A Fuzzy-Based Approach for Improving Team Collaboration in MobilePeerDroid Mobile System: Effects of Time Delay on Collaboration Work

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Abstract. Mobile computing has many application domains. One important domain is that of mobile applications supporting collaborative work, such as, eLearning and eHealth. In this work we present a distributed event-based awareness approach for P2P groupware systems. Unlike centralized approaches, several issues arise and need to be addressed for awareness in P2P groupware systems, due to their large-scale, dynamic and heterogeneous nature. In such applications, a team of people collaborate online using smartphones to accomplish a common goal, such as a project development in e-Business. Often, however, the members of the team has to take decision or solve conflicts in project development (such as delays, changes in project schedule, task assignment, etc.) and therefore members have to vote. Voting can be done in many ways, and in most works in the literature consider majority voting, in which every member of the team accounts on for a vote. In this work, we consider a more realistic case where a vote does not account equal for every member, but accounts on according to member's active involvement and reliability in the groupwork. We present a voting model, that we call qualified voting, in which every member has a voting score according to three parameters. Then, we use fuzzy based model to check the effect of time delay on collaboration work. This model will be implemented in MobilePeerDroid system to give more realistic view of the collaborative activity and better decisions for the groupwork, while encouraging peers to increase their reliability in order to increase their voting score.

1 Introduction

Peer to Peer technologies has been among most disruptive technologies after Internet. Indeed, the emergence of the P2P technologies changed drastically the

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concepts, paradigms and protocols of sharing and communication in large scale distributed systems. As pointed out since early 2000 years [1–5], the nature of the sharing and the direct communication among peers in the system, being these machines or people, makes possible to overcome the limitations of the flat communications through email, newsgroups and other forum-based communication forms.

The usefulness of P2P technologies on one hand has been shown for the development of stand alone applications. On the other hand, P2P technologies, paradigms and protocols have penetrated other large scale distributed systems such as Mobile Ad hoc Networks (MANETs), Groupware systems, Mobile Systems to achieve efficient sharing, communication, coordination, replication, awareness and synchronization. In fact, for every new form of Internet-based distributed systems, we are seeing how P2P concepts and paradigms again play an important role to enhance the efficiency and effectiveness of such systems or to enhance information sharing and online collaborative activities of groups of people. We briefly introduce below some common application scenarios that can benefit from P2P communications.

With the fast development in mobile technologies we are witnessing how the mobile devices are widely used for supporting collaborative team work. Indeed, by using mobile devices (such as PDAs, smartphones, etc.) members of a team can not only be geographically distributed, they can also be supported on the move, when network connection can change over time. In this paper, we propose a fuzzy-based system for qualified voting in P2P mobile collaborative team.

Fuzzy Logic (FL) is the logic underlying modes of reasoning which are approximate rather then exact. The importance of FL derives from the fact that most modes of human reasoning and especially common sense reasoning are approximate in nature [6]. FL uses linguistic variables to describe the control parameters. By using relatively simple linguistic expressions it is possible to describe and grasp very complex problems. A very important property of the linguistic variables is the capability of describing imprecise parameters.

The concept of a fuzzy set deals with the representation of classes whose boundaries are not determined. It uses a characteristic function, taking values usually in the interval [0, 1]. The fuzzy sets are used for representing linguistic labels. This can be viewed as expressing an uncertainty about the clear-cut meaning of the label. But important point is that the valuation set is supposed to be common to the various linguistic labels that are involved in the given problem.

The fuzzy set theory uses the membership function to encode a preference among the possible interpretations of the corresponding label. A fuzzy set can be defined by exemplification, ranking elements according to their typicality with respect to the concept underlying the fuzzy set [7].

In this paper, we propose a fuzzy-based peer voting score system for MobilePeerDroid system considering three parameters: Number of Activities the Member has Successfully Finished (NAMSF), Number of Online Discussions the Member has Participated (NODMP), Time Delay on Collaboration

Work (TDCW) to decide the Voting Score (VS). We evaluated the proposed system by simulations. The simulation results show that with increasing of NAMSF and NODMP the VS is increasing, but with increasing of TDCW, the VS is decreased. Thus, the proposed system can choose reliable peers with good voting score in P2P mobile collaborative team.

