INCENTIVE MECHANISM FOR COOPERATIVE TASKS IN MOBILE CROWDSENSING

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DECLARATION

I declare that this thesis entitled "*Incentive Mechanism for Cooperative Tasks in Mobile Crowdsensing*" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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This thesis work is dedicated to my parents and my teachers throughout my education career who have not only loved me unconditionally but whose good examples have taught me to work hard for the things that I aspire to achieve.

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ABSTRACT

Nowadays Mobile Crowdsensing System (MCS) is served as a building block for the emerging Internet of Things (IoT) applications. A lot of work has been done in the designing of Incentive Mechanism. However, in existing mechanism the performance of workers neglected during recruitment of new workers or termination of existing workers which lack the interest of worker. The main problem is that rewards paid to the participants of performing sensing task are fixed whether the task is easy or extensive. It enhances the interest of participants to earn same amount with easy task and avoid the extensive tasks which results in less competition due to less number of participants for extensive task. In this work, an incentive mechanism based on Reverse Auction with Dynamic Price, in which the total cost of performing task is not fixed and participants awarded with rewards on the basis of difficulty level of task present. System also selects the potential candidate on the basis of their contribution to the system. Firstly, the auctioneer gives bids then the platform selects the lowest bidder. The aim of this design is to give reward of existing workers in the form of lottery or bonus. The proposed design also gives inner lottery to the terminating workers on the basis of their contributions to the system. Present detailed design of Dynamic Price incentive mechanism which is based on Reverse Auction Process. The performance of proposed system model is examining by developing testbed for evaluating and analyzing the datasets and a simulation performs for the collection of data from sensing devices, with respect to metrics such as number of workers, rewards, level of tasks and rank of users. Results are compared for participation of workers in each cell, rewards and the total cost for the task with the existing RAB and RADP scheme.

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LIST OF ABBREVIATIONS

DLT	-	Difficulty Level of Task
DP-ORA	-	Price Optimal Recurring Auction
ITS	-	Intelligent Transportation System
MCS	-	Mobile Crowdsensing System
POI	-	Position of Interest
PI- ORA	-	Participation Incentive Optima Recurring Auction Discriminatory
QoC	-	Quality of Crowd
QoD	-	Quality of Data
RSFP	-	Random Selection Fixed Price
ROI	-	Return of Investment
RADP	-	Reverse Auction Dynamic Pricing
VPC	-	Virtual Participant Credit

LIST OF SYMBOLS

co_j	-	Total cost of potential candidate
TH_w	-	Set of threshold for willingness.
b_n	-	Bid of the user
ψ	-	Base Lottery
ϕ_r	-	Winners maximum bid value
PC_k	-	Potential Candidate for the Cell
W_j	-	Willingness of Candidate
lry_j	-	Potential Candidate Lottery
$NAuc$	-	Newly Workers for Auction process

CHAPTER 1

INTRODUCTION

1.1 Overview

Mobile Crowdsensing System (MCS) a term devised by Raghu K. Ganti, defined it as a large number of group sensing paradigm in Internet of Things (IoT) based on the mobile devices power. Today mobile phones are embedded with large number of specialized sensors like gyroscope, ambient light, accelerometer, compass, GPS and general type sensors like camera and microphone for collecting information dynamically from the surroundings. Table 1.1 shows different sensors of smart phones with brief functionality. There are different sensing activities which are performed by the Smartphone users' [1]. These devices collect data from a crowd, and then further send it for the processing and sensing by the platform. In this era, when the world becomes global village Mobile Crowdsensing glimpse the world expand the Internet of things (IoT) look over another group quick organizations, connection of things with things and individuals. Data can be collected in both ways passively, without the immediate response or actively that means an immediate response is necessary [2]. In MCS there are two different modes of data generation. Data generated in social network services is termed as user-generated and the other one is mobile sensing that is used in both mobile crowdsensing and participatory sensing mechanisms [3]. Mobile Crowdsensing empowered a lot of mobile phone users to share their domestic information about surroundings like environmental conditions, traffic and road situations, through sensors.

Smart Phones are now rich with sensors which are used to identify different changes in the surroundings like environmental changes, movement of vehicles and devices etc. [4]. Mobile devices have different types of sensors which can be used for sensing different types of data from the environment e.g. accelerometer, gyroscope, compass, camera etc. Mobile Crowdsensing tasks rely on these sensors for sensing data at different areas. Fast and High Speed internet communication (LTE, 4G) and rapid use of mobile devices becomes very common all around the world for the chores of business, communication, entertainment and academia industry.

Table 1.1: Functionality of Sensors in Smartphones

Sr.No	Sensor	Functionality	Type
1.	Accelerometer	Used for calculation and Identification of footsteps Speed, direction of moving objects.	Specialized
2.	Gyroscope	Used for 3D technology, measure angular velocity inclination of objects and rotation of angle.	
3.	Barometer	Used for gathering data of weather conditions like air pressure, humidity etc.	
3.	GPS (Global Positioning System)	Used for identifying ground position of objects.	
4.	Light	Used to identify the strength of day or artificial light around mobile devices.	
5.	Camera	Capturing image for detecting data Visually.	General
6.	Microphone	Identifying level of sound.	

According to different functionalities of sensors, Mobile crowdsensing used them for collecting data from the surroundings. Due to the 3G and 4G network the mobile crowdsensing emerged dynamically. CISCO reported in white paper that in 2021 the number of mobile devices users will hit 11.6 billion and 79% of the data will be collected from the use of 4G network [5]. In the Gartner statistics, the sales of mobile phones to end users around the world reach 1.57 billion units in 2020 [6]. Although MCS is an emerging technique but there is some worthwhile research work in this area which forwards the mobile crowdsensing.

Different words and terms had been used earlier for mobile crowdsensing. Some authors give idea of crowd wisdom where a group of people made decisions instead of a single person and it results better [7]. Participatory sensing is another concept for mobile crowdsensing in which each individual mobile device had to charge for making network of sensors. These networks collect, evaluate and share the local information. Participatory sensing is only dedicated for the public sensing but MCS involved both individual and public sensing. Explicit participation of users are involved in participatory sensing but in mobile crowdsensing both type of users are considered explicit and implicit [8].There are different applications of mobile crowdsensing which develop interest for both type of group of people either they belong to academia or commercial business.

