A Fuzzy Algorithm of Peer Selection for P2P Streaming Media System Based on Gossip Transmission Protocol

Xunli Fan [1,2] Weiwei Zhang [1] Lin Guan [2]
[1] *School of Information Science & Technology, Northwest University, Xi'an 70127 China*
[2] *Department of Computer Science, Loughborough University, Loughborough, LE11 3TU, UK*
xunlfan@nwu.edu.cn, wewei_dongting@hotmail.com, L.Guan@lboro.ac.uk

Abstract

The traditional Gossip protocol selects the neighbor nodes randomly. It does not consider the factors, such as the capacities of network transmission and node storage, which affect the network performance. It further causes the drawback of successful search ratio relatively lower, and also network transmission payloads have the characteristics of randomness. In this paper, to overcome those drawbacks of traditional Gossip protocol, a neighbor node selection algorithm has been studied, and various factors that may affect the neighbor node selection have been analyzed in P2P networks. A new neighbor node selection policy has been proposed, which is a reliable Gossip message transmission Protocol based on fuzzy theory. Empirical simulation experiments with various data analysis have demonstrated the improvement of efficiency of the proposed strategy on node selection and correctness of the proposed algorithm in P2P networks.

1. Introduction

With the rapid development of the Internet, a major drawback of the traditional center server based client/server model is that it cannot use the spare resources including computing capacities and storage spaces on the Internet. The Peer-to-Peer (P2P) technology, however, can make better use of the spare computing capacities and storage spaces of those end nodes effectively. Besides, P2P can provide user with high reliability and high performance service in a dynamic network environment.

Related work Gossip-based protocols have gained notable popularity in various contexts [1-3, 10-12, 13-17]. At present, Gossip transmission protocol is the most popular algorithm used in message transmission [2, 14, 16]. P2P transmission network based on Gossip protocol doesn't distinctly construct any topologic structure as the warranty of node exchange or data transmission, and at the same time, all the nodes are not strict in the situation of peer-to-peer. Any node affiliating to the network just maintains part of the system node views and its local data buffer information respectively. To apperceive the state of whole P2P network and adjust its state accordingly, the node needs to communicate with other nodes in the view continuously through gossip interaction. Also the node exchanges stream data with other nodes according to its needs and the data buffer information of the node apperceived through gossip interaction.One may need to know how to find out resources effectively if it wants to use P2P networks resources adequately. That means, firstly, it may search resources in P2P networks. At present, the key problem of P2P technology investigation is how to select the neighbor nodes while resource searching [4, 5, 6, 8].

In this paper, our aim is to study the neighbor node selection algorithm used in Gossip message transmission protocol and analyze the factors that affect the neighbor node selection in the P2P network. This is conducted by using fuzzy theory and prompts a new neighbor node selection policy. Meanwhile we merge the fuzzy policy into gossip message transmission protocol and demonstrate the improvements of the efficiency of the new strategy of neighbor node selection in P2P network through simulation experiments and the analysis of its data. The rest of the paper is organized as follows. Section 2 reviews the traditional gossip distribution protocol, its drawback, and some knowledge of fuzzy theory, while Section 3 elaborates and implements the new gossip protocol based on fuzzy algorithm used. Section 4 presents numerical evaluation results for the gossip protocol based on fuzzy algorithm applied to this model, and Conclusions and Future work follow in Section 5.

2. Technical Background

2.1. Traditional Gossip Transmission Protocol

Gossip algorithm is an effective mechanism of distributed message diffusion, and Gossip algorithm makes it possible for nodes in the network to exchange any information that they got and update their information timely [7, 14]. But the drawback of traditional gossip algorithm is the high failure probability of message sending, for it selects k target nodes from the local neighbor table randomly to transmit the message and prescribe the times i of rotation of the message transmission. Accordingly with the increment of node size, the failure probability that message sends to all the nodes will increase obviously. The traditional Gossip protocol uses a technology of randomly selecting neighbor node to transmit the message, which is the variation of flooding mechanism [9, 11]. Also called Rumor protocol, the traditional Gossip protocol can be described as following.

