Influence of new mobile tools on communication

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ABSTRACT

With the advent of such new communication tools as cellular phones and the Internet, communication styles have diversified. This diversity has brought changes in community formation as well as such serious problems as network addiction and mutual distrust among users. The purpose of this study is to find clues to these problems produced by those new communication tools. Thus, we focus on the diffusion of cellular phones and simulate a community-forming mechanism to clarify the influence of mobile tools on community formation. We propose a model for cellular phones as mobile tool and represent a community by a communication network using Heider's theory of "The psychology of interpersonal relations." The results of the simulation confirmed the propriety of this proposed model. In addition, we simulated the formation of a community to clarify the relationship between the diffusion of mobile tools and the community. This experiment reveals the useful results about effect of mobile tools to communication and community that will be applied.

Keywords: Multi-Agent Simulation, communication, network model, social society

1. Introduction

Recently, communication styles have diversified due to the development of such new communication tools as cellular phones and the Internet. This rapid change of communication styles is influencing community formation. However, such serious problems as network addiction and mutual distrust among users are increasing in scope and severity.

This study clarifies the relationship between the new communication tools and community formation to find clues to various problems produced by those new tools. We form a community model and simulate a community-forming mechanism. We then evaluate the process of creating a network and the features of that network to analyze the resulting community. Following that, we evaluate the influence of new communication tools on community formation. To analyze this influence, we focus on the diffusion of cellular phones, the mobile tools in question..

2. Proposed of Simulation Model

This section includes a description of the proposed simulation model for community formation. First, we present the model of the community, followed by details of models for messages, mobile tools, and communication.

2. 1. Network Model of Community

Through communication, people exchange opinions, and often change their attitudes to reflect such obtained information and opinions. Continual communication gives rise to various types of relationships such as friendship or hostility between people, and through communication people form communities. In this simulation, a network approach is employed where people are nodes (agents), relationships are links, and a community is a network .

2. 1. 1. Agents

In the case where there are n people belonging to the community, we describe each person as an agent $a_i \quad (i = 1,2,\ldots,n)$. During a conversation, we might talk about a specific subject such as soccer or music and so on. In this simulation, we describe each subject that could be a topic of conversation as s_k . Each agent a_i has a remark r_{ik} to the subject s_k , which represents "likes" or "dislikes. " The remark r_{ik} takes a real number as follows:

$$-1 \le r_{ik} \le +1 \tag{1}$$

When the value of remark r_{ik} is 0, agent a_i shows no interest in subject s_k , and the closer the value is to 1, the friendlier the opinion; on the contrary, the closer it is to -1, the more negative is the opinion. If the number of subjects is d , a set of subjects are described as a d dimensional vector $\mathbf{s} = [s_1, s_2, \ldots, s_d]$, and the remarks of agent a_i to the set of subjects are described as vector $\mathbf{r_i} = [r_{i1}, r_{i2}, \ldots, r_{id}]$. We can assign a concrete subject such as "soccer, " "music" and so on to each s_k . However, in this simulation, we do not give a specific

meaning to each subject.

2. 1. 2. Links

We describe a relationship between an agent a_i and an agent a_j $(i \neq j)$ as a directed link L_{ij}. Each link has a weight (f_{ij}). The friendship f_{ij} represents the strength of feeling friendship from agent a_i to agent a_j, and it is a real number as follows:

$$-1 \leq f_{ij} \leq +1 \quad (i \neq j, (i, j) = 1,2,\ldots,n). \qquad (2)$$

The greater the value of friendship f_{ij} ,the better the impression of agent a_i to agent a_j, and a value of 0 means that agent a_i has no interest in agent a_j. The initial link L_{ij} is created after the first communication between agent a_i and agent a_j with the initial value 0.

2. 2. Model of Message

When agent a_i tries to communicate with agent a_j as a partner, agent a_i sends a message m_{ij} to partner a_j .The following subsection provides details of message m_{ij} .

