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Trust Calculation with Ant Colony Optimization in Online Social Networks

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Abstract

Real world lives in the 'Aeon' of virtual connectivity; social network is a platform where people share emotions, activities, relation etc. Second generation online social networking online comes in existence with service-oriented environment, In which lots of service requester and service provider, connect to each other with many different paths. Among 'N' number of path finding a trust path for trustworthy services is major task. In this paper with the help of ant colony optimization (ACO) we are calculating trust path, trust cycle. Hence we are proposing an algorithm (Trust-ACO) to calculate trust in online social network. Trust calculation is based on probabilistic trust rule, social intimacy pheromone.

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Keywords: Swarm intelligence; ACO; Trust; Social intimacy pheromone; Probabilistic trust rule; Trust ACO.

1. Introduction

Second generation social networks comes in existence with lots of emerging applications, which creates service oriented environment. Service requester always require the evaluation of the trustworthiness and satisfaction of service[6,15]. There are many paths between service consumer and service provider but finding optimal path is big issue. If a social network consist lots of buyer and seller than find most trustable path for product selling or buying is major task[20,27]. Online social network always attract to participant to share variety of rich activities. Microsoft has developed a dynamic consumer relationship management (CRM) system which allow business people to analyze customer behavior and conversation on social networking[15]. Social network like, face book[4] is a platform for activity sharing and recommendation of products links between friends. Now, it is big issue to evaluate trust friends path from source to Service provider user or start from one user (service requester) traverse to all users in network (including service provider) and return to service requester. Trust value of recommendation is Evaluated by activity sharing between users, Sharing more number of activities is creating more trust value between social friends and also increase recommendation trust. Ant colony optimization (ACO) is meta heuristic which helps us to solve classical problem of computer science and other existing domain problem, such as TSP, graph color, machine learning, network routing, job sequencing etc.

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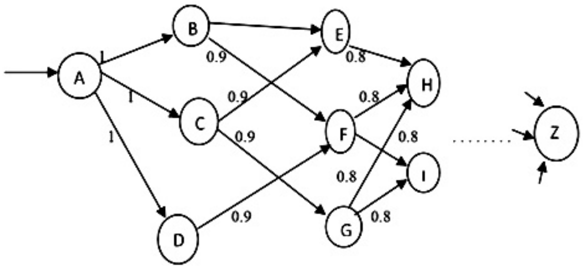

Fig. 1. (a) Social intimacy pheromone.

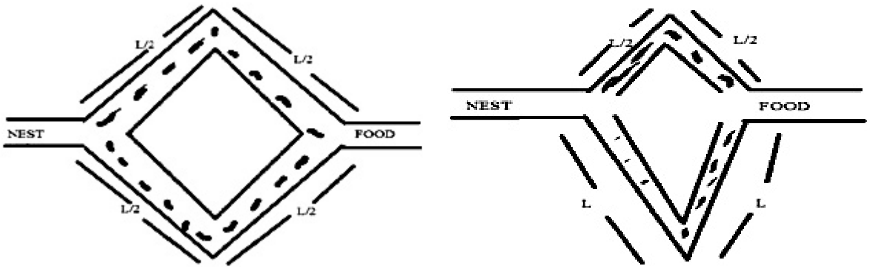

Fig. 2. (a) Branch with equal length; (b) Branch with different length.

1.1 Swarm-intelligence

Swarm like little bit species and some high level animals such as ants, bees, fish birds, wolfs, lives in group and Perform complex task. Each and every member of group perform their own task with 'Decentralize' self-organization and finally perform 'emergent and collective behavior'[1]. Figure 1 denote hierarchy of computational intelligence, which deployed in fuzzy system, ANN and evolutionary system.

1.2 About ants

Ant little swarm insect lives in group, performing 'foraging' 1autocatalytic' and 'stigmergy' behavior and find optimum path[2] during food search. Although most of the ant species are complete blind and also not acoustic sense, but they can find food (in a group) with optimal path with the help of following properties[2].

(a) Branch with Different Length

Now consider the scenario where both branch is different length if one is 'L' length than other is '$2L$'. Pheromone is not equally deposit in both branches due to different length. Consider Fig. 2, shorter branch $(L/2, L/2)$ have higher level of pheromone concentration rather than longer $(2L)$ branch[2,17].