The structure of this paper is as follows. In Sect. 2, we introduce the scenarios of collaborative teamwork. In Sect. 3, we introduce the vote weights and voting score. In Sect. 4, we introduce FL used for control. In Sect. 5, we present the proposed fuzzy-based system. In Sect. 6, we discuss the simulation results. Finally, conclusions and future work are given in Sect. 7.

2 Scenarios of Collaborative Teamwork

In this section, we describe and analyse some main scenarios of collaborative teamwork for which P2P technologies can support efficient system design.

2.1 Collaborative Teamwork and Virtual Campuses

Collaborative work through virtual teams is a significant way of collaborating in modern businesses, online learning, etc. [8]. Collaboration in virtual teams requires efficient sharing of information (both data sharing among the group members as well as sharing of group processes) and efficient communication among members of the team. Additionally, coordination and interaction are crucial for accomplishing common tasks through a shared workspace environment. P2P systems can enable fully decentralized collaborative systems by efficiently supporting different forms of collaboration [9]. One such form is using P2P networks, with super-peer structure as show in Fig. 1.

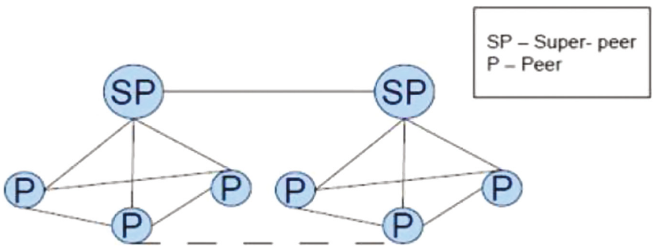


Fig. 1. Super-peer P2P group network.

During the last two decades, online learning has become very popular and there is a widespread of virtual campuses or combinations of face-to-face with semi-open teaching and learning. Virtual campuses are now looking at ways to effectively support learners, especially for online courses implemented as PBL-Project Based Learning or SBL Scenario Based Learning there is an increasing need to develop mobile applications that support these online groupwork learning paradigms [10]. In such setting, P2P technologies offer interesting solutions for (a) decentralizing the virtual campuses, which tend to grow and get further centralized with the increase of number of students enrolled, new degrees, and increase in academic activity; (b) in taking advantage of resources of students and developing volunteerbased computing systems as part of virtual campuses and (c) alleviating the communication burden for efficient collaborative teamwork. The use of P2P libraries such as JXTA have been investigated to design P2P middleware for P2P eLearning applications. Also, the use of P2P technologies in such setting is used for P2P video synchronization in a collaborative virtual environment [11]. Recently, virtual campuses are also introducing social networking among their students to enhance the learning activities through social support and scaffolding. Again the P2P solutions are sought in this context [12] in combination with social networking features to enhance especially the interaction among learners sharing similar objectives and interest or accomplishing a common project.

2.2 Mobile Ad Hoc Networks (MANETs)

Mobile ad-hoc networks are among most interesting infrastructureless network of mobile devices connected by wireless having self-configuring properties [13]. The lack of fixed infrastructure and of a centralized administration makes the building and operation in MANETS challenging. P2P networks and mobile ad hoc networks (MANETs) follow the same idea of creating a network without a central entity. All nodes (peers) must collaborate together to make possible the proper functioning of the network by forwarding information on behalf of others in the network [14]. P2P and MANETs share many key characteristics such as self-organization and decentralization due to the common nature of their distributed components. Both MANETs and P2P networks follow a P2P paradigm characterized by the lack of a central node or peer acting as a managing server, all participants having therefore to collaborate in order for the whole system to work. A key issue in both networks is the process of discovering the requested data or route efficiently in a decentralized manner. Recently, new P2P applications which uses wireless communication and integrates mobile devices such as PDA and mobile phones is emerging. Several P2P-based protocols can be used for MANETs such as Mobile P2P Protocol (MPP), which is based on Dynamic Source Routing (DSR), JXTA protocols, and MANET Anonymous Peer-to-peer Communication Protocol (MAPCP), which serves as an efficient anonymous communication protocol for P2P applications over MANET.