2. 2. 1. Contents of Message

The message m_{ij} contains the following information.

a) topic t
b) opinion to the topic o

When we communicate, we might talk about not only a general subject like soccer or music, for example, but also a subject concerning a specific person in the community like gossip about another member or appreciation of a friend. In this paper, we suppose the agent selects a "subject" or an "agent" with a probability of 1/2. Then, if a "subject" is selected, the agent selects one subject s_k for a topic t from the set with a probability of $1/d$, and if that an "agent" is selected, the agent selects one agent $a_{k'}$ with a probability of $1/n$.

$$t = \begin{cases} \text{Subject } a_{k'} \text{ of set} & (1 \leq k \leq d) \\ \text{Agent } a_{k'} \text{ of community} & (1 \leq k' \leq n) \end{cases} \qquad (3)$$

The value of the above opinion o to the topic t is either the remark r_{ik} to the specific subject s_k or the friendship $f_{ik'}$ of the agent a_i to the specific agent $a_{k'}$.

$$o = \begin{cases} r_{ik} \\ f_{ik'} \end{cases} \qquad (4)$$

2. 2. 2. Intention and Gap of Message

Messages comprise three media: verbal, vocal, and facial. Mehrabian showed that the power of each effect of the three media on "the meaning of a message" is different[2]. "The meaning of a message" is represented by the following equation.

$$\text{The meaning of a message} = 0.07 \times \text{verbal} + 0.38 \times \text{vocal} + 0.55 \times \text{facial} \qquad (5)$$

Note that the verbal information is not necessarily transmitted exactly. Thus, we devide the opinion o into three media, verbal o_{verbal} , vocal o_{vocal} , and facial o_{facial} , and add noise to each of them according to the following equation. Adding noise means that there appears a gap between the true information of the opinion o and transformed information. Each value of the three opinions $o_{verbal}, o_{vocal}, o_{facial}$ is set as the following equation,

$$\begin{cases} o_{verbal} = o + c_{verbal} \times N(0,1) \\ o_{vocal} = o + c_{vocal} \times N(0,1) \\ o_{facial} = o + c_{facial} \times N(0,1), \end{cases} \qquad (6)$$

where $N(0,1)$ represents a Gaussian distribution, and $c_{verbal}, c_{vocal}, c_{facial}$ are noise coefficients of each opinion. Vocal and facial can provide more real intention unconsciously than verbal. Therefore, we set $c_{verbal} > c_{vocal} > c_{facial}$.

In this simulation, we set the value of each noise coefficient of the three media according to the power of each effect on the meaning of a message. The values are shown in Table 1.

Table 1 Noise Coefficients

	Effect on meaning	Noise Coefficient
Verbal c_{verbal}	0.07	0.93
Voice c_{vocal}	0.38	0.62
Facial c_{facial}	0.55	0.45

2. 3. Model of the Mobile Tool

2. 3. 1. Contents of a Message

Cellular phones have the following two features with respect to communication that face-to-face communication does not have.

Feature 1: Freedom from restrictions of place and time

When two persons try to communicate face-to-face, they have to share their place and time. Cellular phones, however enable persons in separate locations to communicate with each other, and those user can also send messages by e-mail to others without worrying about place and time. Accordingly, with cellular phones, people can be free from the restrictions of place and time.

Feature 2: Limitations of media

As mentioned before, the meaning of a message is influenced by information from each of the three media verbal, vocal and facial. However, cellular phones still experience limitations of media when transmitting a message. For instance, the telephone function cannot use verbal information, while e-mail, which is another function of cellular phones, cannot use vocal or facial information.

2. 3. 2. Models for Communication Tools

Cellular phones have two functions for sending messages, "phone calls" and "e-mail." In this simulation, we regard these two tools as individual communication tools. We focus on these two features and provide three models for them: face-to-face communication, phone call communication by a cellular phone, and e-mail communication by a cellular phone (Table 2.). Any communication tool that can make both phone calls and send and receive e-mail is treated as a "mobile tool."

