J. Appl. Environ. Biol. Sci., 4(12)22-40, 2014
© 2014, TextRoad Publication

ISSN: 2090-4274
Journal of Applied Environmental and Biological Sciences
www.textroad.com

A Trust Development Model in Dynamic Ridesharing

[1]Maria Mushtaq, [2]Adnan Ahmad, [3]Hamid Turab Mirza, [4]Ibrar Hussain

[1]MS Researcher, Department of Computer Science, COMSATS Institute of Information Technology, Lahore, Pakistan
[2,3]Assistant Professor, Department of Computer Science, COMSATS Institute of Information Technology, Lahore, Pakistan
[4]Assistant Professor, Department of Computer Science, COMSATS Institute of Information Technology, Attock, Pakistan

Received: August 26, 2014
Accepted: November 18, 2014

ABSTRACT

Ridesharing enables different people to share ride with each other to reach a common destination. It helps the users as individually to save cost, the community as collectively to reduce air pollution and road congestions. Now a day's smart phone technology has enabled people to share rides on short notices. However, trust is a major apprehension of people while providing ease in selecting a safe ride and developing acceptable and comfortable environment inside the ride. So, a trust development mechanism may elevate ride sharing systems as a common transport system which can greatly reduce the road congestion. This research puts the users as the primary stakeholders and thus encapsulates the human preferences in trust evaluations. It then formalizes the mathematically traceable concepts through temporal logic where the treatment is formal and based on logics. The reliability and the trust ranking is done by Chronbach's alpha and Kruskal-Wallis tests. Overall, the necessity to improve the trust development in dynamic ride share is the main contribution of this article.
KEYWORDS: Human factors, Positive and Negative norms, Rating reviews, Reputation, Trust, Trust models.

INTRODUCTION

TRANSPORTATION has become an important aspect of today's world. People travel from one place to another on daily basis in order to go offices, do shopping, and visit friends. However, travelling is becoming more and more cumbersome due to high prices of fuel and high congestion on roads. These factors greatly affect the working class in terms of time and money, who prefer to have access to different places with reduced cost and in less time. Due to inadequate financial resources, fast paced life, and dynamic human behaviors the problems of transportation remained unsolved. Consequently, air pollution and traffic congestion have become major public problem in metropolitan areas, as accounted by [1]-[3]. For example, in USA alone 4.6% of the population consumes 21.6% of the world's energy resources which is about 102 quadrillion of energy, as reported by [4]. To worsen the situation, more people prefer to travel by their personal vehicles, which results in more air pollution and congestion on roads, thus resulting in more wastage of time and money. Town administration committees are constantly engaged in planning and development of mechanisms to reduce the traffic load from highways, as described in [5]-[8]. It is exemplified in [9], [10]. Also go green week, pollution prevention week, and clean air commute projects are efforts to improve the quality of air we all breath in [4], [7]. Also the environmentalists constantly discourage the use of single man ride to reduce air pollutions and encourage sharing of ride in some way [4]. To overcome these challenges, an intelligent rideshare system is required, which may reduce the environmental pollution with low consumption of assets.

Rideshare enables different people to share ride with each other to reach a common destination, as demonstrated in [4]. Different people decide about the trip among each other prior to the pickup, where both the users – driver as ride giver and passenger as rider, get facilitated in terms of time, effort and cost efficiency. Internet based mobile technologies have enriched the concept and created many opportunities for people to share rides on short notices. People can offer and request rides anytime from anywhere, as described in [1], [11]. This approach enables dynamic behaviors and such a system is often termed as dynamic rideshare [1]. This system is dynamic as rideshare plans can be made on short notices even in seconds and minutes. Real time ride sharing system is enabled by smart phones, wireless communication systems and social networks which arranges ad hoc shared rides for people to make the system dynamic, as explained by [5]. It is the on demand service by which people can access any ride at runtime which is the core benefit of system to people.

Suggested system of dynamic ride share, as illustrated in [1] can satisfy up to 25% of the transportation needs. It shows that the tested efficiency and scalability of this system raised up to 25% by satisfying maximum number of requests of people which were sharing rides. Moreover, according to an estimate ride share reduces the congestion of traffic and 120 million liter of gasoline can be saved resulting in the reduction of air pollution, as depicted in [1]. Although, dynamic ride share systems improve the roads congestion, help to reduce the air pollution, and allow people to travel with reduced cost in less time, people are often reluctant to travel with complete strangers. This reluctance is due to the differences in their backgrounds and the lack of trust that is naturally associated with the fear of stranger. This fear is usually associated with the unknown travelling preferences and behavior of the other user. Also, as noted in [12], trust is one of the major concerns of people in ride sharing systems. To address these problems, this research aims to develop a trust model for dynamic ride share, which may enhance the trust of different parties in the ride. This will help to increase the chances of ride share within a community, and allow people from

***Corresponding Author:** Maria Mushtaq, MS Researcher, Department of Computer Science, COMSATS Institute of Information Technology, Lahore, Pakistan. Email: mariamushtaq90@yahoo.com

diverse backgrounds to take rides with each other. This not only save the fuel, time, cost and congestion, but also the diverse nature of different parties may offer interesting collaboration opportunities among different groups which may enhance the cultural richness of a country.

However, trust is a multidimensional concept that includes human factors as a major constraint, e.g. different people assume trust on their thinking, background, trustee's attitude etc., as expressed by [13]-[15]. In general, trust is the willingness of a party to be vulnerable to the acts of the other party on the assumption that the other will not harm it in any way, as explained in [16].

Human based trust models have their own importance in the socio technological world because they deal with social, behavioral and technical problems collectively, as detailed in [6]. It can help to design a system which deals with such problems of behavior, affinity and familiarity. Designing a human based trust model has various challenges associated with it, such as identity validation, trust rating, new membership, trust decay, constant behavior toward ride and trust match-ups. These human factors should be embedded with trust evaluations, intentions, behaviors and beliefs which will constitute to develop a trusted ride share and their description is as follows:

i. Identity validation

Identity validation is the confirmation of a person for reducing the danger of stranger and authenticating the individuality. It is required in dynamic ride share to distinct the entity as trustworthy by identifying his profile. This challenge refers to the problem that rider and ride giver should be members of the system, otherwise they should be verified through social network identities. Members should enter in the system through log on identities by which they are registered to the system. In contrast to other systems, as reported by [17]-[20], preference of seats, pets, luggage, AC/non-AC rides and medical issues should be decided earlier to a ride to cope up with the challenge of safe ride considerations (described in Section 4). To address such problems, ride share applications are confined to more clogged environments like universities and work places, as mentioned by [13], which eliminates the fear of sharing rides with strangers. Many systems, as mentioned in [17]-[20], are working which provide features of profile sharing. By profile sharing people exchange information with each other to reduce the fear of strangers, as expressed in [4]. These applications increase the trustworthiness of users too which strengthens contribution of our system.

ii. Trust rating

Trust rating is the feedback which evolves by individual entities and helps in the trust update (increase or decrease in trust position of single entity each time). It can help in contributing toward trust in rideshare systems to make decisions about ride selection by weighing up the previous trust ranks. This is done to reduce the problem of trust addition (increase over each iteration) or deletion (decrease over each iteration) in trust construction, as exemplified in [21].

iii. New membership

New membership is meant for a person having new entry in the system due to not having membership in the system already or who, he is not using the system formerly. Such a person has no previous trust rating in the ride share system. Challenge lies that how we can rate that person by social network ids to define his trust position? What rating should be provided to that person initially which may not harm the system integrity and may attract the person to develop his rating by his own to sustain in the system?

iv. Trust decay

Trust decay is the trust position of a person when he is not using the system from a elongated tenure. If a person is not using the system for a prolonged period such as months or years then what will be the effect on his/her rating in the profile using ride share system? In such cases trust decay happens which reduces the prior rating of rider or ride giver and gradually decreases the trust update (trust rating at each iteration) value. It can be a challenge of reputation building in the system, as accounted by[13]. Moreover, problem of defining stable reliability scale from different ratings of the data set may arise [13].

v. Constant behavior

Constant behaviors show stability in behaviors and circumstances in a ride to develop trustworthy attitude in the ride. So, there should be a method to derive constant behavior (positive and negative) toward ride share system that learns to get rating of individuals trust and decides to go toward next iteration which may happen when it is assumed that particular riders and ride givers given a successful ride or not because the conditions inside the ride changes on every ride e.g. route, road, mileage and car's condition. Two persons having better rating individually may not give a good rating while traveling together, can be a major problem to overcome.

vi. Trust match-ups

Trust match-ups are the feasibility of users to have a ride when travel preferences and travel distances are minimized. Trust in ride share is required in a ride when people are reaching their destination in minimum travel time, distance and preferences. This could be a challenge to the system e.g. Fig.1 illustrates that from origin to destination, path 2 has minimum mileage but travel preferences are not fulfilled which means that say a person wants to have a ride, ride has been matched, mileage is lesser than any other route but he has a preference that no smoker should be allowed in the ride because he is motion sick. But the available ride do not fulfill his demand (human trust factor). So it is not considered for a safe ride to be initiated and the person can travel only in compromised state. Therefore, Path 1 is selected because it fulfills both the conditions; minimum travel distance and rider/ride giver satisfaction criteria's for the safe ride. This means that Path 1 has a little mileage more than Path 2 but it fulfills the preference of user which develops his trust level in the ride and he can compromise for the little more mileage (because he found a perfect match of his preferences).

