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A Fuzzy Approach for Reputation Management in Online Communities for Bittorrent P2P Network

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***Abstract*— Reputation management for users in Bittorrent P2P network is very much important due to its open and anonymous nature in online forums. Users are from all over the globe register themselves in the torrent websites to download their interested content. Some malicious peers distribute low quality or fake files in the forums and pollute the environment. We have to identify those malicious users & not allow them to spread the fake files to more users by giving reputation to each users present in the forum/website. Each user id registered in the forum is associated with a reputation value from which we can know the user is malicious or not. In this paper, we propose a fuzzy inference system to design P2P reputation management system which generates the reputation values automatically without interacting with other peers, for each peer who are the members of the torrent communities. This will reduce the extra communication overhead of the system. Fuzzy logic is effective for calculation of reputation as factors affecting the reputation are uncertain and has fuzziness. After getting the reputation values we will divide the users in layers according their reputation value. We have taken three factors that affect reputation and simulate the result.**

***Keywords*— Fuzzy Reputation Management, Bittorrent P2P Network, Torrent Community, Forum.**

I. INTRODUCTION

The popularity of the Bittorrent file sharing protocol is growing extensively as it can distribute large files by efficiently utilizing the peers upload bandwidth. But due to open and anonymous nature of P2P network some malicious peers distribute low quality or fake files in the online communities and pollute the environment. So there should be some techniques present which will let the peers know about the trustworthiness of the shared files and the peer who is sharing the file. So a reputation management system is required, which will store the reputation based on some input factors given to the fuzzy inference system and the output will be the reputation of the peers registered in a community.

There are many reputation schemes are proposes in P2P networks. But there are very few number of reputation system exits for Bittorrent P2P network. Lan Yu has proposed a reputation management system X2BTRep [9]. In this scheme after download complete the peers will vote for the torrent file as well as for the peer who share that file. The votes are stored in three different repositories- Offerer repository, Torrent Repository and Credibility Repository. The votes are encrypted and sent to the central tracker. The tracker manages the vote submitted by the pooler & rejects the votes which will look suspicious.

In this paper, we will manage the reputation of the peers joining the Bittorrent P2P community system. To calculate the reputation of the peer there are six steps: fuzzification of crisp input variables, application of fuzzy operator in the antecedent, fuzzy rule base creation, rule evaluation, aggregation of consequent across the rules, defuzzyfication to get the crisp output. The process is shown in the fig. 1.

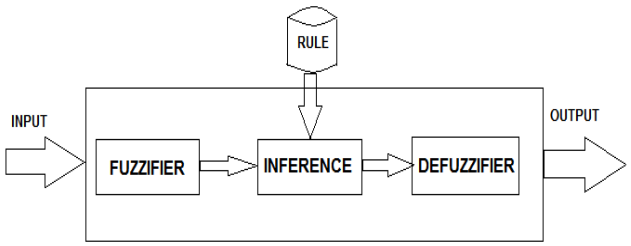

Fig. 1 Fuzzy Inference Model

II. RELATED WORK IN P2P TRUST MANAGEMENT

Damiani et al. propose XRep [4], a protocol for trust management in decentralized P2P systems. In XRep peers query about the reputation of resources or peers by using network broadcasts to retrieve votes from neighboring peers. X2Rep [11] proposed by Curtis, Safavi-Naini, Susilo, extends XRep and is designed to protect against the weaknesses of XRep.

Cornelli et al. present a trust system, called P2Prep [6], where peers poll the network for reputation opinions on service providers. Both of these approaches are designed for Gnutella, a first generation P2P system which allows message broadcasting to discover information sharing peers. Fajiang Yu, Huanguo Zhang, Fei Yan [7] presented a trust model of choosing trusted source peers in P2P system based on the fuzzy relation theory in fuzzy mathematics. The authors defined four types of fuzzy trust relations, and gave the ways of fuzzy global trust relation matrix computing, which used as the base of judging which source peers were trusted peers.

Shanshan, Hwang, Runfang, Kwok [11] proposed a fuzzy reputation aggregation system which can better handle uncertainty, fuzziness, and incomplete information in peer trust reports.

Elodie Fourquet, Kate Larson and William Cowan [5] proposed a layered reputation mechanism concept. The layered reputation mechanism classifies participants into reputation categories which govern their privileges and rewards. Participants in the top layers have a high reputation, having demonstrated good behavior; participants in the bottom layers have a low, or not yet determined reputation.

In our previous work in the first paper [1], we have developed a fuzzy inference system which generates reputation for peers automatically by taking three fuzzy inputs number of files, seeding time and upload bandwidth of peer which reduces the communication overhead between peers of the Bittorrent system.

