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Aggregation Model and Algorithm of Mobile Social Network

Haogui CHEN
Hunan City University, Yiyang Hunan 413000, China

Abstract: Due to situational awareness information not available under the social network environment, social network users generally have low situation awareness degree for other users in the network, which lost a lot of interaction, cooperation and participation opportunities. This paper proposes the aggregation model and algorithm of mobile P2P network. The model and algorithm introduce user's location information, environmental characteristics and trajectory into the aggregation algorithms, which intelligently aggregate into potential P2P network. According to the needs of users to found potential social relations independently, the blindness and liberty of social activities are avoided.

Keywords: Network Coverage; Link; Map; Node

1. Introduction

The study of the Social Network originated from six degrees of separation proposed by psychology professor Stan of Harvard University in 1967 ,"everyone will be able to meet any strangers only need through six men at most "[1]. Social networking service is an Internet application, aimed at offering service of information sharing and interaction for a bunch of users which exist or have common interests, various forms of online aggregation. Social network, users use social network services to organize, maintain the existing social relationships, discover new social relations, and present themselves as a social person on the Internet and do some related social activities [2]. As the popularity of smart phones, tablets, laptops and other portable mobile devices and the development of mobile communication technology, the mobile wireless network with high character such as distribution, autonomy, topological dynamic change is becoming the foundation of the social network. Rely on Web support centralized, social network, it is difficult to adapt to the dynamic, heterogeneous distributed mobile network environment, also cannot satisfy independent discovery, new demand such as peer-to-peer sharing data. At the same time, people no longer satisfied with simple activities to make friends, hope to be able to find potential social relations actively and smartly according to scene information such as the user's environment, personal interests, behavior characteristics, and then get more and more valuable opportunities for entertainment, communication and cooperation [3-7]. Therefore, research how to use situational awareness information to build potential social network, find relevant higher social relations based on their interests and preferences, for the further development of the social network has important significance.

Social network is the virtual reflection to the real social activities, both from the real social relations, but also has new features different from real communication. The main research direction and the results of this field are: a) the study of topology and information propagation characteristics of the social network entire network diagram; b) user behavior research of data mining based on social network; c) the study of social network traffic characteristics and the group structure based on Web2.0; d) social network privacy policies, credibility research [8-12]. The research is mainly based on centralized social networking sites, research on P2P networks of mobile mode is still less.

In order to improve the service level of social network, researchers have begun introducing context-aware technology to the social network. At present, mainly use the search engines and data mining technology, by sensing properties characteristics habits, etc [17-19]. of the user to improve the service of social networks. Most of the existing research is based on the Web, as Sehmidt sense behavior characteristics of browsing the Web page by integrating the user information, personal perception the visitors. Acquist et take Facebook as an example, discusses the social perception, information sharing and privacy of network, points out that the importance of users' sensing, such as social network properties, structure, and the personal privacy settings. Matsuoa build a social network "Pollyypho-NET" extraction system based on search engines, implements the extraction of relationship, community structure detection through the GOOGLE search engine [20-23]. Mika has set up a system called Flink, extracted personal information from Web pages, personal data and other information resources, and carry on reasoning based on semantic, rea-

lized the extraction, gathering, analysis, and visualization of online social network.

As can be seen from the research results above, combined with context-aware technology to study the social network is the main research direction, the current study is based on Web history data, research of social network of situational awareness based on real-time, mobile users is very few. In the process of realistic social interaction, the user through the face-to-face interaction, in mutual contact and informal communication to collect the information needed. But in the network environment, or situational awareness information are not provided, or very limited, this leads to social network users for other users in the network situation awareness degree is generally low, lost a lot of interaction, cooperation and participation opportunity. At present, mobile devices will have more and more sensing function, including video, voice, GPS, accelerometer, acceleration sensor, six axis gyro, the infrared induction, etc., to obtain the node's perception information is no longer a difficult and expensive thing. Therefore, this article discusses the construction method of mobile social network and discovery algorithm of the potential social relationship by introducing more situational awareness information, such as GPS, trajectory, physical environment, interests, preferences, etc..

2. Social Network Overlay Topology

Mobile P2P social network topology is shown in Figure 1, various mobile devices to access in different ways, such as cell phone users can through the 3 g base station connected to the Internet, tablets, laptops are probably more through Wi-Fi access to Internet, they formed a blending underlying communication networks between them, between these devices at the same time can also share data via blue tooth technology to a short distance. These devices run the authorized client software, on the basis of the underlying hybrid communication network, through situational awareness, autonomous aggregation to form a potential virtual fitting P2P overlay network, on the basis of this virtual P2P overlay networks, can further implement active social discovery service, recommend social relations to the use which meet their requirements.