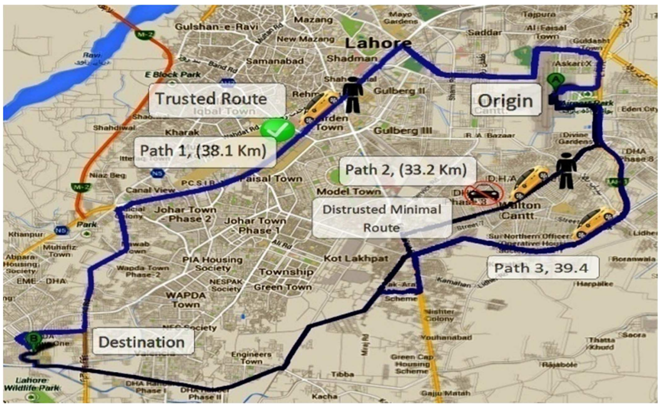

Fig.1 Trust matchups

We found that ride sharing system is not so popular for reasons such as lack of awareness, inconvenience, trust and time availability. It is stated that 69% of the people are unaware of ride share systems, as reported by [4], because there are only few sites which allow members to share rides. Only 13% of the people use these services if they have heard about it and the remaining use Facebook or other social networks to share rides. The existing ride share systems are uneasy to use due to lack of flexibility and coordination in planning a rideshare. Pronouncement and setting up a ride is the most difficult task to be fulfilled. Another major problem is the sacrifice upon personal preferences, as demonstrated in [6]. According to the survey described in [6] people usually do not trust the one who is offering a ride. Ride sharing must always be planned and requires detailed co-ordinate plan in order to make it successful.

Therefore, when these problems are overcome, then the system can evaluate and rank the trust cycle easily Specifically, our work is focusing on the following five phases; development of a model which 1) verifies every user by human based trust factors, 2) evaluates system factors , 3) ride factor evaluations, 4) trust evaluation cycle and 5) constitution of trust norms and beliefs. The model described (in Section 4) is the inspiration of basic trust constructs and social exchange theory described in [22]. Afterwards, the model is modified with human trust constructs based on experience values which depends on people's feedback called as trust rating. This concept afterwards helps in understanding the experience values and trust values which help in increasing or decreasing the trust update values, as explained by [23], [24]. It is a necessary and preliminary step to gather travel information and reviews about riders and ride givers in data sets (explained in Section 5). When commuters have given choice, their behavior and choices can alter from day to day in changing circumstances. Development of common data specification for ridesharing enables the aggregation of multiple rideshare reviews which might help in successful rideshare trips. Wrapping up the discussion, modeling of trust factors will help us in decision making scenarios. Our work differs from others because we are focusing on joint plans and long term societal norms which are based on dynamic properties. Dynamic properties include changing preferences, daily routines and habits which include time, fuel, cognitive costs and travel behaviors in terms of human beliefs. The reminder of the article is organized as follows: Section 2 describes the related work to assess and discuss trust constraints. Section 3 illustrates the approach we opted for model testing, for explaining dynamic properties of ride, trust ranking and stability constraints. Section 4 reports the design of model and implementation of human, system and ride factors by formalization. Section 5 presents the demography and quantitative assessments of data set, reliability and ranking analysis. Section 6 provides the conclusion and suggests some future work which can further illustrate the trust gaining process in ride share for healthier understanding of influencing socio behavioral and environmental factors upon human.

RELATED WORK

In dynamic ride share, most of the work has been done on optimization of routes and matching of partners. It includes efficient matching of riders and ride givers on run time, as mentioned in [11], [25], [26], engendering ride share schedules reducing total travel distance, as reported in [1], measuring the closeness of a match between pairs of potential partners, as represented by [3], development of fast shortest path algorithms on road networks, dynamic matching to schedule ride share, spatial indexing for retrieving information of cars, as exemplified in [5] and payment mechanisms for ride share plans, as revealed in [26]. However no work has been done to handle the travel preferences and trust customs to evaluate trust norms and beliefs for the development of long term societal standards for trusting dynamic ride share. Though, some of the work is done in trust of ride share by using different applications used in social networks. These applications might be; discussions on safety jeopardize, societal discomforts working in social sites by [2], ride sharing behaviors, mind-set, bond between passengers adopted from facebook, as reported in [8], absolute comprehensiveness of preferences of the people to develop trust among themselves and on the system explained in [7] and developing trust, handiness and enticement for people in ride share programs, as expressed by [4]. All these works define trust in terms of social networks which can be embedded in traffic control systems. But our work lies in a different way that social networks do not embed trust in a way of travelling with a person. Making friends on social sites and travelling with those people might be a different experience which we are focusing in developing trust of ride share plans. That is why all the security measures took in social networks cannot be applied in designing trust model because trusting a strange person to travel with is a huge responsibility where social networks are not much afraid of believing on strangers. We can say that ride share systems have a great responsibility of trust which is not much focused in trust systems of social networks. The performance oriented view (past reviews) can provide a community of experience to trust on one another. It is explained in [27] that to trust in agents when experiences of performance are used to estimate trust in different trustees. It shows that different trustees can believe on one another to design trust in agent models.

Despite of the less work on trust in dynamic ride share, some recent studies have focused on trust dynamics in different domains such as social networks, as focused by [2], [4], [7], [8], agent modeling, as emphasized by [13], [21], [23], [24], [27]-[29], web semantics, as stressed by [15], distributed networks, as expressed by [14], [22], [30] etc. Whereas, many models focused on agent trust by having experience counts, [28]-[31] showed the analysis of awareness in agent trust models with one trustee or between different trustees and trends of agent trust behaviors. So, there are lacking models, which are developed to fit these trends to human trusting behavior which will constitute a trustworthy and long term relationship in a ride share system.

The work on trust in other domains can be categorized as rating reviews, fault detection and trust update.

i. **Rating reviews:**

Rating review is the individuals feedback which is updated each time positively or negatively in some one's profile who is using ride share system. It is used in ride share system to make a facility to unknown people who are strangers to each other. People can review the past rating reviews of a person to from his profile and decides whether he is trust worthy to have a ride with or not.

Discussions in [32], explains trust as a temporal logical model in which trust was viewed as mathematical and philosophical point of view. It assured that previous models of trust were devoted to computer implementable solutions. No sufficient formalization of trust gaining problem was available. Unlike those models, intention of the study is focusing on formalization of trust gaining processes. Dissimilarly, recent histories were considered more valid than the older ones. Whereas, all the feedback reviews must be considered important (recent or older) for evaluation of riders and ride givers which will be focused in this system. It is important to observe that, distrust happens when feedback reviews, proper rating evaluations are missing or not yet retrieved previously.

Alternatively, the model used in [33] discusses the behavior in ride share system. It explains that ride review and rating feedback forms were provided when a ride has took place but past reviews were not available at the run time to trust a person. Contrary to the model [33], feedback reviews are maintained where rating criteria is developed to establish trust among the people, which system may not know, to reduce danger of stranger. Therefore, there is a need of feedback review at run time which constructs a reliable rider or ride giver.

On the other hand, it may happen that individually, the trust rating of trustor and trustee is very good but their rating do not work well in the situation of mutual ride. Unlike the model described in [31], aim of this study is to develop a model which may involve rider and ride giver in facilitating conditions that they may intend to make the ride successful by their past experiences and good individual reviews.

ii. **Fault detection:**

Fault detection is determining whenever some problem has been occurred. It is necessary to detect a faulty or unauthorized person in the ride which can be a harm to the ride. Profile matching and feature extraction is necessary to make a ride safe and trustworthy.

Earlier works focused that it is important to detect the faulty or unauthorized person [34] who wants to have a ride by different correlation methods and these models were deployed offline due to consumption of time and memory. Contrary to this method, it may be very useful to detect attack scenarios at run time dynamically when we are having continuous negative progressions (rating reviews) of past experiences. It is feasible not to allow rides in such conditions. There is a model described in [34] which explains that fault detection is done by graph model known as casual relation graph. Queue trees were constructed to generate alerts in offline modes. But unlike the model, proposed study aims at extracting features at run time from the reviews about each single variable in the system dynamically which is expressed in [35]. According to [24] feature matching will be the main constraint to be focused which identifies if any of the features is similar to the prior existing faulty feature then it should not intrude into the system for safety. It means that if a person having continuous negative reviews is matched and reported again for the ride then he will be excluded from the ride considerations at run time.

iii. Trust update:

Trust update is the increase or decrease in the trust position of an individual to rank them. Whenever trust update is positive, it's added in the trust value and when its negative then it is deleted from the trust value. We need to know individual's trust ranking over each update. This will help the people to stay updated by everyone's experience review to travel with and it will develop a sense of trust and safe ride development over each update.

Hence, [13] reported that trust values show some degree of interdependency for competitive, neutral or co-operation phase. Hence, positive trust value may lead toward competitive state (progressive state) and negative trust value lead toward co-operation stage (conservative stage). Research contribution should show that trust and flexibility may express experience count. Autonomous trust decay will indicate that how fast trust will go toward its neutral state (inactive state), when there is no new experience to update the trust value of a trustee.