Table 2 Features of Communication Tools

	Feature 1		Feature 2		
	Time	Place	Verbal	Vocal	Facial
Face-to-face	Restricted	Restricted	-	-	-
Phone call	Restricted	Free	-	-	x
e-mail	Free	Free	-	x	x

2. 4. Communication Model

One communication cycle between agent a_i and agent a_j is defined as several actions such that the agents exchange messages m_{ij} , m_{ji} , and change their friendship status according to information in obtained messages. The communication cycle is given below:

1. a_i : selects a partner a_j and a communication tool
2. a_i : creates a message m_{ij} and sends it to agent a_j
3. a_j : receives the message m_{ij}
4. a_j : changes the friendship f_{ji} to agent a_i according to message m_{ij}
5. a_j : makes a reply m_{ji} and sends it to agent a_i
6. a_i : receives reply m_{ji}
7. a_i : changes the friendship f_{ij} to agent a_j according to reply m_{ji}

At an initial communication, an agent selects a partner and the communication tool in the following two ways:

1) First, select a partner with high friendliness (friendship).
   Second, select a tool that enables the agent to communicate with the selected partner.
2) First, select a tool that is available to the agent.
   Second, select a partner with whom the agent can communicate by the selected tool.

Agents prepare 1) or 2) randomly; however, in the case where the agent can select neither a partner nor a tool by way of 1), the agent tries to select them by way of 2).

Heider's theory of "The psychology of interpersonal relations" [1]

In this simulation, friendship and attitude toward the partner are updated based on Heider's theory of "The psychology of interpersonal relations." The attitude of one person toward a subject is affected by the relations among the person himself (P), the subject (X) and the partner (O) of communication. Each of the three opinions PO, PX, and OX is expressed as "+" when favorable and "-" when unfavorable(Fig. 1.). When the sign of the product of these three opinions is positive, the relations preserve the balance. On the other hand, when the sign of the product is negative, the relations are out of balance. According to Heider's theory, when the relations are out of balance, the person tries to "change one's opinion to the object (PX)" or "change one's remark to the partner (PO)" to achieve the balance.

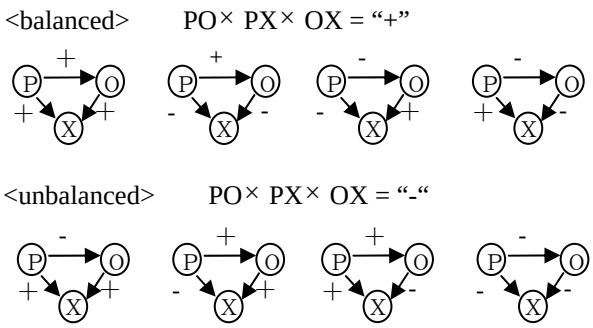

Fig. 1 Heider's theory of "The psychology of interpersonal relations"

In this simulation, the interpersonal relations are represented as follows.

PO : friendship toward the partner f_{ij}
PX : opinion on the topic $o^* = l_{ik'}$ or r_{ik}
OX : partner's opinion on the topic o'

The opinion of the message on the topic is assumed from the following equation.

$$o' = 0.07 \times o_{verbal} + 0.38 \times o_{vocal} + 0.55 \times o_{facial} \quad (7)$$

When the relation is out of balance, the agent changes either PO or PX to achieve it. In this simulation, even when the relation is balanced, the agent changes either PO or PX to try to strengthen the balance, because people tend to change their mind when they receive new information from the partner. In both of balanced and unbalanced cases, the agent changes PO or PX, whichever has the smaller absolute value, by the following equation,

$$\begin{cases} \bar{f}_{ij} = f_{ij} + w \times o^* \\ \bar{o}^* = o^* + w \times f_{ij}, \end{cases} \quad \text{In case of (a), (b), (e), (f) of Fig. 1.}$$

$$\begin{cases} \bar{f}_{ij} = f_{ij} - w \times o^* \\ \bar{o}^* = o^* - w \times f_{ij} \end{cases} \quad \text{In case of (c), (d), (g), (h) of Fig. 1.} \quad (8)$$

where w represents the rate of change, and $\bar{f}_{ij}$ and $\bar{o}^*$ respectively denote the changed values of f_{ij} and o^*.