When (node p receives a message m from node q)

If (p has received m no more than f times)

p sends m to b randomly chosen neighbors

That p knows have not yet seen m

It means that node p sends the message m to randomly selected b neighbor nodes, where parameter b denotes the maximum number of neighbor nodes that the message can be transmitted to in a transmission process, and parameter f denotes the times that message is allowed to be sent from one node to its neighbor node. Unfortunately, the traditional Gossip protocol fails to consider the capacity of network transmission and the node storage. This is the present drawback of the traditional Gossip protocol. To overcome this weakness, we put forward a new concept of reliability node based on fuzzy theory, and prompt a reliability evaluation mechanism, named the most reliable Gossip message (MR-Gossip) transmission protocol, which is effective in node selection.

2.2. The Drawback of Traditional Gossip Protocol

Although Gossip algorithm has good performance of extensibility and adjustability of dynamic environment, Gossip mechanism has an innate immunity to node abnormity or instability. In other words, if any node becomes abnormal or instable, it will not affect the system running. Theoretically, the capacity of nodes can be extended unlimitedly. However, in implementation, the node needs a large local buffer to store the data, and at the same time, the exchange of data among the neighbor nodes has the characteristic of uncertainty. As a result, it produces a relative great delay of the node startup.

As we know, the traditional Gossip selects the node randomly and also the node just randomly sends the message to part of the nodes in the system. Once a node receives a message from the other node, it also randomly sends the message to other neighbor nodes. The process goes repeatedly until the message is sent to all the nodes in the system. Therefore, it gives rise to the problem of causing a plenty of redundant messages, and meanwhile, because of the node random selection, it makes the search less efficiently [17].

In order to keep the correct list of member node in dynamic network environment and diffuse the high efficiency of local information, we need to look for the proper node select-strategy to substitute the random select policy in traditional Gossip protocol.

2.3. Fuzzy Theory

2.3.1. Concept of fuzzy

The most useful gossip protocols turn out to be those with exponentially rapid convergence towards a state that "emerges" with probability 1.0. For example, a classic distributed computing problem involves building some form of tree whose inner nodes are the nodes in a network, and whose edges represent links between nodes [13]. To describe the uncertain transmission, fuzzy logic is introduced. Fuzzy logic is a form of multi-valued logic derived from fuzzy set theory to deal with reasoning that is approximate rather than precise. Just as in fuzzy set theory the set membership values can range (inclusively) between 0 and 1, the degree of the truth of a statement can range between 0 and 1 in fuzzy logic and is not constrained to the two truth values {true, false} as in classic predicate logic. For example, as for the reliability of node, in what situation it is strictly reliable, and relatively reliable, or unreliable at all.

2.3.2. Fuzzy set and subjections

In order to depict the concept of fuzzy, we normally use fuzzy set and subjection degree. Here we simply describe the fuzzy set and subjection degree as follows. Suppose U is a domain, μ_A is a function that can map the arbitrary $\mu \in U$ into a certain value in the domain of [0, 1]. That is

$$\mu_A : \text{U} \rightarrow [0, 1], \quad \mu \rightarrow \mu_{A(U)}$$

μ_A is called the subjection function defined on domain U, the set A constructed by $\mu_{A(U)}$ ($u \in U$) is called the fuzzy set on domain U, and $\mu_{A(U)}$ is called the subjection degree of μ to A.

There are many approaches to construct the subjection function. They mainly include fuzzy statistics, contrastive sort routine, expert decision, and basic concept expansion etc. In this paper, we use contrastive sort routine to construct the subjection function.

2.3.3. Fuzzy pattern recognition based on close-neighbor strategy

After we describe the subjection function and fuzzy set of the concept of reliability, we will divide the nodes into the domain of reliability. In the following of the paper, we divide the nodes into several catalogues by using the most-near neighbor strategy. What is the most-near neighbor strategy? The explanation of the most-near neighbor strategy is described in the below. Suppose: A_1, A_2, …, A_n are n fuzzy sets in domain U, and the object to be recognized S: s_j ($j=1, 2, \ldots, m$) is also the fuzzy set in domain U. We compute the most-near measurement s_jA_k, which is the certain measurement between s_j and A_k ($k=1, 2, \ldots, n$). If the measurement s_jA_i is the smallest one, we say, s_j belongs to A_i.

