Community Communication Technology for Achieving Timeliness in Autonomous Decentralized Community Systems

Khaled Ragab, Takanori Ono, Naohiro Kaji and Kinji Mori

Tokyo Institute of Technology
2-12-1 Ookayama, Meguro, Tokyo 152-8552
Tel: +81-3-5734-2664, Fax: +81-3-5734-2510,
Email: {ragab@mori., nouri@mori., nkaji@mori, mori@}cs.titech.ac.jp

Abstract

The headway towards the outstanding future can be realized with the productive cooperation among peoples and organizations. Inspired from the spirit of cooperation in the rapidly social changing communities, we propose an Autonomous Decentralized Community (ADC) concept. It is a group of autonomous members, whereas each member has his own objectives, complies with the community obligations and cooperates with the others for achieving his own objectives. ADC system has to meet the heterogeneous and continuously changing requirements of the community service utilization and provision. It requires support for real-time communication among community members. Therefore, we propose an autonomous decentralized community communication technique. It satisfies the fairness by granted an equal opportunity among the community members. Moreover, it approves the scalability of the system regardless with the number of the community members.

1.Intorduction

Due to the advances in wire and wireless communications, the number of worldwide Internet and mobile users is predicted to exceed 1 billion by the end of 2005 [3]. Those users want to make decisions in their daily life: where to go, what to buy, how to sell, and what to do. Furthermore, they demand to enrich their experiences by cooperating with others having knowledge, ambition, enthusiasm and inventiveness. Therefore there are increasing needs to gather those users who having common interests in a friendly cooperative digital environment. Users join and leave this environment as a result of their rapidly changing demands and interests. They expect information services that are flexible and continuously available [4]. Moreover, they have heterogeneous and dynamically changing requirement levels of timeliness [5]. Adaptability is the key attribute of the modern systems. Timeliness is key component in modern high assurance systems [8].

Inspired from both the spirit of cooperation in the social communities, and the Autonomous Decentralized System (ADS) concept [1][2], the concept of an *autonomous decentralized community system* is proposed to meet these requirements. The major focus of this paper is the proposition of the autonomous decentralized communication technology for achieving the timeliness system requirement.

The remainder of this paper is organized as follows. The next section presents our proposed autonomous decentralized community concept. Section 3 exposes our proposed autonomous decentralized community communication technology and then presents experiment showing time improvement. The last section draws conclusions.

2. Autonomous Decentralized Community Concept

2.1. Autonomous Community

Community as a social phenomenon deals with establishing and working with meaningful connections between people. The constructive cooperation between people guarantees the successful community. Indeed the

cooperation in the social science is a problem because how might a group of people ever manage to establish or maintain cooperative relation? The characters and qualities of this problem are different when users use computer-mediated communication to interact, but the differences do not guarantee a uniformly positive effect or resolve many of the long-standing problems of cooperation [7].

The concept of an **Autonomous Decentralized Community System** (**ADCS**) is proposed to realize a scalable online community system that successfully able to carry out, and achieve community goals in dynamic environments. It guarantees not only the cooperation among people but also the autonomy for each one. Autonomous Decentralized Community is defined as a group of autonomous members, whereas:

- Each member has his own objectives.
- Each member complies with the community obligations.
- There is no member control the flow of the information to the other members.
- The community members have to be mutually cooperative for achieving their own objectives.
- The community membership burdens must be less than its benefits.

The community member objectives and the community obligations change based on the application requirements. The community members achieve their own objectives timely in the community. ADCS supports the next generation of the collaborative e-commerce. For example, service provider collects the market information from the community consumer members to customize his service timely. Moreover, the community consumer members cooperate together and form a pressure group to drive down prices based on their purchasing power. Within the cooperative e-commerce community, the success of any member is inextricably to the success of its business partners. It's one for all, and all for one.