Previously, relevant aspects of trust, as mentioned by [32], contexts the human based trust factors and the risk attitude of trusting party. Earlier models did not discuss human evaluations on the basis of past experiences to evaluate trust update values in ride share plans. This research intends to propose a system which may add the flavor of human based trust and distrust situations along with trust evaluation cycle which formally defines the trust process. This integration is not compiled yet previously (combination of trust values and evaluation cycle of trust with socio behavioral factors and security constraints).

The main research contributions can be summarized as:
Unlike the models discussed in [28], [29], [31]

a) Intention of the study is to develop validation properties of trusting human behaviors.
b) In contrast to [32], our work focuses toward trust formalizing processes where no feedback is considered un-important and reviews contain the utmost importance.
c) Our approach not only focuses on collecting feedbacks like in [33], but these feedbacks are used on run time for selection of rides appropriately.
d) Instead of being constrained to view the reviews offline and fault detection by correlation and casual relation graph in [34], we are formalizing an online system which can detect the attack scenarios dynamically by feature matching and observing the trust norms.
e) This study contributes towards trust ranking which will rank each participant. Safe ride priority will be the highest ranked participant.
f) Our approach is utilizing the combination of human factors, trust evaluations and norms toward a ride in socio behavioral constraints. Previous works like [32], did not discuss human behaviors by their past experiences and reviews.

Collectively, these factors emphasize the fact that it is not necessary to have a social relationship with others in order to develop trust. We can trust people by learning it. Trust is a norm which is organized by imitating the behaviors of people what they are doing in the society. Community trains us how to trust each other in different behaviors and situations between the people of different geographical locations and socio behaviors.

METHOD

The concept of trust development in ridesharing is a topic of research for many years, as demonstrated by [36], [37].

Though, main intention is considering relations and interactions between two people, the concept of trust is of high importance. [28], [29], [31] suggested that among trustor and trustees direct experiences, accurate model of trust can be presented. However, research includes interaction between different riders and ride givers, their relationship to collaborate with in a customized environment to develop proactive circumstances of safe ride. Research statement belongs to two constraints;

i. Ride Giver:

Let us assume that set of passengers *"P"* requesting for a ride*" Pr"* and *"Pr∈ P"*. We have set of human based trust factors "T" for ride givers (ratings, privacy, security, safe ride matchup, constant behaviors etc).We can say that *"Pr"* should satisfy set of *"T"* (preferences of ride giver) to fulfill ride request from origin node *"O"* to destination *"D"*.

ii. Rider:

Let us assume that there are set of rides *"R"* and we have to select a safe ride *"S"* which fulfills the preferences *"T"* (preferences according to the rider) by using a trustworthy optimal path from origin *"O"* to destination *"D"* for acquiring safe ride *"S"*.

In order to design the proposed model, there must be some things which should be confirmed earlier e.g.

a) How to construct "Trust Reputation Model" with Feedback Mechanism?
b) What are the specifications of the Trust Reputation Model?
c) How to attain convenience sampling for user's acceptance and allotting statistical scores w.r.t to trust ranks?

Likewise in the model designing, we logically provided the formulas of temporal logic for better understanding the expressions used in the model. For having the considerations of safe ride we have to verify the inputs that greater the rating, greater will be trust for accruing a safe ride.

A predicate logic named as LTL[1] is best suited for analysis of dynamic properties. Temporal specification is best suited for both qualitative and quantitative aspects, as emphasized in [23], [24], [38]. When a rider interacts to dynamic environment, LTL provides an input and output state to the rider or ride giver. Consequently, the input states are the observations to the environment and output states are actions to the environment. LTL provides the definition of relationship between each participant. Likewise many of the processes of our model can be easily verified by LTL including monotonicity progressions, safety encounters between respondents, option creation for ride, successful rides etc.

First of all in the section 4, aim is toward proposing a model, designing it and integrating that model with defining human trust based constructs and trust evaluation cycle. Accuracy check of the model design is done by generating formal formulae in Temporal Logic, as reported by [23], [24]. Model design is traced by predicates of LTL which defines the dynamic properties of trust gaining processes.

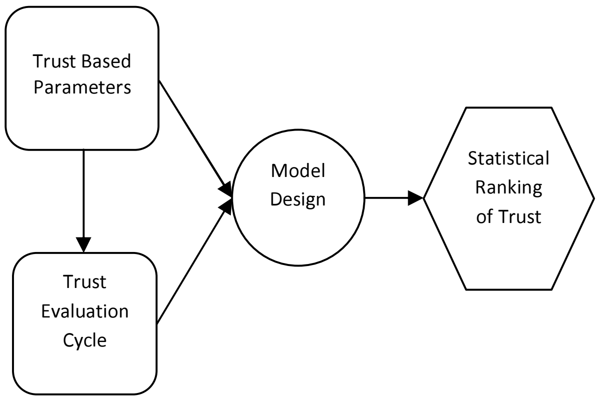

Fig.2 Fundamental process Model

Furthermore, a data set is analyzed statistically, which is about ranking trust position of each individual entity. We are exemplifying a data set with reviews of seventeen riders and ride givers in different scenarios and preferences. Five-point Likert scale of rating review varied from poor, unsatisfactory, neutral, satisfactory and highly recommended is used. In addition, reliability significance of the data set is evaluated by statistical test using Chronbach's alpha [39]. Afterwards, frequency analysis of trust ranking was applied on the data set using kruskal-Wallis Test[2]. Moreover, this ranking is viewed graphically for clear demonstration in the Section 5. Furthermore, the model defining the summarized view of work is represented in Fig.2 and the research methodology for the whole system is represented in Fig.3.

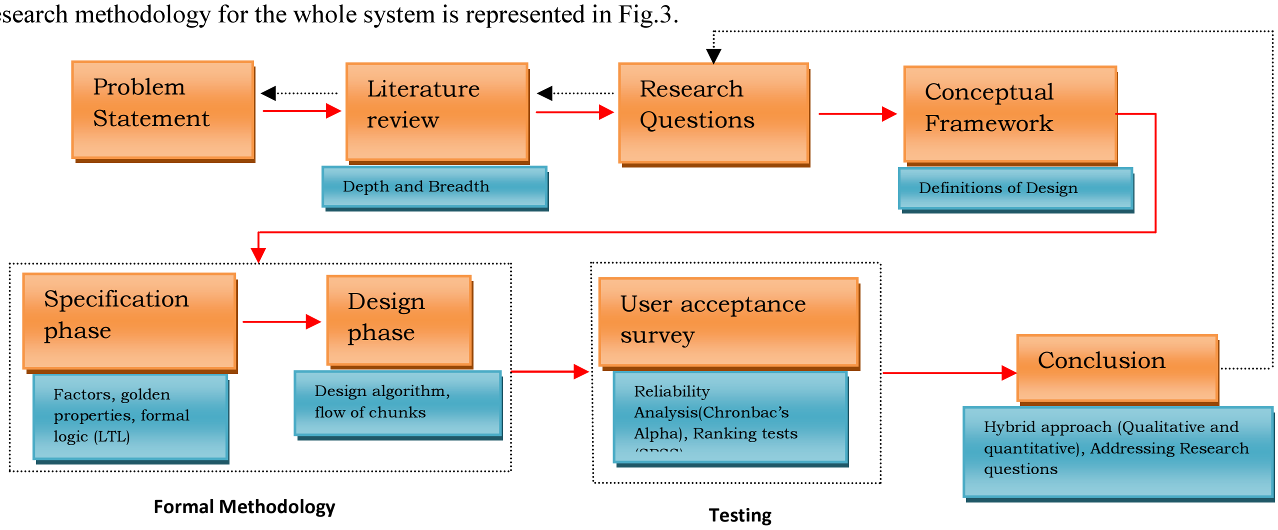

Figure.3 Research methodology model

[1]Linear Temporal Logic, it includes temporal commands and regular formulae which can easily define how to respond toward human factors, habits and norms of behavior control.

[2]This test evaluates whether the population medians on a dependent variable are the same across all levels of a factor.

THEORETICAL FRAMEWORK

Fig.3 includes a model of trust constructs and algorithm of its design to be followed which includes factors, participants and trust evaluation cycle which will further define trust building norms, intentions, trust beliefs, interactions of trust processes and attitude toward the trust, as described by [22]. All this flow will reveal a fact that user may select a ride on the basis of security of behaviors and other evaluations for having a safe ride e.g. lower cost and mileage for a ride.

At the initial state development starts from temporal logic for data retrieval, new memberships and decay functions, and then there is a need to understand all the human factors regarding trust that may happen in a ride. The human factors will be strongly evaluated by trust evaluations in the form of positive and negative trust progressions which will further lead us to form trust beliefs, intentions, norms and relationship development toward a ride.