3 Vote Weights

3.1 Votes with Embedded Weight

The weights can be included in voting bulletins distributed to voters, which would then be copied into the votes sent to Counters. But this approach requires a strong assumption: the voters' application must be trusted not to forge weights. Since the voters' application may be tampered in some scenarios, namely when "voting anywhere" is considered, the voters' side cannot be trusted to give the correct input for the system when weights are considered.

The simple copy/paste of weights could be strengthened by adding a cleartext value of the weight when submitting a blinded vote digest for getting a signature from an Administrator. Then, the weight, checked and signed by all the required Administrators, could be added to the final vote submitted to Counters. A bit commitment value should also be added to the weight to prevent stolen, signed weights, to be used by other voters. The drawback of this approach is that protocol messages from voters to Administrators and from voters to Counters would increase in size, namely would double in size. This collides with the requirement of keeping the performance of system close to the performance of the initial version of REVS (Robust Electronic Voting System [15]).

3.2 Voting Score

Score voting (sometimes called range voting) is a single-winner voting system where voters rate candidates on a scale. The candidate with the highest rating wins. For comparison, consider ratings systems from site like: Internet Movie Database, Amazon, Yelp, and Hot or Not. Variations of score voting can use a score-style ballot to elect multiple candidates simultaneously.

Simplified forms of score voting automatically give skipped candidates the lowest possible score for the ballot they were skipped. Other forms have those ballots not affect the candidate's rating at all. Those forms not affecting the candidates rating frequently make use of quotas. Quotas demand a minimum proportion of voters rate that candidate in some way before that candidate is eligible to win [16].

4 Application of Fuzzy Logic for Control

The ability of fuzzy sets and possibility theory to model gradual properties or soft constraints whose satisfaction is matter of degree, as well as information pervaded with imprecision and uncertainty, makes them useful in a great variety of applications.

The most popular area of application is Fuzzy Control (FC), since the appearance, especially in Japan, of industrial applications in domestic appliances, process control, and automotive systems, among many other fields.

4.1 FC

In the FC systems, expert knowledge is encoded in the form of fuzzy rules, which describe recommended actions for different classes of situations represented by fuzzy sets.

In fact, any kind of control law can be modeled by the FC methodology, provided that this law is expressible in terms of "if ... then ..." rules, just like in the case of expert systems. However, FL diverges from the standard expert system approach by providing an interpolation mechanism from several rules. In the contents of complex processes, it may turn out to be more practical to get knowledge from an expert operator than to calculate an optimal control, due to modeling costs or because a model is out of reach.

4.2 Linguistic Variables

A concept that plays a central role in the application of FL is that of a linguistic variable. The linguistic variables may be viewed as a form of data compression. One linguistic variable may represent many numerical variables. It is suggestive to refer to this form of data compression as granulation [17].

The same effect can be achieved by conventional quantization, but in the case of quantization, the values are intervals, whereas in the case of granulation the values are overlapping fuzzy sets. The advantages of granulation over quantization are as follows:

- it is more general;
- it mimics the way in which humans interpret linguistic values;
- the transition from one linguistic value to a contiguous linguistic value is gradual rather than abrupt, resulting in continuity and robustness.

4.3 FC Rules

FC describes the algorithm for process control as a fuzzy relation between information about the conditions of the process to be controlled, x and y, and the output for the process z. The control algorithm is given in "if ... then ..." expression, such as:

If x is small and y is big, then z is medium;
If x is big and y is medium, then z is big.

These rules are called *FC rules*. The "if" clause of the rules is called the antecedent and the "then" clause is called consequent. In general, variables x and y are called the input and z the output. The "small" and "big" are fuzzy values for x and y, and they are expressed by fuzzy sets.

Fuzzy controllers are constructed of groups of these FC rules, and when an actual input is given, the output is calculated by means of fuzzy inference.