In the second paper [2], we have developed a fuzzy inference system which generates reputation for torrent files shared by peers in the torrent sites. From the reputation of the torrent files we can know which torrent files are of good quality & which are of bad quality files.

From the above study we came to the conclusion that the reputation is not only required for peers which are on the Bittorrent network but also required for peers present in the online communities. So we have added a third method for verification of trustworthiness of peers in online communities. We study from other papers that the trust management system works on the interaction between peers i.e. the reputation is given by one peer to the other peer directly or by recommendation basis. But our system generates reputation automatically by taking three fuzzy inputs, reducing the communication overhead between peers of the Bittorrent system. So we have taken three factors such as: time spent in forum, No. of post count, Bandwidth donation.

III. Proposed Fuzzy Reputation Model

In this section, we introduce our proposed fuzzy model for the calculation of reputation of peer participating in the Bittorrent network.

A. The Concept

The reputation of a file is decided by three factors taken by us: time spent in forum, No. of post count, Bandwidth donation. The factor time spend in forum is taken in to consideration because it will give us the idea about the malicious activity of the user. This time spend in the forum also include the seeding time of the user as it uses the tracker of that community. The second factor no. of post count shows us the helping nature of the user. Some users give good guidelines for compressing the video files to reduce size with good quality. Some helps other users if they are in some problem in downloading or uploading or just commenting on others torrent post to increase their interest in posting new quality torrents. Like this the post count shows the quality of the user. The third factor bandwidth donation means to donate some megabytes of data to other users to increase their upload ratio. It is compulsory for many communities that all users should maintain their upload ratio more than one. Upload ratio is the ratio of size of data uploaded to the size of data downloaded. Some users have less upload bandwidth. So the upload speed of those users is very less that they can't maintain their upload ratio to one. So there is a provision for users that those have high upload speed they can help other users by donating some size of data to maintain their upload ratio, which would helpful for the less speed users to maintain that ratio & upload more. So the users taking part in the community gets a good environment & the torrent files are not dead for long time. So all the factors depend upon each other and combinedly affect the reputation of the peers.

B. Fuzzy Inference Model

As seen from Fig. 1 there are four basic parts of a fuzzy inference model: fuzzifier, Inference system, Rule base, defuzzifier. Fuzzification is the first step in which the inputs are taken and determine the degree to which they belong to each of the appropriate fuzzy sets via membership functions. As the peers stays in the system for very short period of time, it is much difficult to measure exact values for the input variables. It is difficult to derive a mathematical formula involving the three inputs to calculate reputation. So we are using fuzzy logic to calculate our reputation for peers associated with the system. The input variables are first fuzzified by using membership functions. We determine the degree to which they belong to each of the appropriate fuzzy sets via membership functions.

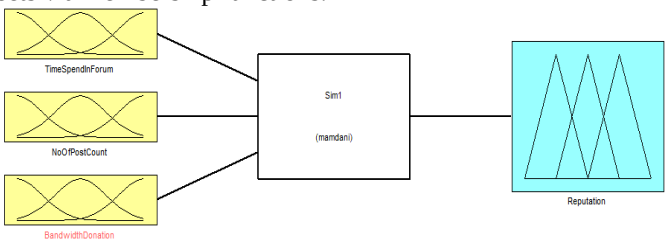

Fig. 2 P2P Reputation Model based on Mamdani-type Fuzzy Inference System

A membership function is a curve that defines how each point in the input space is mapped to a membership value (or degree of membership) between 0 and 1. There are many Membership Functions such as triangular, Gaussian, Bell, Z, PI, Trapezoidal, Sigmoid and so on.

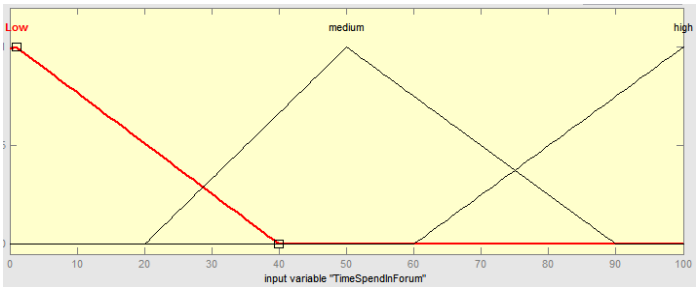

Fig. 3 Membership function for Time spent in forum

Fig. 3, 4, 5 shows the membership function for time spent in forum (in seconds), No. of post count and Bandwidth donation (in GBs) respectively which has three linguistic values low, medium, and high for quality & popularity of file and less, medium, large for size of file.

