DUBLIN CITY UNIVERSITY
SCHOOL OF ELECTRONIC ENGINEERING

Determining Trustworthiness of Data in IoT Crowd Sensing Environments

Final Portfolio

Omkar Pabshetwar

ID Number-18210473
2nd September 2019

MASTER OF ENGINEERING
IN
ELECTRONICS AND COMPUTER ENGINEERING
Supervised by: Dr. Conor McArdle

Acknowledgment

I would like to thank Dr. Conor McArdle for his constant support and guidance throughout the project phase. He encouraged and motivated me all the time. I would like to thank my friends and family for suppoting me.

Declaration

I hereby declare that, except where otherwise indicated, this document is entirely my own work and has not been submitted in whole or in part to any other university.

Signed: Omkar Pabshetwar

Date: 2nd Spetember 2019

Table of Contents

Determining Trustworthiness of Data in IoT Crowd Sensing Environments

Omkar Pabshetwar

MEng. in ECE Student
School of Electroncs Engineering
Dublin City University
Glasnevin, Dublin 9, Ireland
omkar.pabsheywar2@mail.dcu.ie

Abstract: The trustworthiness of data is one of the important aspects taken into consideration in Mobile crowd sensing context where number of users submit the data which can be false or malicious and eventually affect future predictions. In this project trustworthiness of data is determined on the crowdsensing data related to traffic and transportation domain where various users submit road traffic information which can help to determine the shortest path of travel and other traffic related parameters. This project aims to implement trustworthiness model based on voting mechanism where game theory is used to motivate participants or users to submit crowdsensing data and based on the votes submitted by user then parameters such as voting capacity, user reputation, user pay-off and trustworthiness are calculated. Another model implemented to evaluate trust on different user's data is based on concept of Experience and Reputation where Experience is calculated based on how many times the user interacts with other user. Rewards are given to each user in the form of badges based on their reputation values. The stability of both algorithms is checked by performing it for several number of times.

Keywords—crowdsensing, trustworthiness, voting, experience, incentive, reputation.

I. INTRODUCTION

The technological developments in the field of IoT have been able to change the face of today's generation. The technologies and their implementations have been playing the role of a bridge by keeping the connection alive amongst people. The Internet of Things (IoT) is a global approach that is gaining lot more attentions of the researchers and scientists associated with the field of Wireless Communication Engineering. The rapid developments of IoT speak that, it is going to emerge as one of the fastest growing markets around the world. Internet of Things predicts the future that, the advance digital world and the physical world will get linked by means of proper information and wireless communication system technologies. Many developed countries like the United states of America, Europe and some countries of Asia like India, china and japan, they are now a days considering internet of things (IoT) as an area of innovation and growth [1].

Daniele Miorandi et.al. presented in a paper [2] that, the revolution will be empowered by the embedding of electronics into everyday physical objects, making them ''smart'' and letting them seamlessly integrate within the physical world and this will be giving rise to new opportunities for the Information and Communication Technologies (ICT) sector, paving the way to new services and applications able to leverage the interconnection of physical and virtual realms. The concept of IoT stands with a simple sensor which means connection of multiple sensing devices over internet. And these sensing devices can sense the incoming data from various sources. The sharing of data/ information with the use of smart devices like mobile phones amongst large number of individuals are often called as crowd-sensing. However, the trustworthiness of data along with their accuracy is being considered as a major concern of crowd sensing mechanism.

The popularity for the crowd-sensing applications is being increased day by day especially in mobile platforms and other smart devices which means the large amount of complex data need to be processed, estimated and validated in such a way that it could be capable of easily extract context level information and would be capable of following decision making procedures [3]**.** In today's world, people try to submit malicious data to get some rewards but this situation is taken into consideration by many researchers and they are working on different mechanism to determine the quality of data specially in "visual crowd-sensed data" provided by mobile users or participants in MCS and ignore unwanted data and do not consider them for reward [3][4]. Built in sensors of mobile devices plays a vital role in enabling the mobile crowd-sensing.

It is found that [3], the quality of information is mostly associated with the trustworthiness of the received data once we apply data analytics to the data aggregated**.** Participants are selected for any sensing task by MCS system based on the information collected by them, there is a selection process which helps system to work efficiently with minimal cost and maximum contribution of participants to get high accurate data but participants get payed for the use of resources in contributing crowdsensing data by incentive and reward strategies[3][5].

