Detection of Power User Patterns Among High School Students in a Mobile Communication Network

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Abstract

Diffusion of innovation has recently received much attention from both practitioners and scholars of many different disciplines. In this study, we report initial results studying a mobile communication network. We have analyzed communication data gathered from 15 high school students using different mobile phone services, applying methods of social network analysis based on TeCFlow (Temporal Communication Flow Visualization). We tentatively conclude that the network positions of individuals and their usage patterns are important variables influencing the pattern of diffusion. In particular, more central position in the mobile communication network is found to be correlated to the early adoption of new services. An early adopter's usage pattern of the new service is also found to be an important influencing factor on the adaptation behavior of other individuals who are communicating with the original individual.

1. Introduction

This paper analyzes the process of how innovations are adopted by lead users (von Hippel, 2005). We study how new services are first accepted by innovators – the "power users." Those power users are critical for the diffusion of innovations, to overcome the tipping point and being accepted by larger user groups (Gladwell, 2001). In particular, we look at how new services offered by providers of mobile phone services spread out among a community of users.

The diffusion literature has developed across a number of disciplines to explain the flow of new ideas and practices and the adoption of new products and services throughout a social system (Gatignon & Robertson, 1985). The diffusion process consists of four key elements: an innovation, the social system on which the innovation impacts, the communication channels of that social system, and time (Rogers, 2003). Of these elements, diffusion theory's main focus is on the means by which information about an innovation is disseminated within the social system. The influence of interpersonal communication, including nonverbal observations, is seen as a key factor accounting for the speed and shape of the diffusion pattern. Therefore the main question we want to explore in this paper is how interpersonal communication relates to the diffusion of innovation in a social network.

For our analysis we are using the TecFlow software tool (Gloor et. al. 2003) that enables the longitudinal representation of social network data. We were able to establish a method that can represent the spread of the new service usage across the network of individuals and services. We also used conventional methods of social network analysis such as centrality measures (Wasserman&Faust, 1994). This multi-method approach enabled us to look at the diffusion network more carefully, and led us to several interesting findings.

We are analyzing a dataset gathered from high-school students. These students were equipped with free mobile phones and free services, in return they agreed to share their communication records (Schnorf, 2005). Out of 17 students who were handed out free mobile phones, 15 were active users, i.e. they used their devices to send and receive message. Two students only received messages. The communication data of the 15 active subjects were gathered during a period of six months in 2004 (Figure 1).

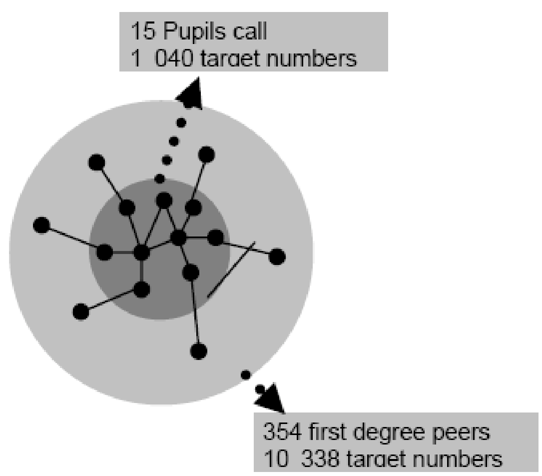

Figure 1. Data structure

We started by looking at the representation of the total communication network to see if there is an aggregate effect of heterogeneous communication types. Figure 2 represents the network diagram of several different communication types such as voice, SMS, MMS, VAS, and GPRS[1].

