Trust Management in P2P Networks using Mamdani Fuzzy Inference Systems

Sandhya S
Assistant Professor
MVJ College of Engineering, Near ITPB, Bangalore, India

ABSTRACT
Peer to peer (P2P) systems are autonomous and decentralized systems with a form of distributed computing. Hence each peer in the network is heterogeneous and is not fully reliable. In this paper it has been tried to estimate the trustworthiness of each peer in the network using Mamdani Fuzzy Inference Systems. For estimating the trust only some of the parameters are considered, namely - Capability, Reliability, Availability and Integrity

General Terms
Trust Management, Fuzzy logic

Keywords
Trust, P2P, Mamdani FIS

1. INTRODUCTION
Peer to Peer (P2P) systems are one of the popular distributed systems which are used in many areas of communication for many years. This is because P2P systems are autonomous systems where any number of systems can come and join the network without the need for any central coordination. This gives these networks the property of scalability, robustness and diversity.P2P systems rely on the collaboration of two or more peers using appropriate information and communication systems, without the necessity for central co-ordination.Peers have varying degrees of reliability, quality &honestyand hence interactions may fail, produce substandard results, or cost more &take longer than expected.But this decentralized nature of P2P networks will affect the trustworthiness of these networks.Since peers are autonomous, they determine for themselves when to cooperate, when to cease cooperating, and how to conduct themselves. For example, a peer may choose to delay the provision of information, and reduce its quality. To function effectively peers must manage the risk of interactions failing or having reduced performance. So trust holds the key for security in P2P systems.

Trust represents an individual'shonesty, reliabilityetc.vis-a-visanother.Generally, trust in the field of information systems can be considered an abstract mapping of a subset of human trust, where the choice of subset and interpretation of trust are defined depending on applications (and corresponding circumstances). Therefore, trust in information systems is usually the quantifiable or describable belief on a given entity. System trust can be subjective, objective, or by consensus. Because information systems emulate and enhance the physical systems, system trust, on one hand derives many characteristics from human trust, and on the other, introduces new characteristics unique to it. Trust representation and management has a long history of research work, and recently has attracted more attentions due to the explosive use of online social networking. Depending on the circumstances and applications, trust has many different interpretations and therefore different representation and management principles in different systems.

The typical trust models in P2P include EigenRep,Poblano,Bayesian Network trust etc. But the subjective nature of trust in these models results in uncertainty and fuzziness in characters. Fuzzy logic offers better ability to handle thisuncertainty and imprecision effectively. Fuzzy inference system uses linguistic terms and hedges to effectively represent trust. So by using Fuzzy logic, terms like trustworthy and honesty are quantified and can be more accurately used for analysis of trust in P2P networks

1.1 MAMDANI FUZZY INFERENCE SYSTEMS –BASIC STEPS
Fuzzy inference is the process of formulating the mapping of input to output using fuzzy logic.Mamdani-type fuzzy inference method is the most commonly seen fuzzy methodology.Mamdani's method was among the first control systems built using fuzzy set theory. Mamdani-type inference, expects the output membership functions to be fuzzy sets. After the aggregation process, there is a fuzzy set for each output variable that needs defuzzification.In order to compute the value of output using Mamdani FIS, one must go through the following six steps

1. Determining a set of fuzzy rules
2. Fuzzifying the inputs using the input membership functions
3. Combining the fuzzified inputs according to the fuzzy rules to establish rule strength
4. Finding the consequence of the rule by combining the rule strength and the output membership function
5. Combining the consequences to get an output distribution and
6. Defuzzifying the output distribution (this step is only if a crisp output (class) is needed).

The basic model of a Mamdani FIS is as shown in Figure1.The process of Fuzzification is to map the inputs in to fuzzy sets via membership functions. Membership function is a curve which defines how each input value is mapped in to some value between 0 and 1 i.e., it defines the degree of membership. There are so many membership functions like Gaussian, Bell etc.Fuzzy rules are a collection of linguistic statements that describe how the FIS should make a decision regarding classifying an input or controlling an output. Fuzzy rules are of two types Generalized Modus Pones (GMP) and Generalized Modus Tollens(GMT).The input of the defuzzification process is a fuzzy set (the aggregate output set) and the output is a single number. There are various defuzzification techniques out of which Centroid of Area

(COA) is the most popular one. This method returns the centre of area under the curve

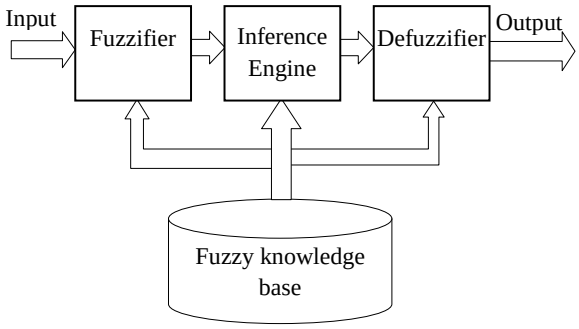

Fig1: Mamdani FIS

2. GENERAL P2P TRUST MODEL

A System model was designed for evaluating the trust value of each peer in a P2P network. This is as shown in figure 2