There are many incentive strategies offered to attract number of users to the platform and various strategies have been proposed for providing mutually beneficial platform [3][6]. So, to further increase the user participation in user centric system, Gamification methodology has been implemented [3] [7]. Now the question may arise in our mind that, "What is the necessity of using this gamification method?" The simple answer would be to analyze and predict user behavior in contributing crowd-sensing data in order to get rewards and incentives. Apart from the same, trustworthiness also plays a vital role in crucial applications such as public safety, disaster preparedness, providing health conditions of a patient, road and traffic conditions etc. So, the fundamental aim of crowd-sensing application is to provide the trustworthiness [3]. However, few challenges faced by MCS system is to detect false users as they exchange large amount of data to get some valid information for future predictions in different applications along with a suitable language [8] to store and analyze reported data by various users or participants in proper format.

This project has aimed to implement game theory and some gamification techniques to motivate the user not to provide any vindictive data. But if in case the user sends such data then the system would prevent the same by restricting the vote capacity of the user. Based on the game theory approach, in the paper [3] this project aims to implement a "collaborative decision-making algorithm" to check the data quality reported by users and rewarding them in the form of badges "Hi-award and Lo-award" using gamification technique. Also, this project aims to implement an evaluation model to determine trustworthiness of multiple users by carrying out mathematical analysis of "Experience and Reputation" and giving rewards to them based on their reputation [9]. The analytical comparison between two approaches will be based on the final rewards given to the users and based on their reputation values.

In this report, I am going to cover the following sections such as Framework and Inspiration, Technical Description, Results, Conclusion and Future Work.

II. Framework and Inspiration

Participatory and opportunistic sensing are the two unique approaches used based on how a specific user has been involved in sensing task [3] [10]. It is defined that [3], the mobile devices are involved in the decision-making process in opportunistic sensing. Nowadays it has been quite possible to enable various applications (such as: health monitoring, video surveillance etc.) along with their features by integrating mobile crowd-sensing, cloud computing, data analytics etc. The Decision on allocation of sensing task to designated users is done by the idea of "Social crowd-sensing" [3][11]. In the next sub section, I am going to briefly describe how big data and crowd-sensing associated with each other and plays an important role.

A. *Importance of crowd-sensing, bigdata and associated challenges*

It is estimated that [3][12], by the end of 2020 the volume of data bytes would be increased to approximately 35 Zetabytes as since last couple of years' tremendous volume of data has already been generated. The dataset created by the crowdsensing task which is comparable to "Big data" will be too huge to handle by a relational data base [3] [13]. The integration of mobile crowd-sensing and data analytics encourages new innovative methods for storing, processing and management of crowd sensed data.

The trustworthiness of Data nowadays is becoming an issue as mentioned by study of Hashem et al [14] in various domains such as health care, transportation and smart cities etc. In this project, I have worked upon the trustworthiness of the crowd-sensed data, as it is challenging to collect a large amount of it. I determined trustworthiness by considering a dataset of N users where N could vary from 20 to 100 users.

There are certain issues such as queuing, user recruitment, reputation maintenance and task delegation have been reported and these issues have to be resolved before implementing mobile crowd-sensing. However, one of the major challenges in mobile crowd-sensing in incentivizing the users but to compensate this issue, I am going to demonstrate the usage and benefits of game theory by implementing the same.Till now, the gamification technique has gained relatively less attention when applied to mobile crowd-sensing. The good area of Wi_Fi hotspots can be determined by users contribution and rewarding them based on their contribution using gamification technique as suggested by Wu and Luo [15].The best way to incentivize the user is the rating system. Data trustworthiness is considered as one of the prime concerns in crowd-sensing mechanism.