1.3 Towards artificial ants

Based on affirmative discussion 'Marco Dorigo'[2,17] proposed concept of artificial ants and determine solution of TSP (Travelling sales man problem) which we will discuss later.

(a) Artificial Pheromone

In the concept of artificial ants pheromone is denoting by 'τ' during each movement pheromone decrease constant factor and update local way. After end of iteration it updates globally[2,16,17].

(b) Probabilistic Decision

At each node ants take decision where to move next, this decision is taken by pheromone trail. At initial level constant amount of pheromone assign to each edge (arc) (τ_{ij} = constant(c) for all i, j)[2]. Due to pheromone storage on each node ant take decision with apply probabilistic rule, which define in following way.

$$P_{ij}^{k} = \tau_{ij}^{\alpha} / \sum_{n=1}^{Ni\,k} \tau_{ij}^{k} \text{ if } J \in N_i^k \tag{1}$$

$$P_{ij}^{k} = 0 \text{ (otherwise)} \tag{2}$$

where 'Ni^k' is neighbourhood of ant k in node i and α, β is relative influence which vary according to different ant systems.

(c)Pheromone Evaporation

During traversing of single path pheromone evaporated, at each node (vertex) updated local information is stored, and updating of pheromone is carried out in following ways.

1.4 Ant meta-heuristic

Ant meta-heuristic deployed in three inner processes that is 'construct solution', 'update pheromone' and 'Daemon action'[2,17]. All three processes can describe in following ways.

(a) Construct ant Solution

Ant apply decision policy between neighbour vertices, decision is carried out with the help of probabilistic rule on arcs.

(b) Update Pheromone

Deposit new pheromone on arc attract ants to choose that path, hence it increase probability that a particular connection is used by many ants. Pheromone evaporation prevents ants to use suboptimal region and explore new search space.

(a) Local Updating

Let τ be pheromone between neighbour nodes local update carried out following way[2,16,17].

$$\tau_{ij} \longleftarrow (1-\phi)\tau_{ij} \tag{3}$$

where ϕ is constant factor (0,1] and τ_{ij} is pheromone between i and j.
Local update is carried out during movement between one node to another.

(b) Globally Update

After evaporation has been applied to all arcs pheromone is updating global way.

$$\tau_{ij} \longleftarrow (1-\phi)\tau_{ij} + \text{del}\tau^{k}. \tag{4}$$

where delτ is total amount of pheromone deposited on all arc (edge)[2,16,17].

(c) Daemon Actions (Optional)

Among N number of path daemon action chose few or single path which is optimal solution in present iteration and also allow deposit more pheromone on particular path. Next Figure denote automata[5] model of ant Meta Heuristic with four states. Machine is start from initialize data and it can be stop either pheromone update of daemon action (which is optional).

2. Related Work

Social network with ant colony optimization in growing discipline, base on this we are discussing some related proposed work which is combination of ant Meta heuristic and social network.

2.1 Food node

Dolores and all[13] in 'bio inspired algorithm for searching relationship in social network' given concept of 'food node'. Food node is kind of high centrality node (node with lot of friend).

(a) Diffusion of Food Odor

It may sure 'Odor' diffusion in limited area. Dolores defines mathematically expression to represent evaporation rate of food smell[13].

$$O(n_i) = O(n_j) - k * W_{ij} \tag{5}$$

$O(n)$ denote food order on node(either i or j) 'W' is weight on corresponding edge and k is evaporation factor.

(b) Path Search Phase

Tabu list use to prevent repetition of visited node. Selection of valid node in based on equation (6). n_i is set of actual node, node R is visible node after tabu list applied, n_j are indexed node through node R, τ is pheromone value between adjacent vertices[13].

$$P(n_i, n_j) = \tau_{ij} / \sum k = \text{nodeR}(\tau\ ij) \tag{6}$$

2.2 Predict stock market movement on twitter

Salah and all[18] in 'Ant colony based approach to predict stock market movement from mood collected on twitter' define prediction model which maps the relationship between input attribute (measure public mode states on twitter) and output (attribute present movement of stock market).