Table.I defines the factors that may involve in the model and it defines all these factors through temporal methods which are as follows:

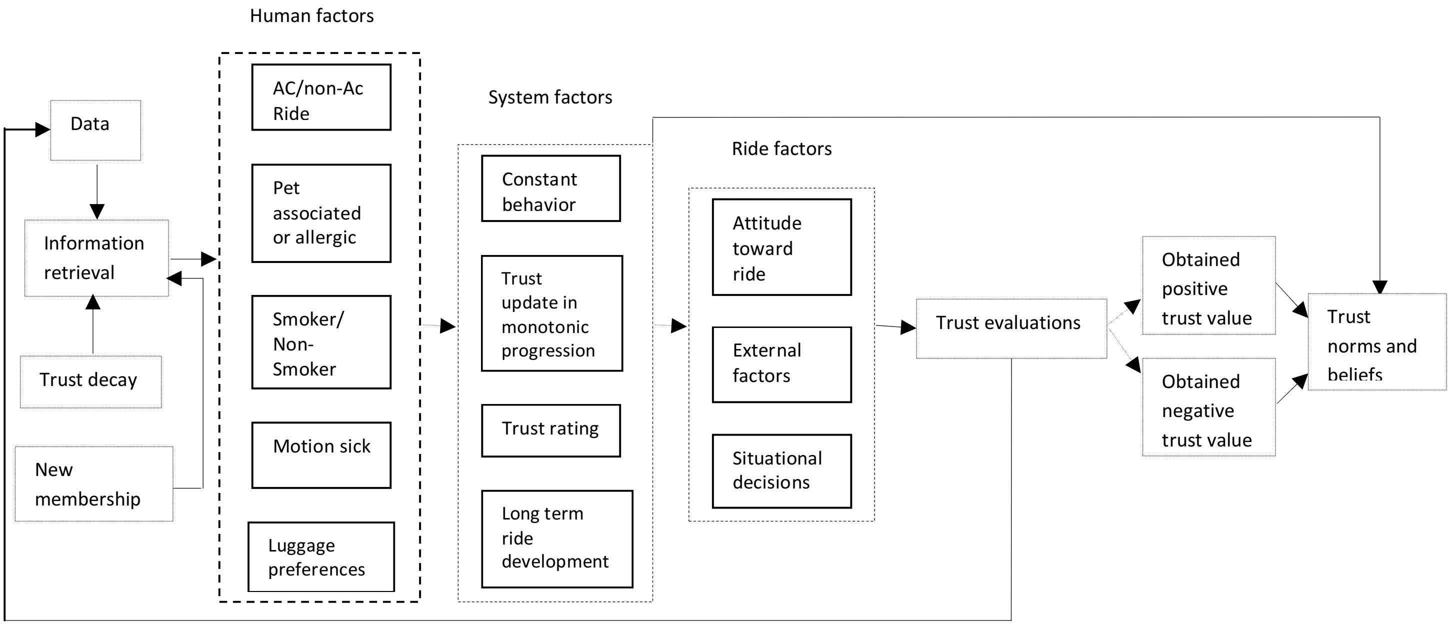

Fig.4 Trust model

Table I: Factors Influencing Trust Formation Process

Segments	***Factors***
Trustee	Rider, Ride giver: compatible, Secure
Trust Factor	Reliable, reputed, confirming common expectations
System Trust	Security, Privacy, Legality, Cooperative Norms
Interactions	End-user satisfaction, length of relationship
Belief	Positive attitude towards trust, developing positive limit approximation, system is reliable, trust is benevolent, integrity is capable and situation is general
Attitude	Developing a trust worthy system
Intentions	To have a safe ride with greater match up of preferences and reduced mileage, Trust beliefs constitute intentions
Behaviors	Getting a ride and having long term relationship if trust is maintained
Norms	Behaviors to ride
Assurances	Rating towards each behaviors in ride including less cost and mileage of ride
Conditions	Preferences to ride
External Environment	Situational normality, structural assurances, facilitating conditions

1Function Human factor(ac/non ac, pet association/allergic, smoker/non smoker, motion sick, luggage, seating){

2Do(User1∈ride(r) ∧ next in the ride (user 2, TVi_n, user1) ⟶ user1∉ride(r) with (user2));

```
End Do}
Function system factors (constant behavior, trust update, long term relation, trust rating){
DoTrust_state_of(Q,T) ∧Next_is_the_trust_state_of ⟶
(Qnext,T)
(b∈Q(u)∧ Next is (a,TVi_n,B) ⟶b∉Qnext(a));
End Do
Do ev1≤ev2 ∨ tv1 ≤tv2⟶ tu(ev1, tv1) ≤tu(ev2, tv2);
End Do
DoExp_val(Vo) ∧ Pos(Vo)∧ Y(Exp_val(V1)) ∧....Yn-1
(Exp_val(Vn-1)) ∧ Pos(Vn-1)) ∧Yn-1(Trust_val(w))⟶ Pos_trusted_ride(w);
End Do
Do Exp_val(Vo) ∧ Neg(Vo)∧ Y(Exp_val(V1)) ∧....Yn-1 (Exp_val(Vn-1)) ∧ Neg(Vn-1)) ∧Yn-
(Trust_val(w)) ⟶ Neg_drop_out(w);
End Do}
Function ride factors (external decisions, situational decisions)
If(external decisions || situational decisions){
Do trust ⟵update;
End do}
If(human factors && system factors && ride factors){
For all (exp count)> 1
Doexp count ⟵ Pos;
End Do
For all (exp count)<0
Doexp count ⟵Neg;
End Do}
{trust evaluation
If(trust evaluation is positive || trust evaluation is negative)
Return
Do trust ⟵norms;
Do trust ⟵beliefs;
End Do}
```

Algorithm-trust model design

i. Check for Membership:

First of all we have to retrieve information from the database that the user is a member of the tree (system) or not. If the user is a member of the system then his/her confirmation is required.

Additionally, if there are no recognized members of the system then users should get the membership and that time their reliance toward the system and systems reliance toward them will be zero. Number of experiences will update their rating of trust on each iteration. So it leads to two options first: membership, second: no membership.

System should first check for the requesting member if one exists in the system already or not. A logic can be generated to query this:

[True*][s](<rider>true&&<member>true) true (1)

It states that a system will always check if there exists some rider and it is a member of the system then there exists a state of membership. It can be checked by a number of list containing valid members of system.

$$\text{True} \xrightarrow{+} B \qquad (2)$$

By this method we are checking one user in the whole list.

$$\text{True}\checkmark \xrightarrow{+} B\checkmark \qquad (3)$$

✓Shows that the user is matched with the given list and validated. So above formulas yields that

$$\text{Rider} \xrightarrow{+} [\text{member}\checkmark, \text{member}\checkmark\ldots]^{3} \quad (4)$$

[True*][s](<rider>[4]true &&!<member>false) true (5)

It states that a system will always check if a rider exists and one, not the member of the system then he should get the member ship first. This can be illustrated by! (Negation) which shows that the match encountered failure state and validation is not done. [][5], <> are operators in the equation. Arrow sign ($\longrightarrow$) shows a state.

$$\text{True} \xrightarrow{+} \text{B!} \quad (6)$$

So if there is any failure state we can summarize all the above formulas as:

$$\text{Rider} \xrightarrow{+} [\text{member},!\ \text{member}\ldots.] \quad (7)$$

If the person wants to get membership

[! membership. True*.*$\overline{\text{membership}}$] false (8)

*[6]is a regular expression operator. After the membership has been done, each user has to provide valid identity e.g. SSN (social security number) or passport number. So we can conclude it as:

$$\text{Valid rider} \xrightarrow{+} [\text{SSN}\checkmark\&\&\text{Pasport number}\checkmark] \quad (9)$$

Valid rider should provide correct [✓] SSN and passport number so that it can be validated at each iteration [+]. Every new member's rating will initiate from zero.

ii. Trust Decay:

Trust decay means that once the user stops using the system for some reason then the trust rating will gradually decrease by time, as defined by [13]. However, once a rider lose its trust in the security mechanism so the trust value which was developed at the initial state will no longer remain valid or we need to revise the value of trust. If we have a trust state of *(Pi, T),* for *i=0, 1, 2…T.* We can say that *T* specifies the initial trust. If at some time $T, \cap a \in A\ Po(a) \subseteq \cap a \in A\ Pt(a)$ do not hold then some member of the system is losing its trust and the trust value should be revised.

There can be many experiences $(E_i(t))$ to human at each ride. These experiences may range from [-1, 1]. -1 indicates the most negative trust experience and 1 shows the most positive trust experience. After every ride the riders and ride givers update the trust values by giving reviews about the ride (η). Experience count (α), trust decay(β) indicate that how rapidly trust goes back to its original value or neutral state when there are no new experiences. On receiving an experience $E_i(t)$ from a trustee S_i at time point t, the human trust on S_i at the next time point $(t+1)$ is the sum of the human trust on S_i $(T_i(t))$ and the experience $E_i(t)$ minus the autonomous decay in trust, this is expressed as follows:

$$T_i(t+1) = \alpha * E_i(t) - \beta * T_i(t) \quad (10)$$

iii. Human Factors:

a. Safe Ride Considerations

Safe ride considerations may include that rider and ride giver should have all preferences fulfilled to have a safe ride. We will define a relation such that: $u \in U,\ Q(u) \subseteq U$

[Motion sick user .true*.smoking] false (11)
[Allergic. true*.pet] false (12)

[3] [], shows an action can occur any time in the set of actions of transition.
[4]<>, shows there exists only one state of action in the whole transition.
[5] [], shows an action can occur any time in the set of actions of transition.
[6]It explains if there exists no membership in the system then after some state of actions membership should unavoidably be done.* $\overline{\quad}$, indicates an action must unavoidably be done.