1. 2 Architecture of Mobile Crowdsensing System

Crowdsensing users, smart buildings, vehicles, phones, and mobile devices etc. which are equipped with the different number of sensors (accelerometer, gyroscope, camera, GPS, microphone, light sensor, compass and Bluetooth) used to sense the data from the crowd. These mobile devices send data by using different network communication modes to the server. Cloud computing server senses the data. Then this data is visualized by System platform to extract information as shown in Figure 1.1. To collect data from the different areas e.g. traffic monitoring, environment monitoring, healthcare monitoring, social network applications etc. Mobile Crowdsensing system can be considered and utilized [2].

From the last few years, Mobile Crowdsensing becomes robust approach in the field of business to gain the interest of customers and the business partners. Mobile Crowdsensing open vast ideas into the global world. In a short time period, Mobile Crowdsensing delivered data immediately to the sensing platform and to be expected that have less faults about the accuracy of the sensed data [8], [9].

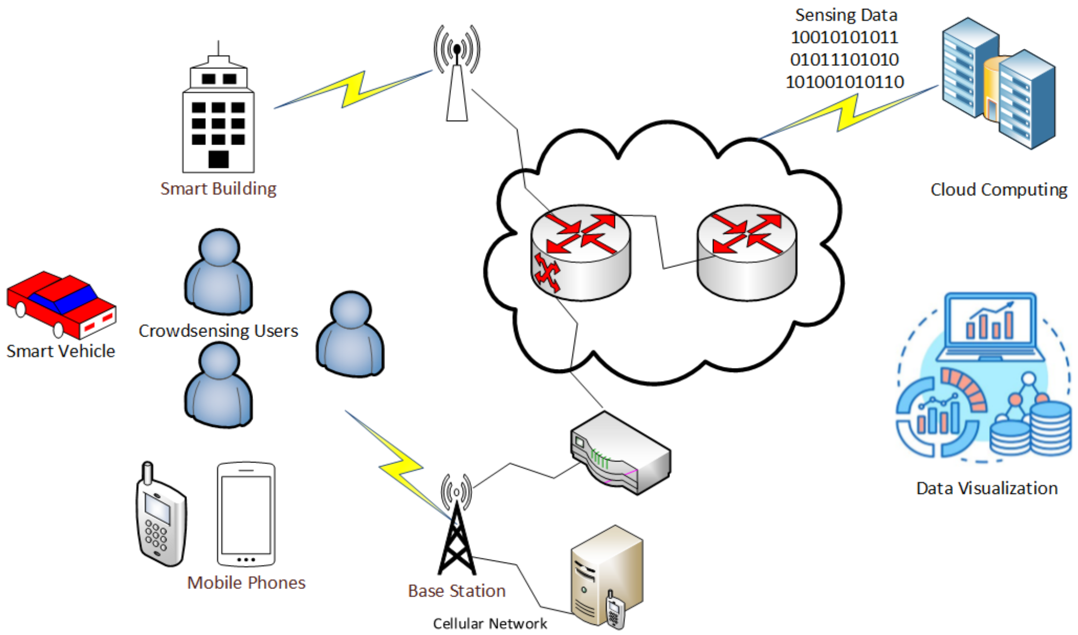

Figure 1.1: Architecture of Mobile Crowdsensing System

Incentive Mechanism is divided into two main types: Crowdsourcer-Centric and User-Centric. In these models users have to participate on the basis of paying rewards. Participants have to complete the task immediately with a little prior arrangement. Therefore, Mobile Crowdsensing is the system in which users participate to performed different activities [10], [11]. To maximize the user participation well defined incentive mechanisms have to be designed. If the Return of Investment (ROI) is much more than the participant assumptions, then the participation of users increases. User’s true valuation investment includes usage of resources, battery consumption and security or privacy of information. Expected ROIs depends on the true valuation investment and on the basis of different factors like Spatial and Temporal situations, True Valuation investment changes effectually.

Incentive Mechanisms of constant price cannot attract the participants which declined the user’s participation in the area of sensing tasks. Furthermore, it might be difficult to deduce optimal incentives for the participants [12]. In present industry incentives are given from the following categories. It is categorized on the taste of user’s demands e.g. entertainment. Each type of the incentives emphasizes some aspects of user needs, such as enjoyment, comfort, support, satisfaction and for making money in terms of profits.

Here is the short explanation of the categories of incentives:

i. Mobile Crowdsensing tasks becomes sensing games influenced by location based games where users can sense the data from surroundings by playing sensing games on mobile devices. This task is also enjoyable for the participants. Games based incentive mechanisms should be interesting and enjoyable for motivating users Tycoon game is designed by Broll and Benford, in pre-planned area players buying virtual items to obtain highest credits.
ii. Different beneficial Services are given to the users in the form of incentives, and users perform tasks given by the services providers. In this mechanism users play double role, as a contributor or as well as a consumer for example in traffic monitoring user provides information about the traffic to the service and then after processing from the large amount of sensing data, the provider informs the participants about congestion of traffic etc. by sending back data to them. In LiveCompare application users take pictures of items marked with price tags and share it with points of price data to get items pricing information from nearby grocery stores.
iii. Last one is the monetary incentives, in which certain or variable amount of money is given to the users on performing or completing the given task. This type of category attracts the users for sensing data in the sensing region through the use of smart phone sensors [13].

The main problem is that a fixed amount of reward is paid to each contributor on sensing different types of data. It does not consider the difficulty level of the task. It may hinder the contributors to take part in difficult tasks that results in less competition for difficult tasks and more competition for easy tasks. This thesis presents novel incentive mechanism scheme based on reverse auction mechanism consisting of three modules: Recruiting new worker process, Reverse Auction process and Drop-out worker process. The participants are selected during the process of recruitment where participants are sorted as per willingness level higher than the threshold. The system offers a bonus amount as a lottery to adjust the contributor on the basis of their contribution to the system. For detaining the workers from the system there are also inner lottery to maintain the number of workers in the system. Existing schemes had fixed amount of reward for all the sensing tasks without considering the difficulty level of tasks, therefore the participation rate is not so much higher. The proposed scheme offers rewards according to the level of task performed by the participants, which will motivate the workers to participate in the sensing area.

1.3 MCS Application Areas

Cities are highly densely populated as compared to rural areas. Due to abundance of traffic and industrial area, environment is being polluted rapidly. From the last few years, collection of data via Smart-phone or mobile devices has been increasing rapidly for monitoring purpose. MCS has several influenced features which make it an emerging mechanism for monitoring surroundings. Modern smart phones and mobile devices are embedded with variety of sensors for the different capabilities of sensing, computing and communication in order to perform different complex tasks other than just the use of calling functions. It gives a new direction to our life style and society.