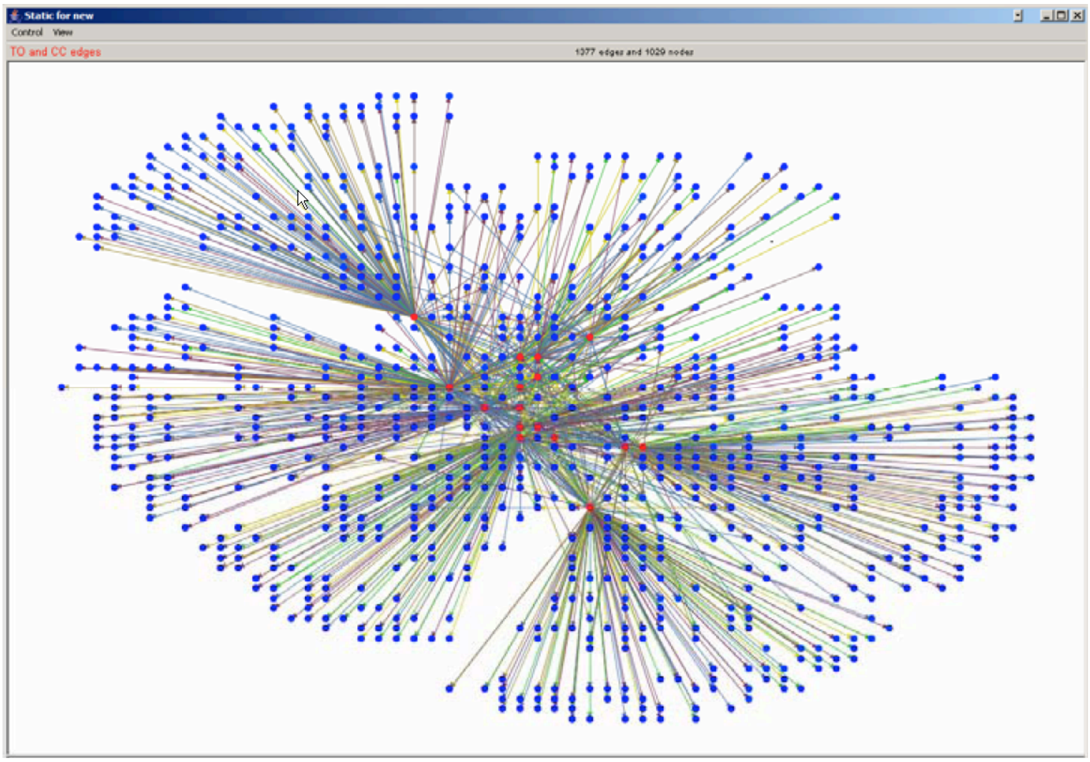

Figure 2. Network representation of heterogeneous communication flows

Using TecFlow, we created dynamic movies of the overall network diagram. Unfortunately, both the static and dynamic diagrams did not produce recognizably distinct significant patterns. Simply speaking, the diagrams were too complicated to find meaningful results merely by looking at it.

We therefore used a more sophisticated two-step approach to discover the diffusion patterns. First, we looked at the usage pattern of existing services representing the communication flow among the subjects, and tied it to the usage pattern of the new services. By focusing on the communication network, we identified the key individuals positioned in the center of the social

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[1] SMS – Short Message Service, MMS – Multimedia Messaging Service, VAS – Value Added Service, GPRS – General Packet Radio Service (wireless standard for delivery of data).

system. Second, we examined the usage pattern of new services separately by looking at the individuals and their usage of the new services within the same time interval. This was only possible because TecFlow allowed us to examine the longitudinal changes of the network structure over time. At the end of these two steps, we aggregated the data and searched for patterns worth examining in the subsequent analysis.

2. Existing Services vs. New Services

The first part of the data analysis was done comparing the usage of existing services and new services. We started by looking at the usage of existing services. Figure 3 displays the amount of communication sent and received by the students. Students number 9, 13, and 17 clearly stand out in terms of the amount of usage.

The network representation of the communication pattern is shown in Figure 4. An important result from this diagram is that there are people who are central in this network and people who are engaged in boundary spanning communication connecting the target students with the outside. Because we do not have data about the external communication, we will now focus on communication patterns within the group of 17 students.