[Asthmatic.true*.smoker] false (13)

It states that if any user is motion sick no user in the ride should be smoker. It means that if a user has negative trust value that he/she is a smoker and already existing user in the ride is motion sick then he/she should not be preferred for the ride. It can be formally induced as;

$$(User1 \in ride(r) \wedge \text{next in the ride } (user\ 2, Tvi\_n, user1) \longrightarrow user1 \notin ride(r) \text{ with } (user2)) \quad (14)$$

This temporal logic may be induced for different preferences of rider and ride givers like ac/non ac settings (In LDC)[7] described in [40], luggage privileges, seating preferences, full ride booking, pet association etc.

iv. System Factors:

a. Constant Behavior Toward Ride:

According to the previous scenario we can review constant behaviors toward the ride, which states that this may happen that two trustees of a ride share system say *{a,b}* have good trust values *(tv)* individually but they do not show constant behaviors toward a ride arise some compatibility problem. In this scenario, we should not allow the two users to have a same ride because a state of negative trust is built and one should go for the next ride. The negative trust value *(TVn)* is denoted as *{TVn1,TVn2….}* where *{ i=1,2,3….}*

$$Trust\_state\_of(Q,T) \wedge Next\_is\_the\_trust\_state\_of$$
$$(Qnext,T) \longrightarrow (b \in Q(u) \wedge Next\ \ is\ (a,TVi\_n,B) \rightarrow b \notin Qnext(a)) \parallel b \in Qnext(a)) \quad (15)$$

b. Trust Update in Monotonic Progression:

We can update trust monotonically[8]which means that greater the experience values, greater will be trust value, as exhibited in [23], [28]. So this will eventually lead to higher trust update values. We can explain this in mathematical terms:

$$ev1 \leq ev2 \vee tv1 \leq tv2 \Rightarrow tu(ev1, tv1) \leq tu(ev2, tv2) \quad (16)$$

Where*'ev'* shows experience value, *TV* shows trust value and *tu* shows trust update. This mathematical indication shows that on L.H.S experience value and trust value in the next iteration *(ev2 and tv2)* is always greater than the prior one *(ev1 and tv1)*. R.H.S shows that eventually the trust update of *ev1* and *tv1* is lesser than the trust update of *ev2* and *tv2*. It will be further explained in trust evaluation by having negative and positive trust progression.

c. Trust Rating:

Trust rating is the evaluation of personal experience of a person toward the ride. Once a person trusts a system, he updates the trust value. There can be many trust reasons i.e. trusting the comments or reviews of people to derive your own trust onto the system, after every experience updating the trust in negative or positive way, trusting friends of friends to evaluate the system, distrusting the people on whom we trusted to have safe ride, and deleting the trust values by continuously minimizing the value of trust on each iteration. All these aspects can be formally analysed.

For instance we say that we have a trust state *Q*, for any user *'u'* we can say that $u \in U$, $Q(u) \subseteq U$.It is considered a set which all the users on which a single user *"u"* can trust. Now we can define the trust state as (Q,T) which means that *Q* is the trust state of system *T*. Initial state of *T* can be written as (*Qo,T*). Initially there are some users on which all the users may trust as they all can trust security mechanism or reliability on other users. Suppose that:

a) Trust state of*(Q,T)* $\wedge$ Next is the trust state of *(Qnext,T)*
b) *Q=Qnext* this state can be used when no user want to change the trust value and have constant trust on the system.
c) *Q=Q_* this states that at the next stage or anywhere standing in the system, a user has changes its trust and revise the value of trust which will show change in the trust rating of the system.

Now, it can be concluded that in the first statement the trust state remains same at the current moment and there are no changes to the trust of the system. Second statement shows that there is some change to the state of the system trust. Two processes or actions can be made while changing the trust, the trust may be added or deleted, as mentioned in [21]. For example *JOHN* trusted *BOB* to have a ride. But the experience went wrong and *JOHN* concluded that trusting *BOB* was a bad decision and his trust to the system minimized (trust value for *BOB* eventually decreased).We can assume it as if *(JOHN, BOB)*$\in$***R*****.** Then the trust relation ***(****JOHN, BOB****)***will be deleted from relation R. Trust experiences can be negative or positive. Negative trust experience can be written as *{E1n,E2n,….},*and positive trust experience can be written as *{E1p,E2p,…}*where E is the

[7] Least developed countries can face such problems.
[8] The term Monotonic functions show that the output increases or remains constant as input increases which is then understood as the more positive experiences are, the higher will be trust.

experience, *n* stands for negative relation and p stands for positive relation. The change in the relation when negative trust is deleted can be concluded as:

Trust state of (Q, T)∧next is the trust state of $\longrightarrow$
(Qnext, T) (BOB∈Q (u)∧Next is (JOHN, Ei_n, BOB) $\longrightarrow$
BOB∉Qnext (JOHN)) (17)

Negative trust is deleted, where (i=1, 2, 3….)

Trust state of (Q, T)∧next is the trust state of $\longrightarrow$
(Qnext, T) BOB∉Q (u)∧Next is (JOHN, Ei_p, BOB) $\longrightarrow$
BOB∈Qnext (JOHN)) (18)

d. *Long Term Ride Development*

System factors conclude a need to evaluate that either the experience values are so positive that people (riders, ride givers) only do not prefer ride but want to consider this system for long term. There may be two options; 1) may be experience values are positive enough to develop a trusted a ride for now and as a long term relationship. 2) experience values are not enough to make ride possible and using it constantly afterwards in a long term relationship which eventually drops the user(rider, ride giver)from the system. Both of the relationships can be temporally expressed as:

Exp_val(Vo) ∧ Pos(Vo)∧ Y(Exp_val(V1)) ∧....Yn-1
(Exp_val(Vn-1)) ∧ Pos(Vn-1)) ∧Yn-1(Trust_val(w)) $\longrightarrow$
Pos_trusted_ride(w) (19)

Exp_val(Vo) ∧ Neg(Vo)∧ Y(Exp_val(V1)) ∧....Yn-1
(Exp_val(Vn-1)) ∧ Neg(Vn-1)) ∧Yn-1(Trust_val(w)) $\longrightarrow$
Neg_drop_out(w) (20)

v. Ride factors:

a. *Attitude toward Ride*

Attitude is built when we have some external factors and situational decisions which make us realize to take the decision toward ride. Such decisions will help in the formation of trust intentions in the form of valid or invalid system (theory of soundness), as depicted in [21]. They can be interpreted individually as: External Environment Factors and Situational Decisions.

External environment faces two basic problems 1) decrease in social trust 2) increase in online trust. External environmental focuses on three factors which are: situational normality, facilitating conditions and structural assurances. Situational normality deals with all the compliances of the system which are already checked in the portion of human factors. By confirming to these formalities, trustees make trustors more potential, comfortable and assured that every condition and preference is being fulfilled. Facilitating conditions follow that all the perceived norms should be accumulated with a general condition that trustor and trustees have to follow those norms to fulfill a possibility of ride. e.g. norms should be defined accordingly and rider and ride giver are accustomed to follow them to make a suitable and soothing mechanism, as mentioned in [22]. Structural assurances follow different terms at each stage. It is interpreted by the studies that privacy security and integrity of the system should be followed so that a rider or ride giver can trust to have ride which is depicted in [22]. Security and privacy is checked earlier in the model where we have defined trust addition, deletion, person's validation and fault detection.

As it is earlier defined that trust is a dynamic term and it changes dynamically with time due to some situational decisions which can vary in different conditions as described in [22]. Due to these factors we can say that decisions may incorporate trust gaining or trust losing mechanisms in the system. If we assume that from initial state of time to sometime *t*, no user is losing its initial trust, then this will be a valid theory of soundness[9], as depicted in [21]. This property can be explained as:

i. Assume we have a system *t*, and trust_state_is*(Pi,t),* where i=0,1,2,3… and T is the sound theory of trust for t which will identify the initial trust as $\cap a \in A\ Po(a)$, so from time 0 to sometime $t, \cap u \in U Po(u) \subseteq \cap u \in U\ Pi(u)$, therefore $0 \le 1 \le t$ means that the soundness theory is valid for the time interval(0,t) and any condition derived from theory is considered as valid.
ii. However, once the user (rider or ride giver) loses its trust then the theory is no longer valid and we need to revise it.
iii. Assume we have a system t, and trust_state_is*(Pi,t),* where i=0,1,2,3… and T is the sound theory of trust for t which will identify the initial trust as $\cap a \in A\ Po(a)$, and at a stage where $\cap u \in U\ Po(u) \subseteq \cap u \in U\ Pt(u)$ is not valid or does not hold then it means that user(rider or ride) is losing trust at some stage t and the theory must be revised for security measures.

