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Abstract:

We consider the effect communications by mobile phone have on the process of building relations of individuals, and discuss the impact such communications have on interpersonal relationships among individuals in a network society. Our research results indicate that a network society is significantly affected when mobile communication becomes widespread within that society. In the field of management, the value of having an online community for purposes of management is becoming ever higher, but, to our knowledge, no descriptions have yet been made about what features of communication fundamentals affect (1) the process of building relations of individuals in a network, and (2) the characteristics of the relations. This paper describes our use of simulation with a multiagent model to ascertain how various communication fundamentals generate and change interpersonal relationships among individuals in a group.

Keywords:
Mobile Communication, Computer Simulation, Multiagent Model, Internet Society, Relation Formation

1. Introduction

The development of mobile communication tools has injected a new form of communication into society. Initially conventional mobile communication was limited to special uses, such as cases in which it was necessary to establish communication under out-of-the-ordinary circumstances. In recent years, however, as it has become possible to use this form of communication over the Internet, and its influence on economic and social conditions has rapidly and significantly expanded. New developments in and the increasing spread of mobile communication media have generated changes in individual communication

consciousness and new communication opportunities.

The type of communication medium used significantly affects communication formats and the speed and range at which information is circulated. As an example, the development of E-mail on the Internet caused a new problem of an explosion of rumors being spread through chain letters. Another example is the use of portable telephones to send short greetings such as "hello" messages.

Our interest is in how communication standards differ according to the communication medium being used. This is an important subject not only in a sociological sense but also as an enterprise management phenomenon (Matsuda, 1998). It is important in the latter sense because in enterprise management, CMC (computer mediated communication) research has led to an expanded role for the corporation as a community within itself. For example, such communication between corporation and customer now has a major impact on how agreements are formed relative to the development and sale of goods (Kokuryo, 2000), (tanomi.com[1]) and on the manner in which customer evaluations of products and services are exhibited and circulated (PTP[2]: Power To the People).

To build corporate communities and manage them effectively, it is necessary to develop mechanisms to govern the actions of the self-generated communities, and to obtain indicators of management effectiveness. A feature of these mechanisms is that they are generated and developed in self-generation by dispersed interaction among individuals. To understand the means by which a group is formed by the interaction of two or more agents and macroscopic opinions and macroscopic tastes emerge, one must understand that study of these means is essentially limited to analytical techniques, such as differential equations, with which behavior as a whole is described in a top-down manner.

Executing these techniques requires a computational approach that describes dynamic interaction of agents (Ohta, 1996). Previous research clarifying computational approaches involving distributed agents and macroscopic phenomena has been reported by Okada, Shimba and Yamamoto. In their work, they observed the emergence of group formation and a global phenomenon from local interaction rules (Okada, 1999; Shimba, 1997; Yamamoto, 1999).

This paper describes our use of multiagent simulation to ascertain the changes that are generated in the process of relation formation, and the dynamics of communication that have been generated with the development of mobile communication tools. In the paper, we use the term "mobile-mail" to describe the communication function provided by cellular phones, and "PC-mail" to describe the communication function provided by E-mail via the use of personal computers.

However, as reported in this paper, our main goal is to develop a model concept and to build it. See Yamamoto(2001) for details on simulations performed and a discussion about our

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[1] tanomi.com (http://www.tanomi.com/)
[2] PTP (http://www.ptp.co.jp)

insights obtained from the results.

1.1. *Mobile communication*

How has the development of mobile communication changed the face of communication in society? To answer this question, we made a comparison between new communication media such as mobile communication devices and conventional communication media. We clarified relationships among global phenomena that emerged from local interaction among agents. We then reviewed previous research results concerning mobile communication, group formation, and multiagent systems. A summary of previous research we reviewed on the subject of mobile communication using portable telephones follows:

Matsui (1999) and Hyuga (1999) described a comprehensive information medium comprising university students using portable telephones. They claimed that the "character" of cellular phones changes along with changes in user consciousness as new functions are added to cellular phones.