3. Experiments

We simulate the formation of a community using our proposed network model, and evaluate the community created by this simulation based on the approach of social network analysis to clarify the influence of a mobile tool (cellular phone) on community formation. First , we confirm the validity of this model, then analyze the influence of the mobile tool on community formation.

3. 1.Verification of the Model's Validity

3. 1. 1. Purpose

In this experiment, we investigate that whether the proposed model can accurately reflect real society, and confirm the propriety of this model. To do this, we need to determine whether our model conforms to the rule of "interpersonal attraction" proposed in the field of psychology.

3. 1. 2. Criterion

"Interpersonal attraction" is a set of three factors that increase one's motivation to intimate a friendship with other person. These are:

Familiarity[3] : frequency of contact
Similarity[4] : similarity of attitude
Rewardingness[5] : being made to feel good

Thus, in the case where there are correlations between these three factors and the friendship in the community created by the model, we can reach the conclusion that the model is appropriate.

In the experiment, validity is evaluated using correlations between friendship f_{ij} and the following three values:

A Familiarity : the frequency of communication with a_j
B Similarity : the degree of similarity between opinions $\mathbf{r_i}$ and $\mathbf{r_j}$
C Rewardingness : the friendship f_{ji} from agent a_j

3. 1. 3. Simulation Conditions

In all experiments, agents are modeled as 100 students who start communication without any knowledge of other agents and communicate for 365 days to form a community. The number of subjects **s** is 40, the rate of change w is 0.1. These conditions are listed in Table 3.

Table 3. Conditions of the experiments

Number of agents	120
Number of subjects	40
Rate of change	0.1
Period of communication	365 days

Mobile-tool communications are not employed in this experiment because "interpersonal attraction" was proposed at a time when no mobile communication tools were available.

3. 1. 4. Simulation Results

Figures 2~4 show each relationships of the three factors of "interpersonal attraction" and friendship from the simulation results for 100 agents over 365 days.

