A Model of Computing Trust in Web Based Social Network Using New Aggregation and Concatenation Operators

[1] Heisnam Rohen Singh, [2] Arambam Neelima, [3] Lourembam Suraj Singh, [4] Sarangthem Ibotombi Singh

[1]Dept. of CSE, Assam down town University, Assam, India

[2]Dept. of CSE, NIT Manipur, India

[3]Dept. of Computer Centre, Mizoram University, Mizoram, India

[4]Dept. of CSE, Tezpur University, Assam, India

Abstract

Web-based social networks can be considered as a representation of our real social network existing in our society. Web-based social networks led to the foundation for the study of trust. Trust is the measure of belief one person has on another person in relation to some tasks which will give him some good or bad result. The statistical approaches work best where the account of trust is naturally based on evidence which can be used to assess the trust one party places in another. The evidence is converted into trust which is represented by belief, disbelief and uncertainty. The concept of vector is used for representing the trust and for the combination of trust. The vector of 3-dimension can represent the trust with each dimension representing the direction of belief, disbelief and uncertainty respectively. Using the vector analysis rules the trust of an agent will be inferred.

Keywords: *Social network, Evidence, Trust, Belief.*

1. Introduction

1.1 Web-Based Social Network

Web-based social networks are of great interest in recent time. They are real live examples of social network existing in our society. This social network in this society is consist of individual human being, which are linked with each other by some kind of relationship between them like friendship, kinship, common interest, financial exchange, dislike etc. Social networking is becoming a new trend in the web with the large public interest in some of the social networking sites like Facebook, Twitter, Linkedin, Orkut etc.

In web-based social network there can be some link not only between individual person in Facebook etc. but also between videos in youtube, articles in wikipedia. So, all individual person, videos, articles or pages can be refers as node. This link means that there exists some kind of relationship between them. The relationship in web-based social network can be very complex describing the social relationship between them using a variety of information. This information in the relationship can be used to derive more information about other which they didn't have any direct relationship. For example, if a person 'A' has relationship with 'B' then information can be added to there relationship to tell that 'A' not only know 'B' but also tell how much 'A' trust 'B'. And also 'A' can gather information about another individual 'C' which 'A' doesn't has a direct relationship but 'B' has direct relationship using the information 'A' has for 'B'.

Suppose that an individual want to buy a laptop of a specific brand and then he/she can take opinion from social network sites about that. Many suggestions can be there regarding the quality of the laptop and service provide by the company. These opinions can be beneficial or harmful to the individual. It depending upon from whom he/she take the opinion. If the opinions are true and if he/she takes it then it is beneficial but if the opinions are false one and if he/she takes it then it will be harmful to him/her. Some kinds of security policies are required in this system.

1.2 Security in Web-Based Social Network

The traditional security policies are based on techniques such as password, access control, cryptography, program verification, intrusion detection and so on. Such traditional security policy can detected only the unauthorized user or access to the system. However they didn't provide any provision to detect anything about the nature behavior of the other. The concept of trust played an important role for proper formulation of security policies in a system which based on social network. Trust allows the social networking systems to work with confidentiality, integrity and availability. To represent trustworthiness numerical value are added between their relationships.

2. Trust

Trust is not a new idea in research. It is a broad concept with several connotations. Researches are going on about

trust in many fields like sociology, psychology, philosophy, economic and so on. For trust to be useful in web-based social network numerical value are added.

2.1 Definition of Trust

Lets begin with the definition given by Grandison and Sloman[1]:

Trust is defined to be the firm belief in competence of an entity to act dependably and securely within a specific content.

Distrust is defined as the firm belief in the incompetence of an entity to act dependably and securely within a specific content.

According to Dr. Piotr Sztompka[2] , professor of sociology, *trust is a bet about the future contingent action of others.*

According to Deutsch[3], *trusting behavior occur when a person (say Alice) encounters a situation where she perceives an ambiguous path. The result of following the path can be good or bad and the occurrence of the good or bad result is contingent on the action of another person (say Bob).*

By J.Golbeck and J.Henders[4], *trust in a person is a commitment to an action based on a belief that the future actions of that person will lead to a good outcome*

2.2 Properties of Trust

There are 3(three) main properties of trust, namely transitivity, asymmetry and personalization.

a) Transitivity:
This property is not perfectly transitive in the mathematical sense. According to this property of trust if a node 'A' trust node 'B' and node 'B' trust another node 'C' then node 'A' will also trust node 'C' but the trust value A has on C will not be same will the trust value B has on C.