[9] If some rider or ride givers do not lose trust and remain in a valid state for next states.

vi. Trust Evaluations

Trust evaluations depend on all the human factor ratings. From each scale we will attain different Trust value *(tv)* and all the ratings will amalgamate to form positive or negative progression toward the trust which will state the evaluation of trust for being further processed. Positive or negative trust *(P_N)* states that higher the positive (negative) trust leads to high(low) trust. We can conclude it by temporal logic as:

$$\text{Exp\_val}(v) \wedge \text{P\_N}(v) \wedge \text{Trust\_val}(w) \wedge \text{Ytv}(w') \longrightarrow w \leq w' \tag{21}$$

If at a point in time the experience value is v and v is positive, and the trust value is w, then the next trust value w' is higher than w or no trust values higher than w exist. *Ytv*shows that the trust value is repeated at some instant.

a. Obtained Positive Trust Value

If there is positive experience of trust then we accumulate trust gaining process that after how many positive experiences there comes a positive state of trust which helps in forming a trusted ride. Positive assurances to trust and positive evaluation of system also depicts that system can be trusted. It can be temporally analyzed as:

$$\begin{aligned}&\text{Exp\_val}(Vo) \wedge \text{Pos}(Vo) \wedge \text{Y}(\text{Exp\_val}(V1)) \wedge \ldots \text{Yn-1}\\ &(\text{Exp\_val}(\text{Vn-1})) \wedge \text{Pos}(\text{Vn-1})) \wedge \text{Yn-1}\\ &(\text{Trust\_val}(w)) \longrightarrow \text{Pos}(w)\end{aligned} \tag{22}$$

Therefore, it can be interpreted as; if *Exp_val*is *Vo* and this *Vo* is positive for the next state *Y(Exp_val(V1))* uptill*Yn-1*, then trust value remains positive. Positive trust leads to make a ride possible. By positive experiences in the trust it will be easier for riders and ride givers to trust a ride and to make a ride possible which will be called a safe ride because the trust experiences (human factors) and trust update(evaluations of trust) will help to make a ride safe accordingly.

b. Obtained Negative Trust Value

If there comes some negative experience of trust then trust may drop[10] (Marx & Treur, 2001) from its previous value. This can be temporally analyzed as:

$$\begin{aligned}&\text{Exp\_val}(Vo) \wedge \text{Neg}(Vo) \wedge \text{Y}(\text{Exp\_val}(V1)) \wedge \ldots \text{Yn-1}\\ &(\text{Exp\_val}(\text{Vn-1})) \wedge \text{Neg}(\text{Vn-1})) \wedge \text{Yn-1}\\ &(\text{Trust\_val}(w)) \longrightarrow \text{Neg}(w)\end{aligned} \tag{23}$$

Whenever, it occurs a negative trust due to negative experience values, means that the system should be evaluated again by adding some positive experiences with time, so that a trusted system may be accomplished. If after many iterations and experience values the trust is negative then no ride can be made possible in this case and the system will stop over there.

vii. Trust Belief

Experiences in the system lead us to believe the factors which are happening in the community and these intentions normally become our belief whether positive or negative. Our system may lead to trust gaining processes when we attain positive trust values and we may attain positive trust approximations[11], as verified in [23], [28]. This positive belief will lead us to safe and healthy communicative ride with maximum trust values in the system. Trust factors and trust evaluations will lead us to trust beliefs. By positive limit approximation we mean that we have a belief in the system that trust may lead toward its maximal limit. Trust beliefs lead toward trust intentions. If trust beliefs are positive then it may lead to a trusted ride. After long experiences trust will go toward positivity. This can be explained by temporal logic:

$$\text{Future\_time}(\text{exp\_val} \rightarrow \wedge\, v' \; ! v' > v) \; \rightarrow \; \text{Future\_time}(\text{Trust\_val}(w) \; \rightarrow \wedge\, w' \, ! w' > \; w) \tag{24}$$

$\wedge v'$ here shows conjunction of overall experience values *(exp_val)* and $\wedge w'$ shows conjunction of overall trust values *(trust_val)*. This logic explains that if some future time exists (*future_time*) and for all the later time points v is the experience value then no value(experience) is higher than v and same for if some future time exists and for all the later time point w is the trust value then no value(trust) is higher than *w*.

viii. Trust Norms

By different studies we concluded that norms[12]described in [30], present a direction to follow that after how many positive or negative actions we concluded that our developed action is a positive norm or negative one. Usually norms are developed by constructing beliefs.

---

[10]We have to see that after how may negative experiences the trust will drop or come in negative state.

[11]It is always possible to reach maximal trust, if a sufficient log period is provided for positive experiences (same for the negative experiences).

[12]∨+ shows conjunctive property for positive

Suppose we have set of rides *R*, set of roles *(q1,q2)* and different participants like *r1,r2* which belong to *R*. we can say that *r1* is generalized to *r2* and vice versa. It can be exemplified that for example a ride giver *r1* needs a rider *r2* and a rider *r2* needs to have a ride *r1* in terms of generalization. Now we have to see that at what conditions the norms can be developed between the below three constraints:

$$\text{Ride(R)} \wedge \text{participants(r1,r2)} \wedge \text{saferide(r1,r2,t)} \longrightarrow \vee{+}\wedge \ \wedge{-} \tag{25}$$

$$\text{Positive norms: role(q1,r1)} \wedge \text{role(q2,r2)} \wedge \text{role(q,r)} \wedge (t \in to) \wedge \theta \wedge \varphi \tag{26}$$

$$\text{Negative norms: role(q1,r1)} \wedge \text{role(q2,r2)} \wedge \text{role(q,r)} \wedge (t \in to) \wedge \theta \longrightarrow \varphi \tag{27}$$

DATA COLLECTION & EVALUATED RESULTS

From the above model, it is concluded that experience values and trust values are important factor to define and rank trust within human perspective. The general idea to formalize human factors is described in the previous section. Trust performance mainly depends on feedback and reliance among trustor and trustees. Since real world related large transport feedback system or social systems to evaluate trust rating in ride share are not available. We need to assume a data set of different experiences and feedbacks of people about their ride to rank trust appropriately. However, it is assumed that a data set which evolves different trust rating scenarios, results to develop trust (specifically by, reliability analysis using Chronbach's Alpha, suggested by [39], rank test using Kruskal-Wallis Test and frequency analysis of trust ranking). The contribution to this section will be:

a. How the rating reviews of different sessions will be attained?
b. What will be the effect of rating progression or degradation on different constraints?
c. What will be the reliability scale analysis of the data?
d. How we will rank trust of average mean square ratings?

i. Data set:

Formed data set belongs to reviews of different sessions of respondents who tested a ride. The input fields represent the rating review of these participants (respondents) and it include *PID*=Person Identification, *RR*=Rider Rating, *RGR*=Ride Giver Rating, *PE*=Past Experiences, *DT*=Decay to trust, *NM*=New Membership, *ID*=Identity via Social Networks, *SRM*=Safe Ride Matchup, *CB*=Constant Behavior, *NR*= Number of rides, As *RG*=As ride giver, As *R*= As Rider, *TR*=Trust Ranking.

ii. Participants:

Furthermore, an experimental scenario of seventeen participants twelve male and five female took part in the rides with a mean of eighteen to twenty four years to develop data set. Participants were under graduate and post graduate students of university, majoring in computer sciences and management sciences. All participants were informed to attend the training session of rides and they were recruited to give feedbacks about the personal experiences in the ride. All the respondents were fully consented.

iii. Experimentation scale:

The feedback is differentiated by a likert scale say, [0-4] poor=0, unsatisfied=1, neutral=2, satisfactory=3, highly recommended=4, respectively. Reliance decisions and trust ranking is translated by this scale.

iv. Apparatus:

For locating the rides, students used GPS (Global Positioning System) systems in smart phones and tablets. They checked past reviews about people and given the feed back to people in feedback forms by smart phones with they were travelling.

v. Procedure:

We corresponded to each members rating upon trust development (by evaluating mean ranks) and ranking trust by checking priority of highest rating value in each iteration. After every iteration, a priority queue of trust ranking by Kruskal-Wallis test was achieved. Thus, a satisfactory reliability scale is assumed by testing this data set.

vi. Reliability Analysis

Reliability of the scale is checked through chronbach's alpha. The Cronbach's alpha obtained was 0.738, which indicates an acceptable range and shows a reasonable level of internal consistency of our scale, as in criteria defined by [39]. Reliability is the general uniformity of the measure. A measure is said to be reliable if it fabricate similar results under consistent circumstances, as

---

norms, and $\wedge-$ is disjunctive property for negative norms, it is the attribute which can be computed from t0,θ is the relation between ride, participants and safe ride where φ is a temporal condition which accounts for past occurrences and actions of future occurrences.

defined by [34]. The range of consistency in Chronbach's alpha is provided below in Table.II. It shows that the internal consistency of our data set falls in an acceptable range which is considered a satisfactory reliability standard for the data set.

Table II: RELIABILITY SCALE

Chronbach's Alpha	Internal Consistency
$\alpha \geq 0.9$	Excellent
$0.7 \leq \alpha < 0.8$	Good
$0.6 \leq \alpha < 0.7$	Acceptable
$0.5 \leq \alpha < 0.6$	Poor
$\alpha < 0.5$	Unacceptable

Table III: FACTS & FIGURES OF DATA SETS AND ANALYSIS OF TRUST RANKING

PID	Gender	Age	RR	RGR	PE	DT	NM	ID	SRM	CB	NR	As RG	As R	TR
1	M	22	3	2	0	0	0	2	0	0	5	3	2	13
2	F	24	4	4	5	0	0	2	5	4	6	4	2	1
3	M	22	5	5	4	0	0	4	3	2	5	2	3	3
4	M	18	2	3	2	2	0	4	2	2	3	2	1	9
5	M	22	0	0	0	0	1	5	0	0	3	1	2	6
6	M	21	1	1	2	1	0	3	2	1	2	1	1	15
7	M	21	2	2	3	2	0	4	3	3	2	1	1	8
8	F	22	3	3	3	0	0	3	3	2	1	0	1	11
9	F	22	1	1	2	3	0	2	2	2	1	0	1	12
10	M	23	0	0	3	5	0	4	2	2	4	1	3	5
11	M	24	2	2	3	0	0	3	2	4	3	1	2	10
12	M	24	0	0	0	0	1	4	0	0	3	1	2	6
13	M	19	4	3	3	0	0	4	4	4	6	2	4	4
14	F	20	2	1	2	0	0	3	2	3	3	1	2	14
15	M	21	3	4	4	2	0	4	4	4	1	1	0	2
16	M	22	3	4	2	0	0	1	3	4	6	3	3	7
17	F	19	1	2	2	0	0	3	2	1	2	2	0	16

vii. Trends and effect to rating:

If we assume Fig.5, it shows that the PID 16, is having 6 rides from which his past experiences given a dramatic increase of behavior to SRM and CB. It shows that the user took maximum rides as ride giver and rider 3 times respectively. Rating of his past experiences increased due to which he got an increase in safe ride match ups and he showed positive constant behavior toward the ride ignoring the identity via social networks. This showed positive progression of trust rating which is mutually dependent to each other.