A and friendship
B and friendship
C and friendship

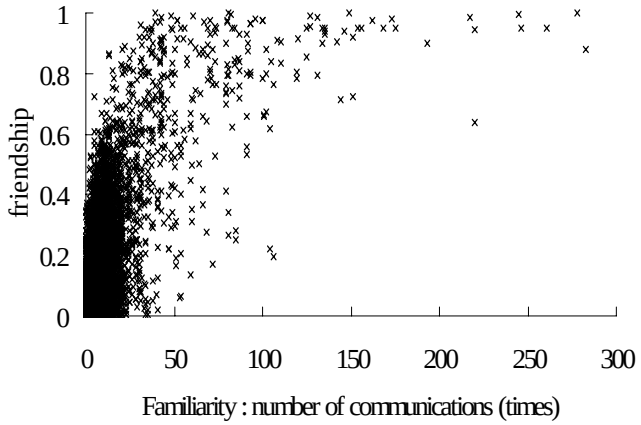

Fig. 2. Relationship between number of communications and friendship

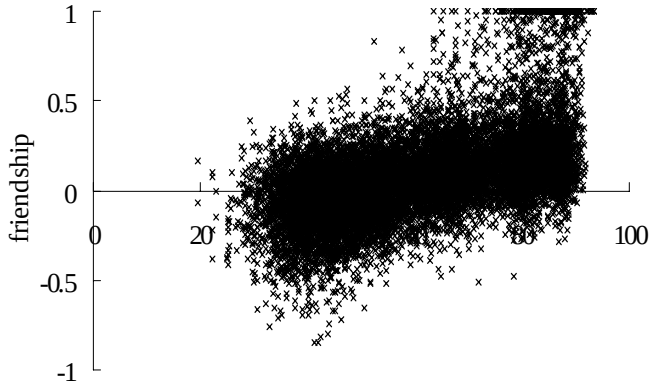

Fig. 3. Relationship between the degree of similarity of remarks and friendship

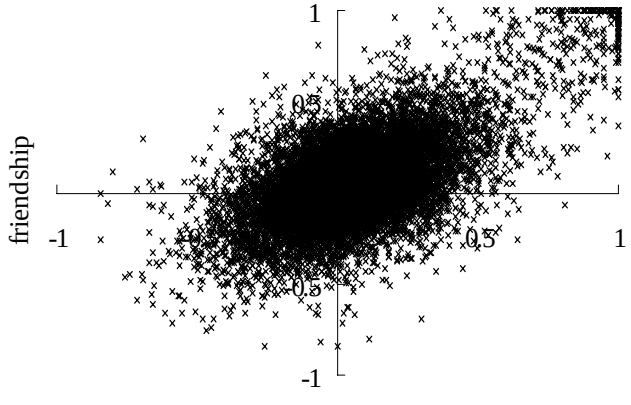

Fig. 4. Relationship between friendship from a partner and friendship

These three figures show that friendship increases with an increase of A, B and C. Therefore, we suggest that all three factors - familiarity, similarity, and rewardingness - have a positive correlation with friendship. Each correlation coefficient is found to be as follows:

Familiarity : 0.666
Similarity : 0.536
Rewardingness : 0.601

Since the three factors of "interpersonal attraction" correlate with friendship, it can be said that the strength of friendship is affected by these factors. Accordingly, it is reasonable to suppose that the communication model we propose is appropriate from the viewpoint of social psychology.

3. 2. Investigation of Effects on Human Relations

3. 2. 1. Purpose

In this experiment, we analyze the influence of the diffusion of the mobile tool on the relationship among agents by a simulation using the proposed model.

3. 2. 2. Criterion

In this experiment, we focus on the gap of the friendship that two agents have between each other to evaluate the influence of the diffusion of the mobile tool on the relationship among agents. As for the relationship between agent a_i and agent a_j, we define the "gap of friendship" as the absolute value of the difference of the friendships f_{ij} and f_{ji}. The gap of friendship is calculated according to the following equation. The gap represents the relationship among agents:

$$\text{The gap of friendship: } g_{ij} = \left| f_{ij} - f_{ji} \right| \quad (9)$$

In this experiment, we analyze the change in the gap of friendship for all agents affected by diffusion of the mobile tool.

3. 2. 3. Simulation Conditions

In this experiment we analyze the influence of diffusion of the mobile tool. The diffusion (the rate of agents who use the mobile tool) increases from 0% to 100% in increments of 10%. In each tried, we evaluate the gap of friendship in the community created by the simulation.

The other conditions of this experiment are the same as in Experiment 3.1 (see Table 3).

3. 2. 4. Simulation Results

Figure 5 shows the change in the gap of friendship as the mobile tool's diffusion increases. The simulation result shows that the diffusion of the mobile tool causes

an increase in the friendship gap. In the case of low diffusion, in a relationship between two agents, either they often feel friendship toward each other, or they do not feel any friendship at all. However, with an increase in diffusion, a new case stands out in which agent a_j feels friendship toward agent a_i, though a_i does not feel friendship toward a_j. Thus, it is likely that the relationships among agents become more complicated by the diffusion of the mobile tool.

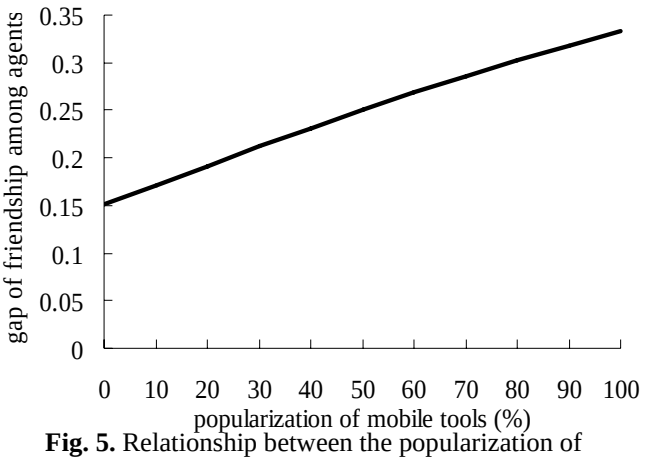

Fig. 5. Relationship between the popularization of mobile tools and the gap of friendship