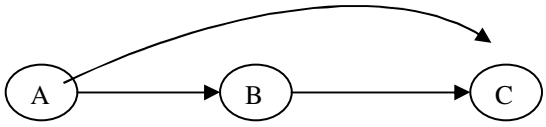

Fig. 1 Transitivity property of trust

b) Asymmetry:
If two nodes 'A' and 'B' trust each other it is not necessary that they are identical i.e. the trust 'A' have on 'B' i.e. $trust_{AB}$ may not equal to the trust 'B' have on 'A' i.e. $trust_{BA}$.

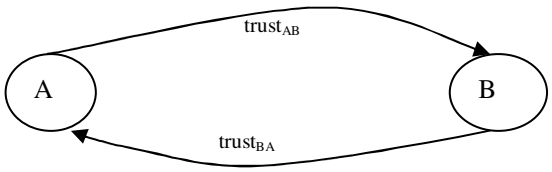

Fig. 2 Asymmetry property of trust

c) Personalization:
The opinion of the people whom the user doesn't trust are given less consideration then the opinion of the people then the user trusts highly. In following figure the opinion A get from B will be more consider then the opinion A get from C.

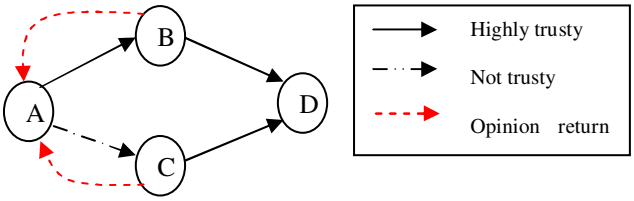

Fig. 3 Personalization property of Trust

2.3 Trust Value

The relationship between the nodes is associated by some numerical value which represents the trust value. There are many models which different rating system. In Golbeck and Hendler[4] rounding algorithm, the numerical value is either 0 or 1. But the 0 value doesn't represent distrust.

The Advogato system uses three – tiered system (apprentice, journeymen, master) for rating its member. Orkut allow user to rate his friends with zero to three smiley faces as trust rating. The numerical rating given in these systems is interpreted different in each model.
The numerical rating 0 doesn't indicate distrust. It merely means that the person can't reply upon a task to provide good outcome.

2.5 Operation of Trust Propagation

For inferring trust from the third party, there are two main operators for the propagation of trust .

a. Aggregation (Φ): This operator combines trust from two or more different paths. Suppose that a node 'A' place trust T_{1B} and T_{2B} on another node 'B' from path 1 and 2 respectively. Then the trust of 'A' to 'B' (T_{AB}) is given by the aggregation T_{1B} and T_{2B}.

i.e. $T_{AB} = T_{1B} \Phi T_{2B}$

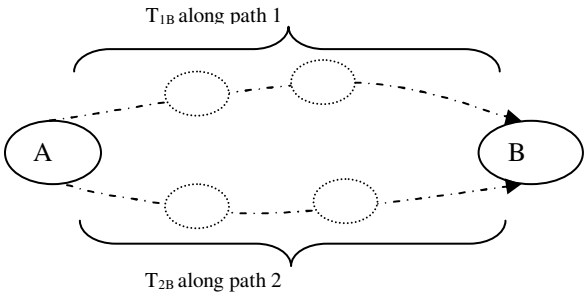

Fig. 4 Aggregation Operation

b. Concatenation (Θ): This operator combines trust on the same path. Suppose that an agent A place trust T_1 in agent B and agent B place trust T_2 in agent C. then concatenation gives the trust A place on C
i.e. $T = T_1 \Theta T_2$

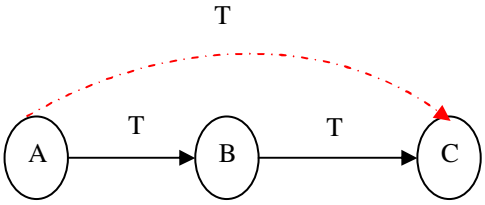

Fig. 5 Concatenation Operation

3. Related Work

There have been a number of trust models based on different concepts. One of the concepts is based on belief. The literature survey is done on those trust model based on the concept of belief [1] [2] [3] [4] [5]. The authors of [1] were the first to define the concept of belief and also give the rule of combination of those. In [4] trust is defined in term of the probability of probability of outcomes i.e. belief based on evidence and adopts his idea of a trust space of triples of belief, disbelief and uncertainty.