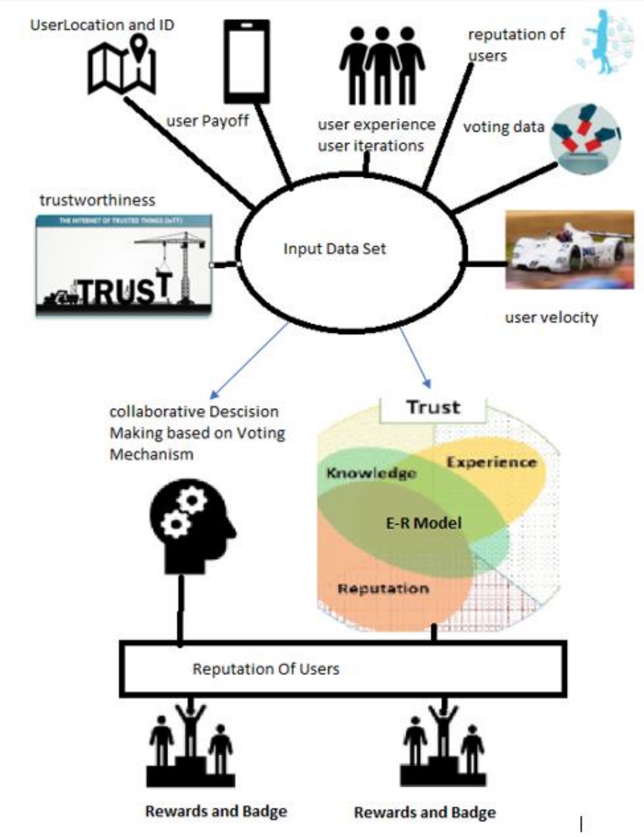

Figure 1 Design Model

III. Technical Description and Implementation

In this project crowdsensing data plays an important role as it is taken an input to the algorithm to determine user's trustworthiness. This Crowd-sensing data is created for N users by considering the users reputation referring to "SONATA (Social Network-Aided Trustworthiness Assurance)"[3] which determines trustworthiness of users based on the votes. I will be using similar approach like SONATA used in paper [3] were votes decides the reputation of users and depending on it users will be rewarded in the form of badges. The input data set is created manually by referring the latest Collison report which is available online in Geojson format and route files and trip data obtained by running OSM (Open Street Map) file in Simulation Software SUMO (Simulation of Urban Mobility) during initial set-up. The input data is in json format which includes initial user experience and user's iterations [9] because experience is gained by any user based on the number of interactions, they do with the sensing task to maintain reputation of user. Reputation is considered same at initial phase for each user i.e. value 1 for all.

This project determines trustworthiness of users by mathematical calculation from "SONATA" [3] which uses voting mechanism and "REK (Reputation Experience and Knowledge) Trust Evaluation Model" [9] which uses experience and iteration of each user or participant.

A. Trustworthiness calculation based on collaborative voting system from "SONATA"

In this section **trustworthiness** is determined using following equation 1 shown below based on "SONATA" which uses vote capacity of users for analysis where, user 'i' trustworthiness is denoted as Ti, voting capacity is denoted as VCi, actual vote is denoted as AVi and for user 'j' trustworthiness is denoted as Tj, voting capacity as VCj [3] all are analysed at time t.

$$T = \frac{\sum \mathrm{iVC} * \mathrm{AV} * \mathrm{T}}{\sum \mathrm{VC} * \mathrm{T}}$$ …. equation (1) [3].

As "SONATA" uses technique constructed on votes cast for each users by remaining users called as voters, this casted votes can be negative if voter doesn't find data useful and positive when voter find it as useful and based on this information voting capacity of each user is increased or decreased [3] and this phase is used as recruitment part for user based on votes. This can be attained if each user has knowledge of data submitted in a sensing task at time t, voting based decision system is considered were gamification technique is in action where "Sub-game perfect Equilibrium"[3] environment is formed and each user decides their vote independently by observing submitted task without interfering with other user in the game.

The next stage in this project is to **calculate the "payoff"** for all users taking part in the sensing task, considering each user in environment of subgame they are ask to vote for other users they can choose to vote negative (-1) or positive (1) sometimes user may not want to vote in that case pay-off for that user will be round off to zero[3] this is a game-theoretic approach. While increasing the pay-off for the user casting the vote, it is important to check the distance between the two users if the user doesn't fall in the geographic radius set as threshold and also doesn't come under the set user velocity then the pay-off will be decreased and if the user voting comes under the desired parameters then there will be increment in pay-off for both user i.e. the user voting and the user who is being voted and if it is found that user has submitted data which is not useful by gaining negative votes from the voters co-users then its voting capacity is increased or decreased due to which there is variation in reputation of each user submitting data which is not useful and badges will be given in the form of rewards if it is found the data submitted by user is useful this is taken in the context of "reverse auction"[3]. I have used formula of "Vincenty" [16] to calculate distance between two users and resulted distance will be compared with pre-defined threshold distance, and if resulted distance and user velocity from the input data set falls below threshold value then increment and decrement action is carried on pay-off of both users. Vincenty is used because its result on earth-ellipsoid has accuracy of about 0.5mm.