Besides sensing, Mobile Crowdsensing (MCS) has an effective impact against a wide range of applications but it is not limited to Environmental monitoring, Intelligent Transportation System, Healthcare [14], [15].With the low implementation cost feature, it has been focused for utilizing in different areas such as environmental observations, transportation conditions, health care conditions and social applications etc. Many of the applications are based on Gamification techniques to motivate more and more users for this goal. A large number of Mobile Crowdsensing (MCS) applications have been deployed for monitoring such as Environmental monitoring

PEIR,END, Intelligent Transportation System (ITS), Noisetube, Healthcare, SFPark, VTrack [14], [15]. On the basis of sensing criteria these applications can be categorized in the following types as shown in Figure 1.2.

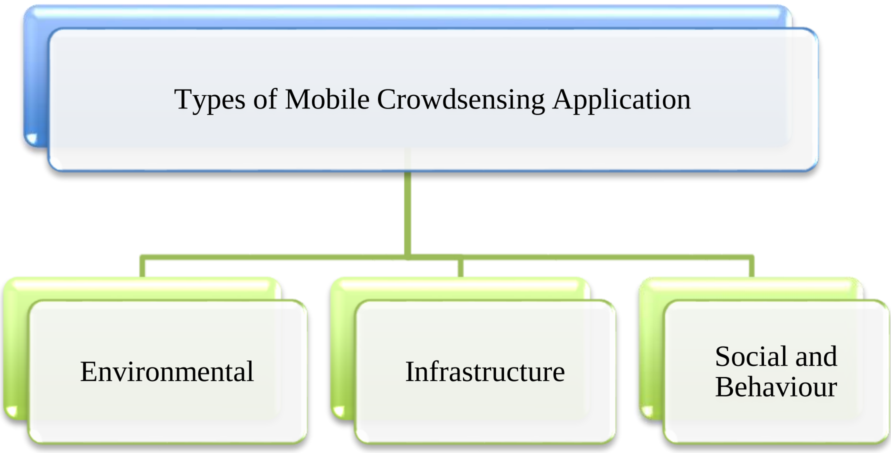

Figure 1.2: Types of MCS Applications

1.3.1 Environmental

Environmental sensing all around the world becomes an important domain. To monitor the different factors of climatic conditions, sensors are now deployed in Smart phones or mobile devices to collect data from the environment. Space weather, air pollution and noise pollution etc. are the different environmental MCS applications use to collect the data for minimizing the high cost and maintenance problems of the deployed system. A project Personal Environment Impact Report (PEIR) uses mobile sensors to allow reporting about the environment, how people have the impact on environmental activities. People Infrastructure application refers to the smart transportation including route planning and public safety, blockage of traffic, car parking area, road conditions and disruption of surroundings. In this field of MCS application, a lot of work has been done for the Traffic analysis and transit tracking monitoring [4].

1.3.2 Health and Public Protection

Mobile Crowdsensing is also used to monitor different aspects of personal and public health. Different personal monitoring applications are used to get data about their daily life routine and health such as blood pressure, sugar level, heart rate weight etc. Exterior and interior sensors i.e. air contamination are utilized to monitor the psychological conditions of patients. DietSense helps the people to lose weight. Nutritionist experts give suggestions by examining their reports about daily food choices through pictures and sound samples [16]. Another Health Aware sensing application used to allow people to improve their health by sending health feedback.

Public protection means to protect people from natural disasters (earthquake, floods etc.) and crimes which could be dangerous for the community. Global positioning system locates the users' current location to make their movement profiles. Smartphone users of active crowdsensing can upload pictures, addresses or any other current information. Mobile crowdsensing is also implemented for getting the information about the natural disasters area to help the victims of the area to find the correct data about the causalities [17]. Twitter social media is used to make the people aware of the future disasters. Similarly, Geo hash tag posts observed real time earthquake reported in different regions [18]. To collect data from public area for to maintain safety in smart cities SAIS (Smartphone Augmented Infrastructure Sensing) was designed [19].

1.3.3 Space Weather

Space weather belongs to situations which are caused by sun and solar wind such as solar bursts, particle events (SPE), powerful thundering near sun's surface (CMEs) etc. These conditions spoil the atmosphere's different layers especially ionosphere and lithosphere. Therefore, its forecasting is important as sun emits radiation with the large solar burns and these rays can be dangerous for the spaceman, airplane crafts and satellites etc. The MahaliSpace Weather project use sensors to forecast the space weather in smart phones, mobile devices, and tablets. To penetrate the ionosphere, GPS signals are used to get the data from the earth sensors that saves data through mobile devices into a cloud-based processing environment for analysis purpose [20].

1.3.4 Pollution

Pollution becomes the harmful agent for the environment. It dynamically influences the standards of human beings' life such as, high blood pressure, diseases of hearing, anxiety, irritation etc. Air pollution monitoring gives the details of polluted area with the help of mobile devices or via Bluetooth pairing or tethering connecting to the air quality sensing devices, for real time data visualization on the phone and later to upload on a server. One of the World Health Organization (WHO) reports states that annually seven million premature deaths are associated with air pollution. MobGeoSen enable individuals to observe environmental conditions regularly by using smart-phones and collect information [21].

Noise pollution is also harmful for the surroundings as well as for the human health. It can also monitor the level of noise in the area with the help of microphones when used by the crowd. In developed countries, to monitor the noise pollution sensing applications had been deployed. Noise map is the graphical presentation of the noise level distribution in surroundings. The Commission of Europe directed the generation of noise for monitoring noise pollution and collecting data to create noise maps. For creating noise maps shared measurements were used. Although it is a difficult task and as the efforts of high authorities are limited because it is not possible for deployed sensing nodes to secure all areas of city. Earphone was also used as a noise participatory map sensing system. Mobile Sensor Data EngiNe (MOSDEN) is a synergic framework for sensing and sharing data with the different distributed applications and users to monitor environmental conditions [22]. European Noise Directive (END) used to monitor harmful sounds in surroundings produced by the means of human behavior and traffic of road, air and rail etc. Noise Tube is used to show personal noise pollution [23].