The computation of the measurement between s_j and A_k ($k=1, 2, \ldots, n$) is is listed below.

$$s_j A_i = \vee_u \mu_{s_j}(u_k) \wedge \mu A_i(u_k))$$

$$s_j \odot A_i = \wedge_u \mu_{s_j}(u_k) \vee \mu A_i(u_k))$$

$$(s_j, A_i) = 1/2(s_j A_i + (1 - s_j \odot A_i))$$

3. The Implementation of Gossip Protocol Based on Fuzzy Theory

3.1. MR-Gossip Message Transmission Protocol

In order to overcome the drawback of traditional Gossip protocol, we improve the traditional Gossip protocol, and prompt a new transmission node selection strategy based on reliability degree instead of the random node selection policy of transmitting node.

Through a deep analysis of the current Gossip protocol in the world adopted in non-structural P2P network, we put forward a most reliable Gossip (MR-Gossip) message transmission protocol. In the traditional Gossip protocol, message is sent to randomly-selected b neighbor nodes. While in our MR-Gossip protocol, the message is sent to k most reliable neighbor nodes.

The details of MR-Gossip can be found in the below. If node n wants to send a message m, it sends the message m to the k most reliable neighbor nodes, which mostly matches the given threshold.

When(node p receives a message m from node q)

if(p has received m no more than F times)

P sends m to the top k most reliable neighbors

that p knows have not yet seen m

3.2. Node Selection Strategy Based on Fuzzy Theory

As we mentioned above, in our MR-Gossip protocol, the message m is sent to k most reliable neighbor nodes. The new problem of how to evaluate the reliability of the selected nodes is brought up. To solve this problem, we put forward a new algorithm: we compute the reliability of node in accordance with the physical performance of different nodes respectively and the network state at the moment. Then the proper nodes are selected. The details of how to compute the reliability of node are described below.

To evaluate a node to be most reliable or not, we select the factor of the quality of service, network bandwidth, node contribution, and node online time as the evaluation targets through the simulate test and analysis.

To discuss the problem, let domain U
U={Uservice, Ubandwidth, Uconribution, Uonline}

Where Uservice stands for the quality of service provided by the selected node, Ubandwidth for the network bandwidth, Uconribution for the node contribution, and Uonline for the node online time.

Before computing the reliability of certain node, we should confirm the subjection degree of the above four factors that my affect the performance of network to the reliable node. To compute the subjection degree, we use the approach of contrastive sort routine. The subjection degree g{Uservice, Ubandwidth} is defined as follows.

Definition 1: g(Uservice, Ubandwith) = service/bandwidth
Where the value of service is between 0 and 1. If the value is much more near to 0, it means the worse quality of service, while the value is much more near 1, it means better quality of service, and 1 means the best quality of service.

Definition 2: bandwidth = $bandwidth_{node}/bandwidth_{network}$
Where bandwidth is the ratio of node bandwidth and network bandwidth, the value is also between 0 and 1.

Definition 3: contribution = Bout/Bin
Where Bout denotes for the output bandwidth of the selected node, and Bin for the input bandwidth of the selected node. The value of contribution is between 0 and 1.

Definition 4: online = (node average online time daily)/24
The value of online is between 0 and 1.

We make a unitary process on the obtained relative subjection degree prior to computing the fuzzy set. According to the requirement of node reliability, we adjust the rights of Uservice, Ubandwidth, Uconribution, and Uonline. serWeight presents for the right of Uservice, bwWeight for Ubandwidth, conWeight for Uconribution and onWeight for Uonline respectively. Then we get the subjection degree of each element belonging to fuzzy set of reliable nodes through the approach of contrastive sort routine. The subjection degree of each effective factor in the fuzzy set equals the weight multiples sum of the subjection degree in each group. The details are stated as follows.