4.4 Control Knowledge Base

There are two main tasks in designing the control knowledge base. First, a set of linguistic variables must be selected which describe the values of the main control parameters of the process. Both the input and output parameters must be linguistically defined in this stage using proper term sets. The selection of the level of granularity of a term set for an input variable or an output variable plays an important role in the smoothness of control. Second, a control knowledge base must be developed which uses the above linguistic description of the input and output parameters. Four methods [18–21] have been suggested for doing this:

- expert's experience and knowledge;
- modelling the operator's control action;
- modelling a process;
- self organization.

Among the above methods, the first one is the most widely used. In the modeling of the human expert operator's knowledge, fuzzy rules of the form "If Error is small and Change-in-error is small then the Force is small" have been used in several studies [22,23]. This method is effective when expert human operators can express the heuristics or the knowledge that they use in controlling a process in terms of rules of the above form.

4.5 Defuzzification Methods

The defuzzification operation produces a non-FC action that best represent the membership function of an inferred FC action. Several defuzzification methods have been suggested in literature. Among them, four methods which have been applied most often are:

- Tsukamoto's Defuzzification Method;
- The Center of Area (COA) Method;
- The Mean of Maximum (MOM) Method;
- Defuzzification when Output of Rules are Function of Their Inputs.

5 Proposed Fuzzy-Based Peer Voting Score System

The P2P group-based model considered is that of a superpeer model. In this model, the P2P network is fragmented into several disjoint peergroups (see Fig. 2). The peers of each peergroup are connected to a single superpeer. There is frequent local communication between peers in a peergroup, and less frequent global communication between superpeers.

To complete a certain task in P2P mobile collaborative team work, peers often have to interact with unknown peers. Thus, it is important that group members must select reliable peers to interact.

In this work, we consider three parameters: Number of Activities the Member has Successfully Finished (NAMSF), Number of Online Discussions the Member has Participated (NODMP), Time Delay on Collaboration Work (TDCW) to decide the Voting Score (VS). The structure of this system called Fuzzy-based Vote System (FVS) is shown in Fig. 3. These three parameters are fuzzified using fuzzy system, and based on the decision of fuzzy system a voting score is calculated. The membership functions for our system are shown in Fig. 4. In Table 1, we show the Fuzzy Rule Base (FRB) of our proposed system, which consists of 36 rules.

The input parameters for FVS are: NODMP, NAMSF and TDCW the output linguistic parameter is VS. The term sets of *NODMP*, *NAMSF* and *TDCW* are defined respectively as:

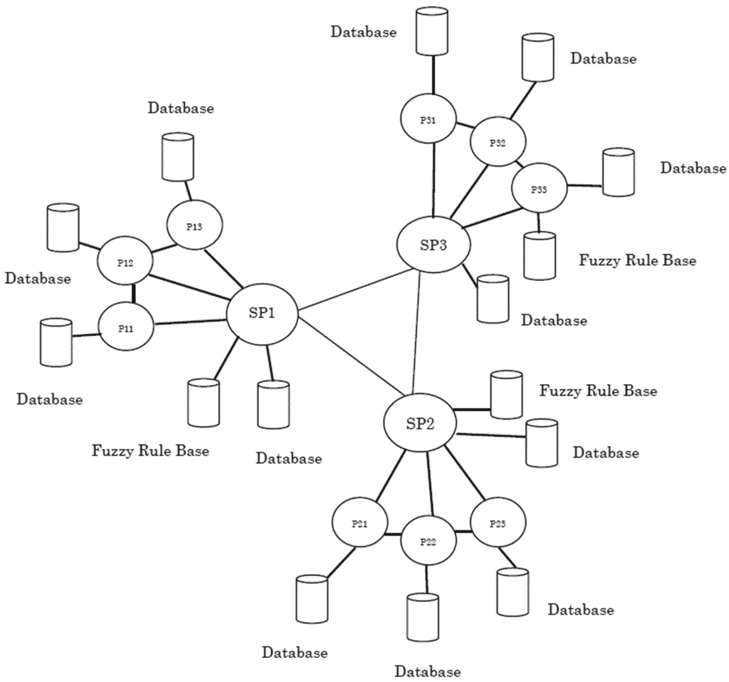


Fig. 2. P2P group-based model.