1.3.5 Intelligent Transportation System

Traffic crowding becomes the primary crime for undisciplined environment, wastage of fuels and anger of passengers. The Traffic crowding is the serious issue around the world as this single problem has a poor impact on environment and as well as wastes time of human beings. Vehicles which are equipped with GPS can store the location and current time continuously to send it to servers by using wireless networks. Different traffic monitoring applications have been implemented to resolve problems related to the traffic e.g. Nericell, Potholes, VTrack and WreckWatch etc. ITS (Information Transportation System) used to make traffic more effective by decreasing the traffic problems faced by the people. Through this application, user gets to know the preliminary information about traffic i.e. arrival and departure time of the local/public buses, availability of vacant seat etc. which saves the time of passengers. ITS also gives security and comfortable journey to the passenger [24].

Many organizations around the world have developed applications for providing ITS services. Practically ITS is implemented in the city of Glassgow, which gives information about the public/local/route vehicle, availability of vacant seats, active location, arrival and destination time, upcoming stop, and how much passengers are there in vehicle. Around the globe, searching automobile parking becomes problem for a lot of people on the regular basis. It is time consuming and frustrating process for the citizens and also influences environment and produces pollution [6]. Smart Parking System is a solution which is used to explore the parking availability that sends data about free and occupied parking areas around different regions through navigational direction. It also makes the city less congested, safer and livable. In San Francisco SFPark and in Melbourne CBD in-ground sensors projects are infrastructure based which are significant initiative of Smart Parking System [25].

1.3.6 Social and Behavioral

In Social Sensing, users can share their data to the specific group of people and communities for the sake of security and personal information. In mobile crowdsensing social applications, individuals have great interest to participate for sensing data. Different social media applications i.e. Twitter, LinkedIn, Facebook, MySpace, Amazon etc. are used by millions of people around the world to share information and views online with others or in groups [19]. Social application for sensing purpose includes Place characterizing, Travel Packages recommendation, Place finding, Diet Sense Control, Emergency control, geo location characterizing, and citizen behavior characteristics, Social characteristics, Energy saving, Basic healthcare with weight loss, Measuring intake in healthcare [26]. It is a group awareness system that combines mobile computing and social networks. At different group activities of organization, it delivers assistance. It endorses the activities of current user which are based on distance and interaction dynamics in a community [6].

1.4 Applications of Mobile Crowdsensing

With the development of smart phones or mobile devices with different built-in sensors, makes the area of mobile crowdsensing an emerging paradigm. It has led to the implementation of different applications of mobile crowdsensing for different purposes. Here are some application domains of mobile crowdsensing which makes it valuable for the society, environment and human beings.

1.4.1 Smart Cities

Cities are densely populated around the world therefore it is the big challenge to manage it effectively. Therefore, in this modern era, a lot of research coming from government and industrial domain to make cities smart. Different applications have been used for making it smart through mobile crowdsensing. Korean’s national plan and strategy is to build low carbon green growth that aimed to make full smart city and provide suitable environment to the society which will be enjoyable. Smart city will cost effective but crowdsensing reduce the cost as data can be sensed on a large scale. For the better management of cities, crowdsensing motivate the users to participate for sensing data in exchange of incentives. Smarter Planet project is one of the projects of IBM which also encourage to make cities smart [27]. Roads can be safe by using mobile crowdsensing applications. Lorenz Cuno Klopfenstein surveying the MCS regarding the road safety and making simulation results by taking different samples. Road maintenance is very important element for the whole society as from economic point of view it is the backbone for development, that’s why it is difficult to monitor it efficiently.

So, mobile crowdsensing could be an efficient technique to monitor the roads. Periodically data sensed by users regarding the infrastructure of roads and informs the authorities about their instruction in order to get rid from reconstructing again and a huge amount used on it. Users involved actively for sensing task regarding road safety [28]. Through mobile crowdsensing large number of user can be motivate by engaging them in the sensing tasks to make the cities smarter.

1.4.2 Real data Evaluation and Emergency Management

Data collecting from mobile crowdsensing can be used for handling the emergency situation. Real data evaluation can be used to manage congestion in different regions. For example, in stadiums crowd can be managed by evaluating the real data through crowdsensing applications. Anastasios Tsifts is designed Crowd simulation model based on to handle the crowd dynamically in the situation of congestion by using general type of sensor camera. Proposed mechanism compared with real videos captured in the football stadium and concluded that proposed system evaluated the data rapidly and finds the best possible routes to handling the problem of congestion [29].

Baoxi Liu proposed SFM Social Force Model for the clearance from the congested area and motivated the pedestrians by energizing their behaviors in crowd. It takes the situation of students in school, and proved that the proposed framework works efficiently by making suitable dynamic crowds [30]. Real Time Vehicle Tracking is proposed by Huihui Chen by using mobile crowdsensing, where the users have to take photos of vehicles in order to keep the track of moving vehicles especially in those areas where the cameras cannot be deployed. For the selecting optimally participants, the system locate patterns of vehicle and as well as participants [24]. Emergency reacting applications based on the sensitivity of time for example in natural disasters which caused different problems therefore people have to be connected for helping purpose. For this purpose, Viktoriya Kutsarova proposed model in which mobile crowdsensing can combined with the smart watches. In this model, wearable smart watches sensors detect the harmful situations and get hold for resolving the emerge situation [31].

1.5 Research Motivation

Mobile Crowdsensing becomes an emerging paradigm now a days and also mobile devices or smart phones embedded with variety of sensors which are popular innovation among the human beings. It creates new ways to collect data for monitoring in the different fields e.g. environment, health care, pollution, entertainment and social networking etc. Different types of users want to perform sensing tasks and willing to obtain highest rewards in the form of incentives. Incentives limit the participation of users as the difficulty level of tasks cannot be considered. Thus, for increasing the participation of users, there is need to consider the level of performing tasks and rewards. It motivates to do research on the incentive mechanisms of Mobile Crowdsensing and present a novel solution.

1.6 Problem Statement

There are several studies available in literature which are concentrated on different aspects of incentive mechanisms of mobile crowdsensing. Although these studies rarely mark the interest or participation level of users, behavioral characteristics of users, performing tasks, awarding rewards, quality and privacy of data. The main problem is that a fixed amount is paid to each contributor and it does not consider the difficulty level of the task. It may hinder the contributors to take part in difficult tasks that results in less competition for difficult tasks and more competition for easy tasks.

1.7 Research Questions

Following research questions are identified that are based on the research objective.

i. How can participants get their rewards on the basis of difficulty level?
ii. How can drop out workers be managed?
iii. How can suitable cost for the task completion be managed?
iv. How can users have ranked?