Belief- it is the probability to have good outcome.
Disbelief- it is the probability to have bad outcome.
Uncertainty- the probability of any outcome is unknown.

In model of [4] is based on the certainty on the strength of evidence, and not just the amount of evidence.

4. Propose Model

Our proposed model is very much similar to the model [5]. However, in their model the concatenation operation of the trust is based upon the belief. It doesn't consider the disbelief and uncertainty associated with trust. In our model all these parameter (i.e. belief, disbelief and uncertainty) with be consider and the concatenation wii be based on vector analysis

4.1 Model Foundation

In the model for inferring trust, the following type of the Actor can be found:

Trustor – is the one that compute the trust.
Trustee – is the one for which trust is computed.
Recommender – is the one from whom the trustor takes opinion about the trustee.

4.2 Information Sources

Direct trust: Trustor computes the trustworthiness of the trustee based on the experience of trustor with the trustee indirect trust: Trustor computes the trustworthiness of the trustee based on the recommendation give by the intermediate recommender.

In this system there is always a risk involved while taking recommendation from recommender. The behavior of the recommender is very much necessary to consider while taking the recommendation. Because most of the time we are interested in calculating trustworthiness of some unknown.

4.3 Definition

- *Trust: Trust is the measure of belief one node has on another node in relation to some task, whether it will lead to some good or bad result.*
- *Evidence: It can be considers as the number of positive and negative experience encounter by one node on another node.*
- *Belief: It is confirmation of one node on another, that the other node will give some good result.*
- *Disbelief: It is confirmation of one node on another, that the other node will give some harmful result.*
- *Uncertainty: It is state when the behaviour of the node is unknown.*

4.2 Representation of Trust Model

Just like all the previous models, in this model the network of node is represented by using a directed graph G (V, E), where each vertex v_i represents the i^{th} node and each edge e_{ij} represent the relationship between the i^{th} node to j^{th} node. In the graph the Trustor is represented as the Source

and the Trustee is represented as the sink. In the figure, vertex 1 is the Trustor and vertex 8 is the Trustee. Each edge e_{ij} is weighted by the two parameters (d_{ij} ,c_{ij})

d_{ij}: value of the direct rating of node i on node j.
c_{ij}: credibility of node j in giving recommendation as maintain by node i.

where,

$$0 \leq d_{ij} \leq 10$$
$$0 \leq c_{ij} \leq 10$$

From these two parameters d_{ij} and c_{ij}, the direct and recommendation trust is computed.

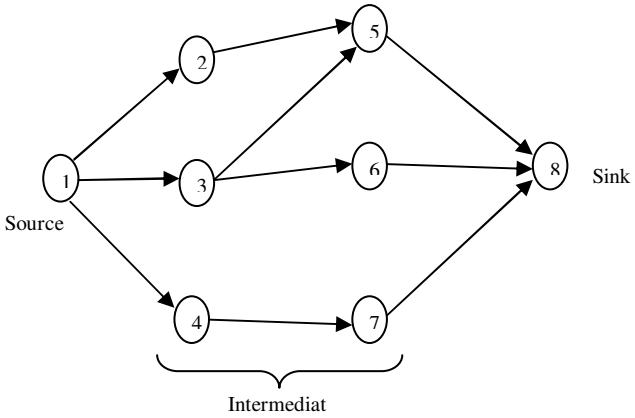

Fig 6. A empirical model of social network

Most of the time, there will not be direct link between source and sink. So, need the value c_{ij} to calculate the trust that Trustor have with Trustee.

4.3 Working formulae

The weight in each edge has to be converted to the evidence. Here only the conversion of credibility measure is given. For the conversion of the weight linear transformation [5] is used.