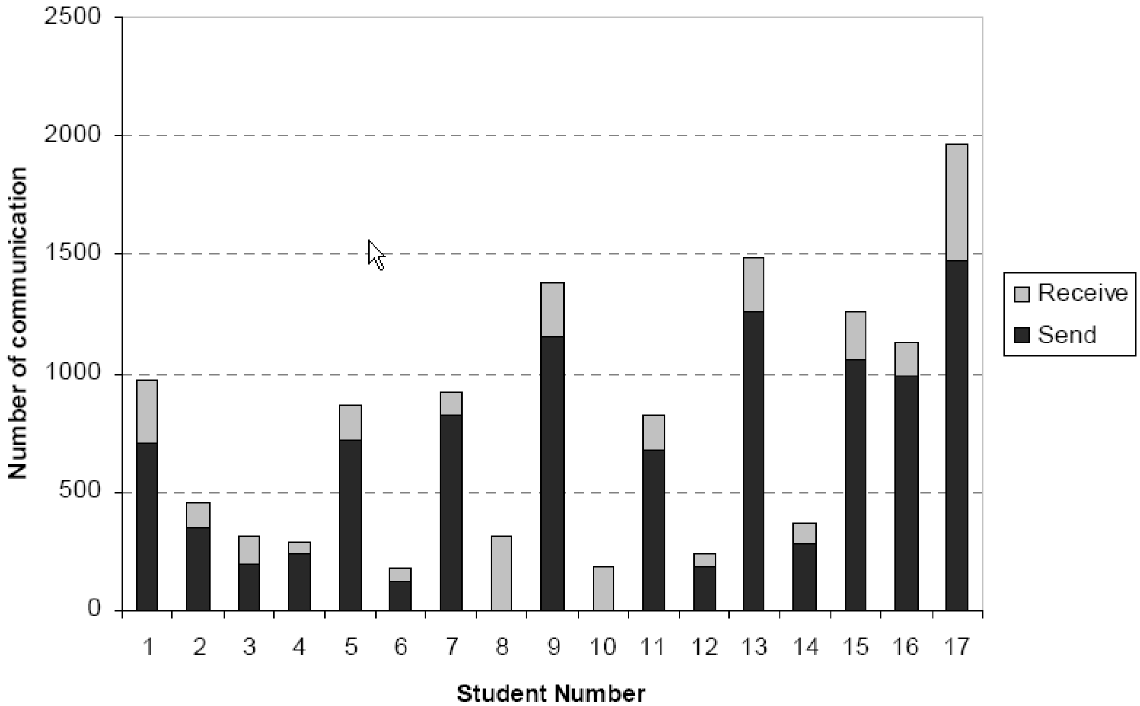

Figure 3. Usage of existing services among 17 target students

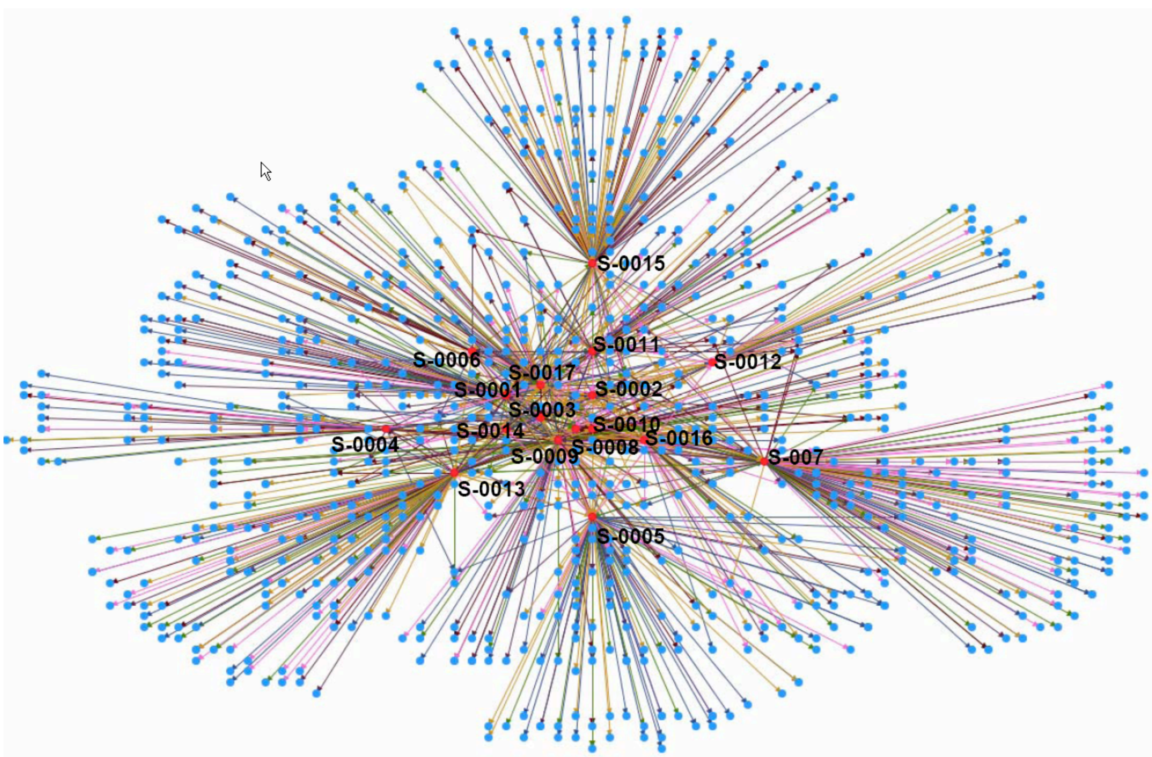

Figure 4. Representation of communication network

The network diagram shown in Figure 4 is simplified in Figure 5. Obviously there are students who are at the core of the communication network, and students who are positioned at the periphery of the network. Since our focus here is to look at the diffusion of innovation among the 15 active students, boundary spanning communication means that people at the periphery are better connected with people other than the target students.

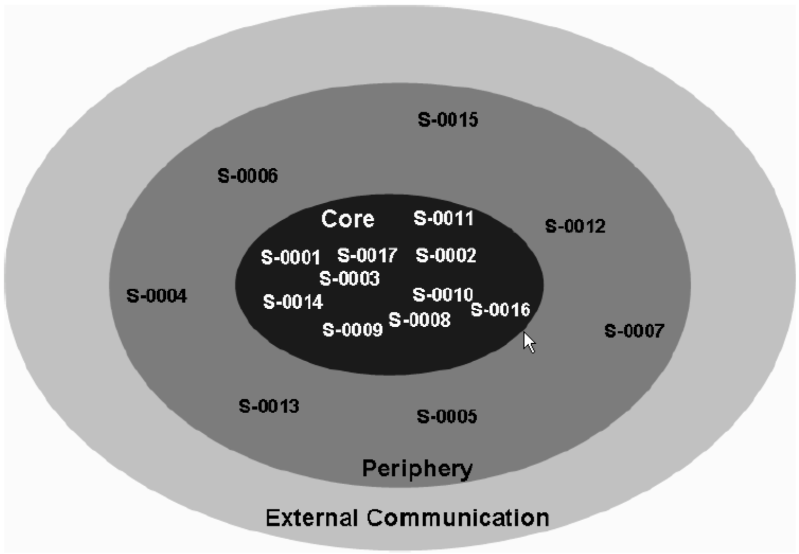

Figure 5. Simplification of communication network

We speculate that boundary spanners are crucial for the diffusion of the new services. As the 15 active students are allowed to use the new services without having to pay for it, boundary spanners connecting to outside users influence the usage behavior of those outside users who have to pay for these services. On the other hand, we can speculate that the students at the periphery are less influenced in their usage of novel services by the core users. Additional qualitative data such as interviews or surveys are needed to further investigate this hypothesis.