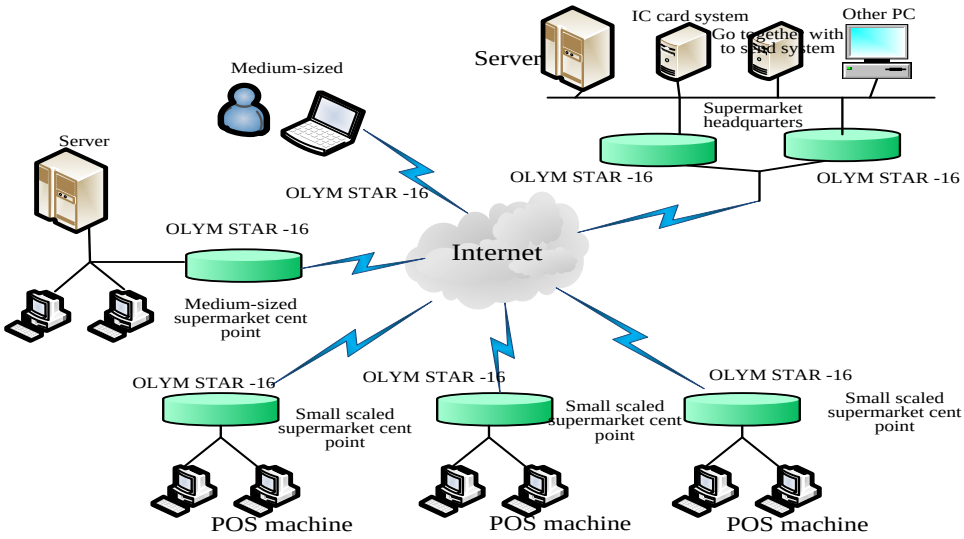

Figure 1. Social network topology

Mobile social network system architecture is shown in Figure 2, the mobile client with situational awareness, automatic aggregation, social discovery, social maintenance functions The server has a registration records management, privacy control, behavior records, user preferences, etc. The user login on the server, and have authority to get client software, once the user to run the software, with the support of the hardware, can obtain situational awareness data, such as GPS location, temperature, illumination, speed, etc., of course, these must be under the premise of the privacy control, then under certain conditions (such as a geographical location), running distributed aggregation algorithm, automatically form the covering social network topology, also is the potential social network. After that, you can according to user's interest and preference and so on, recommend matching social relations, the user can decide what people to be contacted, and have their own social activity (build friends directory, start the conversation, Shared data, etc.).

3. Key Indicators of Social Network

A practical social networks can be abstracted as a graph $R=(E,W,Q)$ which is made up of a point set E, the

edge set W and power set Q, hereinafter referred to as social graph. In the social graph R, $W \in Q$ represents an object in a social network, such as people in social networks; $E \in Q$ represents relationships between objects in social network, such as interpersonal relationships, colleague relationship or partnership, etc.; Weight $W \in Q$ represents the weight of the relation between object in a social network, such as degree of familiarity between friends. If the weights of each edge in the social network are equal, says that the social network is no right network, can represent using a graph $R = (E, W, Q)$.

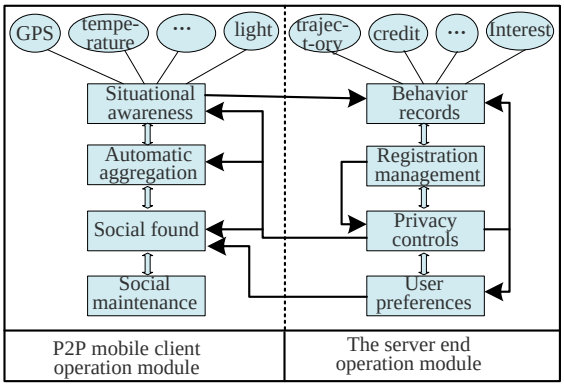

Figure 2. System architecture of mobile P2P network

3.1. Degree distribution

Degree is simple but very important concept in node properties. r_i of i nodes is defined as the number of the other nodes connected with the node. In a directed network, the degree of node refers to the number of edges from the node to other nodes; into the degree is the number of edges from other nodes to that node. Look from the intuitive, the greater the degree of a node means the more important the node is in a sense. The average valve of degree r_i of all nodes i in the network referred to degree of network, remember to r. u_r represents the probability distribution of node which no less than k.