1.8 Scope of Research Work

Mobile crowdsensing has emerged greatly over the last few years and this is due to the popularity of smart phones and mobile devices which are embedded with the different number of sensors. Sensing data from different areas for different purposes results into various problems, such as participation of users for sensing data, awarding rewards, cost of performing tasks, coverage area for sensing. Time for performing tasks, quality and privacy of data and all these problems becomes the major concerns in the research area. After analyzing the different mobile crowdsensing incentive mechanisms, considerable challenges are seen in sensing data through performing different tasks. To tackle these challenges, the proposed system model will show effective results regarding participation of user, performing tasks on the basis of difficulty level of tasks, awarding rewards, maintaining and ranking the participants and estimated budget.

1.9 Research Objectives

The main objectives of this work are listed as follows:

i. Maximize the participation of workers by giving rewards on the basis of the difficulty level of tasks perform.
ii. To minimize the drop-out rate by giving inner lottery to the workers.
iii. To maintain the estimated budget by considering the level of tasks.
iv. To keep the participants’ interest by ranking them on the basis of sensing data.

1.10 Thesis Organization

The rest of the thesis is organized as follows; Chapter 2 reviews the related work. In Chapter 3, methodology of system model is described. In Chapter 4, details of the proposed scheme, by describing the Recruiting New Worker Process, Reverse Auction Process and Dropout Worker process are explained. Next, results present in Chapter 5. Finally, conclude the work in Chapter 6.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

In this Chapter, became familiar about many existing incentive mechanisms of Mobile Crowdsensing System (MCS). On the whole alot of issues explored in research area regarding mobile crowd sensing incentive mechanisms based on participation of users, paying rewards, coverage sensing area, Task assignment, Cost of tasks, Quality and Security of Data. It was discussed that different schemes in which researchers try to get through different challenges of mobile crowdsensing system such as involvement of participants, Paying Rewards, Cost of Tasks, allocation of tasks, Quality and Security of Data to bring out the problems and forwarding the necessary requirements in the proposed models.

2.2 Mobile Crowdsensing Incentive Mechanisms

Mobile Crowdsensing becomes a paradigm for Internet of Things (IoT). It collects data from a huge number of mobile users or a crowd. Mobile Crowdsensing system consists of different stages. Daqing Zhang classified these stages as, 1: Task Creation: Tasks created by the system platform and deployed in it the respective mobile sensing applications to share it with the participants. 2: Task allocation: After creating tasks, it should be allocating to the participants by recruiting them. Amazon

Mechanical Turk (AMT) commonly used application for recruitment process. Existing literature of mobile crowdsensing proposed different schemes for selecting subsets of participants, towards to achieve goals of reducing task allocation time and increases involvement of participants etc. 3: Task Execution Individually: In this stage, participants try to sense tasks within the given time. This stage has three sub stages sensing and computing the task then uploading data to the platform.4: Integrating Data: In the last stage, collected sensed data by participants and processed it to extract appropriate data and share to the platform. It is integrated by using different techniques. Some MCS applications directly stored the data on servers and provided it to the end users, some MCS applications use complicated algorithms to integrating and processing the data and then share it to the end user interface [16]. In incentive mechanisms, each user wants to achieve maximum reward by performing the allocated task. If there are insufficient incentives for the participants than the user may not will to participate in sensing tasks, therefore it is necessary to design such effective incentives which are beneficial for the participants. To incentivize mobile users' monetary based incentive mechanisms has great influence than the other mechanisms. Amazon Mechanical Turk (MTurk) is the famous company which paying monetary incentives to the participants on performing Mobile Crowdsensing tasks.

Xiaowen Gong discussed different incentive mechanisms based on truth which incentivize the participation of users. Cost is an important factor in MCS as users does not want to disclose real cost of task to the requester, for getting more reward to balance its cost. For this purpose Cost Elicitation incentive mechanism proposed based on reverse auction strategy where the auctioneer themselves a requester, who give rewards to the participants for performing mobile crowdsensing tasks [32]. Andrea Capponi presented survey on the existing frameworks of mobile crowdsensing. It basically highlights the problems of existing MCS frameworks and also classified the applications, methodologies and architectures. It presents the detailed taxonomy of each architecture layer which consists of four-architectural layers 1: Application Layer. 2: Data Layer. 3: Communication Layer. 4: Sensing Layer and also discuss the difference between domain-specific and general purpose frameworks for data collection. It also directs future work and team work with other areas of research [6]. Mobile Crowdsensing is using to sense the data from the environment or local area. People usually don't want to share their personal data, therefore incentive mechanism is designed to collect the data from the crowd which encouraged the users for participate in the task and by completing assigned task, there will be a payment for it. Hamed Vahdat-Nejad presented two different categories of incentive mechanism: Monetary Incentive Mechanism, the user get rewards after performing the given task and Non-Monetary Incentive Mechanism, By performing the task, user cannot be awarded any cash or non-cash reward [33]. Table.2.1 shows different frameworks for incentive mechanisms with important features.

Table 2.1: Frameworks for Incentive Mechanisms

Sr. No	Framework for Incentive Mechanism	Features	Learning area
1.	**Auction (Winner / All Pay-Auction APA)**	Allocating Tasks. Payment.	Microeconomics
2.	**Lottery (Tullock)**	Successful contest Unsuccessfully	
3.	**Trust/ Reputation**	Socially identification	Artificial Intelligence
4.	**Games**	(Rubinstein/ Nash)	Computer Science and Economics
5.	**Contract**	Moral threat Select unluckily	
6.	**Market-Driven**	Suppliers Demand	

Rest of the explored studies categorized in the following ways on the basis of different methods of incentive mechanisms of mobile crowdsensing.

2.2.1 Reverse-Auction Based Incentive Mechanism

In mobile crowdsensing, auction process is commonly used framework for incentive mechanism. In a typical auction process, auctioneer announced some goods or services for the users and then users share some bids for buying these goods. After this, auctioneer decides the winner who wins the goods or services by applying some auction rules. In (VCG) Vickery Auction, multiple goods are announced for selling with the highest bid and allocating multiple tasks to users in mobile crowdsensing system and then select those participants whose total sensing cost lowers the total cost of task. In mobile crowdsensing system, auction process takes place in contradictory way such as here the mobile device users are bidders who want to sell the sensing data and from these bidders auctioneers buy that sensory data and it is often termed as Reverse-Auction [16].