Matsuda (1998) claimed that non-synchronous communication such as that which occurs when the mail functions of cellular phones or pocket boards are used eases the pressure of having to answer questions right away, which telephone users sometimes feel.. He reported that female high-school students tend to use cellular phones as a matter of individual preference to generate what he called "social utility", and that that social utility would be generated as long as the student had a close friend who also had a cellular phone. On the other hand, the technical utility of the phone is the ease with which it can be used and the convenience it provides. In other words, a change from technological utility to social utility exerts a large influence on the individual's choice of communication medium. Matsuda (2000) proposed a "selective relationship" theory and a "weakened relationship" theory. According to the selective relationship theory, mobile phone users choose conversation partners with whom they communicate closely and intimately on the basis of partner, conditions and situations. On the other hand, according to the weakened relationship theory, young people who communicate with many friends via cellular phone have a wide circle of friends but their interpersonal relationships tend to be rather shallow. Matsuda claims that the origin of selective relationships is not only the result of the increased use of cellular phones but also the increase in the number of people that an individual may encounter on a daily basis as a result of urbanization.

Mohri (2000) investigated portable telephone usage among the high-school student population and concluded that (1) users tend to form very close relationships with each other, and that (2) no social wall was formed between users and non-users. In adopting a multiagent approach as a method for dealing with mobile communication, we reviewed previous research in which a multiagent approach was used in dealing with the formation of groups and network communities. We describe our developments in this research in terms of problems that

occurred in previous research.

1.2.   Relation formation and multiagent simulation

Ongoing technical developments in computers have made it possible to simulate complicated social phenomena. The construction of a simulatable model will create added operational and observational possibilities, and more importantly enable simulation to serve as a foundation for the development of objective theories. A multiagent system is a suitable approach to the kind of research we are engaged in since it has the following features

- Since it can deal with objects in system theory, it can describe the relationship between a system and the agents, which are the elements of the system, as being the relationship between an organization and the persons within it.
- It simplifies the description and operation of a complicated model. That is, it enables a model builder to change control parameters or dynamics of the system characteristics simply by making corrections to the algorithm.
- The above-described features mean that, unlike a mathematical model, it does not need to undo a system analytically, thus enabling it to express the strict dynamics of the model.
- Since the model builder is out of the system, he or she can observe all the interesting phenomena about the system. All of these features make computer simulation with the use of a multiagent system a suitable approach to this type of research.

Axelrod (1995), in simulating the generation of cultural boundaries, expressed culture as a set of characteristics, and made a model comprising that set of characteristics. He claimed that the model could express changes in local conditions and in conditions as a whole simultaneously. In the model, however, agents are fixed to a certain location, and furthermore, neither individual strategy nor exchanges of information are taken into consideration. In order to explore the mechanism of boundary emergence, Shimba (1997) developed a communication medium making use of information among agents. He demonstrated the phenomenon of excessive information being generated in information systems. Axelrod's and Shimba's research results show that local interaction among individuals in virtual communities may cause global phenomena. However, they did not address the topic of mobile communication and the process by which it leads to the generation of communities. In order to analyze this topic, we developed a new model which includes differences between different communication media, and thus enables us to analyze the influence which such media have on relation formation.

2.   Communication Model

The conditions which characterize communication include a number of environmental conditions and behavioral models. Kawakami et al. (1993) argued that the social communication structure has changed in recent years. From the standpoint of our research, company (in the sense of companions) and contents are the conditions which characterize communication. Contents refer to genre comprising individual interests or topics such as news stories which permeate society as a whole. Therefore, we use the terms "relation", "genre", and "topic" to define the conditions.

Our model is formulated as follows. The conditions for communications by telephone are that relationships are shared and that either genre or topics are also shared.

In using the telephone, human beings do not "communicate", in the strictest sense of the word, with persons with whom they share no relationship. This can be said because human beings do not communicate well with others whom they do not know; sometimes they do not communicate well even with persons they know. In a telephone conversation, moreover, one does not merely say "Good morning" and then hang up. An actual example of sharing relationship and genre by telephone is people who share a common interest in soccer talking to each other about the game. In contrast, an example of sharing relationship and topic by telephone is agents talking to each other about a soccer game to be played next week.