2.2. Concept

The main goal of the autonomous decentralized community is work together to move forward. The key aspects of the ADC system are the timeliness, and flexibility (i.e. members join and leave the community) of the community member interactions. Therefore, it must assure the following aspects:

1. **Autonomous Coordinability.** If any member leaved the community, his node failed, or a new member joined the community, the other community members can coordinate their individual objectives among themselves and each member able to operate in a harmonious (coordinated) fashion.
2. **Autonomous Controllability.** If any member leaved the community, his node failed, or a new member joined the community, the other community members able to continue to manage themselves to commit their own tasks.
3. **Mutual Cooperation.** The constructive cooperation among members is the vehicle of the successful community. Through the mutual cooperation, the community members reap the useful information and achieve their own objectives with low efforts. In other word, the community benefits have to cover its liability in order to be attractive for both its members and the other users have intention to join it.

These aspects assert that the community structure dynamically change, each member has autonomy for interactive communication and information processing. Furthermore, the community members cooperate for utilization and provision of the community services and information sharing under the evolving situations.

The autonomous decentralized community concept can be realized with autonomous controllability, autonomous coordinability and mutual cooperation. Moreover, each member is required to satisfy the following conditions:

- **Equality**. Each member must be equal and able to handle his objectives without being directed by or giving the directions to the others. In other words, there is no master-salve relation among the community members. All the community members have the same rights and the same responsibilities (e.g. load) in the community. In fact the fairness among the community members has to be satisfied. Unfairness pushes the community members to leave the community. In the next section an autonomous decentralized community communication technology is proposed to grant fair and uniform communication among the community members.
- **Locality.** Each member handles his objectives and coordinates with the others based only on his local information. Furthermore he enriches his information and knowledge by joining the community.
- **Self-Containment.** Each community member is self-contained in managing his objectives while he coordinates with the others.
- **Synergy.** Cooperation among people, and organizations would be the main characteristic of this era. Prompted from the dictum that one for all and all for one, each community member has to cooperate with the others community members.

Furthermore, the community's success is subjected to the mutual and productive cooperation among its members.

In order to realize the productive cooperation among those members, an *autonomous decentralized communication technology* is proposed in section 3.

2.3. Autonomous Decentralized Community Network

The autonomous decentralized community network is a self-organized logical topology. It is a set of nodes with considering the non-hierarchy and the existence of loops. Each node keeps track of its immediate neighbors in a table contains their addresses. For example, figure 1 shows that each community node knows four members as maximum. The bold lines represent the logical link among the community nodes. Each node judges autonomously to join/leave the community topology by creating/destroying its logical links with its neighbors based on its user preferences. Each community node keeps a short memory of the recently routed messages in order to avoid the congestion in the community network.

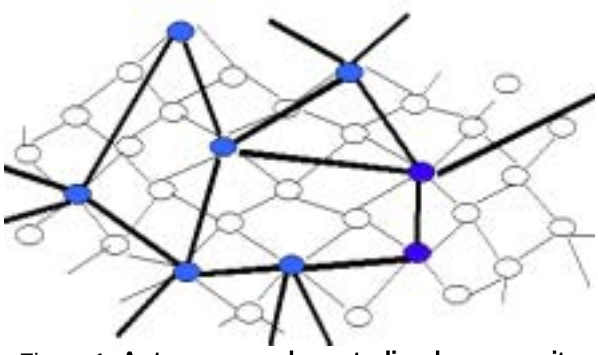

Figure 1. Autonomous decentralized community network logical topology

3. Autonomous Decentralized Community Communication Technology

The conventional communication, typically through Web browsers, has been built upon the one-to-one communication protocol. In one-to-one, data travels between two clients, e.g., e-mail, e-talk. This unicasting protocol gobbles up the network bandwidth and makes the real time services unresponsive. From the standpoint of the users an unresponsive service is virtually equivalent to unavailable one. In e-commerce milieu unresponsive service depresses users from using it, and results in a business loss his customers. Moreover in e-commerce settings, no one member has complete control of the game. Therefore, there is need for a communication technology that guarantees the uniformity among the community members. ADC system has to meet the heterogeneous and continuously changing requirements of the community service utilization and provision. To ensure the communication among the community members fairly, uniformly and timely, an autonomous decentralized community communication technology is broached in the next subsection.