The next phase in this set of algorithms will be mathematical calculation of **reputation** for each user based on the vote they cast i.e. voting based on collaborative decision. There can be case were one user will try to give negative vote to other user to prove the data as unusual or not useful, in this case its important to have prior understanding of task assigned by the platform without that it will be difficult to detect users submitting wrong votes that impact on final accuracy. If any of the user is found casting a wrong vote, it will directly affect to voting capacity of that user. To avoid this situation, it is essential to motivate users to cast correct votes and get rewards in the form incentives by game like platform. The decision can be made by analysing data similarity between two users, this is done for a user giving vote with respect to all users being voted by the user, the value given to user after calculation of similarity is called "rating"[3] which is decided based on comparing the distance between two users with the predefined threshold value. The equation given below indicate the criteria to be met by the similarity calculation between two users i and j, where 'PT' denote pay-off threshold, 'DS' denote the criteria of similarity of data is met or not, delta ij (Δij)is the calculation of distance between the two users and the vote submitted by user i is denoted as 'uv'[3].

$$DS = \begin{cases} 1, & x \le PT \\ -1, & x > PT \end{cases}, \text{ where } x = \frac{\Delta \mathrm{ij}}{uv}$$ …equation (2)[3].

Next step is to get or update the new voting capacity 'UVC' for each user based on the votes they get from their neighbors using the mathematical calculation given below where DS is obtained from the calculation of similarity and 'vn' denotes the vote received from neighbors [3] .

$$UVC = \frac{\sum \mathrm{ij}\ \mathrm{DS}}{\mathrm{vn}}$$ …. equation (3)[3].

The new updated voting capacity is used to calculate reputation of each user in the sensing task by adding it with the previous reputation of user which was considered in the input data set based on the recruitment criteria. In the equation given below 'RU' indicates the new Reputation of user, 'R' indicates the previous reputation of user and UVC is obtained from previous calculation [3].

RU = UVC +R …... equation (4)[3].

Accuracy of data is maintained by getting maximum number of correct information from the user in data contribution, this is done by giving incentives to user if they submit correct and useful data, in this project incentives are given in the form of "**rewarding badges**" such as "Lo-award" for user who submit data which is not useful and "Hi-award" for useful data [3]. Badge are given to user based on simple calculation that if the new updated reputation is greater than the pre-defined threshold then "Hi-award" and if less than threshold its "Lo-award" [3]. In this project I have used similar reward technique in determining trustworthiness of user based on the "REK" model [9] which is explained in the next section.

B. *Trustworthiness calculation based on collaborative Reputation Experience Trust evaluation model.*

In the context of social network i.e. "Social Internet of Things", the key elements to determine trustworthiness of data are Experience and Reputation which are calculated using mathematical expression from the "REK Trust evaluation model" [9], this can bring a new approach to solve data trustworthiness related issues in crowdsensing environment. When a user "(Trustor)" get information about certain user"(Trustee)" from various other users in the network the reputation of that user or Trustee can be determined which is first key indicator to determine trust in the REK Model, along with that when user interact other user it will gain experience after each interaction depending on the interactions made which is one of the key indicator to determine trust.

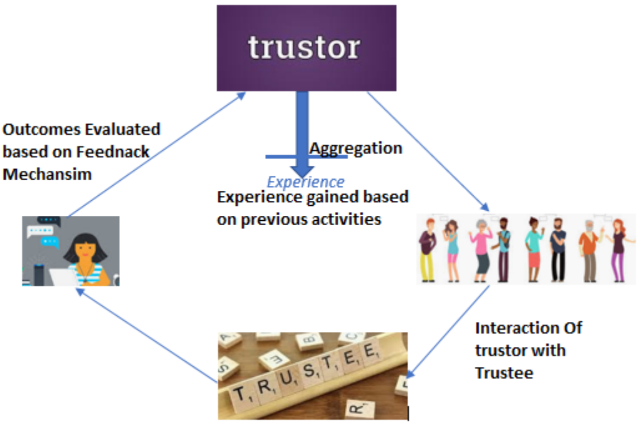

Figure 2 Analysis of Experience Model in REK [9].