2.3 Recommendation trust model for E-commerce

Zhang wei[20] in 'A novel trust model based on recommendation for E-commerce', zhang developed computational trust and reputation model based on recommendation in online service oriented environment. Two user can exchange information based on test scenario (TS). User i, j, k exchange information based on test scenario T, user $i.j, k$ exchange item $I_{i.j}$ and $I_{j,k}$ based on test scenario $T(i.j)$ and $T(j,k)$, and similarities of test scenario is gives as[20].

2.4 Dynamic social network from sensory data feed

Md Abdur Rahman, Abdulmotaleb El Saddik and wail Gueaieb in[18] 'Building dynamic social network from sensory data feed' developed frame work that bridge body sensor network (BSN) and social network by mapping a sub group of member's of social network with sensory data feed. A open stack is created and any sensor data push from BSN in stack and direct forward to interested subgroup of social network[18].

2.5 Mining community in social networking with ant colony optimization

Zhang Nan and Wang Zhe[27] proposed clustering base an algorithm (CIACA) [cluster base improved ant colony algorithm], related to community mining in dynamic social network.

2.6 Related work for trust calculation

Trust is major issue in service oriented environment for decision making[15] between service consumer and service provider for the completion of trustworthy service. Golback and Hendlery[21] established trust model based on avg. trust value on social trust path. Guha *et al.*[22] proposed a trust propagation model with the help of number hopes in trust propagation an calculate trust value between source to destination participant. Walter *et al.*[23] proposed recommendation system for online social networking in which they assign priority trust value to a recommender based on recommendation behaviour of participant. Jamali and Ester[24] proposed random walk method between buyer and seller in fix number of hops, buyer perform several random walks with fixed hops and find rating given by end participant to seller, who want to sell product preferred by buyer, confidence degree of seller is calculate by number of random walk path, hops, rating of seller on each path. Bedi *et al.*[30] says recommendation carried out always by trusted recommender friends.

(a) Social Trust Path Selection Algorithm

Korkmaz and Krunz[14] propose heuristic algorithm H_MOCP for the multiple constrain optimal path selection problem for service innovation, quality of service value aggregate by, where $q_i(p)$ is aggregate value.

$$g(p) \triangleq \left(\frac{q_1(p)}{Q^1_{vs,vt}}\right) + \left(\frac{q_2(p)}{Q^2_{vs,vt}}\right) + \cdots + \left(\frac{q_m(p)}{Q^m_{vs,vt}}\right) \tag{7}$$

(b) MCSP_K

Yu *et al.*[14] proposed algorithm for service computation which consist k path to intermediate node and reduced search space and execution time.

(c) H_OSTP

Based on Dijkastra algorithm yan wang and all[14] propose optimal rust path selection algorithm, in which quality of trust is deployed in trust aggregation (T), role impact factor aggregation (p_p) social intimacy pheromone (r_p).

(d) MFPB-HOSTP-MFPB

HOSTP is enhance version of H_OSTP which deployed in three part

i. Back ward local path (BLP)-In a local network backward path between sources to destination is a path between target node intermediate paths.
ii. Forward local path (FLP)-In a local network FLP is path between source nodes to intermediate node.
iii. Composite local path (CLP)-CLP is a path with maximum aggregation of quality trust attribute (QoT) in a BLP.

3. Proposed Work

3.1 Social intimacy pheromone (τ_s)

In social networking a user can connect to other users with social intimation. We can define social intimation in term of fractional values, that is user 'A' can connect to his neighbour, with social intimation pheromone ($\tau_s = 1$) but user 'A' can connect all other user (Except neighbour) Indirectly with social intimacy pheromone ($\tau_s < 1$). Let consider following graph of social intimation. pheromone (τ_s) relation with respect to node 'A' to other node, at each iteration(movement between nodes) social intimation decreases by constant factor that is '$1/n$', where 'n' is depth of

Table 1. Social intimacy pheromone.

Online social network	Activity (Direct)	Activity (Indirect)
facebook	Like, comment, Tag, recommendation	Share, recommendation
orkut	Like, comment recommendation	Share, recommendation
Twitter	Comment, tag	retweet

Table 2. Weight on activity.