We now focus on the communication network without external communication. External communication is defined as communication between the 15 target students and non-target individuals. By looking at the communication network without the external communication (Figure 6), we can identify the individual's position among the target students without the effect of boundary spanning communication. The upper left corner of figure 6 shows the contribution index. The lower right corner of figure 6 displays the temporal centrality plot. The contribution index is part of the measurement that TecFlow provides. It is defined as follows.

$$\text{Contribution Index (CI)}^{[2]} = \frac{\#messages\_sent - \#messages\_received}{\#messages\_sent + \#messages\_received}$$

We then plotted the contribution index against the total number of messages sent and received by each participant. The information the CI is carrying confirms the findings of figure 3. The difference is that the CI plot in the TecFlow shows each individual and their changes in contribution index over time dynamically.

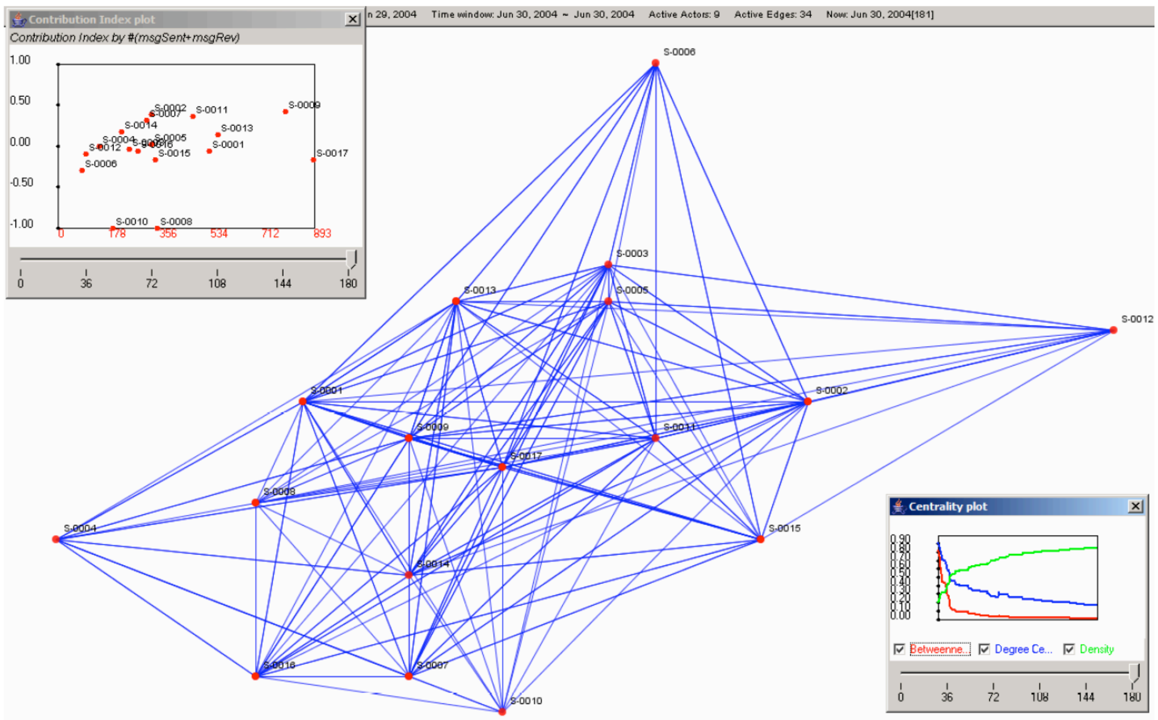

Figure 6. Communication network of 17 target students

Figure 7 shows the simplified version of Figure 6, underscoring the core-periphery positions of individuals in the network (Lakhani, Karim & von Hippel, 2003), and Figure 8 illustrates the changes in network position of individuals if external communication is removed.

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[2] The contribution index is +1, if somebody only sends messages and does not receive any message. The contribution index is –1, if somebody only receives messages, and never sends any message. The contribution index is 0, if somebody has a totally balanced communication behavior, sending and receiving the same number of messages.