In PC-mail communication, one has to share both genre and topic, because one does not send mail to a person only to share a relationship. Since much information can be sent via the PC-mail medium, people do not use it to send only salutatory mail to others, but to share both their relationship and genre in which they have a common interest. When they talk to each other about a short-term topic, they are sharing both their relationship and the topic. An example of sharing genre only is people who do not know each other talking about music via a PC chat function. Internet service providers use different forums to provide services. For example, in Nifty-Serve, one of Japan's leading Internet service providers, there are forums for various themes (genre), including "computer", "animation" and so on. Topics and genre are communicated through the use of these forums(Nifty, 1997).

Finally, the condition mobile communication is that any one of either relationship, genre or topic is shared. An example of topic sharing in mobile communication is to send a "good morning" message, which is only likely to occur when one is using mobile mail to communicate. On the other hand, an example of genre sharing is using an i-mode chat function to talk about common interests. According to the results of a questionnaire circulated over Japan's "Goo" (NTT-X, 2000) provider, communications sent via i-mode tend to be shorter in terms of letter length than those sent via PC-mail. They also tend to be simple messages such as "hello" messages or brief descriptions of the situation that senders find themselves in.

The structure of our model is as follows. There are N persons' agents as subjects who communicate with each other. Agents have an interest in long-term objects and a list of other

agents with whom they share a relationship. Agents' interests tend to be in long-term objects that have significant appeal for them. The level of interest differs in value for every long-term object. There are also short-term objects in addition to long-term objects. Long-term objects are those which have high appeal to agents, and thus they have a high level of interest in them. These long-term objects correspond to genre in which human beings may or may not have interest. In contrast, short-term objects are given a limited life-span and a certain time in which to appear, during which time all agents can communicate with them. Short-term objects correspond to topics. Since human beings tend to communicate easily with those they meet often, we designed our model so as to reflect this tendency. And since people cannot communicate well over the telephone with others they are not acquainted with, the model needs to be able to form shared relationships to facilitate communication. Moreover, since almost no salutatory mail is sent via PC mail media, sharing of both genre and subject is required. On the other hand, since people can communicate via mobile mail media by talking about generalities, current events, hobbies and so forth, we formulated agents that can communicate by sharing any one of either a relationship, a genre, or a topic.
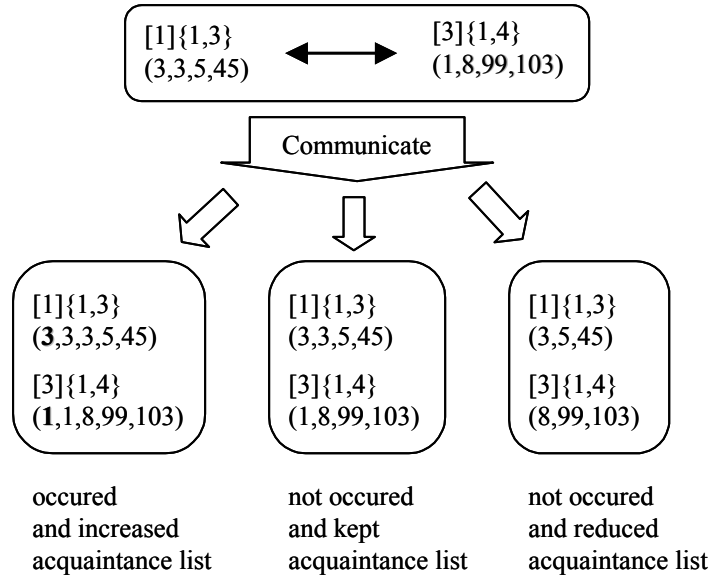
2.1.   Objects