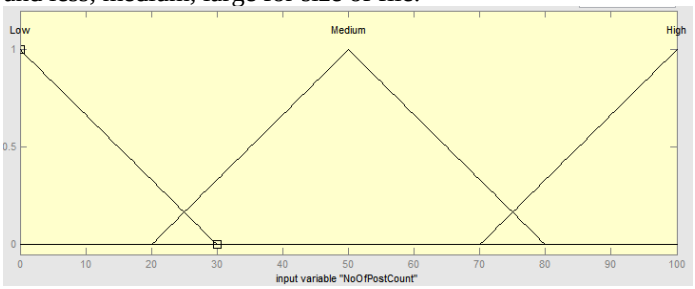

Fig. 4 Membership function for No. of post count

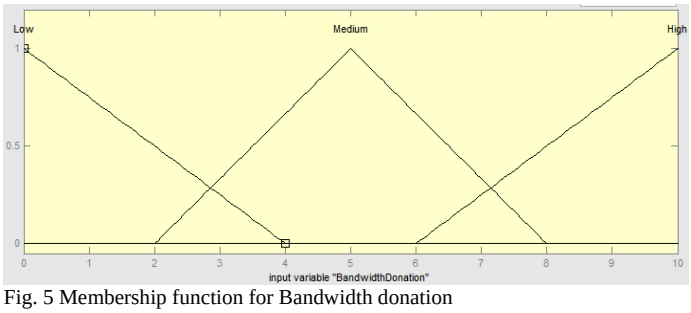

Fig. 5 Membership function for Bandwidth donation

Once the inputs are fuzzified, we apply the fuzzy rule base to arrive at the fuzzy output. Fuzzy Inference Rule Base comprises many Fuzzy Rules. Fig-6 shows the fuzzy rule base for the inference system.

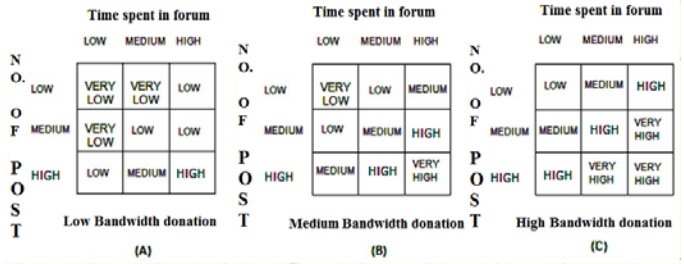

Fig. 6 Fuzzy rule base for reputation management system

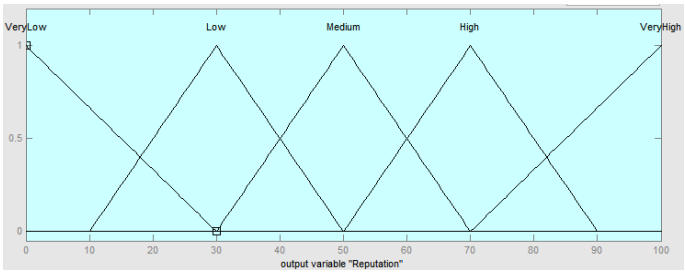

Fig. 7 Membership functions for calculation of reputation

From the fuzzy output, we use center of gravity defuzzyfication to arrive at the crisp output which is our required reputation value. The membership function for calculating reputation is shown in the Fig. 7, which has five linguistic values very low, low medium, high, very high.

We than store this reputation value in a central repository for future use by other peers for decision making. If any peer wants to download any data from a peer it first requests for the reputation of peer and then decides if it download the data. We have proposed an algorithm for this decision making process in section 3.5.

C. Central Reputation Repository

We make the following two assumptions with respect to resources and peers. First, each peer i keep a consistent pair of public (PK_i) and private keys (SK_i) for multiple uses. Also, there is a peer_id (P_i) associated with the peer, which is the digest of the public key obtained using a secure hash function.

Also, we require a tracker that can be trusted by all the peers with respect to BitTorrent's centralized architecture. We assume that a tracker is trusted by all the peers, and plays a significant role in the verification of torrent files and the distribution of reputation to the peers. The trusted tracker T is associated with a consistent pair of public (PK_T) and private keys (SK_T) for verification and security purpose.

A trusted tracker manages the reputation values from different peers and also the layering of peers. After receiving reputation related information from a peer, the tracker verifies it using the public key of the peer, stores it in the central repository and removes suspicious ones. The central repository consists of information regarding time spent in forum after joining in the system, their No. of post count, Bandwidth donation and reputation. At the initial stage when a peer joins the system newly, it's all field is initialized to zero. When the time goes on these values are updated in the central repository automatically.