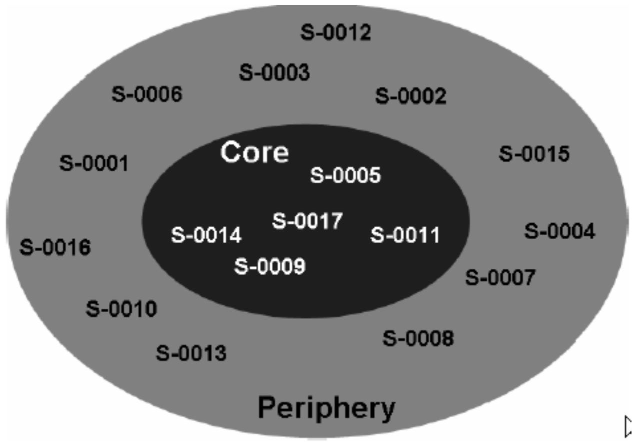

Figure 7. Simplification of communication network without external communication

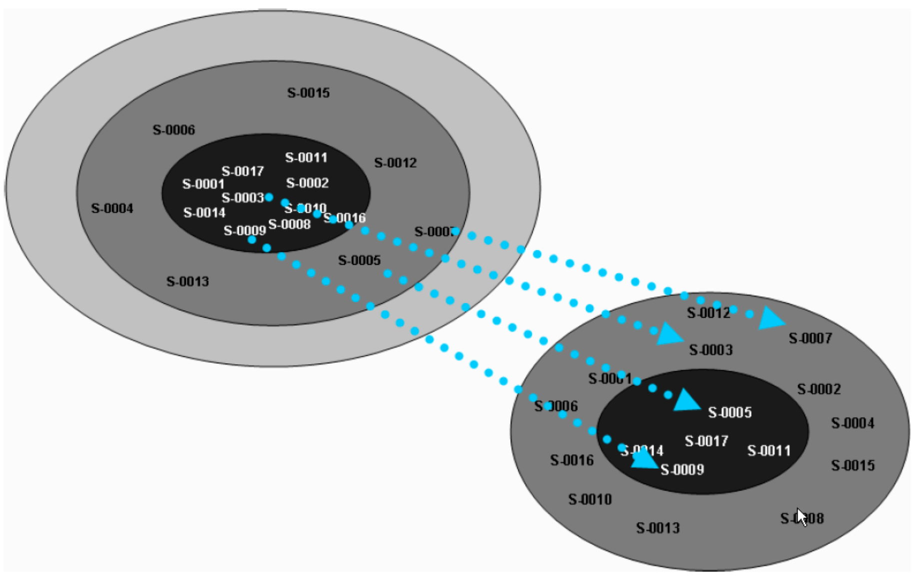

Figure 8. Juxtaposition of communication networks with/without external communication

The most important findings from this juxtaposition in figure 8 is that people who were at the core in the communication network with the external communication becomes peripheral members, and vice versa. There are also people who maintain their core respective periphery position with or without the external communication. For example, student number 3 (S-0003) was at the core in the network with external communication, but S-0003 becomes a periphery member in the network with only target students. This means that he/she might be less affected by the communication that is happening among the 15 users of new services. He/she might not be able to get the information about the novelty and attractiveness of the new services.

3. Adaptation Patterns of New Services

The cumulative usage pattern in figure 9 shows a weak S-curve at the early stage of the data gathering period. Since we only have data for 6 months of usage and the sample size is small, it is very difficult to generalize this finding to conclude that the adoption of new services follows the traditional S-curve. In this preliminary analysis we found that the usage of new services was constantly increasing with little fluctuation over time.

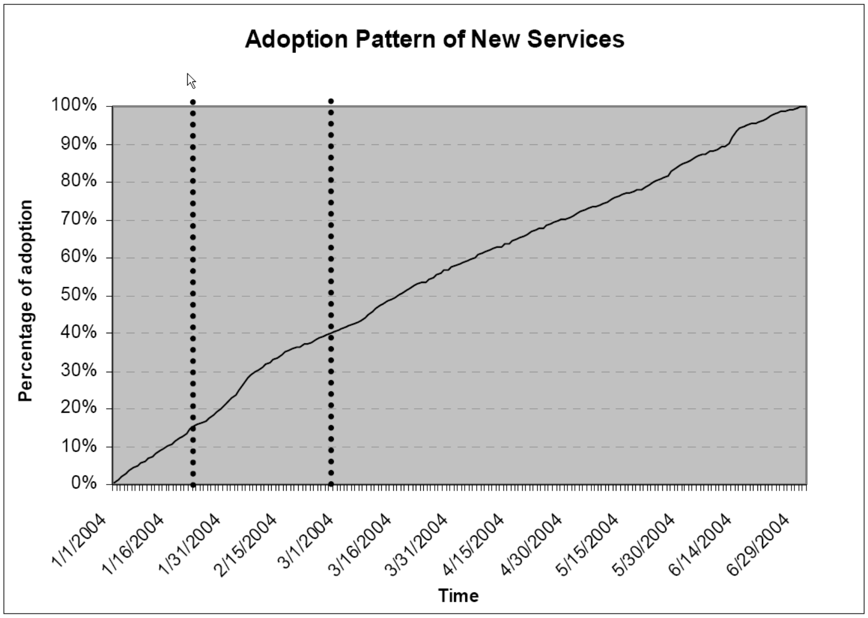

Figure 9. Adoption pattern of new services

Figure 10 shows the usage of new services such as VAS and GPRS among the 15 active target students. S-0003. S-0009, and S-0017 clearly stand out as heavy users of the new services.