Long-term objects each have their own special appeal. Each agent may or may not have interest in each of the long-term objects. Short-term objects have a limited life-span and appearance time. The appearance time is defined with uniform randomness, and life-span is formulated such that 50% of the short-term objects have one period, 25% of them have two periods, 12.5% have three periods, and so on. Since short-term objects have no particular appeal, all agents can use them as a means of communication during their brief existence. Under the initial conditions, they add agents' names to the "acquaintance list" of each agent with a probability factor of 0.1. They express each agent as follows:

[Agent's Name] {Agent's interest in long-term objects} (Acquaintance list)

2.2.   Changes in Relationships

If communication occurs between two agents, each will record of the name of the other in their "acquaintance list", making it easy to choose the other as the next communication partner. This expresses the characteristic of human beings tending to communicate with the same partner. Therefore, any agent held in an acquaintance list can duplicate other agents' names. Fig.**1** shows changing acquaintance list through communication.

[1]{1,3}
(3,3,5,45) ←→ [3]{1,4}
(1,8,99,103)

Communicate

[1]{1,3}
(**3**,3,3,5,45)

[3]{1,4}
(**1**,1,8,99,103)

[1]{1,3}
(3,3,5,45)

[3]{1,4}
(1,8,99,103)

[1]{1,3}
(3,5,45)

[3]{1,4}
(8,99,103)

occured
and increased
acquaintance list

not occured
and kept
acquaintance list

not occured
and reduced
acquaintance list

Fig.1: Changing acquaintance list through communication

2.3.   Requirements for Establishing Communication

This section describes the communication method and requirements for its establishment. We define the communicating agent as X and the agent selected as the partner as Y.

Telephone communication is defined as follows: Agent X chooses agent Y from its acquaintance list with uniform randomness, and also chooses a long-term object in X's list of interests or a short-term object which exists at the time. If X is on Y's acquaintance list, and if the selected object is a long-term object in which Y is interested, X and Y can communicate.

Mobile Communication is defined as follows: X chooses a long-term object on X's list of interests or a short-term object which exists during the simulation time, or an agent Y on X's acquaintance list. Agents X and Y can communicate only if X is on Y's acquaintance list. If X chooses an object, X and Y can communicate only if Y is interested in the selected long-term or short-term object.

PC Communication is defined as follows: In the first step, X chooses a long-term object on X's list of interests or a short-term object which exists during the simulation time, or an agent Y on X's acquaintance list. If X chooses an agent Y in the first step, they cannot communicate if X is not on Y's acquaintance list. If X is on Y's acquaintance list, X chooses a long-term object on X's list of interests or a short-term object which exists during the simulation time. If X chooses a long-term object, X and Y can communicate only if Y is interested in the object. If X chooses a short-term object, they can communicate. On the other hand, if X chooses an object in the first step, X and Y can communicate only if Y is interested in the selected long-term or short-term object.

When an agent X cannot communicate with Y, X reduces the dignity of partner Y from

its acquaintance list with a probability of 0.5.

3.   Simulation

We performed a computer simulation using the above-described model, considering that the simulation can reveal the mechanism of the dynamics of the model, or the phenomenon in question. Simulation parameters are as follows.

- Communication media: telephone, mobile telephone, PC.
- Number of agents: 20, 50, 100, 200, and 500.
- Number of long-term objects: 5, 10, 20, and 50.
- Number of short-term objects: 20, 50, 100, 200, 500, and 1000.
- Simulation Time: 500 periods.

The standard for selection at the time of communicating was selection of identical probability. For long-term objects, however, we used the following parameters:

- Appeal of the long-term object: [0, 1)
- Each agent's interest in the long-term object: [0, 1)

An agent is interested in an object only when the agent's interest is greater than the object's appeal.

3.1.   Observation Indexes

The following three observation indexes were used:

- Total amount of communication
- Total amount of communication according to content
- Time series change of total amount of communication.

Three communication content indexes were defined:

- whether or not one communicates with a long-term object
- whether or not one communicates with a short-term object
- one communicates without using any particular object.