D. A Layering reputation Approach

This is an additional reputation updating mechanism where we increase the reputation of those peers showing good behaviour & decrease the reputation of those peers who will show malicious behaviour. After collecting the reputations of each peer in the forum, the peers are layered in different levels according to their reputation. The layered reputation mechanism classifies peers into reputation categories which determine their privileges and rewards. Peers in the top layers have a high reputation, having demonstrated good behavior; peers in the bottom layers have a low, or not yet determined reputation. A peer's reputation layer determines what content it can access in the system: peers cannot access content more than one layer above them. Thus, peers at the top can access all content, while peers at the bottom have limited access. [11]

The reputation is updated periodically, if the peers provide good content to higher layer peers or peers of same or lower layer peers then their reputation increases & they may be moved to the next higher layer. If the content is seen bad by the higher layer peers the reputation value would be decreased & possibly moving the peer to the previous lower level.

The reputation values are adjusted non-uniformly: providers of good content in lower layers increase their reputations more than those in higher layers. Conversely, supplying poor content from high layers is treated more severely than doing the same from lower ones. This will reduce the free-riders & removes malicious peers from spreading bad content in the forum. After some negative value of reputation the user id will be removed from the forum.

Reputation of each peer is updated by the rule defined in the following table. This rule is just an example to show how the updating takes place. Peers are divided into six layers from which the low reputation peers or newly joined peers having zero reputation will stays in layer-1. This layering management system took the values of the peers & divides them to corresponding layers and regularly updates the reputation by seeing each user's behaviour.

TABLE I
REPUTATION UPDATING POLICY

Reputation Layer	1	2	3	4	5	6
Range of Reputation score	0-15	16-30	31-49	50-70	71-85	86-100
Increment Function	9	5	4	3	2	1
Decrement Function	1	2	3	4	5	9

E. Reputation Management Algorithm

In this section we propose an algorithm for peer who wants to download data from other peers. Peer want to download something from the Bittorrent system, it will send a PollRequest() message to the central tracker with its peer_id. When the tracker receives a download request from a peer this algorithm is invoked. Verification of the peer_id (P_i) of the requesting peer is done by its public key (PK_i). If the peer is verified then the reputation, IP address and port number of the peers, who has the data and is uploading, is sent to the requesting peer by PollReply() message and it is encrypted by trackers private key(SK_T). If the peer is not verified by the tracker the request is neglected and only IP address and port number is sent.

PollRequest (Pi)
If Pi is verified
Queries the central repository for reputation of peers;
PollReply (Rep);
Else
Return (Null);

Peer after receiving the reputation value (Rep) checks the authenticity of the PollReply() message by verifying the trackers public key (PK_T). Then it extracts the reputation value and compares with the threshold reputation. If the reputation of the other peers is greater than the threshold reputation value, then it connects to that peer and the piece exchange takes place.

Reputation updating is done in a regular timely manner or on demand by other peers by following UpdateRepository() algorithm by the tracker. Tracker takes three inputs from peers and the reputation is calculated by the fuzzy inference system, and then stored in the repository. Reputation of those peers is only calculated which are authentic to the system and the peer_id is verified by the tracker.

UpdateRepository (n, t, b)
If Pi is verified
Extract the three inputs time spent in forum 't', No. of post count 'n' and Bandwidth donation 'b';
Input them to fuzzy inference system;
Collect the crisp output;
Store in the central repository;
Else
Update failure;
Retry ();

When a peer requests content, it receives the reputation profiles of owners from whom downloading is allowed. The requester selects owners, who then supply the content. After evaluating it, the requester submits an appreciation mark, which updates the owner's amounts of good and bad content supplied.

UpdateLayeredReputation (Rep)
If Pi is verified
Get the apparition Mark;
Update the Reputation of Pi;
Place the peer Pi in its layer according to the reputation;
Else
Exit ();

A peer who re-enters the system must earn its reputation again. It discourages free-riding because new peers have a strong incentive to contribute novel content.

IV. Implementation

We have implemented our fuzzy inference system in Fuzzy Logic Toolbox Graphical User Interface Tool of Matlab. Fig. 8 is a sketch map of Mamdani-type Fuzzy Inference. The Rule Viewer displays a roadmap of the whole fuzzy inference process. It is based on the fuzzy inference diagram described in the previous section.