Activity category	Sub category	Weight assigned (W)
Sharing	Wallpaper (W_l),	$W_l = 1$
	Photo (W_p),	$W_p = 1$
	Video share (W_v)	$W_s = 1$
Chat	Chat (W_c)	$W_c = 1$
	Video-Chat (W_{vc})	$W_{vc} = 1$
Game playing	Playing-online-games (W_g)	$W_g = 1$
Personal information	Messaging (W_m)	$W_m = 1$
	Recommendation (W_r)	$W_r = 1$

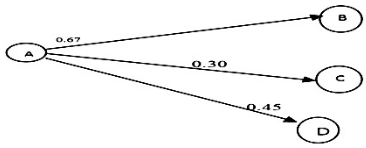

Fig. 3. (a) P_{ij} between users.

graph. Decrement comes due to indirect relation, for example user 'A' is direct connect to his neighbour users B, C, D with social intimacy pheromone $\tau_s = 1$, but user 'A' can share relation to E, F, G in a indirect way with social intimation pheromone value ($\tau_s < 1$). We can represent social intimacy pheromone in interval (0,1], here '$\tau_s = 0$' is not considered, because user 'A' is connect to other by transitive relation or any kind of indirect relation.

Based on above activities Table 1, we can calculate 'heuristic activity function', which can describe in following way, here we assuming rule is in unsymmetrical way that is $\eta_{r\ ij}\ ! = \eta_{r\ ji}$.

$$\eta_r = \text{sum of activities weight between two adjacent users (Ws)/Upper bound of a activity sum (Wt)} \quad (8)$$

If two user share more number of activities then they have generate more trust value, suppose they share wallpaper and video chat together they generate weight '$Wl + W_{vc} = 2$'.

3.2 Probabilistic trust rule (p_{ij}^k)

Probability plays important role in any kind of decision making, based on probabilistic decision we can categorize the entities, networks, process, systems etc. Here based on heuristic function and social intimation pheromone we can describe probabilistic rule to choose next trust user among neighbours.

$$P_{ij}^k = [\tau_{s(i,j)}]^\alpha [\eta_{r(i,j)}]^\beta / \sum_{i=1}^{n} [\tau_s]^\alpha [\eta_r]^\beta \quad (9)$$

Here β, α are relative influence which vary according to different ant systems, P_{ij}^k is probabilistic rule between user i to j of ant k, we are assuming that rule is symmetric way that is $P_{ij}^{k!} = P_{ji}^k$. Other is social intimation pheromone and heuristic activity function explained in previous section. Let's consider Fig. 3; Figure denote fractional values between user A to his nearest neighbour $\{B, C, D\}$, which generated by probabilistic rule. Based on fractional value trust user can select. In Fig. 3 node *A* to node *B* has higher trust value (0.67), which is highest among three neighbours. So finally user B is selected for next movement of trust path selection.

3.3 Trust calculation

In this section we proposing algorithm for calculating trust cycle.

(1) Data Initialization following terms are use in data initialization.

(a) User Activity Matrix (d)

It shows how much activity share between two users. Assign weight in previous table to calculate activity share between users.

(b) Social Intimacy Pheromone

We discussed it in earlier section.

(c) Alpha, Beta

Relative influence with lies according to different ant systems such as ant colony system, max-min ant system, Rank based ant system, Elist based ant system.

(d) Number of ants 'A'

Total numbers of ants for start the procedure.

(e) Number of buyer node B

Number of user node who looking for trustworthy service.

1// Get user database
2//. For (1 to Iteration)
Begin [Where Iteration =total number of iteration]
3//. Calculate upper bound of Activity from user database
4// .Determine user Activity matrix (d) form user database and calculate Heuristic function (η)
5//.Data Initialization (User-Database, d, α, β, A, N, B, φ, el); [Where α = 1, β = 2.5, A = Total number of ants, N= number of nodes,
φ= pheromone evaporation, B=buyer nodes (service requester)]
6 //. Random places 'A' ants on 'B' nodes or a single buyer Node.
[(a) Random Place (A, B)]
7 //. For (1 to N+1) [Calculate Trust tour or cycle, In the case of path construct solution source to destination]
Begin
(a) For (1to A)
Begin
(b) For (1 to n-1 neighbour user node)
Begin
(c) $P_{ij}^{k} = [\tau_{s(i,j)}]^{\alpha} [\eta_{r(i,j)}]^{\beta} / \sum^{n}_{i=1} [\tau_s]^{\alpha} [\eta_r]^{\beta}$ (1)
[Apply probabilistic Rule for selection of trust user]
(d) Update social intimacy pheromone
$\tau s(i,j) \longleftarrow (1-\varphi)\tau s(i,j)$ (2)
End
END
END
END