3.2.   Influence of Random Seeds

Pseudo-random seeds are used in the computer simulation. Although simulation results

are based on a single random seed, it is necessary to determine the influence of the random seed beforehand. Accordingly, we investigated the influence of pseudo-random seeds in 100 types of simulations. A different random seed was used for the simulations, in each of which the number of agents was 200, the number of long-term objects was 5, and the number of short-term objects was 500. The results obtained are shown in Fig.**2**.
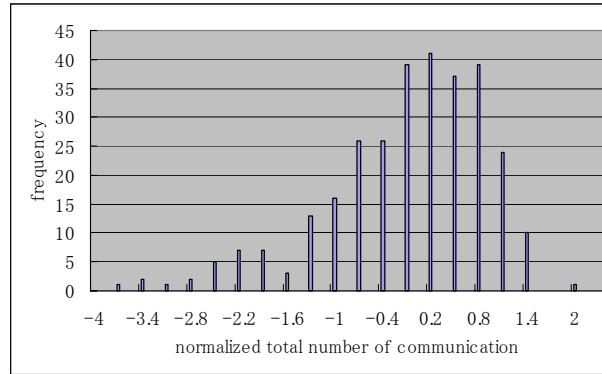

Fig.2: Influence of Random Seeds

4.   Simulation Results and Discussion

We evaluated our model through the use of computer simulation, and the results obtained are detailed below.

4.1.   *Differences in total number of communications*

4.1.1.   *Topics*

For any given medium, the total number of communications differs according to the number of topics available for discussion. When there are few topics(i.e., the communication society is "static"), PC communication is used as a medium in almost the same way as the telephone. In such a society, PC communication seems to be mainly used between acquaintances to enable them to discuss things with each other. When there are many topics, however(i.e., the society is "dynamic"), PC communication is used as a medium in almost the same way as mobile media(Fig.**3**). This suggests the possibility that in future society mobile communication will be used as an alternative to other media according to certain existing conditions.
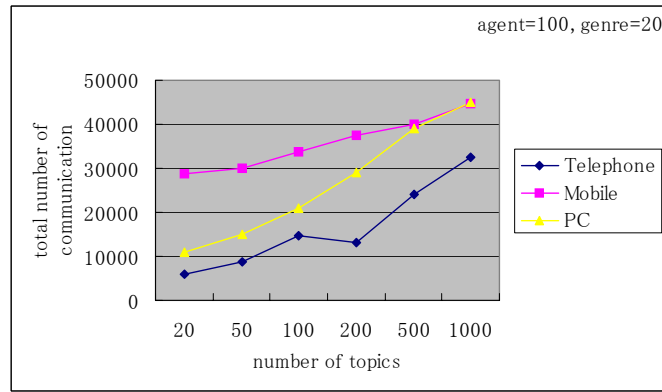
Fig.3: total number of communications differs according to the number of topics

4.1.2. Agents

Regardless of the communication medium used, there is a correlation between the number of agents and the total number of communications; i.e., as the number of agents increases, so does the total number of communications. The rate of increase is especially high for mobile media、which suggests that it is easy to apply the effectiveness of networks to mobile communication (Fig.**4**). In fact, the use of mobile communication devices is spreading much faster than the use of other communications media. The effect that the characteristics of a communication medium have on communication is considered to be a major factor in how quickly the use of the medium spreads.
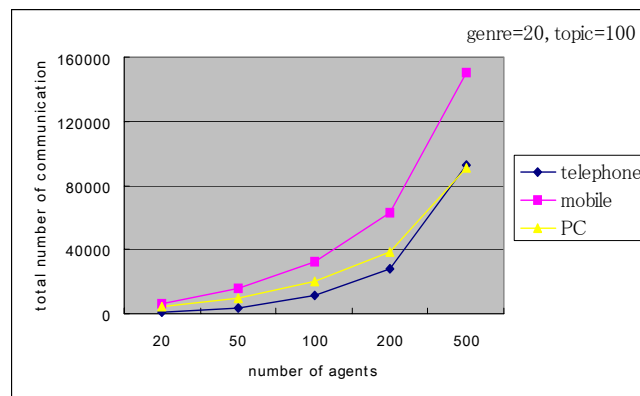
Fig.4: total number of communications differs according to the number of agents

4.1.3. Genre

In contrast, communication is not influenced by changes in the number of communications medium genre (Fig.**5**). It can be said that the type of communications medium a person uses does not have any major influence on his or her personal tastes.