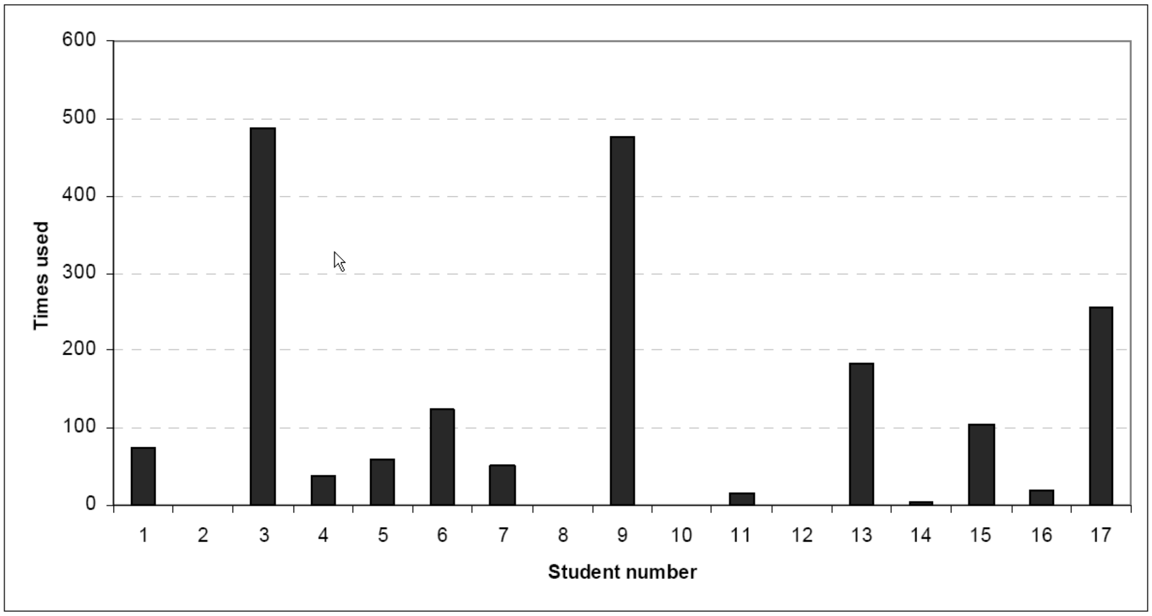

Figure 10. Usage of new services among 17 target students

This finding becomes even clearer if we plot the usage of new services over time. Figure 11 shows the different usage patterns over time. The main result from this analysis is that students not only use different amounts of new services, but they also differ in their pattern of usage. For example, S-0009 used the new services heavily and continuously, while S-0017 used the new services discontinuously. S-0009's usage pattern is spread out in time, while S-0017's usage pattern is concentrated.

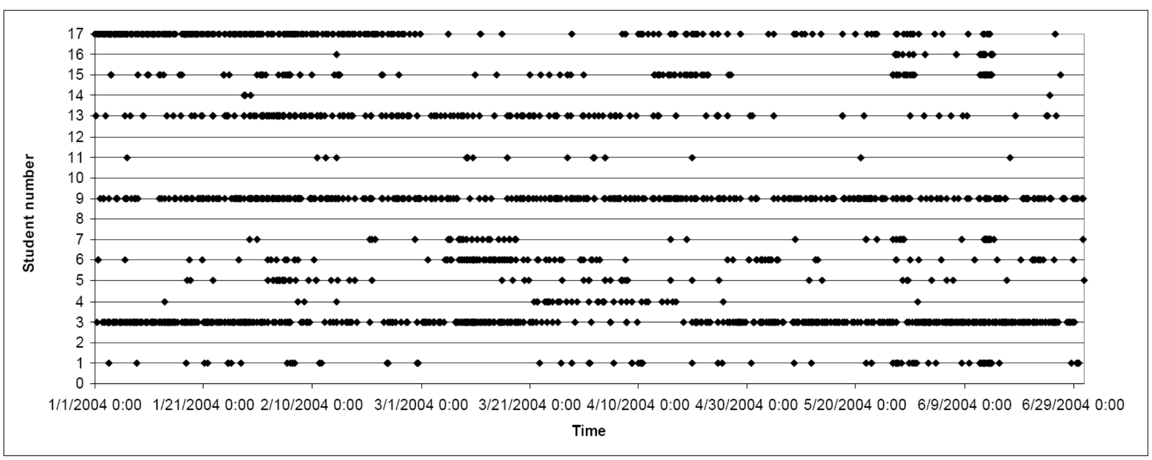

Figure 11. Usage pattern of new services over time

This finding has a very significant meaning for the entire data analysis because the person who uses the new services in a dispersed way can be seen as the person who can influence others. These people have higher chances of developing their own opinion of the services and influence other people's usage. The chance for other people to see the usage of new services is also higher for people who use the services continuously. But if one uses the new services not so heavily, the effect of using them in a dispersed way might give away this influencer effect. In a marketing context, persons who use new services heavily and continuously are a very important target to identify and manage.

Student Number	Communication Usage (Voice and SMS)			Position in the Total Communication Network	Position in the Peer Communication Network	New Service Usage	New Service Usage Pattern	VAS Service Usage	VAS Service Usage Pattern	GPRS Service Usage	GPRS Service Usage Pattern
	Send	Receive	Total								
1	709	263	972	Core	Peripheral	75	Light-Dispersed	6	Light	69	Medium
2	351	102	453	Core	Peripheral	0		0		0	
3	191	128	319	Core	Peripheral	486	Heavy-Dispersed	0		486	Heavy
4	235	56	291	Peripheral	Peripheral	38	Light-Concentrated	1	Light	37	Light
5	713	155	868	Peripheral	Core	60	Light-Dispersed	18	Medium	42	Light
6	120	57	177	Peripheral	Peripheral	124	Light-Concentrated	3	Light	120	Medium
7	822	92	914	Peripheral	Peripheral	51	Light-Concentrated	26	Medium	24	Light
8	0	313	313	Core	Peripheral	0		0		0	
9	1154	229	1383	Core	Core	477	Heavy-Dispersed	40	Heavy	431	Heavy
10	0	187	187	Core	Peripheral	0		0		0	
11	673	149	822	Core	Core	16	Light-Dispersed	3	Light	13	Light
12	182	54	236	Peripheral	Peripheral	0		0		0	
13	1256	231	1487	Peripheral	Peripheral	184	Light-Concentrated	16	Medium	164	Medium
14	284	86	370	Core	Core	4		0		4	Light
15	1060	195	1255	Peripheral	Peripheral	105	Light-Dispersed	3	Light	102	Medium
16	985	145	1130	Core	Peripheral	20	Light-Concentrated	2	Light	18	Light
17	1481	489	1970	Core	Core	257	Heavy-Concentrated	14	Medium	238	Heavy