Algorithm 1. Trust calculation with ant colony optimization TACO

Table 3.

PATH LENGTH	MIN	MAX
1 to 14	121	126

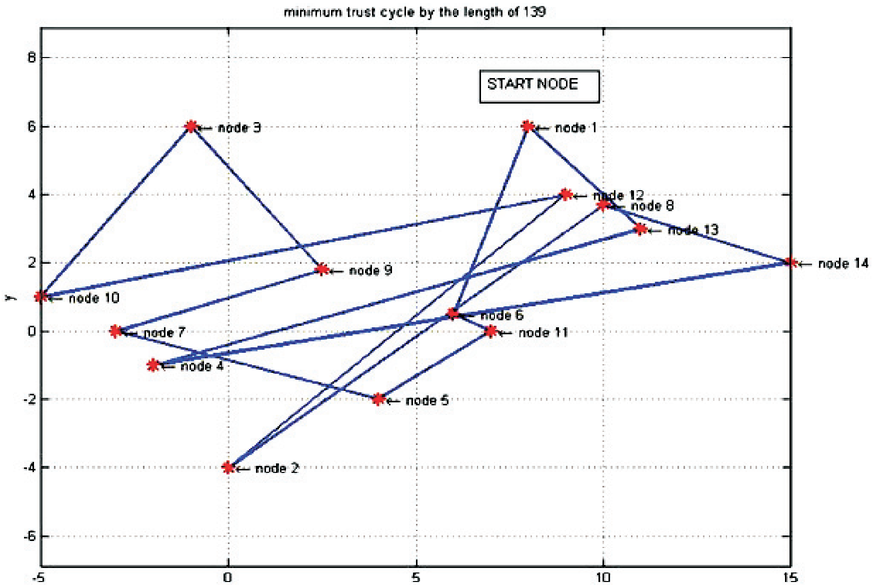

Fig. 4. (a) Minimum trust tour.

4. Experiment Result

To implement this concept we created our own database of 14 users. In this database we suppose that user 14 is service provider and user1is service requester want to access user 14, than it should be a trust path to reach it. We also calculate trust Tour (cycle), that is start from user 1 traverse all the node and return back to starting node. Towards direction of implementation we use 'Android' plate form with SQLITE data base.

(a) SQLITE

The data base of 14 uses is created in such a way they share activity and also recommend links or products. In this database we suppose user node 14 is service provider and share a link related to job, if user 1 wants to access user 14 than there should be trust path between users 1 to user 14. Based on data base we retrieved the information such as user activity matrix which shows how much data share between two uses according to weight assigned by us in Table 3. To calculate trust tour and trust path with respect to user node 1, we use MATLAB 7.10.0.499 (R2010a) with 32 bit version. Procedure initialize by 20 ants and place it in user node 1 for number of iteration 100. After each iteration pheromone cost eliminate by common factor which provides possibility to ants explore another tour or path form node 1. Figure 4 shows minimum length tour with respect to user node 1 with length 139 that is tour is start with node 1 and traverse. Figure 5 denote maximum trust tour of length 205, Next Fig. 6, 7 about avg. trust cycle, avg trust path length in 100 iterations. next Table 4 is about path length.

5. Advantage

TACO not facing imbalance problem that is why at starting of each iteration pheromone cost cut by common factor which help to explore more possibilities from start node.