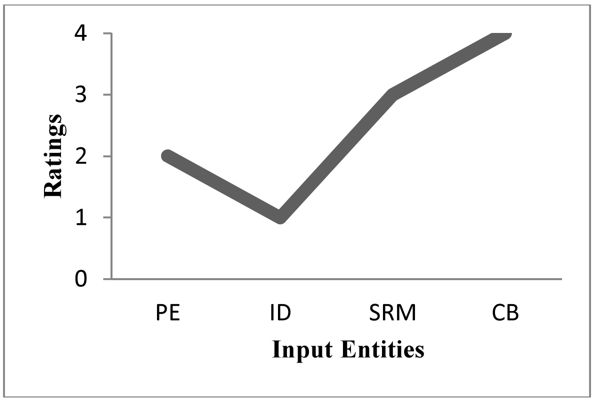

Fig.5 Positive trust progression

Whereas in Fig.6 there happens negative trust rating progression which shows that the PID 17 has decreased it's trust rating due to loss of SRM and CB in the duration of ride and in total she possessed only two rides which gone by a degradation in the trust rating. By the conclusion we got that experiences are co related to each other. Greater the Past rating, greater will be the effect on safe ride match up and constant behaviors rating (positively or negatively).

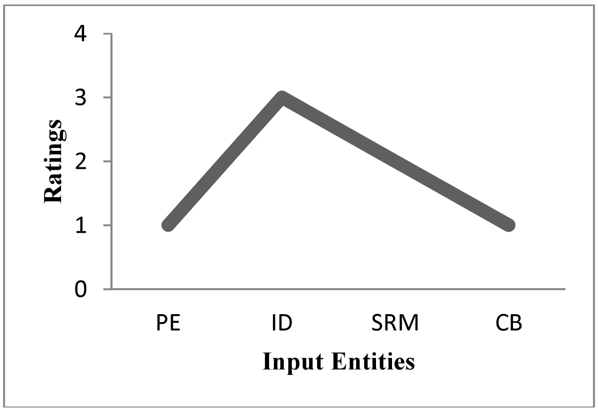

Fig.6 Negative trust progression

viii. Trust Ranking

It is also imperative to rank trust corresponding to each respondent represented in *PID*. To measure trust, *RR,RGR, PE, DT, NM, ID, SRM* and *CB* (input entities) are calculated in mean ranks and higher priority values to each corresponding respondent is determined on every iteration which develops trust ranking respectively. However, rating (defined in the result of people's feedback) depicts that prior experience values can develop a positive (negative) development of trust. Now, it can be concluded that trust is ranked by different human rating factors and a priority list toward a safe ride consideration can be developed. Thus, calculated evaluation can be viewed in a frequency graph (in Fig.7).

Since, this is an experimental data set of seventeen people's feedback which has given a rating as the inputs are combined to evaluate the trust in the form that which respondent has the highest rating to be trusted in a ride? A list of rank is made by prioritizing the largest trust value in the input fields upon each iteration. After checking the reliability scale, we are able to check the ranks by the mean squares of inputs. When all the priority levels are checked we will rank trust accordingly that which respondent stands where in the terms of trust which is clearly shown in Fig.7.

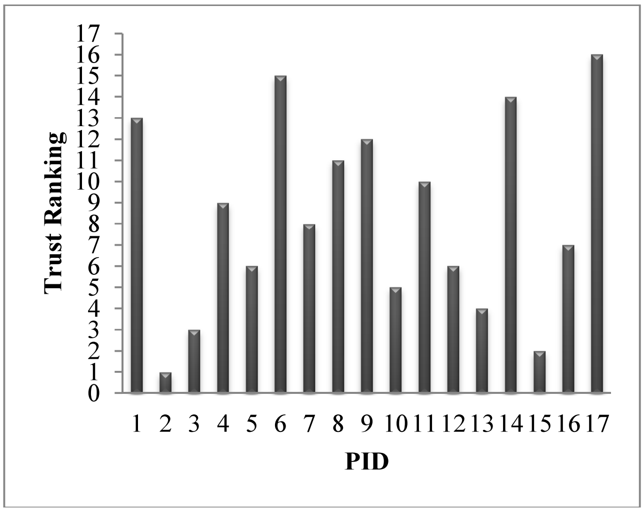

Fig.7 Frequency graph of trust ranking

It is obvious from the Table.III, that one respondent is offering ride to many people in the data set. Sometimes the user is behaving as rider and sometimes it is behaving as ride giver. The correspondents are mutually related to each other. It may happen that if PID 2 is having ride with 3 then it can offer a ride to PID 9 too. PID 3 can offer a ride to 9 or vice versa. So this motion of having rides runs in a circular motion as described in Fig.8:

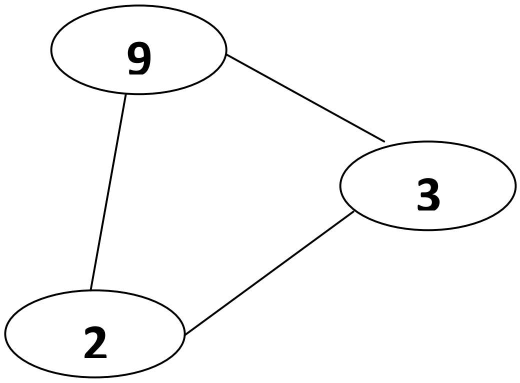

Fig.8 Circular matchups of riders & ride givers

To exemplify this situation we have got the ratings of PID 2,3 and 9 in Fig.9. They showed deviating behaviors in having rides with each other. According to the trust ranking they showed their positions 1, 3 and 12 respectively. The difference to their ranking happened due to the goodness of their behaviors (trust ability) in each ride.

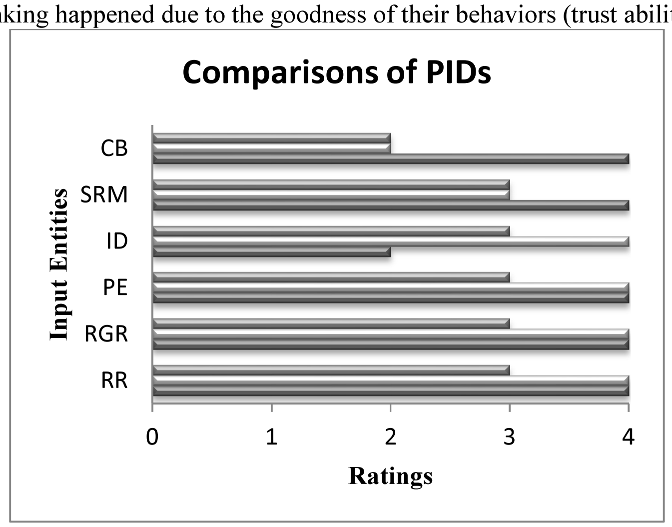

Fig.9 Distribution of trust ranking in three sessions

Conclusion and Future Work

In this paper, an extensive discussion of trust model has been performed to show that human trust behaviors can be accurately predicted using formal methods. Although, an experiment has been designed that places human in a setting that they have to make decisions based upon the experience values and trust values predicted after each ride. In total seventeen participants took part in the experiment. Results show that the experiences of the people got satisfactory amount of reliability. However, trust has been ranked individually by each respondent and a trust priority is maintained (Kruskal-Wallis test). Furthermore, it is predicted that assumptions of the trust model are found in the data set of the respondents (participants).

Of course, much work on the trust models e.g. [21] carried an experiment that has been done to investigate human trust behaviors in terms of security and privacy where [30] discusses the integrity modeling of trust dynamics. Though, the underlying assumptions of trust models have been designed formally up to some extent to fit on to the model. Therefore, other than human perspective and trust evaluation cycle, this proposed model describes behaviors in terms of situational decisions, external behaviors, trust beliefs, trust intentions and long term trust development toward a ride. Unlike other models, the proposed model describes the formation of trust in detail in [21], [23], [30].

Within the domain of trust, some trust models have been developed like [36], [37]. The focus of this paper is on combining different trust constructs formally to make a successful and trusted ride orientation and designing the experimental data upon trust ranking obtained by different reviews. Reviews make it possible to value trust decision numerically using statistical tests.