Guo Liang Ji presented Reverse Auction Based Mechanism to reduce the system overall cost. The workers detained on the basis of their performance in the task by giving them lottery. Cost of the potential candidate is fixed in Reverse auction Based incentive mechanism [34]. Diogo Calado presented incentive mechanism in MCS that allows the users to participate for data sensing in both ways; automatically or manually and get rewards. Ledger for the incentives is Tamper-proof in which each participants access their previous transactions records. Blockchain technique is used to save users data in tamper-proof log. For paying of rewards to the participant develops game based prototype [35].

Mobile Crowdsensing mechanisms have issues of selecting users for performing the task and the rewards calculation which creates the problems of incomplete task. Abdul Razaque presented mechanism based on two algorithms: User Selection Mechanism to obtain the minimum cost of each users and Payment Determination Mechanism [18]. Different Incentive mechanisms have been proposed and presented in the research area of Mobile Crowdsensing based on participation of users, tasks allocation in sensing region, paying rewards or incentives to participants, Location of participants, Cost or expenditures of tasks, Quality of Data, Privacy and Security of Data, but still these issues have not been resolved completely.

Xujiao Kong designed an incentive mechanism based on the limitation of budget for resolving issue regarding user’s interest and spatial-temporal. Logistic regression model is used to select the suitable participants for sensing the task and then Winner Auction algorithm (WAA) is used to select the winner from the sensing area which achieved the goal of truthfulness, individual rationality, computational efficiency and competitive ratio [36].

2.2.2 Online Based Incentive Mechanism of MCS

Many of the existing incentive mechanisms based on offline situations where users have to forward all their information e.g. task completion, bids amount etc, to the platform and after that the platform selects the subset of participants to maximize the utility of the system but in reality the participants change their location uncertainly and arrive dynamically. Dong Zhao highlights this issue and presented two online-auction incentive mechanisms OMZ (with zero interval time) where arrival and departure time of each participant should be equal, no participant have the same interval time. This mechanism has multiple stage sampling process where the sample randomly changed and through the algorithm of GetDensityThreshhold assimilate threshold for the further. OMG (with non-zero interval time) user have non-zero interval time with multiple participants altogether. This mechanism is the modification of OMZ possessed some rules 1: If any users' interval time pass over more stages then the bid-independence will have demolished otherwise any user can affect their payment. 2: To grasp the bid-independence, existing online users are arranged on the basis of marginal values and choose those users who had higher marginal value.3: Selected winner pays off the price greater than the price of selection time. Evaluation results prove the suitable properties; computational efficiency, individual rationality, feasible budget, truthfulness, consumer sovereignty [37].

To stimulate the participation of users and online incentive mechanism social applications involved. Yatong Chen presented an incentive mechanism sensing platform with the inclusion of social network applications to involve the participation of large number of users and to enhance the sensing area based on auction with intermediaries, three-layered network model. 1: Smart Phones 2: Intermediaries 3: Sensing Platform, without user overlapping is designed. The main aim of this incentive mechanism is to solve out the problem of users overlapping. For this the proposed mechanism consists of four layers which are shown in the Figure 2.1. Theoretically proof the properties of individual rationality, incentive compatibility and computational efficiency.

To clarify the mechanism, provide algorithms for bidding preprocessing, Allocation Scheme, Payment Scheme, Duplication identification. It proves the Properties of Intermediary Mechanism, Properties of Platform Mechanism, and Time Complexity. This mechanism design has fault tolerance capability for each sensing task. It proposed auction-based mechanism with clear algorithms and details of intermediary which are Design of Intermediary Mechanism, Platform Mechanism Design without User Overlapping, Duplication Elimination. It evaluates the performance of proposed mechanism which consists of the following aspects: Task completion and its distribution, platform total payment, intermediary revenue and its distribution, and social cost. Evaluation results show the small gap between the designed mechanisms' result and theatrical optical result [10].

To increase the participation for performing tasks, incentive mechanisms have been developed for the online scenario or social networks. A large number of Famous personalities belong to social network and they have great manifest upon it. According to Kickstarter Amanda Palmer gained up to 1.19 million dollars from the crowdsourcing tasks for releasing new CD. Therefore, to increase the participation of users and as well as to improve the quality of users Jia Xu proposed an algorithm of diffuser selection which is based on three components; Diffuser Selector sorts out the participants on the basis of their social community relationships from the set of diffusers. Through Reverse Auction mechanism diffusers participates in the tasks. Evaluator of User Quality determines the bid of each user with the record of their previous sensing data. Sensing platform decides the group of winners through bidding profile and then the winner users perform the sensing task.

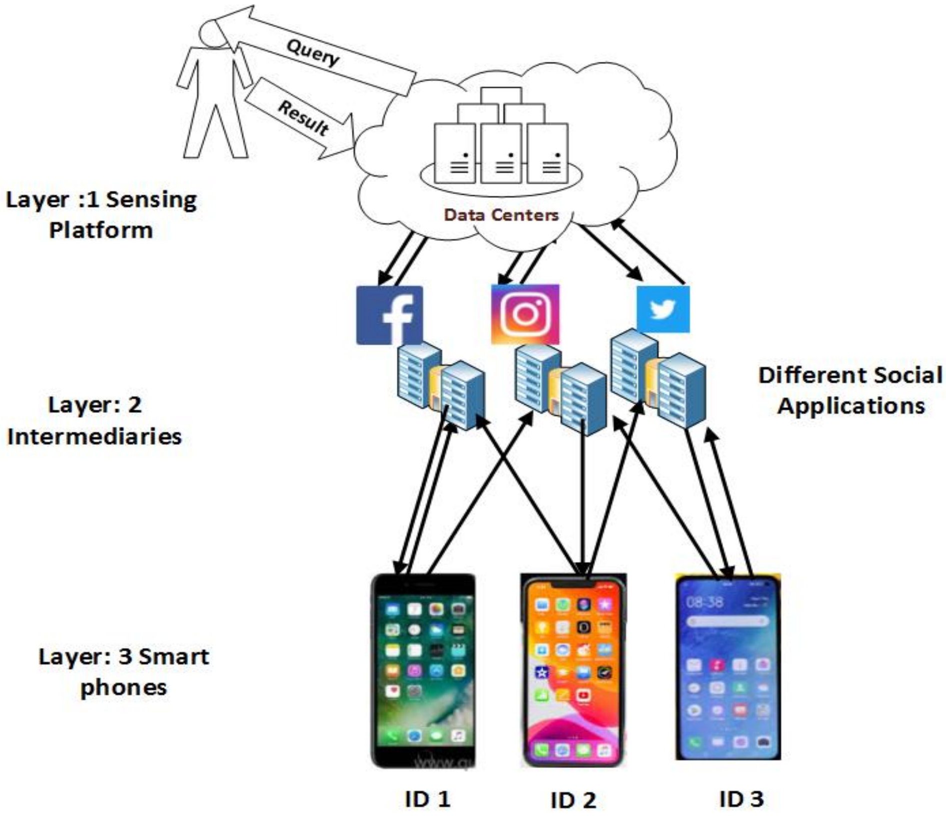

Figure 2.1: Layers of Incentive Mechanism MCS with Social Intermediaries

After sensing task, data will be dispatched to the platform then give winning payment to the participants. Proposed mechanism attained the suitable properties computational efficiency, individuality, truthfulness and approximately guaranteed data [38].