3.1. Communication Technology

From the motto "one for all and all for one", the message sent by one of the community members, all the community members must receive it. ADC communication technology performs the communication among the community members based on a one-to-many (1->N). In the conventional one-to-many the message travels primarily from a server to multiple clients, e.g., web download, software distribution, and video-on-demand. In our model (1->N), there is no specified client-server relationship among the community autonomous members. Moreover, each member knows only a specified number of members (neighbors). The community member asynchronously sends a message to N neighbors. Then, those N members forward the same message to another N members in the next layer and so on gradually layer by layer. This community communication technology handles under the model known like viral propagation. Figure 2-a shows that all the community members receive the message sent by the source s. Node s asynchronously sends a message to its neighbors. Those neighbors forward this message to their neighbors, and so on gradually until all the community members receive the message. Figure 2-b shows the reply to the previous message form one of the community members to all. The message that circulates around the community members is uniquely identify the community interest code. Figure 3 shows message format. It contains the community Interest Code IC (e.g. music, sport, etc.) and characterized code CH that specifies the follows message content data or request, etc.

Assume the number of the community members $M = \sum_{i=0}^{Layers} N^i$. Then the number of layers is

$$Layers \geq \left(\frac{\log[\frac{(N-1)*(M-1)}{N} + 1]}{\log N} \right).$$

Each community member sends to N neighbors, as N increase the number of layers decrease as shown in figure 4.

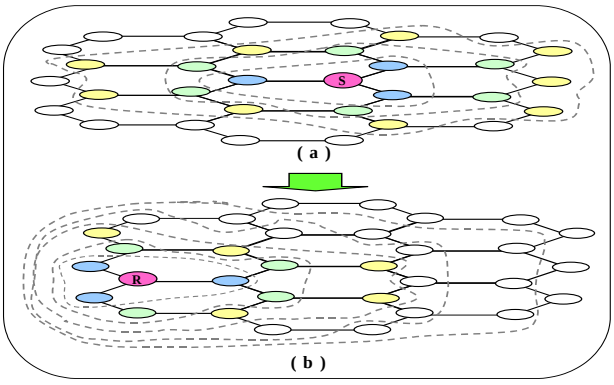

Figure 2

This communication technology is valid only for the community because all the community members have the same interest to receive any message sent by any one of them. Furthermore, if a community member sends a message requesting information then some of the community members will reply and the other community members are implied in receiving the reply message without needing to send the same request. In the ADC network the congestion might be happen if a node forwards the same received message from different nodes multiple of times to its neighbors. In order to avoid the congestion, each node judges autonomously to forward only the first received message to its neighbors and discards the other received copies of this message. This communication technology achieves the fair distribution of bandwidth among the community members. Furthermore it assures uniformly communications among members to be attractive for both the community members and the users have plans to join the community. In other word, it satisfies the fairness by granted an equal opportunity among the community members by receiving the same message. For example in e-commerce community the fairness among buyers must be granted by affording an equal opportunity to buy goods offered by a seller [6].

IC: Music	CH	Data/Request

Figure 3. Message format

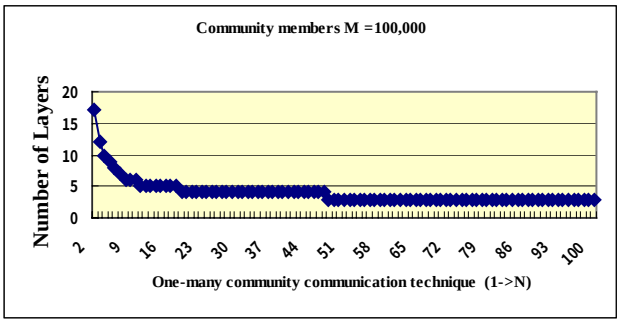

Figure 4.

3.2. Communication Time-Model and Performance Evaluation

Autonomous decentralized community communication technique performs the communication among the community members based on one-to-many (1->N). Figure 5, shows the flow of the information from node s to all the community members gradually layer by layer. Node s sends an asynchronies message to its neighbors. Each one forwards this message to its neighbors too. We assumes the communication cost between each node is $t = T_{cc}$ seconds. Thus the worst transmission time (WTT) to send a message from the sender to all the community members is $WTT = L*N*T_{cc}$. Where: L is the number of layers and N is the number of neighbors of each member it forwards message to them.