As experience of any user will be based on the amount of interaction made if interactions are cooperative experience of user increases otherwise decreases, thus **mathematical analysis for experience** is shown below in a simplified form where 'NW' denote the new calculated experience of user, 'E' is the previous experience and 'β' is interactions made by user and for better understanding of REK model the initial experience value in input dataset is set between 0 to 1

$$NW = E + \beta(1-E) \qquad \text{...equation (5)[9].}$$

From the above equation it can be assumed that the value of 'NW' will be high if previous experience 'E' is small and 'NW' low when 'E' is large, as the number of interactions increase it will directly affect to experience. Calculating Experience is one of the elements in REK model, next step in this project is to analyze the new experience value and calculate reputation which is another element of REK model.

Calculation of reputation is to give trustworthiness information of any user to other which will help them to participate in the task having general knowledge about it. Reputation is different from Experience because reputation is calculated based on interaction by all users to single user while experience is calculated based on interaction from user to user, therefore aggregator is used to combine all feedbacks of other user and get final reputation value [9]. The reputation in this section is calculated only by knowing both reputation of user and experience value between two users, initial reputation of all users is set to '1' in input dataset and experience between the two user is obtained from previous calculation. Reputation mathematical analysis will be based on the experience value compared with the threshold value considering cooperative and uncooperative interaction of users, if 'NW' greater or equal to threshold then positive reputation is calculated and if 'NW' is less than threshold then negative reputation is calculated [9].

$$\mathrm{PR} = (1 - \mathrm{damp})/\mathrm{M} + damp \sum_i Rpos\left(\frac{NW}{T}\right)$$

..... equation (6) [9].

$$\mathrm{NR} = (1 - \mathrm{damp})/\mathrm{M} + damp \sum_i Rnev\left(\frac{1-NW}{T}\right)$$

...equation (7) [9].

In the above equation's 'PR' denotes positive reputation, 'NR' denotes negative reputation, 'damp' is the damping factor set to 0.75, 'M' is the number users, 'NW' is the experience of users, 'T' is different for both users T in PR is sum of all experience values of users coming under cooperative or supportive section and 'T' in 'NR' is for users coming in Unsupportive or uncooperative section, 'Rpos' is the sum of reputation of users coming under cooperative section and 'Rnev' is sum of reputation of users coming in uncooperative section [9]. PR is calculated when experience value is greater or equal to pre-defined threshold and referred as cooperative and NR is calculated when experience value is less than threshold and referred as uncooperative. Finally, the reputation values based on above equations are stored in 'X' by simple mathematical subtraction between PR and NR for each user so that reputation value of any user will not go below zero

$$X = PR - NR \qquad \text{...... equation (8) [9].}$$

As explained in the previous section using game theory rewarding to all users over the network in the form of badges, if reputation is above threshold "Hi-award, and below threshold "Lo-award" [3]. Result and analysis of the input data set using the two-model mentioned in this section is shown in the next section along with it results of both models is compared.

IV. Result and Analysis

In this section I am going to discuss the implementation part of the models discussed above that is "SONATA" and "REK" on the input dataset [3][9]. As mentioned in the technical description of this paper I have created all the input data set in the json format manually. The information is collected from the json files such trip data and route data generated from the SUMO simulation software during initial setup and latest collision data of traffic. The input data set consist of location coordinates of user (latitude and longitude), user id, trustworthiness of user (0 to 5), user experience(0 to 1), user iteration(0 to 9), pay-off (0), user voting capacity(0 to 5) and user reputation (1) for both voting and experience model, values mentioned in the round bracket are predefined values or initial values. Below is the input data set viewed in excel format using pandas and data frame from python library.