To boost the teamwork worldwide, Socialization among participants plays an important role in Mobile Crowdsensing system. Guang Yung presented social incentive mechanism based on novel approach which allows the social circle friends to perform the tasks in sensing area and motivate their social circle friends to participate in the sensing tasks. Proposed framework works with the independent tasks to encourage teamwork in MCS. In this scheme, participants rewarded on the basis of their social friends to motivate the users more and more for performing task. They get low incentives from the social circle friends' pressure on selection of selfish task otherwise will get high incentives for selecting cooperative tasks. For the evaluation of performance, case study method has been used where five participants show their payment of exercise with each other and proved that social incentive mechanism has cost effectively and optimal in cooperative tasks as compared to traditional mechanism [39].

2.2.3 Local Information Incentive Mechanism

Wireless Sensor Networks (WSNs) is an infrastructure-less network that is used to measure physical or environmental conditions of the area i.e. temperature, sound, vibration, pressure, motion or pollutants etc. Furthermore, this sensed data is passed via network connections for processing and analyzing to the main sensor platform system. Advanced research has brought more complexity in Wireless Network area. Location dependent crowdsensing frameworks is some most important area in research as the location becomes another significant factor other than the prize affecting the choice of participants to play out a task or not. In MCS participants personal and location information are essential characteristic for the sensing platform but participants have doubt of hacking or any other privacy issue to share it. Therefore, it is necessary; this information should have to be secured privately for resolving privacy issues. It opens a new gate for the research area.

Luis G. Jaimes presented an algorithm Greedy Incentive Mechanism (GIA) by integrated Reverse Auction Dynamic Price Recruitment (RADP-VPC-RC) and Greedy Budgeted Maximum Coverage (GBMC) algorithm. Greedy Incentive Algorithm (GIA) for the participatory sensing, considering the important factor location with the budget limited. Main purpose of algorithm is to build on the most attracted sensing region by using location of users and minimized unnecessary sensed data. Limited budget is divided fairly among rounds or auctions. In any round, awarded budget cannot fully have utilized in particular round then the remaining budget of that round will be added to the next round which increases the total budget of next round. Through evaluations it can be seen that GIA increased the sensing area equal to 60% as compared to (RADP-VPC-RA) [40].

While recruiting workers their personal or local area information are important for performing task, this may lead to serious problems. To keep this privacy secured during recruited workers, Differential Privacy (DP) based robust method Privacy-Preserving-Data-Analysis has to be adopted. From the understandings of DP Jong Seon Kim proposed histogram based technique Private Spatial Decomposition (PSD) for recruiting suitable workers while assured the privacy of participant. Domain size and density of data set are also the major issues of input dataset which should be skewed efficiently but most of the existing mechanisms cannot consider it. Skew-Aware Grid pArtioning (SAGA) data-dependent method which used histograms based on high density areas are also presented. SAGA has two steps: firstly, divided the network on the basis of hotspots and secondly those hotspots divided into static grid. Hotspots detected through sliding window method. This approach of data-dependent PSD based method evaluated better result than other PSD [41].

Mobile computing devices embedded with a lot of sensors including microphone, GPS, accelerometer, gyroscope, camera etc. These sensors can be used for collecting the information of the users and their environment. Participants have different intrinsic and extrinsic motivations to participate in the task and against the reward, therefore it is important to focus on these motivations during designing of incentive mechanism. Jose Mauricio Nava Auzapresented framework for MCS that represents the actions of users for the system and incentives for MCS. The proposed mechanism based on game theory where different incentives awarded to the participants focused on their specific property of motivation. Firstly, the model used probability method to distinguish between the extrinsic and intrinsic users' motivation. Secondly the platform dispatched incentives with required information for workers' recruitment to the MCS framework. Then the participants decide on the basis of their motivation and incentives to perform the task. The users just focus on their own location and cannot react homogenously on the incentives. It shows the availability of user's resources and non-homogeneity of their responses.

In different existing proposed incentive mechanisms, users need information of their closest user to make a decision. The designed incentive mechanism allocates different incentive values to users on the basis of distinctive feature of user and allows the users to share local location information. This model proved the non-homogeneous response of users by offering them different incentive values which shows the unpredictability participation of the user through simulation results. For future work this model can be deployed practically [42].

In LDSTs sensing frameworks users have to sense the data in the particular region. The participation of users decreased due to the consumption of time and physical resources. Jiahui Hai proposed Demand-Driven Dynamic incentive mechanisms for LDSTs location based MCS which give rule of how dynamically set the rewards on the given time of demand according to location. Worker Selected Task mode is used in this model instead of Server Selected Task which increased the participation of users. For calculating dynamic demands on the basis of location they follow the model of Analytic Hierarchy Process. Optimal dynamic and backtracking algorithms proposed for the users to increasing their rewards and help the participants for selecting an optimal task [43]. As the popularity of crowdsensing increases, the security or privacy issues are also challengeable for this system because users can share personal information location etc. Yongfeng Wang presented a comprehensive literature research on the privacy issues of MCS and classified it into four types: identity privacy, data privacy, attribute privacy and task privacy. Implicative privacy should be provided in MCS [44].

2.2.4 Incentive Mechanism for Multiple Cooperative Tasks

Nowadays large number of sensors are used in the smart phone, through which the adoption of crowdsensing tasks become easily. This technology reduces the cost of hardware requirements. In this context alot of Incentive mechanisms have been proposed. Jia Xu presented the three compatibility relationship models by involving real-life relationships of social networks. Two models of this designed framework are: MCT-M and MCT-S and moreover these models have two process: compatible user grouping and reverse auction. The proposed model allows each user to submit the task with the corresponding bid prices. The platform alerts the winners from the group of selective users. The winners perform task and dispatch the data back to the platform.