Table 1. Detailed activity summary of all students

Table 1 summarizes our statistical findings on the usage of new services. S-0003, S-0009, and S-0017 stand out from others. In spite of using communication methods such as voice and SMS very heavily, S-0015 and S-0016 did not use the new services heavily. On the other hand, not only did S-0009 and S-0017 use both existing and new services heavily, but they also were the ones that were at the core of the network both with and without the external communication network.

S-0003 also looks interesting. He/she was at the periphery of the peer network (without external communication), but demonstrated heavy use of GPRS. We can speculate that a difference between VAS and GPRS might be that anybody can get on to the Internet without influence to/from others, whereas people have to discover the novelty and attractiveness of new VAS services by observing others using it or getting recommendations. At this time, this is just speculation, but the clear difference in network position and communication pattern between S-0003 and the other heavy users of new services is worth further investigation.

4. Adaptation of VAS (Value-Added Services)

In this section we thoroughly examine the usage of one of the new services – VAS. There are VAS of many different types and contents of services ranging from weather forecasts to score reports of soccer matches. Our assumption is that others who are already using it will affect the further adoption of VAS. On figures 12 and 13 we see that S-0009 clearly stands out. He/she not only has a pattern of heavy usage, but also does so in a dispersed way. In comparison, S-0007 who is the most heavy user of VAS, does so in a concentrated fashion.