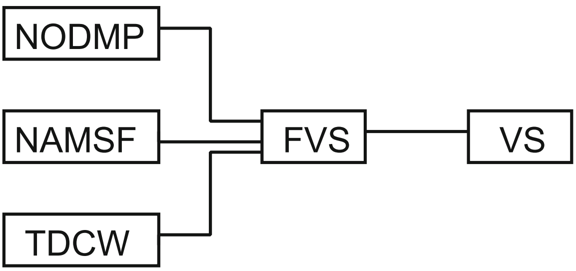


Fig. 3. Proposed of structure.

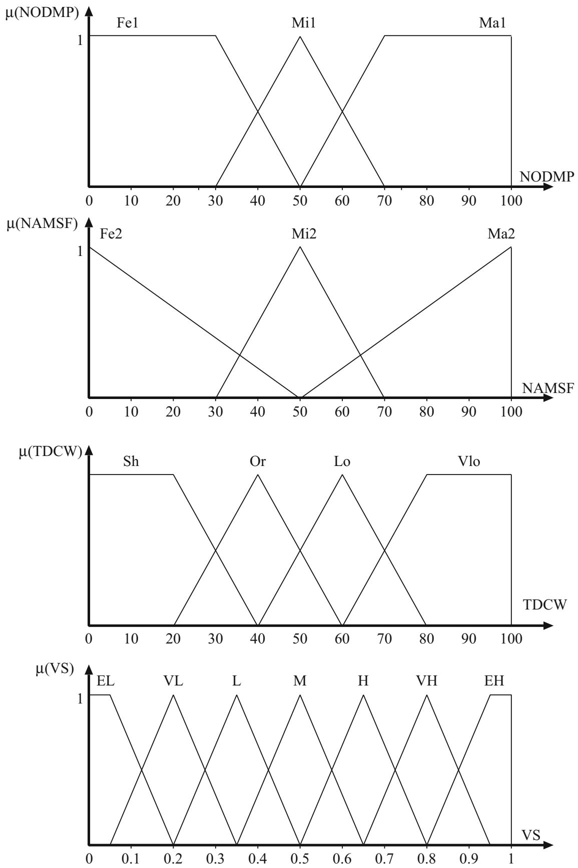


Fig. 4. Membership functions.

$$\begin{aligned} NODMP &= \{Few1,\ Middle1,\ Many1\} \\ &= \{Fe1,\ Mi1,\ Ma1\}; \\ NAMSF &= \{Few2,\ Middle2,\ Many2\} \\ &= \{Fe2,\ Mi2,\ Ma2\}; \\ TDCW &= \{Short,\ Ordinary,\ Long,\ Very\ Long\} \\ &= \{Sh,\ Or,\ Lo,\ Vlo\}; \end{aligned}$$

and the term set for the output VS is defined as:

$$VS = \begin{pmatrix} Extremely\ Low \\ Very\ Low \\ Low \\ Middle \\ High \\ Very\ High \\ Extremely\ High \end{pmatrix} = \begin{pmatrix} EL \\ VL \\ L \\ M \\ H \\ VH \\ EH \end{pmatrix}$$

Table 1. FRB.