Therefore ratings and experience values can be a flaw to the system. According to the term projection, which is a social psychology problem, one may want to reduce the reputation of the system by always giving less rating review to other people to become defensive in the system. Therefore, it can be a huge social debate which should be handled in the future work. Furthermore, parameter adaption methods will be explored and extended which will further account for human learning adaptation to trust in other domains. This feedback mechanism will be experimented on larger communities in parallel to extract the features and norms different societies usually follow. Whereas this system is applicable in different transport systems, reputation system of universities, hostel allotment system, e banking and e trade systems etc.

ACKNOWLEDGEMENTS

The authors thankfully recognize that this paper is based on work developed at COMSATS Institute of IT, and we would like to thank all the authors mentioned in the references whose work enlightened our thoughts to work with ease on this topic. For this cause we would specially like to thank Abeer Imam, Syed Waqar-ul–QuonainJaffry and Mohammad Umair who contributed and motivated us for this research. Their kind help and suggestions were meaningful to us. We as authors will remain responsible for any omissions and inaccuracies.

REFERENCES

[1] S. Ma, Y. Zheng, & O. Wolfson. “T-share: A large-scale dynamic taxi ridesharing service” in *Proc. 29th-ICDE*, 2013, pp. 410-421.

[2] G. Gidófalvi, G. Herenyi, & T. Bach Pedersen. “Instant social ride-sharing” in *Proc 15th-WCITS*, 2008, p. 8.

[3] T. Kammerdiener, & H. Zhang. (2011). Classification of ride-sharing partners based on multiple constraints. *Journal of Computing Sciences in Colleges*. [Online]. 26(4), pp. 95-101. Available: http://dl.acm.org/citation.cfm?id=1953589

[4] V. Chaube, A. L. Kavanaugh, & M. A. Perez-Quinones.”Leveraging social networks to embed trust in rideshare programs” in *Proc. 43rd-HICSS*, 2010, pp. 1-8.

[5] C. Tian, Y. Huang, Z. Liu, F. Bastani,& R. Jin. “Noah: A dynamic ridesharing system” in *Proc. ICMD*, 2013, pp. 985-988.

[6] B. Whitworth, & A. Ahmad, “Socio-Technical System Design” in *The Encyclopedia of Human-Computer Interaction,* 2nd Ed. 2013.

[7] V. Chaube, “Understanding and Designing for Perceptions of Trust in Rideshare Programs,” Ph.D. dissertation, Virginia Polytechnic Institute and State Uni. 2010.

[8] K. Hwang, & G. Giuliano. (1990). The determinants of ridesharing: Literature review.eScholarship*University of California and University of California Transportation Center*. [Online]. *38,* pp. 1-29. Available: http://escholarship.org/uc/item/3r91r3r4#page-7

[9] RIDEsolutions. (2013). Available: http://www.ridesolutions.org

[10] Craigslist. (2010). Available: http://craigslist.org

[11] N. A. Agatz, A. L. Erera, M. W. Savelsbergh, & X. Wang. (2011). Dynamic ride-sharing: A simulation study in metro Atlanta. *Transportation Research Part B: Methodological*. [Online]. 45(9), pp. 1450-1464. Available: http://www.sciencedirect.com/science/article/pii/S0191261511000671

[12] R. Wash, L. Hemphill, & P. Resnick. “Design decisions in the RideNow project” in *Proc. ACM SIGGROUP,* 2005, pp. 132-135.

[13] S. W. U. Q. Jaffry, “*Analysis and Validation of Models for Trust Dynamics,” Ph.D.* dissertation, Vrije Uni. 2011

[14] B. Shneiderman. (2000). Designing trust into online experiences.*Communications of the ACM*. [Online]. *4*3(12), pp. 57-59. Available: http://dl.acm.org/citation.cfm?id=355124

[15] P. Cofta. (2011). The trustworthy and trusted web. *Foundations and TrendsÂ® in Web Science*. *2,* pp. 243-381.

[16] R. C. Mayer, J. H. Davis, & F. D. Schoorman. (1995). An integrative model of organizational trust. *Academy of Management Review*. [Online]. *20(3),* pp. 709-734. Available: http://amr.aom.org/content/20/3/709.short

[17] Erideshare. (1999). Available: http://www.erideshare.com
[18] Goloco. (2013). Available: http://www.goloco.org
[19] Nuride. (2011). Available: http://nuride.com
[20] Zimride. (2012). Available: http://zimride.com
[21] C. Liu, M. A. Ozols, & M. Orgun. (2005). A temporalised belief logic for specifying the dynamics of trust for multi-agent systems. *Advances in Computer Science-ASIAN 2004. Higher-Level Decision Making*, [Online]. *3321,* pp. 142-156). Available: http://link.springer.com/chapter/10.1007/978-3-540-30502-6_10
[22] X. Zhang,& Q. Zhang. "Online trust forming mechanism: approaches and an integrated model" in *Proc. 7th-ICEC,* 2005, pp. 201-209.
[23] M. Marx,& J. Treur. "Trust dynamics formalised in temporal logic" in *Proc. 3rd*-ICCS, 2001, pp. 359-363.
[24] M. Hoogendoorn, S. W. Jaffry, & P. P. van Maanen. (2011). Validation and verification of agent models for trust: independent compared to relative trust. *Trust Management V*. [Online]. *358,* pp. 35-50. Available: http://link.springer.com/chapter/10.1007/978-3-642-22200-9_6
[25] N. A. H. Agatz, A. Erera, M. W. P. Savelsbergh, & X. Wang. (2010). Sustainable passenger transportation: Dynamic ride-sharing. (No. ERS-2010-010-LIS), ERIM Report Series Research in Management. [Online] Available: http://repub.eur.nl/pub/18429
[26] E. Kamar,& E. Horvitz. "Collaboration and Shared Plans in the Open World: Studies of Ridesharing" in *Proc. 21st-IJCAI*, 2009, pp. 187-194
[27] M. Hoogendoorn, S. W. Jaffry, & J. Treur. (2011). Modelling trust dynamics from a neurological perspective. *Advances in Cognitive Neurodynamics (II)*. [Online]. pp. 523-536. Available: http://link.springer.com/chapter/10.1007/978-90-481-9695-1_81
[28] M. Hoogendoorn, S. W. Jaffry, & J. Treur, (2008). Modeling dynamics of relative trust of competitive information agents. In *Cooperative Information Agents XII*. [Online]. pp. 55-70. Available: http://link.springer.com/chapter/10.1007/978-3-540-85834-8_7
[29] C. M. Jonker, & J. Treur. (1999). Formal analysis of models for the dynamics of trust based on experiences. *Multi-Agent System Engineering*. [Online]. pp. 221-231. Available: http://link.springer.com/chapter/10.1007/3-540-48437-X_18
[30] A. Barth, A. Datta, J. C. Mitchell, & H. Nissenbaum. "Privacy and contextual integrity: Framework and applications" in *Proc. IEEE-SOSP,* 2006, pp. 184-196.
[31] R. Falcone, & C. Castelfranchi. "Trust dynamics: How trust is influenced by direct experiences and by trust itself" in *Proc. 3rd-IJCAAMS*, 2004, pp. 740-747.
[32] P. Herrmann. (2006). Temporal logic-based specification and verification of trust models. *Trust Management*. [Online]. *3986,* pp. 105-119. Available: http://link.springer.com/chapter/10.1007/11755593_9
[33] M. Feldman. & J. Chuang. (2005). Overcoming free-riding behavior in peer-to-peer systems. ACM SIGecom Exchanges. [Online]. *5(4),* pp. 41-50. Available:http://dl.acm.org/citation.cfm?id=1120723
[34] Zali, Z., Hashemi, M. R., &Saidi, H. (2013). Real-Time Intrusion Detection Alert Correlation and Attack Scenario Extraction Based on the Prerequisite-Consequence Approach. *The ISC International Journal of Information Security.* [Online]. *4*(2), pp. 125-136. Available: http://www.isecure-journal.com/index.php/isecure/article/view/10
[35] M. Ghiasi, A. Sami, & Z. Salehi. (2013). DyVSoR: Dynamic Malware Detection Based on Extracting Patterns from Value Sets of Registers. *The ISC International Journal of Information Security*. [Online]. *5(1),* p. 71. Available: http://isecure-journal.com/index.php/isecure/article/view/29
[36] S. D. Ramchurn, D. Huynh, & N. R. Jennings. (2004). Trust in multi-agent systems. *The Knowledge Engineering Review*. [Online]. *19(1),* pp. 1-25. Available: http://dx.doi.org/10.1017/S0269888904000116
[37] J. Sabater, & C. Sierra. (2005). Review on computational trust and reputation models. *Artificial intelligence review*. [Online]. *24(1),* pp. 33-60. Available: http://link.springer.com/article/10.1007/s10462-004-0041-5
[38] A. Sharpanskykh, & J. Treur. (2010). A temporal trace language for formal modelling and analysis of agent systems. *Specification and verification of multi-agent systems*. [Online]. pp. 317-352. Available: http://link.springer.com/chapter/10.1007/978-1-4419-6984-2_11

[39] K. R. Murphy,& W. K. Balzer. (1986). Systematic distortions in memory-based behavior ratings and performance evaluations: Consequences for rating accuracy. *Journal of Applied Psychology*. [Online]. *71(1),* pp. 39-44. Available: http://psycnet.apa.org/journals/apl/71/1/39/

[40] LDC. (2013). Available: http://wikipedia.org/wiki/developing_countries