Since the phone call function of cellular phones can use only two media, verbal and vocal, and the e-mail function can use only verbal media, there are obviously fewer usable media than in face-to-face communication. Because of the noise in the verbal medium is the strongest of all, a message's information may not be transmitted correctly, thus understanding between two agents may fail. In the situation where an opinion about a topic cannot be transmitted accurately, according to Heider's theory the agent will misunderstand the partner. Thus, gaps of friendship increase.

As described above, since the feature (2) "limitations of media" increases the gap of understanding, human relationships are bound to become more complicated. Indeed, cases of communicating only using letters or e-mails are sometimes liable to result in misunderstanding. Thus, this simulation result is appropriate.

3. 3. Investigation into the Effect of Diffusion of the Mobile Tool on Group Formation

3. 3. 1. Purpose

Next, we evaluate the influence of the diffusion on group formation by the agents, especially, of groups in which all member agents have a high value of friendship toward each other.

3. 3. 2. Criterion

In this experiment, we evaluate the influence of the diffusion of the mobile tool on group formation by the agents. First, we define two types of specific agent: a_j is an acquaintance of a_i when friendship f_{ij} of a_i to a_j is greater than 0; a_k is a friend of a_i when friendship f_{ik} of a_i to a_k is exceeds 0.2 (Fig. 6).

The agents start communication without any knowledge of each other, and make acquaintances and friends by communication. In this experiment, we evaluate the number of days required for all agents to attain a certain rate of acquaintances or friends as follows:

A : the number of days required for all agents to make friends with 10% of all other agents.
B : the number of days required for all agents to make friends with 20% of all other agents.
C : the number of days required for all agents to make acquaintances with 10% of all other agents.
D : the number of days required for all agents to make acquaintances with 20% of all other agents.

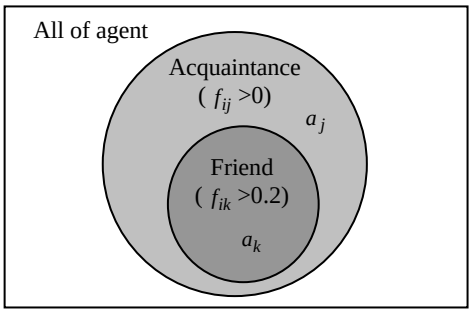

Fig. 6. The relationship between the acquaintance and friend of the agent a_i

We confirm the change of the above four numbers, which are caused by the diffusion of the mobile tool.

3. 3. 3. Simulation Conditions

The conditions of this experiment are all the same as those in the experiment of Section 3.2.

3. 3. 4. Simulation Results

Figure 7 shows the relation between the number of days required to make friends and the diffusion of the mobile tool, while Fig. 8 displays the relation between the number of days required to make acquaintance and the rate of diffusion..

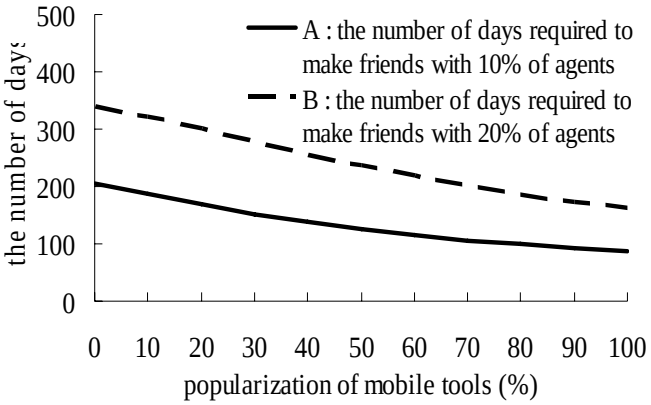

Fig. 7. Relationship between the popularization of mobile tools and the number of days to make friends