4.3.1 Conversion of Credibility Measure to Evidence

$$positive\ evidence(p) = \frac{c_{ij}}{10} \quad (1)$$
$$negative\ evidence(n) = 1 - \frac{c_{ij}}{10} \quad (2)$$

The evidence space [10] in here is defined as follows
Evidence space, E={(p,n) where p ≥ 0, n ≥0 and}

4.3.2 Conversion of Evidence to Trust

The trust is propagated; each node involved would map the evidence to the trust space. So, we need a function to map evidence space to the trust space. This mapping between positive and negative evidence to belief, disbelief respectively is characterized by two properties [4]

i. Conflict of evidence
ii. Certainty of evidence

Conflict of Evidence – This is a quantity which gives the degree of confusion between the two evidence. It is a relative weight between two evidences. It is highest when the evidences are equal and least when the evidence is unanimous one way or the other. The value of conflict is between 0 and 1.

$$conflict = \min(p, n) \quad (3)$$

Certainty of Evidence- This is the quantity that gives the confirmation of the correctness of the two evidences. This formula is defined in [5]

$$certainity, c = \frac{|p-n|}{1-conflict} \quad (4)$$

Using the conflict and certainty we can transformed the evidence space to trust space.

$$Belief, b = p \times c \quad (5)$$
$$Disbelief, d = n \times c \quad (6)$$
$$Uncertainity, u = 1 - c \quad (7)$$

The trust space[10] in here is defined as follows

$$Trust\ space, T = \{(b, d, u) | b \geq 0, \mathrm{d} \geq 0, \mathrm{b} + \mathrm{d} + \mathrm{u} = 1\}$$

4.3.3 Operation for Combination of Trust

The trust space is given by belief (b), disbelief (d) and uncertainty (u). This can be represented by using a 3 – dimensional vector [21][22][23].

V_t=<b, d, u>

The rule for the combination of the vector can be used for combination of the trust.

Firstly the aggregation operation let V_{1B} and V_{2B} represent the vector representation of trust T_{1B} and T_{2B} respectively in fig.4. Then the aggregation of the two vectors, V will be given by the unit vector of the resultant of vector of the two.

If V_{1B} =<b_1,d_1,u_1> and V_{2B}=<b_2,d_2,u_2>
The aggregation trust will be represented by V as <b,d,u>, Using following

$$b = \frac{b_1 + b_2}{r} \quad (8)$$
$$d = \frac{d_1 + d_2}{r} \quad (9)$$
$$u = \frac{u_1 + u_2}{r} \quad (10)$$

Where,

$$r = \sqrt{(b_1 + b_1)^2 + (d_1 + d_2)^2 + (u_1 + u_2)^2}$$

For the concatenation operation let V_1 and V_2 be the vector representation of the trust T_1 and T_2 respectively in fig. 5, then the concatenation of trust V_{AC} will be given by the component vector of V_1 and V_2.

If $V_1 = <b_1,d_1,u_1>$ and $V_2 = <b_2,d_2,u_2>$
The concatenation operation is V<b,d,1-b-d> is the projection of V_2 in the direction of belief component(b_1) of V_1.
Using the following:

$$V = \frac{(b_1 b_2)}{(b_1 b_2 + d_1 d_2 + u_1 u_2)}(b_1, d_1, u_1) \quad (11)$$

5. Implementation

The simulation of our model is done in agent based modeling concept using the agent development platform RePast Simphony. We compare our trust propagation model with that of [4]. We have implemented our model with two different datasets.

a) Random Data
b) Advogato Dataset

5.1 Experimental Setup for Implementation Using Random Data

5.1.1 Creation of the Random Graph

The social network can be represented by a random graph. In the model, for the generation of the random graph, Barabasi Albert random graph generator is used. At each time step, a new vertex is created and is connected to existing vertices according to the principle of "preferential attachment", whereby vertices with higher degree have a higher probability of being selected for attachment.
At a given time step, the probability p of creating an edge e between an existing vertex v and the newly added vertex is given by

$$p = (degree(v) + 1)/(|E| + |V|)$$

where |E| and |V| are, respectively, the number of edges and vertices currently in the network.

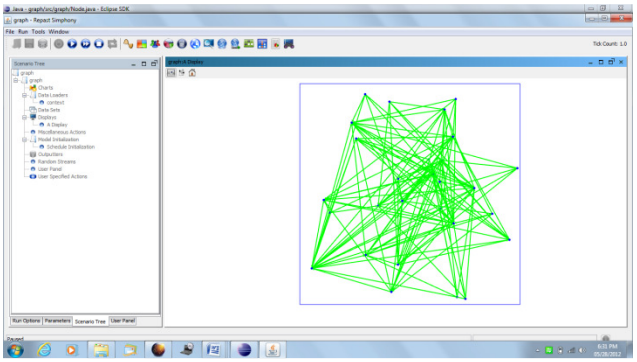

Fig.7 Snapshots of a random graph generated based on Barabasi-Albert model

5.2 Experimental Setup for Implementation Using Advogato Datasets

5.2.1 Creation of the Graph

Using the Advogato dataset we generate a random graph with each node represent one user. In our implementation, we generate the graph with a set of 200 vertices and adding edges between them as found in the Advogato dataset. Each edge has a level giving the relationship quality between the users.

