community can be a somewhat interconnected network where some members form closer relationships between themselves. In our analysis of Wellman's community, we confirmed that his personal Twitter network is more than simply "imagined." It exhibits characteristics of both Jones's "virtual settlement" and McMillan and Chavis's "sense of community." Using social network analysis and content analysis, we demonstrated that members of Wellman's personal community regularly meet, talk, provide support, and help each other on Twitter. The content and nature of their Twitter interactions suggest that they display a sense of belonging to parts of Wellman's network and that they have the ability to influence others in the network through their replies and retweeting.

Thus, Wellman's Twitter network is both real and "imagined." It is real because the participants interact, especially the mutuals. It is imagined because they have some sense of community, of interpersonal commitment. This is profound because, as far as we know, Twitter was not originally designed as a tool to support the development of online communities. It was imagined as a simple tool to share updates with others on the Internet by answering a simple question: "What are you doing?" (which was amended in late 2010 to "What's happening?"). Therefore, Twitter is a good case to understand how people integrate information and communication technologies (ICTs) to form new social connections or maintain existing ones. This finding expands Honeycutt and Herring's (2009) and boyd, Golder, and Lotan's (2010) work that showed Twitter is being used for collaboration and conversations despite being originally designed as a broadcasting platform for diffusing information (including advertising).

Our study of Wellman's Twitter community may also aid in developing theories of online community building. Our study provides at least two possible reasons for why Wellman's online network has grown while maintaining a sense of community. First, the presence of a core set who actively interact with each other and participate in the community for a long time is one of the keys to building a successful online community. Individuals who form this core group likely joined this community because it promised an easy way to follow their friends or colleagues. From analyzing their tweets and from interviewing Barry Wellman, we found that these

individuals do not just rely on Twitter to keep in touch with each other: They also keep in touch by using other forms of ICTs as well as by meeting in person. This is in line with Haythornthwaite and Wellman's concept of media multiplexity (Haythornthwaite, 2001; Haythornthwaite & Wellman, 1998), according to which people with stronger social connections tend to communicate using more communication channels.

The second possible reason for the success of Wellman's community is that it is open to newcomers. This openness is made possible by Twitter's asynchronous method of making connections to other tweeps. Any tweep can start following any other tweep without requiring the other tweep to follow them back. In this community, tweets from newcomers are often responded to, making it easier for them to get connected. This atmosphere can be in part explained by the trust, professionalism, and informality among the active mutuals.

Not to be too congratulatory, we note that our portrayal of a Wellman-centric world is as misleading as it is useful. To foster analysis, we have looked at the world according to Wellman. But a somewhat similar network containing many of the same ties could be created for steve3034 or cyberpsy, and so forth. But the world according to steve3034 would not contain all—or even most—of the world according to Wellman. This is how information flows, as steve3034 retweets or replies to Wellman: The tweet shows up in both of their personal Twitter networks.

In this way, weak ties become strong ties, and both weak and strong ties convey information—and connectivity—to and from other social circles. In such a way, Twitter links Benedict Anderson's concept of imagined communities and Mark Granovetter's concept of "the strength of weak ties" (1973). Indeed, Twitter turns out to be an implementation of the cross-cutting connectivity between social circles that 19th-century sociologist Émile Durkheim (1893/1993) argued was the key to modern solidarity.

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