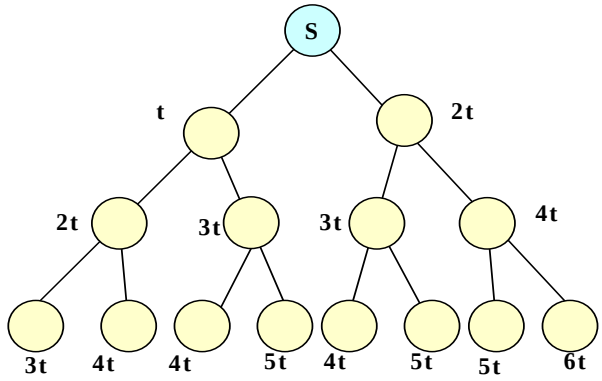

Figure 5. Autonomous decentralized community information flow and time-model

We tried our communication model on a network spending 6-array connectivity to each community node. Our experiment is conducted over 100,000 community members, using 1->5 communication technology and is constituted of a constant communication cost between each node 0.001 second. We concentrate in this experiment on the comparison between the conventional one-one-communication technique and one-many (1->N) communication technique. Figure 6 depicts the effectiveness of our communication technique in compared with the conventional one. Furthermore it approves that the community communication technique is scalable of the response time with the number of the community members.

4. Conclusion

In this era, the necessity of cooperative digital environments has been drastically demanded to enrich the experience of their users and meliorate their lives. To cope with these demands, we take into our holders to propose an

online community system so called **Autonomous Decentralized Community System (ADCS)**. It requires support for real-time communication among community members. We propose an autonomous decentralized community communication technique. It satisfies the fairness by granted an equal opportunity among the community members by receiving the same message. Furthermore, it achieves both the fair distribution of bandwidth among the community members to retain the network bandwidth, and the timeliness requirement of our system.

Experiment demonstrates the potential of our communication technique in comparing with the conventional one. Furthermore it is scalable of the response time with the number of the community members

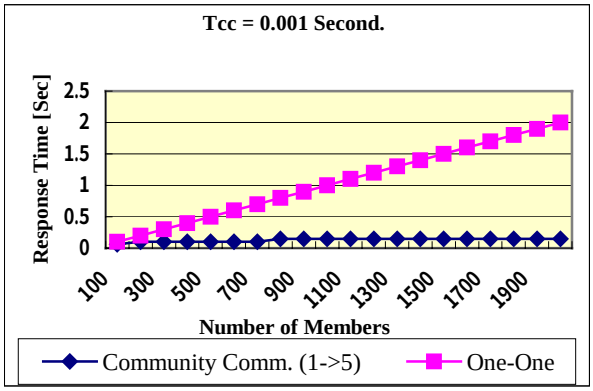

Figure 6: **Scalability of the response time with the number of members**

5. References

[1] K. Mori, "Autonomous Decentralized Systems: Concept, Data Field Architecture and Future Trends," Proc. of the first Int. Sym. on ADS, (ISADS'93), IEEE, Kawasaki, Japan, pp. 28-34, 1993.

[2] K. Mori, H. Ihara, et al., "Autonomous Decentralized Software Structure and its Application," Proc. IEEE FJCC'86, pp. 1056-1063. November 1986.

[3] The world's leading resource for Internet trend and statistics, http://www.nua.com/ surveys/

[4] David B. Ingham, S. K. Shrivastava, F. Panzieri, "Constructing Dependable Web Services," IEEE Internet Computing, Vol. 4, No. 1, pp. 25-33, 2000.

[5] K. Mori, "Applications in Rapidly Changing Environments," IEEE Computers, Vol. 31, No. 4, PP. 42-44, 1998.

[6] J.P. Banatre M. Banatre, G. Laplame, F. Ployette, "The design and building of Enchere, a distributed electronic marketing system," CACM, Vol. 29, No. 1, pp. 19-29, Jan. 1986.

[7] P. Kollock, and M. Smith, "Managing the Virtual Commons: Cooperation and Conflict in Computer Communities," Computer-Mediated Communication: Linguistic, Social, and Cross-Cultural Perspectives, edited by S. Herring. Amsterdam, PP. 109-128, 1996

[8] I.L. Yen, R. Paul, and K. Mori, "Towards integrated methods for high assurance systems", IEEE Computer, vol. 31, No. 4, PP. 32-34, 1998.