From Fig. 7, it is clear that it took at least 150 days to make friends with 10% and 20% of the other agents. This period shortens with the increase in diffusion of the mobile tool. Taking the feature 1) "freedom from restriction of place and time" into consideration, it can be presumed that freedom from restriction causes an increase in the absolute frequency of communication. Therefore, the agents become friendly at an earlier stage.

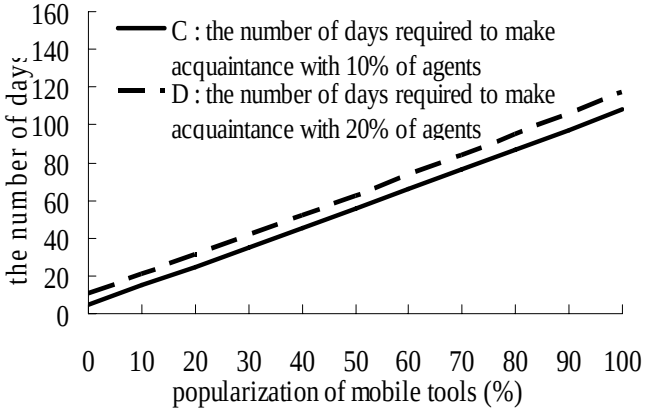

Fig. 8. Relationship between the popularization of mobile tools and the number of days to make acquaintances

Figure 8, on the other hand, shows that the days required to make acquaintances with 10% and 20% of the other agents increases with rise in diffusion of the mobile tool. This phenomenon is also relevant to feature (1): owing to the feature of freedom from restriction, agents do not select communicable partners but select partners with whom they want to communicate. Therefore, agents communicate only with a few others and they become friendly. Consequently, the size of an agent group decreases and the time required to make new acquaintances increase. Accordingly, diffusion of the mobile tool causes a reduction in the size of agent groups, and closer relationships.

3. 4. Effect of the Mobile Tool on the Community

3. 4. 1. Purpose

From the result of Experiment 3.3, we assume that diffusion of the mobile tool causes a close relationships and a reduction in the size of an agent group. To investigate this assumption, we focus on the number of acquaintances and the average of friendship, and we evaluate the difference between a group of agents who have mobile tools and another group who do not.

3. 4. 2. Criterion

In this experiment, we analyze the influence of the mobile tool on the community. To do this, we focus on the difference between agents who have a mobile tool and those who do not. We evaluate the number of acquaintances and also evaluate the strength of friendship toward those acquaintances.

3. 4. 3. Simulation Conditions

In this experiment, we set the diffusion of the mobile tool to 50%. The other conditions are same as in Experiment 3.2

3. 4. 4. Simulation Results

Figure 9 shows the difference in the number of acquaintances between the mobile-tool user and the non-mobile-tool-user. The x-axis indicates the number of acquaintances, and the y-axis indicates the number of agents who have a certain number of acquaintances. Figure 10 shows the friendship difference between the mobile-tool user and the non-mobile-tool-user. Here, the x-axis indicates the value of friendship, and the y-axis indicates the number of agents who have a certain value of friendship.

From Fig. 9, it is apparent that agents who do not have mobile tools have more acquaintances than agents who do. However, Fig. 10, in contrast shows that the average of friendship for mobile-tool users is larger than that of non-mobile-tool-users. In other words, mobile-tool users are closer to each other than agents who are not.

Figure 11 shows the difference in the averaged friendship between three types of relationship: mobile-tool users and users, non-users and users, and non-users and non-users.

From Fig. 11, it is clear that "users and users" are closer to each other than the other types are. Therefore, communication with mobile tools tends to make agents friendly toward other agents who have mobile tools.