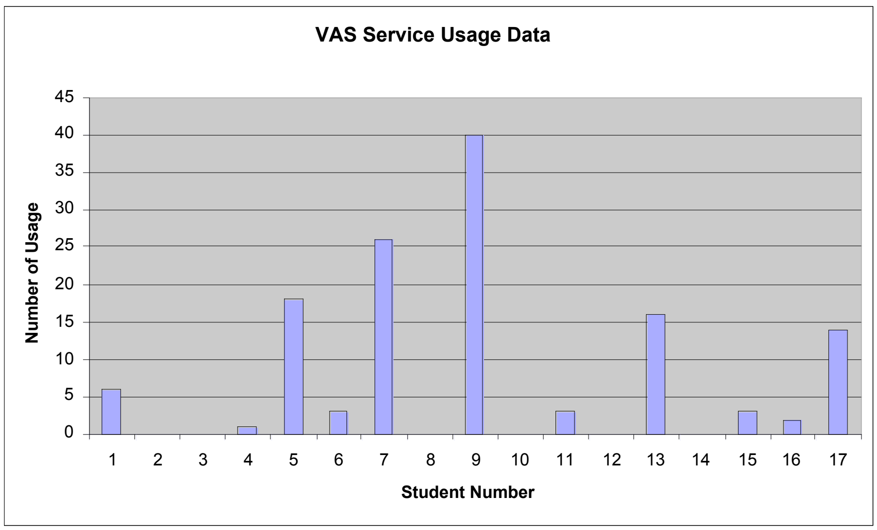

Figure 12. Usage of VAS among 17 target students

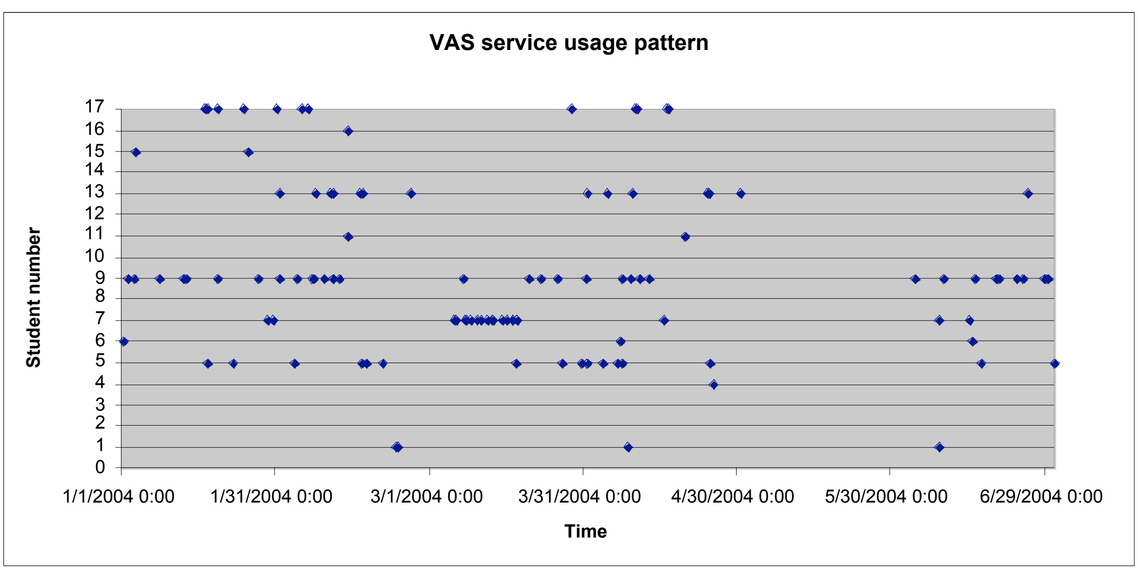

Figure 13. Usage pattern of VAS over time

Figure 14 is the most interesting picture of our initial data analysis of diffusion of innovation. This dynamic diagram shows students and services in the same bipartite dual-mode graph, while capturing their interaction over time. The diagram itself can conceptually be divided into two parts. The left side is dominated by S-0009, who is using many different VAS services. VAS services that are marked with the dotted square are the ones that S-0009 adopts first, while the rest of the students (on the right side of the diagram) follow his lead. Services marked with the dotted circle represent the ones that are used by others first, and then adopted by S-0009.

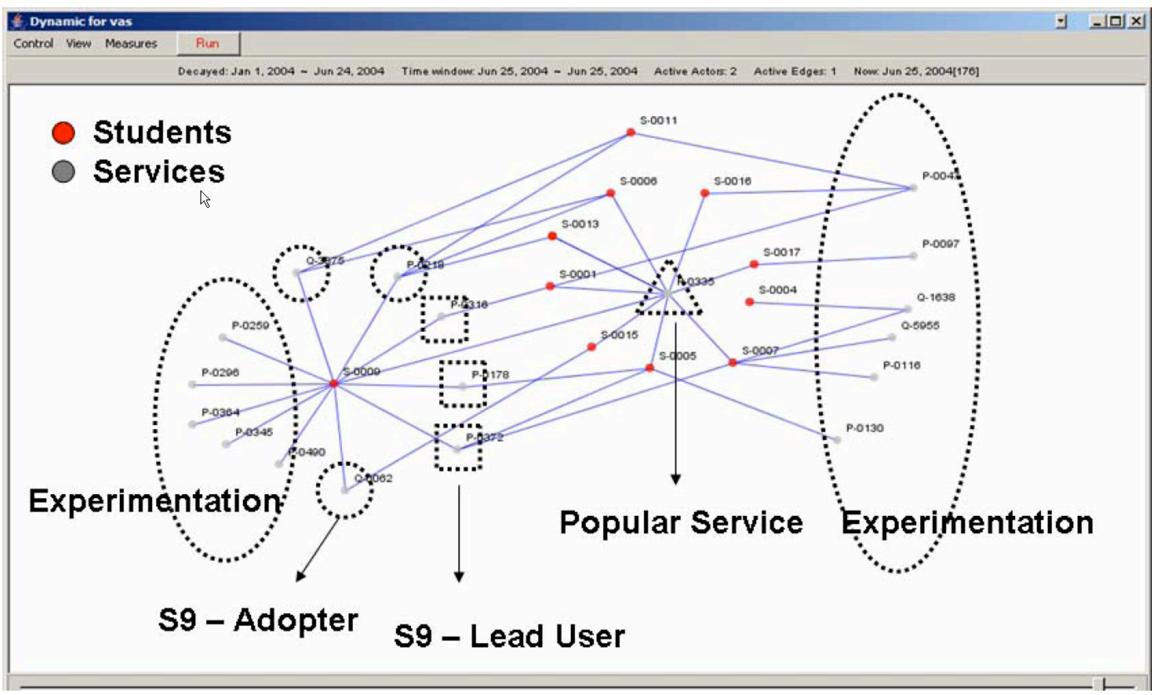

Figure 14. Dynamic representation of VAS usage pattern over time

The right side of the diagram shows how the service P-0335 is used by many different students including S-0009. P-0335 is a very popular service that almost all the subjects have been using. The dotted ovals represent new services that single students are experimenting with. Some of the services are adopted later by other students. This experimentation done by different students shows the same general pattern of diffusion and adaptation of new services as exemplified by power user S-0009.

The dynamic representation of figure 14 clearly shows the dominance of S-0009 in the adoption of new VAS services. Table 1 confirms that S-0009 was at the core of the communication with and without the external communication, and is a continuous user of the new services.

5. Conclusions and Future Research

This empirical paper concentrated on the analysis of a complex and heterogeneous network of mobile phone users. The core-periphery argument in this report should be reexamined, incorporating more measures from social network analysis. Rigorous statistical analysis of a larger sample will be required to prove the general validity of our preliminary results.

Despite limited statistical evidence, this paper reports two very interesting findings. The first one is that the network position plays a very important role in the adoption of new mobile phone services. The second finding is that the usage pattern (concentrated vs. dispersed) might be an important explanatory variable for the adaptation behavior. It can also be used to identify the key actors in the diffusion network. The crucial role of continuous users is speculated to be an important factor for the spreading of new services through interpersonal communication. These two preliminary results matter not only from a research perspective, but also for practical purposes. If we can identify and optimize diffusion and adaptation patterns, we can increase the chances of success for new products and services in the market.

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