userId	userExperience	userIteration	userReputationExp	usertrustWorthiness	userReputation	userVoting	userPayoff
u2000059	0.5	9	1	2	1	1	0
u2000058	0.3	6	1	1	1	3	0
u2001036	0.8	5	1	3	1	3	0
u2005031	0.4	4	1	1	1	1	0
u2006312	0.6	7	1	4	1	4	0
u2004745	0.3	8	1	5	1	5	0
u2001235	0.8	6	1	3	1	1	0
u2006837	0.7	3	1	5	1	3	0
u2002690	0.5	9	1	5	1	5	0
u2006669	0.6	4	1	5	1	5	0
u2007112	0.2	8	1	3	1	1	0
u2000163	0.4	6	1	1	1	4	0
u2009312	0.1	9	1	2	1	2	0
u2008617	0.2	8	1	2	1	4	0
u2008037	0.5	9	1	4	1	1	0
u2006367	0.7	3	1	3	1	4	0
u2007456	0.5	5	1	4	1	3	0
u2006180	0.4	6	1	3	1	5	0
u2009933	0.3	3	1	5	1	3	0
u2001697	0.7	7	1	3	1	1	0
u2000466	0.6	4	1	5	1	4	0

Figure 3 Input dataset

After running the algorithm for first instance or first iteration the preset values like user experience, trustworthiness, reputation based on voting mechanism and E-R mechanism, user payoff is changed taken into note that all values may vary based on the threshold set in the algorithm. Below is snippet of the result from algorithm viewed in excel format.

userId	userExperience	badgeExp	userReputationExp	usertrustWorthiness	userReputation	badgeVot	userVoting	userPayoff
u2000059	0.95	Hi-award	7.62	1	11	Hi-award	1	-50
u2000058	0.72	Hi-award	4.583	1	11	Hi-award	5	-58
u2001036	0.9	Hi-award	4.381	-1	7	Lo-award	-1	-50
u2005031	0.64	Hi-award	3.327	-1	9	Lo-award	-1	24
u2006312	0.88	Hi-award	3.282	-1	8	Lo-award	-1	-56
u2004745	0.86	Hi-award	3.216	1	11	Hi-award	7	-56
u2001235	0.92	Hi-award	3.679	1	11	Hi-award	3	4
u2006837	0.79	Hi-award	2.737	1	11	Hi-award	5	4
u2002690	0.95	Hi-award	4.009	1	11	Hi-award	7	-56
u2006669	0.76	Hi-award	2.534	1	11	Hi-award	7	4
u2007112	0.84	Hi-award	3.252	1	7	Lo-award	-2	2
u2000163	0.76	Hi-award	2.65	1	6	Lo-award	-5	-46
u2009312	0.91	Hi-award	3.915	1	9	Lo-award	0	-48
u2008617	0.84	Hi-award	3.327	-1	9	Lo-award	6	2
u2008037	0.95	Hi-award	4.219	1	13	Hi-award	-3	32
u2006367	0.79	Hi-award	2.885	-1	15	Hi-award	6	34
u2007456	0.75	Hi-award	4.189	0	11	Hi-award	-4	32
u2006180	0.76	Hi-award	3.983	0	9	Lo-award	-6	-50
u2009933	0.51	Lo-award	1.038	1	13	Hi-award	-3	30
u2001697	0.91	Hi-award	2.32	1	17	Hi-award	4	36
u2000466	0.76	Lo-award	1.058	1	15	Hi-award	0	52

Figure 4 Output after running algorithm for one time

User experience has increased for each of the user after first iteration and tending towards value 1. Rewards are given to all users based on there reputation, after viewing results it is observed that reputation in REK based algorithm is between the range of (0 to 1) though it was set to 1 initially because the reputation is completely depending on the experience between two users and number of interactions they make (The reputation is showing value greater than 1 in result table because it is passed through multiplier of 10 to have better understanding). Reputation in SONATA based algorithm is varying between (1-20) this is because the reputation in SONATA is calculated based on the vote submitted by user and geolocation of users. The payoff is increased (positive value) and decreased (negative value) based on the votes submitted by users.

Below are the graphs plot to give better understanding of user's data at input and output stage. The line in 'blue' is input data set and line in 'green' is output data set in the graphs. Users with there id are on x-axis and measurement parameters such as experience, trustworthiness, reputation, pay-off, voting capacity on y-axis. The image of the first graph shows comparison user experience at input and output. Graph 2 shows user trustworthiness comparison at input and output and it is observed that user trustworthiness value is either 0, 1 or -1.