$$u_r = \sum_{i \geq r} P(l) \tag{1}$$

4. Social Network Polymerization and Discovery Algorithm

4.1. Mobile P2P social network aggregation algorithm based on the deterministic annealing technology

The deterministic annealing technique is first proposed in 1990 by the Rose PhD of the California institute of technology, it is an important branch of calculated on the laws of nature. Very effective for solving the following minimization problem:

$$\min W = W(x) \tag{3}$$

Here, x can be continuous, discrete or mixed; $W(x)$ can be regarded as energy of a system. The deterministic annealing technique regards the minimization problem (3) as solving the minimum energy state of a physical system. First, It constructs a free energy function $R(x, M)$, where x is the function variables, T represents temperature. By the analysis above, under a certain temperature, the change of system state is always in the direction of freedom can reduce, when the system reaches equilibrium, free energy function achieve minimal. There are literature proved that when $R(x, M)$ is a continuous map, the global minimum point $XMIN(M)$ is a continuous map of M.

Set $M = \infty$, the global optimal point of $R(x, M)$ is easy to be calculated, and $R(x, 0) = W(x)$. The deterministic annealing technique, in each temperature T, when system meets $M = M + \Delta M$, the condition of minimum free energy function $x \min(M + \Delta M)$ as the initial point, by solving minimum point of $\min R(x, M)$ to simulate the process of system to reach equilibrium. With the decrease of the T, the global minimum point of $R(x, M)$ is changing, when the change of M ΔM T is very small, can think $x \min(M)$ is located in local minimum area of $x \min(M + \Delta M)$, so it can use $x \min(M + \Delta M)$ as the initial point to solve the minimum value of $R(x, M)$. When T continuous decreasing speed is reasonable, can think $\lim_{T \to 0} \times \min(M)$ for the global minimum point of problem (2).

For the social network aggregation problem $\min R(x, y)$ of this article using the deterministic annealing technology to define the free energy function:

In the type: $x_i = \{x_{i1}, x_{i2}, ...x_{il}\}$ for feature vector (L components) of the node i, $y_1, y_2, ...y_n$, represent gathered heart node of $w_1, w_2, ...w_m$, $y_i = \{y_{i1}, y_{i2}, ...y_{il}\}$ for feature vector (L components, $i = (1, 2, ...N)$ gathered heart node y_i, N is the total number of nodes, M for total number of heart nodes, other parameters' meaning with type (2).

probability S of $x_i \in w_i$ is as follows:

In the type: x_i represents a node $i = (1, 2, ...N)$, w_i as a polymerization subset, i, $k = 1, 2, ...M$, other parameters are the same with type (4).

When the $i = (y_1, y_2, ...y_N, \eta)$ about $(y_1, y_2, ...y_N, \eta)$ is continuously differentiable convex function, according to the traditional optimization method to find out the global

optimal point; When the $\eta \in [0,+\eta]$, $S(y_1, y_2, ...y_N, \eta)$ about $(y_1, y_2, ...y_N, \eta)$ is continuously differentiable, minimum point and minimum value of $S(y_1, y_2, ...y_N, \eta)$ is the continuous mapping of the η.

$$W(y_1, y_2, \cdots, y_M, \delta) = \begin{cases} \frac{1}{M}\sum_{i=1}^{N}\sum_{j=1}^{M}\left(\alpha\sqrt{\sum_{i=1}^{L}(x_{it}-y_{jt})^2}+\beta\frac{X_i^T Y_j}{\|X_i\|\times\|Y_j\|}+\gamma\frac{X_i^T Y}{\|X_i\|^2+\|Y_j\|^2-X_j^T Y_j}\right)^2, \delta = 0 \\ -\frac{1}{\beta}\sum_{i=1}^{N}\ln\sum_{j=1}^{M}e^{-\delta}\left(\alpha\sqrt{\sum_{l=1}^{L}(x_{it}-y_{jt})^2}+\beta\frac{X_i^T Y_j}{\|X_i\|\times\|Y_j\|}+\gamma\frac{X_i^T Y}{\|X_i\|^2+\|Y_j\|^2-X_j^T Y_j}\right)^2, 0<\delta<+\infty \\ \sum_{i=1}^{N}\sum_{j=1}^{M}\left(\alpha\sqrt{\sum_{i=1}^{L}(x_{it}-y_{jt})^2}+\beta\frac{X_i^T Y_j}{\|X_i\|\times\|Y_j\|}+\gamma\frac{X_i^T Y}{\|X_i\|^2+\|Y_j\|^2-X_j^T Y_j}\right)^2, \delta = +\infty \end{cases} \quad (2)$$