$$\mu A(Uservice) = serWeight * (g(Uservice, Ubandwidth) + g(Uservice, Ucontribution) + g(Uservice, Uonline)) \quad (1)$$

$$\mu A(Ubandwidth) = bwWeight * (g(Ubandwidth, Uservice) + g(Ubandwidth, Ucontribution) + g(Ubandwidth, Uonline)) \quad (2)$$

$$\mu A(Ucontribution) = conWeight * (g(Ucontribution, Uservice) + g(Ucontribution, Ubandwidth) + g(Ucontribution, Uonline)) \quad (3)$$

$$\mu A(Uonline) = onWeight * (g(Uonline, Uservice) + g(Uonline, Ubandwidth) + g(Uonline, Ucontribution)) \quad (4)$$

Thus, we obtain the fuzzy set on reliability of the given node.

$$A = \mu A(Uservice) / Uservice + \mu A(Ubandwidth) / Ubandwidth + \mu A(Ucontribution) / Ucontribution + \mu A(Uonline) / Uonline \quad (5)$$

In the simulation experiments, we obtain the grade of the most-near neighbor of the given node to reliable swatch using computation method of the grade of the most-near neighbor measurement according to the selected reliable node A_i each time. Thus we consider the grade of the most-near neighbor decides the reliability of the given node.

3.3. Algorithm Implementation

According to the node selection strategy based on fuzzy theory as stated above, the algorithm of computing the node reliability is presented below:

a) Make a unitary process on rights of service, bandwidth, contribution, and online.
WeightArray = unitary (serWeight, bwWeight, conWeight, onWeight).

b) Computing the subjection degree of each group using the approach of contrastive sort routine, e.g. *g(Uservice, Ubandwidth)*.

c) Computing subjection degree of each affect factor in the fuzzy set, using Formula (1) to (4).

d) Computing the reliability of node using the grade of the most-near using Formula (5).

4. Numerical Results and Performance Analysis

4.1. Simulator Environment

NS-2 simulator is used to simulate the MR-Gossip protocol algorithm, and GT-ITM [12] is used to set up the simulator topologic diagram. The diagram of Transit-Stub is shown in Fig. 1. In this diagram, there are two transit domains, which includes 10 transmit nodes. Each transmit node is connected with 6 stub domains; each of stub domain includes 12 stub nodes.

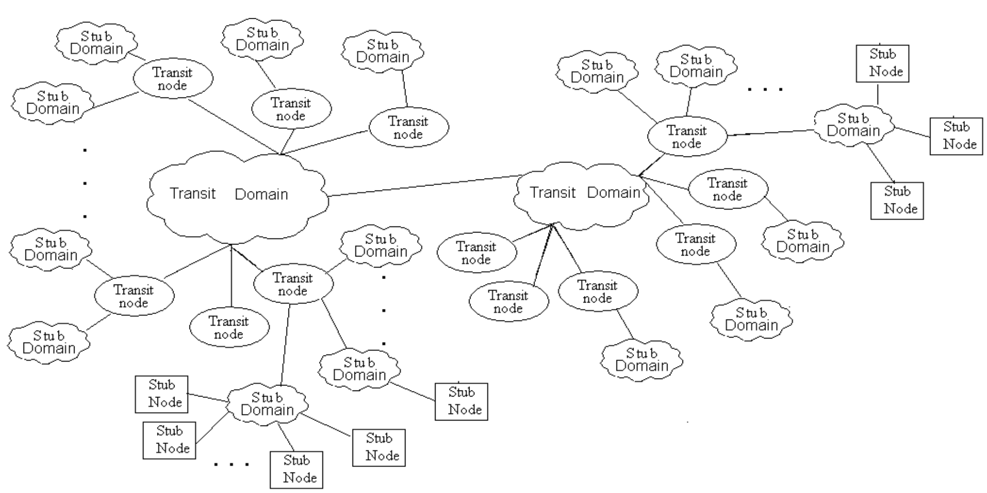

Fig.1 Diagram of Transit-Stub

In the simulation, Peer node can be located on any stub node in the topologic diagram. We set the following parameters.

We randomly select 200 stub nodes as the peer client, and put the resource server on a transmit node. The bandwidth between two transit nodes is 100Mbps, the bandwidth between a transit node and a stub node is 10Mbps, and the bandwidth between tow stub nodes is 4Mbps. To test our algorithm, we select the test stream film with the stream speed of 400KB/s and content length of 40 minutes. During the simulation, we suppose that the nodes are active and effective.