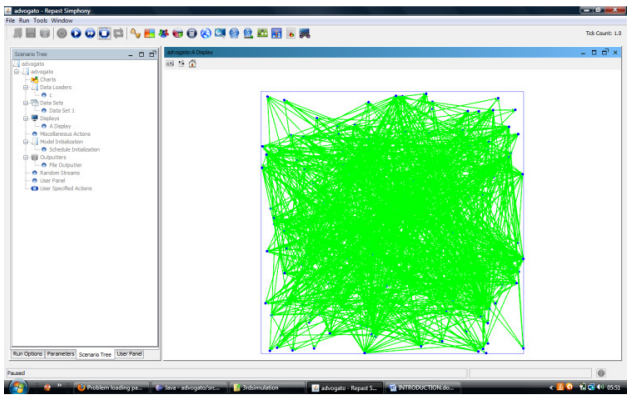

Fig.8 Snapshots of the graph generated, based on Advogato datasets.

5.2 Simulation of Our Model under Different Behavior of Trustee and Recommenders

The behavior of the trustee keeps on changing with time. And the following behavior of the recommender are consider

1. Some of the recommenders have high creditability measure and some are not.
2. All the recommenders have low credibility.
3. Only the recommenders that have credibility greater than certain threshold.

6. Results

Results obtained from data that are generated randomly. The x-axis gives the number of tick i.e. time and y-axis gives the trust value determine by the model.

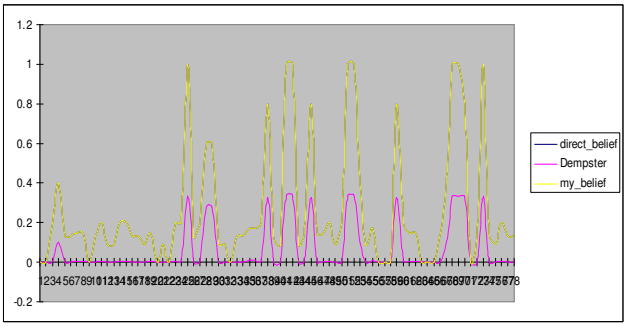

Fig.8 Belief graph for all recommender are trusty.

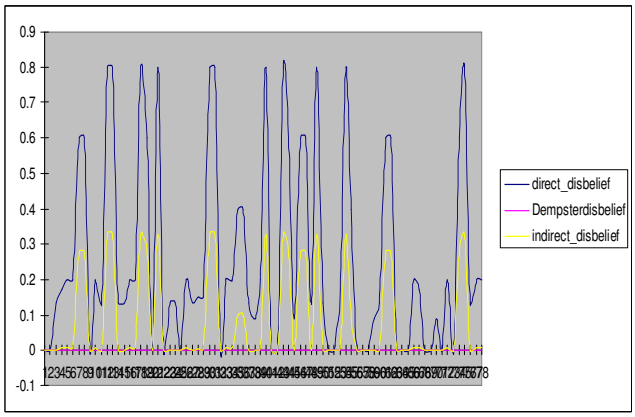

Fig.9. Direct trust Vs. Indirect trust with 50% recommender of honest type, 25% recommender of mix type and remaining 25% recommender of dishonest type.

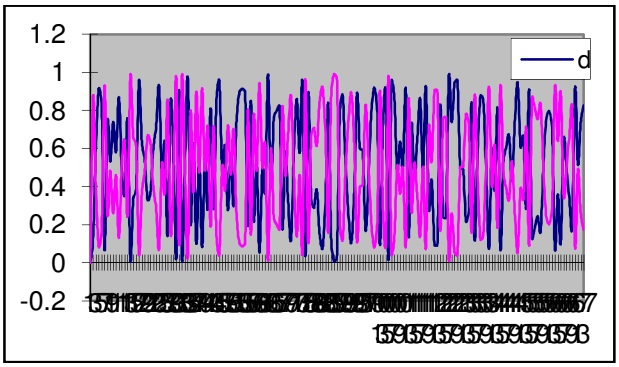

Fig.10 Direct trust Vs. Indirect trust when 75% recommenders are dishonest and 25% recommenders are honest