In minimum point of $S(y_1, y_2, ...y_N, \eta)$, the first-order necessary condition is met, namely

$$\frac{\partial S(y_1, y_2, ...y_N, \eta)}{\partial Y_j} = 0 \quad (3)$$

($j = 1, 2, \cdots, M$, M is aggregation number)

Type (4) plug in type

$$l_i = \frac{\sum_{i=1}^{N} x_i t(x_i \in w_i)}{\sum_{i=1}^{N} t(x_i \in w_i)} \quad (4)$$

$t(x_i \in w_i)$ can be determined by the type (5).

When the $\eta = 0$,

$$t(x_i \in w_i) = \frac{e^{-\delta}\left(\alpha\sqrt{\sum_{i=1}^{L}(x_{it}-y_{jt})^2}+\beta\frac{X_i^T Y_j}{\|X_i\|\times\|Y_j\|}+\gamma\frac{X_i^T Y}{\|X_i\|^2+\|Y_j\|^2-X_j^T Y_j}\right)^2}{\sum_{k=1}^{M} e^{-\delta}\left(\alpha\sqrt{\sum_{i=1}^{L}(x_{it}-y_{jt})^2}+\beta\frac{X_i^T Y_j}{\|X_i\|\times\|Y_j\|}+\gamma\frac{X_i^T Y}{\|X_i\|^2+\|Y_j\|^2-X_j^T Y_j}\right)^2} = \frac{1}{M} \quad (5)$$

In the type, $j = 1, 2, ...M$, M for aggregation number.

Thus, $w_i = \frac{1}{M}\sum_{i=1}^{N} x_i$ for when the $\eta = S(y_1, y_2, ...y_N, \eta)$ global optimal point (because for convex planning, local minimum point for the global minimum point), w_i is the weighted average of all points in x.

By type (6), can get the iterative formula of the optimal w_i:

$$w_i^{(k+1)} = \frac{\sum_{i=1}^{N} x_i t(x_i \in s_j^{(k)})}{\sum_{i=1}^{N} t(x_i \in s_j^{(k)})} \quad (6)$$

In each δ (corresponding temperature t, $t \in 1/\eta$, according to iterative (8) to simulate the equilibrium state of polymerization system, this article will give distributed mobile P2P network polymerization DCMPDA algorithm using the deterministic annealing technology.

Due to More factors that affect mobile node aggregation (e.g., Geographic location, movement, personal preferences, etc.), with symbol $S(y_1, y_2, ...y_N, \eta)$ to represent these sensory information (where $i = 1, 2, ..., N$, N for the node number, number M represents perception factors, namely eigenvector dimension), s_i for a collection of the influence factors of the node x_i, x_{im} as the m factors of i node of. Because some are not base variables in $x_{i1}, x_{i2}, ...x_{il}$, such as ordinal variables such as speed, temperature, various prior index, user experience, etc. In order to provide reasonable basis for aggregation, need data extracted from these effective comparable data, these half qualitative and semi-quantitative problem must be transformed into quantitative data. Take some factor collection $S(y_1, y_2, ...y_N, \eta)$, adopt *AHP* method to get the corresponding weights s_i of factors $x_{i1}, x_{i2}, ...x_{il}$, it satisfies the following conditions:

$$s_i \geq 0, \sum_{i=1}^{L} s_i = 2 \quad (7)$$

Variables S_i are expressed as linear combination of $x_{i1}, x_{i2}, ...x_{il}$: $t_j = s_1 \times x_{i1} + s_2 \times x_{i2} + ...s_m \times x_{il}$ is linear coefficient. Thus the quantitative comparable data y j of the corresponding s_i can got. According to this to work

out all quantitative data S_i of all $S(y_1, y_2, ...y_N, \eta)$ and gets a quantitative data $t(y_1, y_2, ...y_N, \eta)$.

According to deterministic annealing technology mainly iterative aggregation algorithm (9) polymerization, using a distributed polymerization, using master-slave programming model, random aggregation in advance, the calculation of type (9) will scattered to each subordinate nodes. The following is the main framework of parallel distributed program.