4.2. Simulation Results

To illustrate the result of our algorithm, we compare the result of MR-Gossip protocol algorithm with that of the traditional gossip protocol to assess the effectiveness of our MR-Gossip protocol algorithm. The results are shown in the following three figures.

Fig.2 illustrates the efficiency of node searching of MR-Gossip protocol algorithm and compares with that of the traditional gossip protocol. From the figure, we find that the efficiency of successful search of MR-Gossip protocol algorithm is evidently higher than that of the traditional node random selection gossip protocol.

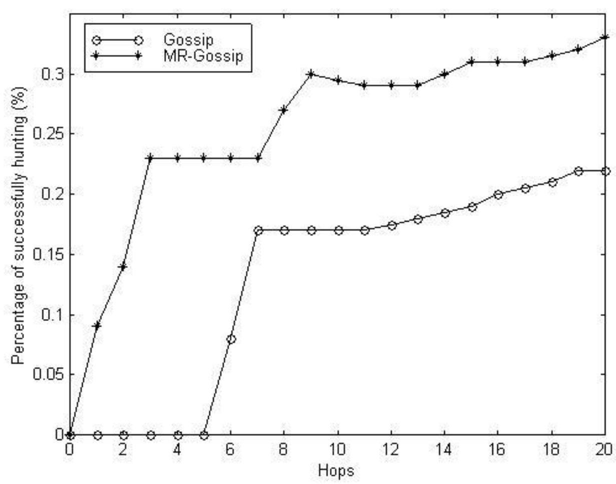

Fig.2 Percentage of successfully hunting

In the node random selection algorithm, the network overlay reaches a relatively high value in a very short time because one node sends the message to all neighbor nodes each time. The diagram of network overlay reflects this result shown in Fig.3. At the same time, since the traditional node random selection gossip protocol selects the neighbor node randomly, the payload of network transmission brings the characteristic of randomness as shown in Fig. 4. However the MR-Gossip protocol selects the most reliable node to send the message each time, and it also considers the factors that may affect the network performance while computing the reliability of nodes synthetically, its overall payload is relatively lower.

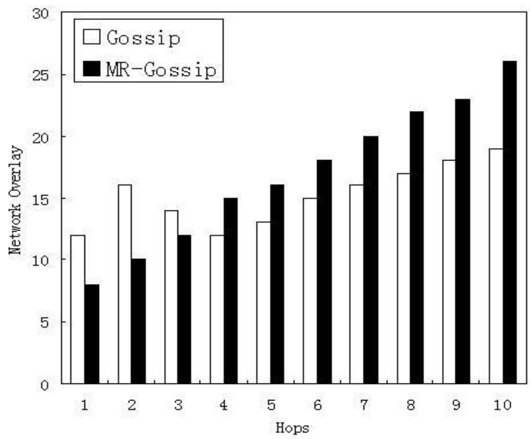

Fig.3 Diagram of Network Overlay

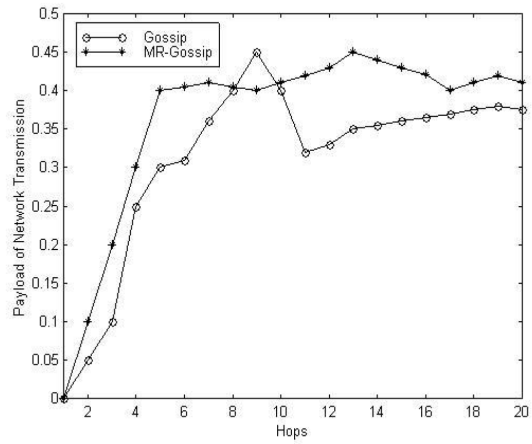

Fig.4 Payload of Network Transmission

An optimal experimental value is obtained to consider the node search efficiency and transmission payload through constantly adjusting the k value of the reliable nodes and the threshold of reliability in the experiment.

5. Conclusions and Future Work

In this paper, the drawbacks of the random algorithm used in Gossip message transmission protocol in P2P networks have been investigated and also the factors that affect nodes selection have been analyzed. A new node selection policy based on fuzzy theory is thus proposed. Furthermore, the fuzzy policy embedded into gossip message transmission protocol, which demonstrates the improvements of the efficiency of the given strategy on node selection in P2P networks through simulation experiments with data analysis.