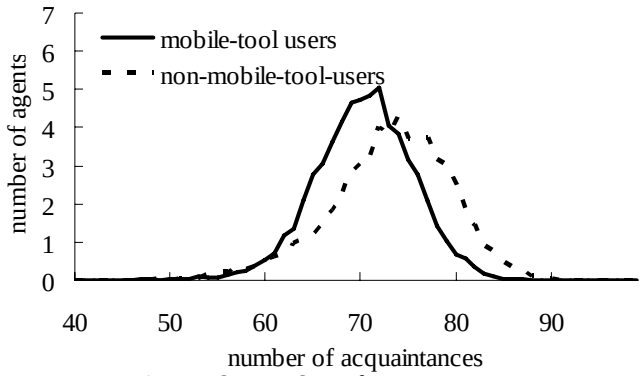

Fig. 9. The number of acquaintances of mobile-tool users and non-mobile-tool-users

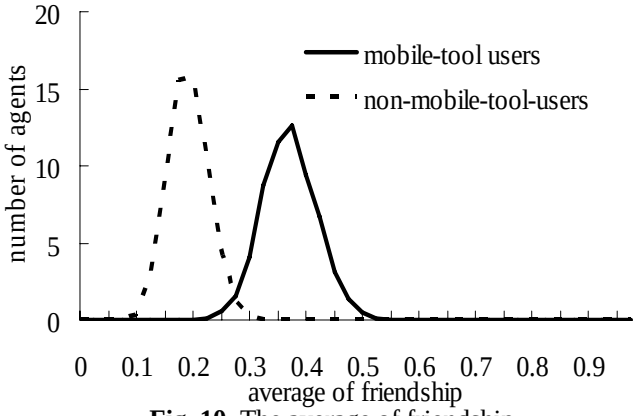

Fig. 10. The average of friendship of mobile-tool users and non-mobile-tool-users

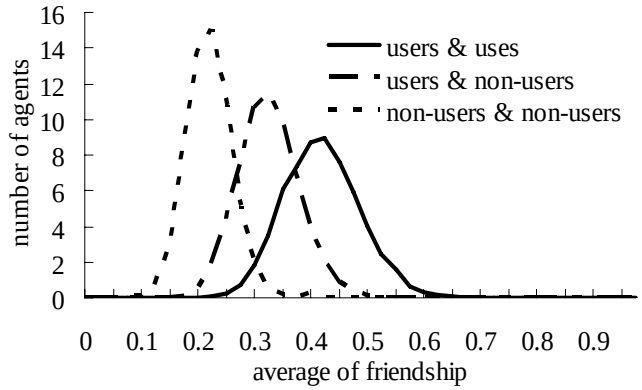

Fig. 11. The average of friendship of three types of sets of agents

The results of these experiments clearly indicates that mobile tools reduce the size of a group of friends, though it does increase the intimacy among the agents belonging to the group. In other words, the mobile tool produces similar and intimate agent groups. The investigation concerning mobile tools from a psychological viewpoint explains this phenomenon, and also supports these results[6]. These simulation results are therefore realistic.

4. Conclusion

Since communication tools have become more diversified, communication style and community formation have changed, and new kinds of communication problems have emerged. In this study, we simulated a community-forming mechanism to clarify the influence of mobile tools on community formation. For this purpose, we focused on two features of a mobile tool, and from them we formed a model. We represented a community through a communication network using Heider's theory of "the psychology of interpersonal relations. " We confirmed the validity of the proposed model in experiments, with the experimental results concerning the influence of a mobile tool on community formation being as follows.

With the diffusion of the mobile tool:

- the gap of mutual understanding tends to increase, and relationships become more complicated;
- the size of a group of friends tends to decrease and the relationship become more closer..

As future works, we plan to propose new criteria to evaluate the community based on the number of stand-alone agents and the number of hubs (agents who have many links). We will also attempt to clarify the influence of mobile tools on the community. Furthermore, we will try to propose a solution to the communication problems arising from mobile-tool use based on our simulation results.

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