An Efficient Communication Technology for Autonomous Decentralized Community Information System

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Abstract

The global information service in the Internet is a heterogeneous and rapidly evolving environment. Users' interests and demands for information services are rapidly changing. Anywhere or somewhere in a specified time there are significant numbers of users having the same preferences. Consequently, a rapid and dramatic surge in the volume of requests arriving at a server often results in the server being overwhelmed and response times shooting up. Current information technologies do not sustain such situation. Therefore, an Autonomous Decentralized Community Information Systems (ADCIS)[1] was proposed to meet the rapidly changing users' requirements for services and cope with the extreme dynamism of the operating environment. It allows individual end-users (community members) having the same demands to mutually cooperate to share information without loading up any single node excessively. To assure a timely communication among the community members an autonomous decentralized community communication technology is proposed. It approves the scalability of the system regardless with the number of the community members.

1. Introduction

The Internet's phenomenal impact, the subsequent growth and the evolving in social and economic environments promote more sever and complex requirements for the information service systems. Anywhere or somewhere in a specified time there are significant numbers of users sharing the same interests and demands. For example, on the web the ubiquitous access of browsers and rapid spread of news about an event, lead to a *flash crowd* when a huge number of users simultaneously access a popular web site. Thus the server, being overwhelmed and users' response time shooting up. Flash crowds are typically triggered by events of great interest, whether planned ones such as sport events or unplanned ones such as an earthquake. However the trigger need not necessarily be an event of widespread global interest. Depending on the capacity of a server, even a humble flash crowd can overwhelm the server. Obviously, current information systems are failing to fulfill the stringent Internet users' requirements (e.g. timeliness) in such situations. Consequently there are increasing needs to design an *assured information system* that provides information that meets the users' demands.

Inspired from both the spirits of cooperation in the social communities, and the Autonomous Decentralized System (ADS) concept [2] [3], the concept of an *Autonomous Community Information System* (ADCIS) was proposed to meet the rapidly changing users' requirements [1]. ADCIS forms a coherent group of autonomous members, so called a *Community*. Those members have the same preferences and requirements. ADCIS allows them to communicate directly with one another and share information without relying on any specified servers. The community members mutually cooperate to assure the high quality of the information service provision and utilization as well for all members.

The contribution of this paper is the proposition of the *autonomous decentralized community communication technology* for achieving timeliness. The remainder of this paper is organized as follow. Section 2 exposes our proposed communication technology.

2. Autonomous Decentralized Community Communication Technology

The conventional communication, typically through Web browsers, has been built on the one-to-one communication protocol. This protocol gobbles up the network bandwidth and makes the real time services unresponsive. Cashing technology reduces the network bandwidth consumption and the access latency for the users. Whereas, the limited number of users per the proxy manifests bottleneck affects. In one-to-many group's communication the message travels primarily from a server to multiple users, e.g., web download. For very large groups (thousands of members) or very dynamic multicast groups (frequent joins and leaves), having a single group controller might not scale well. Currently, there is no design for the application-level multicast protocol that scales to thousands of members.

ADCIS is a very dynamic system: users are frequently joining and leaving. To assure a timely communication among members, the autonomous decentralized community communication technology is proposed as follows. It performs the communication among the community members, and we called it "*1→N*". In this communication technology, the sender does not specify the destination address but only sends the content/request with its interest *content Code* (CC) to its neighbor's nodes. Figure 1 shows the community communication message format. CC is uniquely defined with respect to the common interest of the community members (e.g. politic, news, etc.). The information content is further specified by its *Characterized Code*(CH).

CC	CH	Data/Request

Figure 1. Message Format

A brief scenario for the 1→N community communication is as follows. The community node asynchronously sends a message to N neighbor's nodes. Then, those N nodes forward the same message to another N nodes in the next layer and so on gradually until all the community nodes received it. This technology handles, as the model knew like *viral propagation*. It does not rely one any central controller. Each community node has its own local information and communicates only with a specified number of the neighbor's nodes. There is no global information (e.g. multicast group address). It has two techniques: *publish-based* and *request-based*.

- *Publish-based*. When one of the community members has new information, she/he publishes it to all the community members using "1→N". The publish-based protocol offers an effective solution to the flash crowd problem. The solution scenario is as follows. As soon as one of the community members downloaded an interested content for the community from the server, she/he publishes it to all the community members, thereby relieving the server of this task and alleviating a load on the server. Whereas, the load is distributed among the community nodes and increased slightly even as the number of nodes increases dramatically.

- *Request-based.* When a node wants to locate information, it emits a request message. Then the others community nodes cooperate to locate the requested information. When any node receives the requested message, it processes the request. If no results are found at that node, the node will forward the request to its neighbor's nodes with using "1→N". Otherwise, if any results are found at that node then the node will produce results, such as pointers to the information or the whole content based on the size of the information. Then that node will send a reply message not only to the node, which requested the information but also to all the community members. Thus members get to know new information without soliciting. In addition, avoiding multiple requests for the same content decreases the traffic per node.

This communication technology is characterized by *multilateral benefits* (i.e. all members cooperate for the satisfaction of all the community members) contrary to the P2P communication techniques. In P2P, peers cooperate for the satisfaction of only one, which request the information. To evaluate the performance of 1→N communication technology, we consider the average communication cost between each node is τ_{cc} =0.001 seconds and τ_m =0.001Sec is the average time each nodes are needed for monitoring the recent received messages to avoid the congestion. Thus the transmission time τ to send a message from any node to all the other community members is bounded by $O(N\log_N(M))$, where M is the number of the community members. We tried our communication model on a network spending 4-array connectivity for each community node. Our experiment is conducted over 100,000 community members, using 1→3 and one-one with cashing proxy (hit rate of 30%, 50%). Figure 2 depicts the effectiveness of our communication technology in compared with one-one communications. Furthermore, it approves that 1→N technology is scalable of the response time with the number of the members and guarantees a timely communication among the community members. We think that the request's pattern of information consumers determines an effect on the system. Determining the monitoring period with considering the request's pattern is our further research topic. In addition, we will investigate in the reliability for our communication technology.

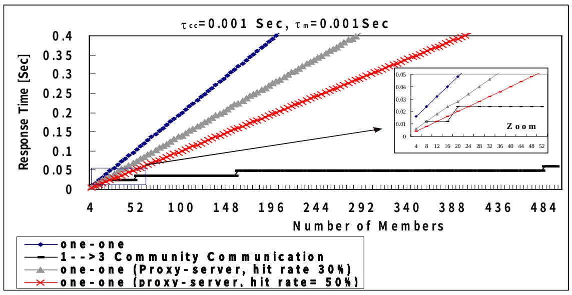

Figure 2. Scalable Community Communication

3. References

[1] K. Ragab, T. Ono, N. Kaji, K. Mori, " Autonomous Decentralized Community Concept and Architecture for a Complex Adaptive Information System," Proc. IEEE FTDCS, Puerto Rico, May 2003.

[2] 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.

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