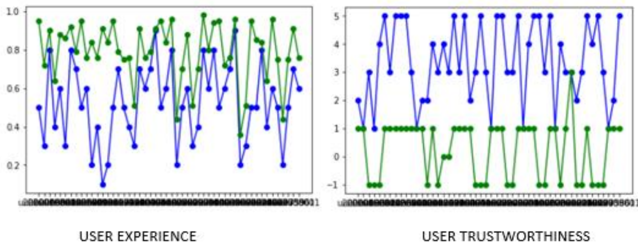

Figure 5 User Experience and User Trustworthiness

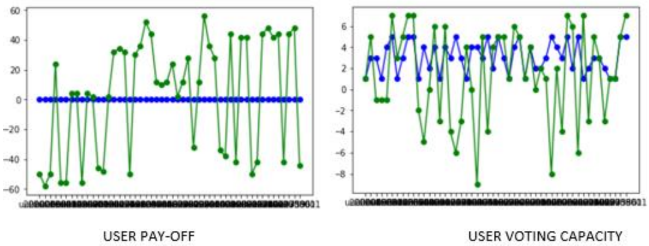

Figure 6 User Pay-Off and User Voting Capacity

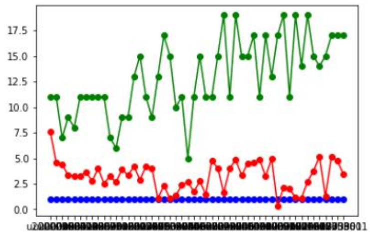

Figure 7 Reputation comparison in SONATA and REK

It is observed that based on the votes submitted by each user its pay-off is ranging between -60 to 60 and voting capacity is also changed based on parameters such as distance between the users and similarity comparison. The computation results of reputation in both models is shown in the graph above, the reputation results from SONATA is plotted in green color and result from REK model is plotted in red color. Initial input value which was set low to 1 is shown in blue color.

userId	userExperience	userReputationExp	usertrustWorthiness	userReputation	userPayoff	userVoting
u2000059	0.99995	3222.458	1	41	-200	1
u2000058	0.98208	2966.716	1	41	-232	11
u2001036	0.9875	2877.768	-1	25	-200	-13
u2005031	0.92224	2584.847	-1	33	96	-7
u2006312	0.99676	2725.523	0	39	-224	4
u2004745	0.99888	2672.362	1	41	-224	13
u2001235	0.99488	2609.001	1	41	16	9
u2006837	0.92797	2385.817	1	41	16	11
u2002690	0.99995	2530.656	1	41	-224	13
u2006669	0.94816	2358.888	1	41	16	13
u2007112	0.99872	2450.141	0	31	8	1

Figure 8 Output after running algorithm for 5 times

After running the algorithm for 5 times at different interval it is observed the all the parameters are increasing as the user reputation is increasing. As I have added a 10 multiplier to reputation of REK model its values are ranging in 4-digit form. After every iteration there is change in pay-off value and voting capacity as observed in the table due the votes submitted by each user and its geolocation coordinates as distance between user is also important parameter to calculate payoff and reputation of user. User experience on the contrary tends to move towards 1 where 1 is the ideal value (highest) for experience.

V. Conclusion and Future Scope

Conclusion: The implementation to determine trustworthiness of data was done using the two models SONATA and REK model and can observe that both models has stable outcomes after few iterations i.e. running algorithm for certain period. The Experience of users was tending to move towards 1 which is the ideal case in the REK model, voting capacity after few iterations seems to be stable as compared to running algorithm for the first time. If the voters trying to vote positive votes and come under the criteria of threshold then vote capacity is stable. Trustworthiness of users is set between values 0,1 and -1 for all users. The number of times the algorithm is implemented on the resulted data the reputation of users is increasing then previous values in both the models. The experience and voting capacity are tending to move towards the stable values after every successful run of algorithm.

Future Scope: The following algorithms can be implemented on the simulation software to understand the behavior of users in the road traffic scenarios. Trustworthiness can be made accurate by implementing more efficient and strong incentive techniques which will motivate users to contribute accurate and useful information. The combination of SONATA and REK model can be an option to improvise the result and achieve the goal of to determine trustworthiness of data and eliminate malicious users.