5. Experiment and Analysis

5.1. Experimental environment settings

Experimental prototype system was built based on hybrid network model, the mobile client based on KJAVA platform, the main functions of figure 2 in section 2 was realized by using the Java and XML language, using the message mechanism to transfer data in various service. Figure 3 shows the main processing procedure of server-side, and figure 4 shows the service platform architecture of P2P mobile social network. The mobile devices used by mobile client include smart phones, tablets, laptops, the access way have 4G network, WIFI.

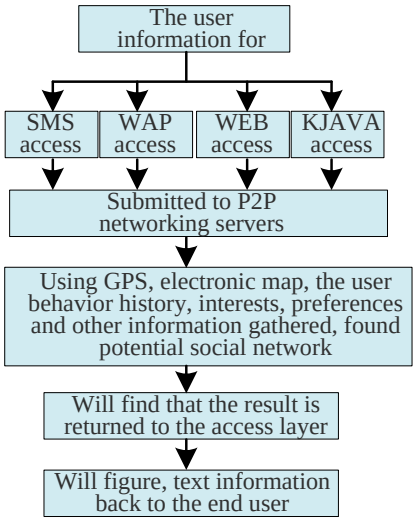

Figure 3. Servers processing of P2P mobile social network

5.2. Result analysis

1) Simulation of Aggregation Algorithm

Distributed mobile P2P network polymerization DCMPDA algorithm Proposed in this paper based on the deterministic annealing technology is a distributed parallel algorithm, to run on mobile devices. Due to the mobile device energy and computation ability are limited, so the cost of the proposed algorithm, the convergence speed and the traffic is very important to the overall performance of the system. To this, we have carried on the massive simulation experiments.

On the basis of Java open source version of BRITE and discrete event driven simulation package Sims java, realize the Java language implementation, ignoring the details in actual network transmission, such as delay, congestion, packet loss. The simulation experiments include node six main parts, such as physical topology generation, aggregation algorithms, discrete event driven simulation program, situational awareness information simulation, and messaging and discovery algorithm. Intermediate node physical topology is generated by BRITE.

BRITE a general topology generator, developed by the Melbourne university, it implements the $S_a \times man, CA, CA-2, GLP$ variety of topology generation algorithm, and can generate the topology in AS (autonomous domain) and router, use both top-down and bottom-up method to generate the Transit-Stub hierarchical model. For as far as possible close to the reality of mobile hybrid network topology structure, the node physical topology of simulation experiment in this paper, in accordance with the GLP generation algorithm in BRITE router level, and random injection location, sensory information, such as temperature, light, movement.

Running the traditional k - means polymerization algorithm In simulation system and social network polymerization DCMPDA algorithm proposed in this paper，the polymerization topology, as shown in figure 6 and figure 7, aggregate outcomes appropriate scale got by DCMPDA algorithm is close to the reality social relations. The time overhead algorithm running as shown in figure 5, it can be seen that with the increase of the number of nodes, the time spent by DCMPDA aggregation algorithm grow gentle, has good scalability, and k - means aggregation algorithm are the trend of exponential growth. Total message of DCMPDA algorithm along with the change of the number of nodes is shown in figure 7, because DCMPDA algorithm is a kind of distributed parallel algorithm, the amount of interaction message presents the fast growth the tendency with the increase of number of nodes, how to reduce the amount of interaction message will be the next problem to be studied.

2) Social Discovery Response Speed

Still adopt the experimental environment of upper segment, and simulation tests for social discovery. One is according to the algorithm proposed in this paper on the basis of the aggregate in advance to find potential relationship; the other is a direct traversal search in the all users. Recommend friends threshold is set to 25. The total result is shown in figure 8, it can be seen that with the increase of users, this article aggregation found the algorithm's response time is slow growth, whereas random traversal search shows a tendency of exponential growth. Investigate its reason, it is because the algorithm of this paper is a distributed parallel algorithm, affection is not big by the size of the problem.