360
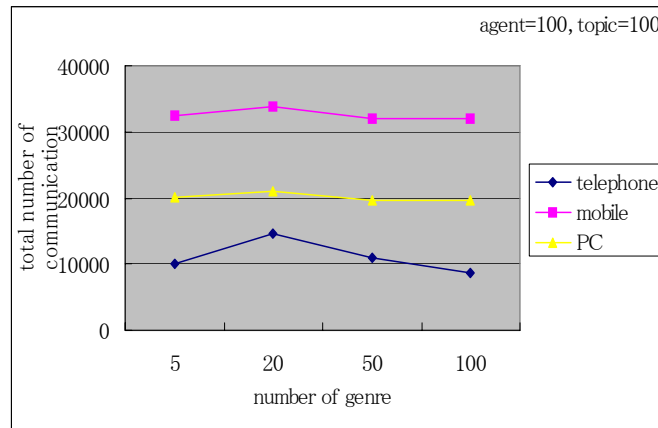
Fig.5: total number of communications differs according to the number of genre

4.2. *Time Series Analysis*

4.2.1. *Change of Relationship by Topic*

For a given number of agents, the relation of topic dependency of communication is largely influenced by increasing topic number. That is, the rate of increase of topic-dependent communication increases according to topic number. However, increasing genre number does not increase genre dependency. This phenomenon is evident regardless of media type.

This result expresses that the existence of a topic is important in the relation formation process. That is, even when the topic is not essential to development of a virtual community, it is used as the starting point of communication. This idea supports the argument in CMC. Moreover, both mobile and PC-mail media show large increases in topic dependency according to topic number compared with telephone media (Fig.**6**). In particular, E-mail is the media that most depends on topic.
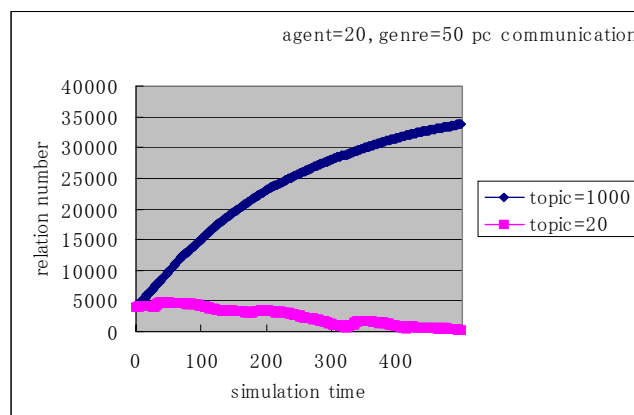
Fig.6:   Dependency of topic in pc communication

5.   Conclusion

We showed how development of mobile communication affects communication relationships by computer simulation. We defined relationship, genre, and topic as important communication factors in the relationships between individuals. These three factors together expressed the characteristics of a communication and communication media. The computer simulation elucidated the behavior of the model of the communication media and social environment.

The simulation result shows that topic plays an important role in relation formation. This result supports the result of CMC research (Endo, 2000). Moreover, the rate of increase in total communication amount depends on scale of society. This observation suggests that mobile communication is favored over other means in large-scale groups. Moreover, the behavior of short messages (hello message), which are characteristics of mobile communication, behave differently from those of the other types of messages. That is, the rate of short messages relative to total amount of communication decreases with increasing group scale. This feature differs very much from the behavior of other communications.

As a result, in large-scale virtual communities, this phenomenon expresses that short messages tend to be ignored. Our model's mechanism of relation formation is generated from a simple structure and the interactions of a local rule. We can use it to explain the phenomena of actual communication. Moreover, we can observe that the character of short messages in mobile communication, which cannot be understood intuitively.

In future work, we will make this model more sophisticated and include a selection rule for agents or two or more communication media. We will study how a virtual community is selected or develops in a society that has several virtual communities.

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