VI. Refrences

[1] V. K. A. A. A. Gourav Misra1, "Internet of Things (IoT) – A Technological Analysis and Survey on Vision, Concepts, Challenges, Innovation Directions, Technologies, and Applications (AnUpcoming or Future Generation Computer Communication System Technology)," American Journal of Electrical and Electronic Engineering, pp. Vol. 4, No. 1, 23-32, 2016.

[2] S. S. F. P. C. Daniele Miorandi, "“Internet ofThings-Vision,applications and research challenges”,Ad Hoc Networks," ELSEVIER, vol. 10, no. 7, pp. 1497-1516, 2012.

[3] C. F. K. T. S. K. P. B. MARYAM POURYAZDAN, "Intelligent Gaming for Mobile Crowd-Sensing Participants to Acquire Trustworthy Big Data in the Internet of Things," *SPECIAL SECTION ON INTELLIGENT SYSTEMS FOR THE INTERNET OF THINGS,IEEE ACCESS,* no. Digital Object Identifier 10.1109/ACCESS.2017.2762238, October 11, 2017.

[4] F. W. a. G. C. Dan Peng, "Data quality guided incentive mechanism design for crowdsensing," *IEEE Transactions on Mobile Computing,* vol. 17, no. 2, pp. 307 - 319, 12 June 2017.

[5] A. A. Obinikpo, Y. Zhang, H. Song, T. H. Luan and B. Kantarcih, "Queuing Algorithm for Effective Target Coverage in Mobile Crowd Sensing," IEEE Internet of Things Journal , vol. 4, no. 4, pp. 1046 - 1055, 28 March 2017.

[6] L. G. Jaimes, I. J. Vergara-Laurens and A. Raij, "A Survey of Incentive Techniques for Mobile Crowd Sensing," IEEE Internet of Things Journal, vol. 2, no. 5, pp. 370-380, oct 2015.

[7] A. G. David Easley, "Incentives, gamification, and game theory: An economic approach to badge design," ACM Transactions on Economics and Computation (TEAC) Special Issue on EC'13, vol. 4, no. 3, 2016.

[8] C. A. Z. A. S. Abdelghani Wafa, "User-centric IoT: Challenges and Perspectives," Twelfth International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies UBICOMM 2018, Nov 2018.

[9] T.-W. U. Z. M. L. Nguyen Binh Truong, "From Personal Experience to Global Reputation for Trust Evaluation in the Social Internet of Things," in Conference: IEEE Global Communication (GLOBECOM), Singapore, 2017.

[10] W. Z. Khan, Y. Xiang, M. Y. Aalsalem and Q. Arshad, "Mobile Phone Sensing Systems: A Survey," IEEE Communications Surveys & Tutorials,Volume: 15 , Issue: 1, 2012.

[11] W.-S. Y. J. W. Wei Chang, "Correlated Friends' Impacts in Social-crowdsensing," SocialSens'17 Proceedings of the 2nd International Workshop , pp. 9-14 , April 18 - 21, 2017.

[12] C. E. d. D. L. Paul C. Zikopoulos, Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data, New York: NY, USA: McGraw-Hil, 2011.

[13] Z. W. Y. W. Y. Y. H. Z. Bin Guo, "Mobile Crowd Sensing and Computing: The Review of an Emerging Human-Powered Sensing Paradigm," ACM Computing Surveys (CSUR), vol. 48, no. 1, September 2015 .

[14] V. B. Ibrahim Abaker TargioHashem, "The role of big data in smart city," ELSEVIER, International Journal of Information Management, vol. 36, no. 5, pp. 748-758, October 2016.

[15] F.-J. Wu and T. Luo, "WiFiScout: A Crowdsensing WiFi Advisory System with Gamification-Based Incentive," in 2014 IEEE 11th International Conference on Mobile Ad Hoc and Sensor Systems, Philadelphia, PA, USA, 09 February 2015.

[16] K. E. Mike Tigas, "GeoPy," geopy contributors , 2006-2018. [Online]. Available: https://geopy.readthedocs.io/en/stable/.

Appendix A: Literature Review

The changes made in the literature review is in the Existing Solution Section, it is updated with the information about the REK (Reputation Experience and Knowledge) model to determine trust, where it uses feedback mechanism in Experience calculation. It was replaced by “Stackelberg game” incentive mechanism in Literature review.