Rule	NODMP	NAMSF	TDCW	VS
1	Fe1	Fe2	Sh	L
2	Fe1	Fe2	Or	VL
3	Fe1	Fe2	Lo	EL
4	Fe1	Fe2	Vlo	EL
5	Fe1	Mi2	Sh	M
6	Fe1	Mi2	Or	L
7	Fe1	Mi2	Lo	VL
8	Fe1	Mi2	Vlo	EL
9	Fe1	Ma2	Sh	H
10	Fe1	Ma2	Or	M
11	Fe1	Ma2	Lo	L
12	Fe1	Ma2	Vlo	EL
13	Mi1	Fe2	Sh	M
14	Mi1	Fe2	Or	L
15	Mi1	Fe2	Lo	VL
16	Mi1	Fe2	Vlo	EL
17	Mi1	Mi2	Sh	H
18	Mi1	Mi2	Or	M
19	Mi1	Mi2	Lo	L
20	Mi1	Mi2	Vlo	VL
21	Mi1	Ma2	Sh	EH
22	Mi1	Ma2	Or	H
23	Mi1	Ma2	Lo	M
24	Mi1	Ma2	Vlo	L
25	Ma1	Fe2	Sh	H
26	Ma1	Fe2	Or	M
27	Ma1	Fe2	Lo	L
28	Ma1	Fe2	Vlo	VL
29	Ma1	Mi2	Sh	EH
30	Ma1	Mi2	Or	H
31	Ma1	Mi2	Lo	M
32	Ma1	Mi2	Vlo	L
33	Ma1	Ma2	Sh	EH
34	Ma1	Ma2	Or	EH
35	Ma1	Ma2	Lo	H
36	Ma1	Ma2	Vlo	M

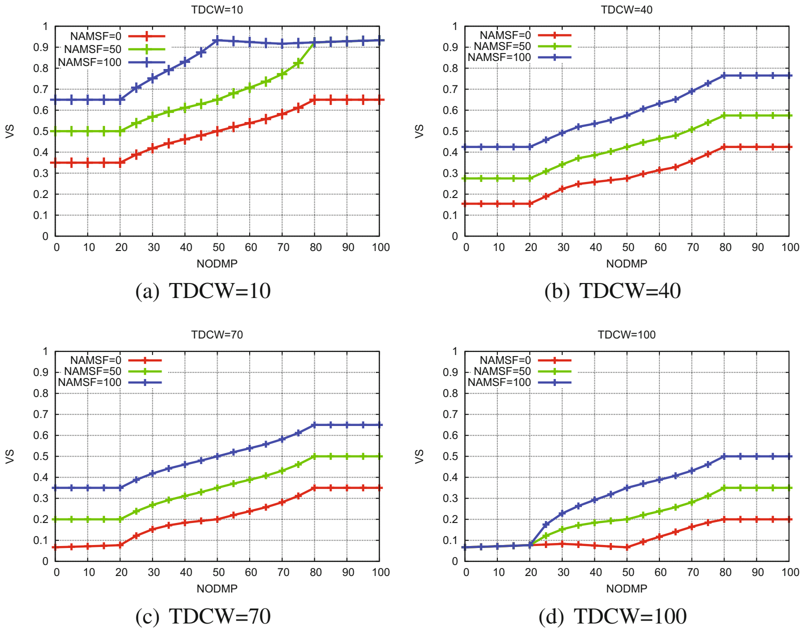
6 Simulation Results

In this section, we present the simulation results for our proposed system. In our system, we decided the number of term sets by carrying out many simulations. These simulation results were carried out in MATLAB.

From Fig. 5(a)–(d), we show the relation between NODMP, NAMSF, TDCW and VS. In this simulation, we consider the TDCW as a constant parameter.

In Fig. 5(a), we consider the TDCW value 10 units. We change the NODMP value from 0 to 100 units. When the NODMP increases, the VS is increased. Also, when the NAMSF increase, the VS is increased.

In Fig. 5(b)–(d), we increase the TDCW values to 40, 70 and 100 units, respectively. We see that, when the TDCW increases, the VS is decreased.



(a) TDCW=10 (b) TDCW=40

(c) TDCW=70 (d) TDCW=100

Fig. 5. Voting Score for different TDCW.

7 Conclusions and Future Work

In this paper, we proposed a fuzzy-based system to decide the VS. We took into consideration three parameters: NODMP, NAMSF and TDCW. We evaluated the performance of proposed system by computer simulations. From the simulations results, we conclude as follows.

- When NODMP and NAMSF are high, the voting sore is high.
- With increasing of TDCW, the VS is decreased.
- The proposed system can choose reliable peers with good voting score in P2P mobile collaborative team.

In the future, we would like to make extensive simulations to evaluate the proposed systems and compare the performance with other systems.

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