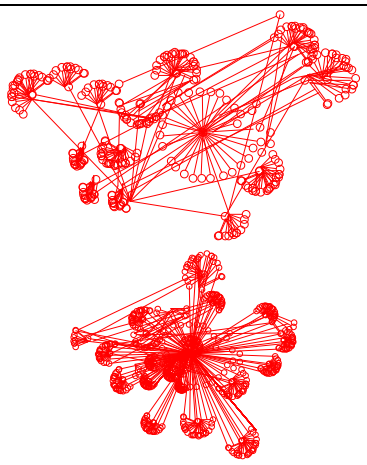

Figure 4. Comparison of the polymerization results between k - means and DCMPDA algorithm

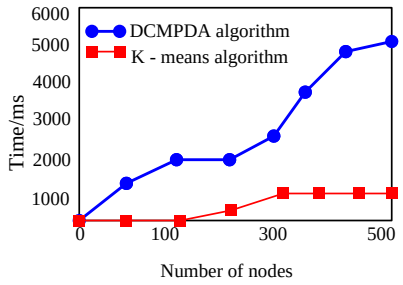

Figure 5. Performance comparisons between DCMPDA algorithm and K - means algorithm

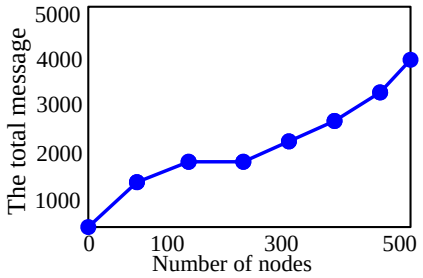

Figure 6. DCMPDA algorithm message volumes vary with the number of nodes

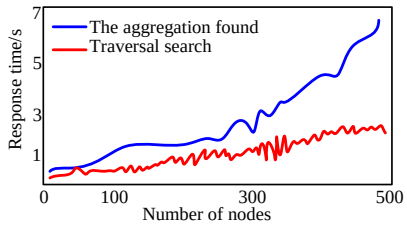

Figure 7. Response speed comparison between aggregation algorithm and traversal search algorithm

3) Actual Mobile User's Social Network Aggregation and Social Discovery Test

We select 34 practical mobile users as test object, register and download the P2P mobile social client software, run the software at the same time, conduct the actual scene perception polymerization and social discovery test, figure 9 shows the result automatically aggregation by the situational awareness, dotted line connecting represents potential social network, the solid line represents the request of the user submits, automatically discover potential friends. As shown in figure, friends that could satisfy the requirement of its most are potential social gathering. This shows that potential social network of automatic perception polymerization and social relations which the user might be interested in, has a great relevance, automatic aggregation of situational awareness will accelerate the speed of automatic social discovery, in social discovery is of great help, and avoid the blindness and randomness of social.

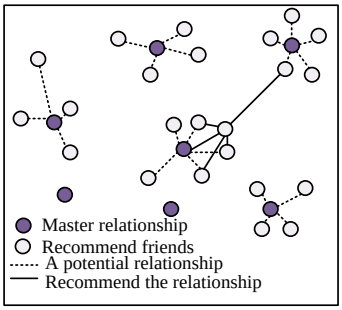

Figure 8. Mobile users aggregate and social discovery results

4) Context-aware Aggregation Found that Customer Satisfaction Evaluation, Precision Ratio and Recall ratio Comparison

In order to test the practical effect of social discovery, randomly select from the different populations, repeated tests. Each test to select 30 test object, carry out the satisfaction questionnaire and interview to the results, and statistical analyze the results of multiple tests. comparing social discovery of this article situational awareness and traversal search information according to the user registration, its recall, precision and user satisfaction as shown in figure 10, you can see that aggregation discovery of the situational awareness has the very high recall ratio and precision and user satisfaction.

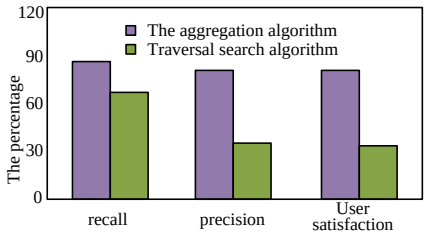

Figure 9. Comparisons among recall, precision and user satisfaction

6. Conclusion

How to get the user's behavior characteristics by using situational awareness so as to automatically discover potential social relations is one of the important research contents of mobile social network. This paper proposes the situational awareness of mobile P2P network system architecture, aggregation model and algorithm. The user's location information, environmental characteristics and trajectory is introduced into the aggregation algorithms, intelligently polymerization to form potential P2P network. It found a potential relationship on their own according to the needs of users, avoided the blindness and liberty of social activities. And the theoretical analysis and experimental verification of the algorithm are conducted. The results show that the presented scheme and algorithm has high response speed, accuracy, and customer satisfaction, at the same time the system has certain load balancing and adaptive ability.

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