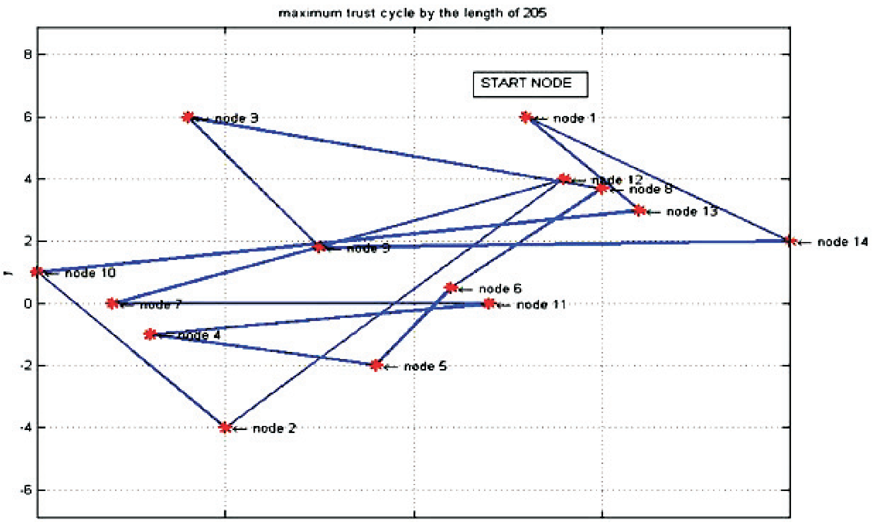

Fig. 5. (a) Maximum path length.

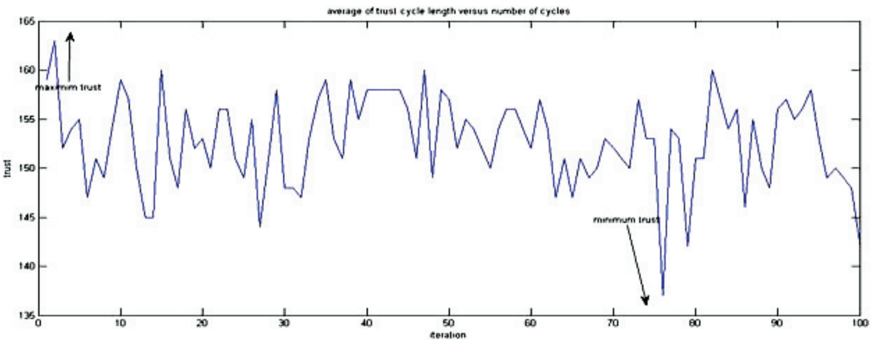

Fig. 6. Avg. trust cycle.

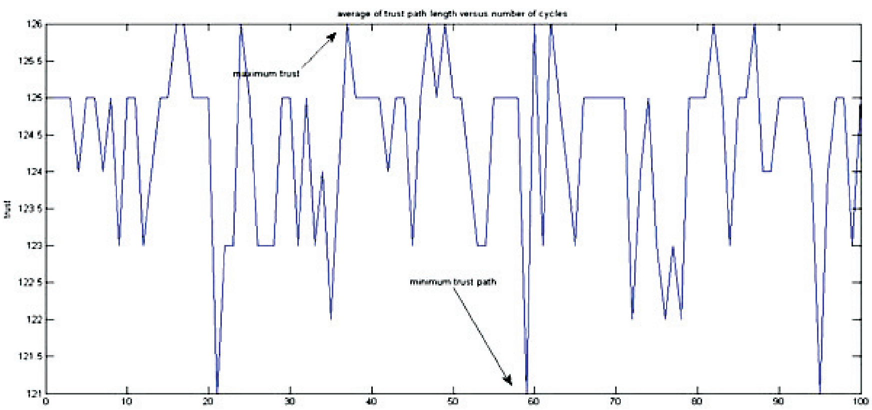

Fig. 7. Avg. trust path.

6. Conclusion

This paper work is novel approach for calculation of trust in online social networks. This novel approach is hybrid from of structural properties and behaviour of the user's. Data share between users is calculated in terms of activity through assign weight. Structure properties include topology along with social boundary and behaviour aspect fully dependant on user's activities in online social community. Ant colony optimization mythology use to calculate trust. Ant colony optimization generally helpful to solve combinational problem, find optimum trust path or cycle among '!N' combination is major task. Hence ant colony optimization is new initiative to solve trust related issue.

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