Through the MR-Gossip node selection algorithm based fuzzy theory, we can select the highly reliable nodes to keep the relatively high efficiency of node search. After considering the synthetic factors which may affect the quality of service and contribution provided by the nodes, it is concluded that the highly reliable nodes can improve the system security and effectively avoid the destroy caused by hostile nodes. Besides, with minimum online time they can reduce the transmission cost for the blight of node selection caused by node’s bandwidth.

In future work, further investigation is needed to improve the efficiency of node selection in unstructured peer-to-peer networks. We will further research on the service evaluation mechanisms and overcome the drawbacks of the partial reliability evaluation in order that the MR-Gossip node selection algorithms can make sense to the Internet.

Acknowledgement

This work is sponsored by Chinese Post-doctoral Funding, Funding of Shaanxi Education Bureau and China Scholarship Council.

References

[1] R. Renesse, Y. Minsky, and M. Hayden, "A gossip-style failure detection service", In Proceedings of the IFIP International conference on distributed systems platforms and open distributed processing, The Lake District, England, September 1998.
[2] M. Lin and K. Marzullo, "Directional Gossip: Gossip in a wide-area network", In Proc. 3rd European dependable computing Conf., volume 1667 of Lect. Notes Comp. Sci. Springer-Verlag, Berlin, Sept. 1999.
[3] M. Lin and K. Marzullo, "Gossip versus deterministically constrained flooding on small networks", In DISC: International Symposium on Distributed Computing. LNCS, 2000.
[4] D. Clark, "Face-to-face with peer-to-peer networking", Computer, 34(1), 2001.
[5] I. Stoica, R. Morris, D. Karger, and etc. "Chord: A scalable Peer-To-Peer lookup service for Internet applications", In R. Guerin, editor, Proc. of the ACM SIGCOMM 2001.
[6] B.Yang, and G. Hector, "Efficient Search in Peer-to-Peer Networks", 1st International Workshop on Peer-to-Peer Systems, Cambridge, MA, USA, March 2002.
[7] A. Kermarrec, L. Massoulie, and A.Ganesh, "Reliable probabilistic communication in large-scale information dissemination systems", IEEE transactions on parallel and distributed system, 14(3), 2003.
[8] S. El-Ansary, L. Alima, P. Brand, and etc., "Efficient broadcast in structured Peer-to-Peer networks", International workshop on Peer-to-Peer systems, 2003.
[9] M. Portman and A. Seneviratne, "Cost-effective broadcast for fully decentralized peer-to-peer networks", Computer communications, 26 (11), 2003.
[10] R. Gupta and A. Somani, "CompuP2P: An architecture for sharing of computing resources in Peer-to-Peer networks with selfish nodes", In Proc. of the Second Workshop on the Economics of P2P Systems, Harvard University, June 2004.
[11] M. Jelasity, A. Montresor, and O. Babaoglu, "Gossip-based aggregation in large dynamic networks", ACM transactions on computer systems, 23(3), 2005.
[12] X. Zhang, J. Liu, B. Li B, and etc., "CoolStreaming/DONet: A data-driven overlay network for live media streaming", In: Proc. of the IEEE INFOCOM. Miami: IEEE Press, 2005.
[13] M. Jelasity and O. Babaoglu, "T-Man: Gossip-based overlay topology management. Engineering self-organising systems", Third international workshop, 2006.
[14] B. Maniymaran, M. Bertier and A. Kermarrec, "Build one, get one free: Leveraging the coexistence of multiple P2P overlay networks", Proc. ICDCS, June 2007.
[15] M. Jelasity, S. Voulgaris, R. Guerraoui, and etc., "Gossip-based peer sampling", ACM Trans. Comp. Syst., 25(3), 2007.
[16] A. Kermarrec, and S. Maarten, "Gossiping in distributed systems", ACMSIGOPS operating systems review. 41(5), 2007.
[17] K. Birman, "The promise and limitations of Gossip protocols", ACM SIGOPS operating systems review. 41(5), 2007.