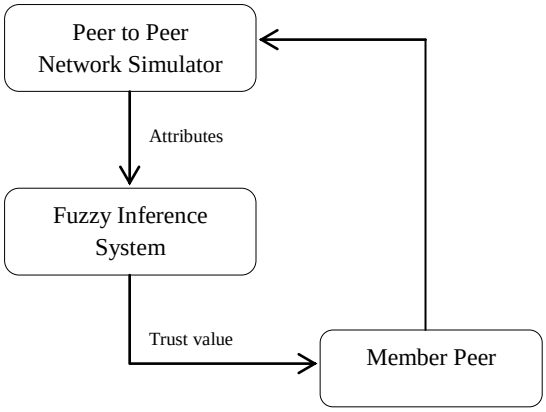

Fig 2: General Model

A peer to peer network simulator was employed to measure the attributes like availability, capability etc. according to the desired standards. These valueswere then fuzzified and given to a FIS which was hierarchical i.e. output of one FIS was given as input to another FIS.The output of FIS which was the trust value of member peer was assigned to each member peer and this value measured for a specified number of interactions if a file sharing application is considered .So if a peer wants to interact with another peer it can see the trust value of that peer for the previous interaction and then decide whether to interact or not.

3.P2P TRUST MODEL BASED ON MAMDANI FUZZY INFERENCE

In this model the trust of a P2P network is calculated using four inputs - Capability, Reliability, Availability and Integrity.Capability Degree of Peer reflects the trustyability of the interactive peer and Reliability Degree of Peer reflects on the trusty attitude of the peer.Availability says whether the system is available for immediate use and integrity is how the system maintains the correctness of interaction.The fuzzy model is as shown in Fig 3

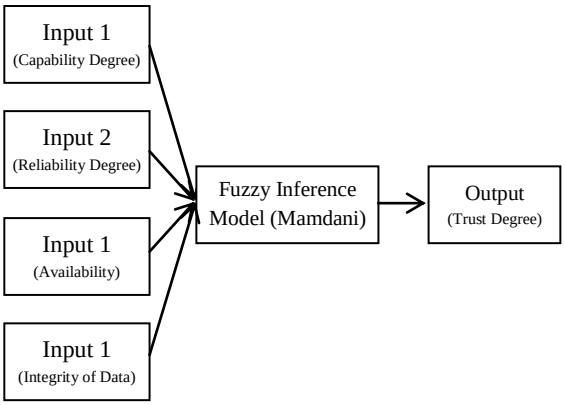

Fig 3: Trust Model

3.1 Fuzzification

In the trust model the input and output values of Fuzzification are defined below

(1)Capability degree:1 (High), 0.5 (Medium), 0(Low)

(2) Reliability degree:1 (High), 0.5 (Medium), 0(Low)

(3)Availability: 1(High), 0.5(Medium), 0 (Low)

(4)Integrity:1 (High), 0.5 (Medium), 0 (Low)

3.2 Fuzzy Member Function

The membership function used in this P2P trust model is Gaussian.

$$\mu(x:\sigma,c) = e^{-\{(x-c)^2\}/\{2*\sigma^2\}}$$

(1) Capability degree, Reliability Degree, Availability, Integrity or Trust degree = low →μ(x;σ,c)=μ(x;0.166,0.2)

(2) Capability degree, Reliability Degree, Availability, Integrity or Trust degree = medium →μ(x;σ,c)= μ(x;0.166,0.5)

(3) Capability degree, Reliability Degree, Availability, Integrity or Trust degree =high→ μ(x;σ,c)= μ(x;0.166,1)

3.3 Fuzzy Inference Rules

There are 81 rules in this model .The definition of some of the rules are as follows:

Rule1: If Capability=low, Reliability=low, Availability=low and Integrity=low Then Trust degree=low

Rule2: If Capability=low, Reliability=low, Availability=low and Integrity=medium Then Trust degree=low

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Rule81: If Capability=high, Reliability=high, Availability=high and Integrity=high Then Trust degree=high

3.5 Mamdani Fuzzy Inference engine

Mamdani is the most commonly seen fuzzy inference methodology. After Fuzzifying the input variables and formulating the rules, these rules are aggregated by using Max-Min method. Mamdani –type inference expects the output variable also to be a fuzzy set. For example:

Rule1: If Capability=l1, Reliability=r1, Availability=a1, and Integrity=i1Then Trust degree=t1

Rule2: If Capability=l2, Reliability=r2, Availability=a2, and Integrity=i2 Then Trust degree=t2

The formula for aggregation using Min-max for the Mamdani inference engine is as follows:

$$t = \max\{\min(l1, l2), \min(r1, r2), \min(a1, a2), \min(i1, i2)\}$$

Where't' is the output fuzzy set Trust degree

3.6 Defuzzification

The input for the defuzzification is a fuzzy set (here the output trust set) and the output is a single number i.e., the trust value. The most popular method, the 'Centroid of the Area (COA)'which returns the area under the curve is used here .The formula for calculating COA is as follows:

$$T = \frac{\sum \mu(x) * x}{\sum \mu(x)}$$

Where 'T' is the output trust value, x is the input and μ(x) is the membership value of each input.