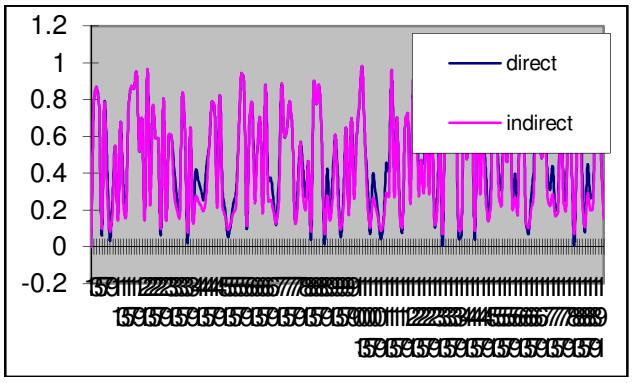

Fig.11 Direct trust Vs. Indirect trust with 50% recommenders of honest type and 50% recommenders of mix type.

7. Results Obtained From Advogato Datasets

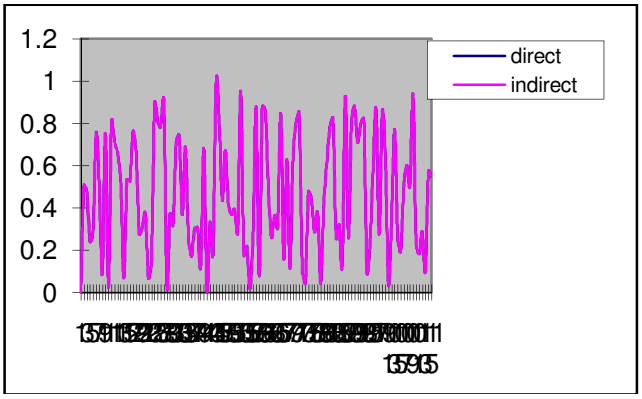

Fig.12 Direct trust Vs. Indirect trust.

8. Conclusion

The different simulation shows that, the indirect trust is almost similar with the direct trust. From fig.6, 7, 8 and 9 we can infer that the generated indirect trust depends on the type of the recommender. Adding a rating mechanism to denote the quality of the relationship between the users can help us classifying the dishonest, honest and mix type of recommender. The trust model makes use of the quality of relationship between the users.

References

[1] Tyrone Grandison and Morris sloman, "A Survey of Trust in Internet Applications " IEEE Communications Surveys and Tutorials,Volume 3,Issue 4,September, 2000.

[2] Sztompka, P. Trust: *A Sociological Theory. Cambridge University Press, Cambridge,* UK, 1999.

[3] Deutsch,.. *Cooperation and trust. Some theoretical notes.* In Nebraska Symposium on Motivation .Nebraska University Press, 1962.

[4] Jennifer Golbeck. *Computing and Applying Trust in Web-based social Network.* PhD thesis, University of Maryland, College Park, 2005.

[5] Yonghong Wang and Munindar P. Singh. *Evidence-Based Trust A Mathematical Model Geared for Multiagent Systems*, 2007 (Detroit).

[6] Audun Josang.*Trust and reputation management in web- based social network,* Queensland University of Technology,2000.

Heisnam Rohen Singh received his B.Tech in Computer Science and Engineering in 2009 from Maharashtra Institute of Technology, Maharashtra, India and M.tech in Information Technology in 2012 from Tezpur University, Assam, India. Currently, he is working as Asst. Prof. at Assam down town University, Assam, India.

Arambam Neelima has received her B.Tech in Information Technology in 2010 from Shillong Engineering and Management College, Jorabat, India and M.tech in Information Technology in 2012 from Tezpur University, Assam, India. She is currently pursuing her PhD from National institute of technology,Manipur.

Lourembam Suraj Singh received his B.Tech in Computer Science and Engineering in 2009 from North Eastern Regional Institute of Science and Technology (NERIST), Itanagar, Arunachal Pradesh, India and M.tech in Information Technology in 2012 from Tezpur University, Assam, India. Currently, he is working as System Analyst at Mizoram University, Mizoram, India.

S. Ibotombi Singh received the B.Sc. degree in Physics and the MCA degree from Manipur University in 1989 and 2004 respectively. Currently he is working as Assistant Professor in the Department of Computer Science & Engineering under the School of engineering, Tezpur University. He also served at the University of Delhi. He has published many papers in the areas of Data Mining, Trust and Reputation Systems in International Journals and Conferences. His current research interests are in Web services, trust management, network security, and GIS.