Fig. 9 and 10 gives a three-dimensional simulative sketch map of P2P Fuzzy Inference reputation. By inputting arbitrary time spent in forum, No. of post count and Bandwidth donation, the fig-8 will maps to a fuzzy output value Reputation. Because this curve represents a two-input one-output case, you can see the entire mapping in one plot. When we move beyond three dimensions, we start to encounter trouble displaying the results. That's why we have represented two figures related to reputation output.

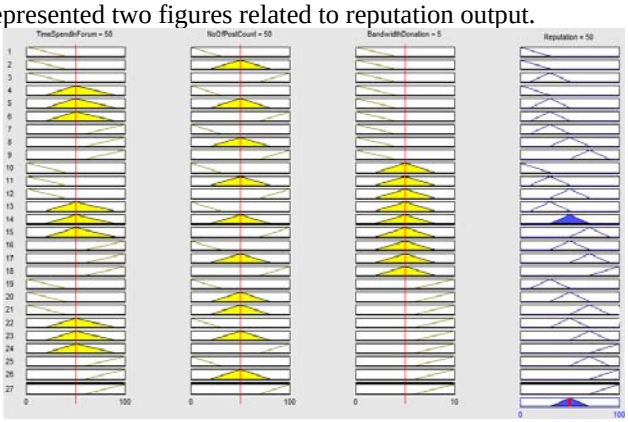

Fig. 8. A sketch map of Mamdani-type Fuzzy Inference

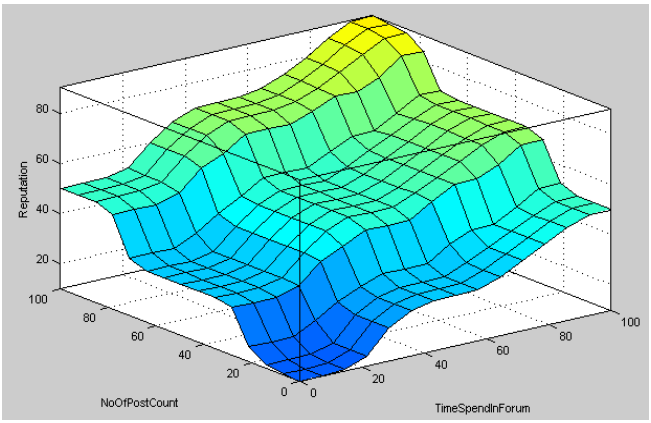

Fig. 9 A three-dimensional simulative sketch map of P2P Fuzzy Inference Reputation plotting No. of Post Count Vs. Time Spend in Forum

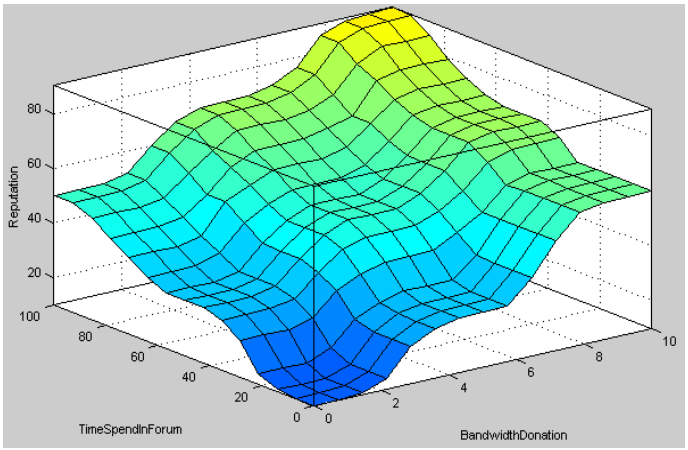

Fig.10. A three-dimensional simulative sketch map of P2P Fuzzy Inference Reputation plotting Time Spend in Forum Vs. Bandwidth Donation

V. Conclusions

The evaluation of trust and reputation is a very important issue in an open, dynamic and distributed P2P environment. As all the factors are changing so dynamically it is good to take fuzzy logic to calculate reputation. In this paper, we present a new fuzzy inference trust model for calculation of reputation for peers registered in Bittorrent P2P online community/forum. Our fuzzy model takes three inputs from the peers automatically and computes the reputation of the peer without any extra communication overhead. Collecting

votes from other peers directly and collecting votes from recommending peers are not required. So this system is much more efficient than other existing reputation management systems. The central tracker automatically generates and stores the reputation securely in the global repository and provides it whenever any peer request for it. The layered reputation approach will reduce the distribution of fake files as the reputation of the peer decreases & the peer will come to the lower reputation level. Thus this combined fuzzy & layered approach will reduce the malicious activities of users in online communities.

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