4. TRUST VALUE EVALUATION USING FUZZY LOGIC TOOL BOX

Thefour inputs provided to the fuzzy logic toolbox are as shown in Fig 4

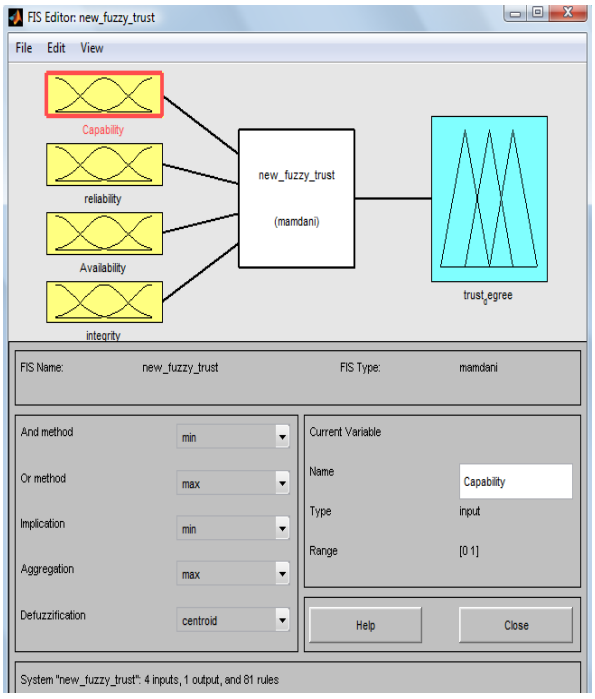

Fig 4: FIS Editor

The formation of rules and trust value evaluation for a set of user defined input is shown in Fig 5

The inputs are as follows;

Capability= 0.1

Reliability= 0.2

Availability=0.3 and

Integrity=0.9

The output waveforms are as obtained in Fig 5

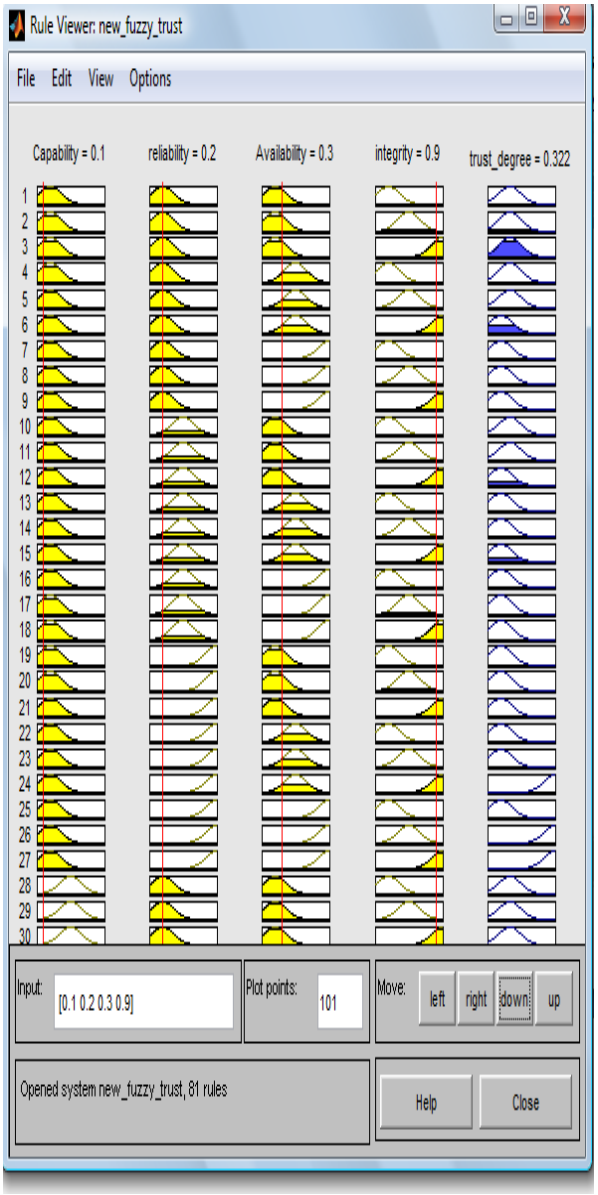

Fig 5: FIS Rule Viewer

The output is obtained correctly according to the rule as three inputs are low and one input is high then output is medium

5. CONCLUSION

In this paper a Mamdani fuzzy inference system for evaluating the trust of P2P systems is proposed. This is better than the previous methods because additional factors for analyzing the trust have been considered which improves the accuracy. Additionally,as fuzzy logic is used, it handles the uncertainties involvedbetter, while considering the factors for evaluating trust. Since fuzzy inference techniques are used, this methodis less complex compared to other existing methods.

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