After it the platform system calculates the payment of each user. The proposed system model is consisting of two different bid models 1: Single bid model 2: Multi bid model. Any user can cooperate with all other users without submits the claimed compatible user set $\zeta i = U/\{i\}$. They presented the incentive mechanisms for multiple cooperative tasks in these special cases, and treat them as the benchmark mechanisms for MCT − M and MCT − S, respectively. They also give the theoretical analysis of incentive mechanism by demonstrating the different desired properties. MCT-S is computationally efficient, individually rational and truthful in the single-bid model; investigate the performance of MCT-M and MCT-S for all three compatibility models. Future works are to develop the geographical distance and user quality compatible models, machine learning based grouping methods, valuate the accuracy of grouping by real-world for some specific mobile crowd sensing applications [45].

Juong-Sik Lee presented the participatory sensing incentive mechanism in which the user has to providing the quality based sensing data to the system which is the most important factor in mobile crowdsensing. In Reverse Auction Dynamic Pricing (RADP) users have to sell their data with claimed bid price, which encourages the users to participate for sensing tasks. It minimizes the cost and prevents the users to drop out of from the applications of participatory sensing. The results are compared with Random Selection with Fixed Price (RSFP) mechanism. This mechanism removed the burden of accurate pricing for user sensing data. RADP-VPC (Virtual Participant Credit) awarded to the lower bid participant which increases the winning probability in future auction rounds and VPC improved the fairness of cost. It reduces the incentive cost 60% as compare to the Random Selection fixed price Incentive mechanism [46].

Chang Xu proposed the truthful incentive mechanism which pays partial payment to the workers on the basis of their reputation in the task performance through future prediction function. In this design participants shares the data independently with the platform there is the no interaction between the participants. Data accuracy and completion time of the task to be considered in the evaluation of workers' performance. The TD algorithm has been used to measure the accuracy of the data. Exponential Recency Weighted Average (ERWA) technique is used to calculate the performance of the worker. From Beta distribution, Dirichlet distribution used to measure the existing performance of the worker. According to the workers' reputation they will be awarded by the advance payment after, when the task has been completed the worker has to be awarded or punished according to the difference of reputation and current performance. A bound value should be set for punishment and reputation of the worker. If the bound value is less than the current performance, then the workers have to be punished otherwise awarded by a reward. Experimental results conducted by the accuracy of the workers performance Evaluation, Weighted Averaged Performance and Prediction and Payment Distribution [47].

Trust and Reputation are essential elements to bring robustness in Mobile Crowdsensing systems. These are the new challenges which expand the research area of mobile crowdsensing. Eva Zupancic proposed conceptual framework to compute the data trustworthiness sensed by the users on the basis of nonparametric statistics. Evaluation results revealed low error rate compared to the reputation system based on Gompertz function [48].

Jia Xu designed incentive mechanism for social mobile crowdsensing to examining both cost and quality of users. This mechanism evaluated different properties and satisfied truthfulness, individual rationality and computational efficiency [38]. Lei Shu presented that Mobile crowdsensing system can integrated human with machine for the betterment of industrial area. MCS based methods provide benefits to the industrial area instead of industrial traditional based methods which provide flexible, scalable and cost-effective methods. The three main components of industry are products, suppliers and customers which can be successfully interconnected with the MCS based methods [49].

The concept of electronic markets (e-markets) in developed countries are increasing economies rapidly due to the advancement of computer networks and information technology. Existing e-services based on fixed price but Juong-Sik Lee presented a model with dynamic pricing which increase the interest of participants. Two optimal recurring auctions proposed for the e-markets: Participation Incentive Optima Recurring Auction (PI-ORA) and Discriminatory Price Optimal Recurring

Auction (DP-ORA) [50]. Individual user can be capable for providing quality data and services. Crowdsensing application highly depends on a quality of crowd that can be recruited to perform the assigned tasks. Quality of Crowd (QoC) should be application-dependent. Jing Wang presented novel auction formulation for quality-aware and fine-grained MCS, which minimizes the expected expenditure subject to the quality requirement of each subtask. Trace driven using the mobility dataset of San Francisco taxies simulation results have shown the proposed incentive mechanism achieves noticeable expenditure savings compared to two well-designed baseline methods, and moreover, it produces close-to-optimal solutions [51].

In mobile crowdsensing, privacy is the main important factor. For resolving these issues alot of work has been done and presented frameworks for different scenarios. Jian Lin presented two algorithms named as Bid-Guard and Bid-Guard-M by using two different models single bid and multi bid model. By using linear and log functions designed score function for realizing these two frameworks. Log function proved both of the models are asymptomatically optimal with respect to social cost. Single bid model allows user to submit one bid for the set of tasks but in multi bid model users can submit one bid for each task in the set and can perform on multiple tasks. The main goal is to achieve suitable properties of incentive mechanism such as computational efficiency, individual rationality, truthfulness etc. and minimizing the social cost [52]. In a mobile crowdsensing, sensing data collected by users may contain sensitive and private information with the chance of data breaches. So users expected that powerful and strong measures are adopted to secure and protect their privacy when sensing data is uploaded to the platform. There may be malicious activities during data transactions between the mediator and the service provider, possibly leading to loss of profits.

Jinbo Xiong presented privacy preserving data aggregation scheme to allow sensing users to upload encrypted data to an incompletely trusted mediator, enabling the mediator to get the sensing data aggregation for each time interval without decrypting each ciphertext. The simulation results indicate that the proposed scheme is effective and efficient, even in the scenario where the mediator has the access to sensing user's auxiliary information while user's privacy is still protected [53]. Different mobile crowdsensing mechanisms are shown in Table 2.2.

Table 2.2: Different Mobile Crowdsensing Mechanisms

Existing Schemes	Task allocation	Incentive mechanism	Privacy	Security
A survey on Mobile crowdsensing Systems[54].	No	No	Yes	Yes
A survey on privacy-preservation[55].	Yes	Yes	Yes	Yes
Blockchain-based Reward Mechanism for Mobile Crowdsensing [56].	No	Yes	Yes	Yes
Dynamic User Recruitment with Truthful pricing for mobile crowdsensing[57].	No	Yes	No	No

In another paper, JinboXiong proposed the PERIO framework for MCS services in IoT, which consists of a personalized privacy measurement algorithm, a rational uploading strategy and a privacy-preserving data aggregation scheme. This framework satisfies the requirements of QoCS, improves the privacy level, and maximizes users' utility. Theoretical analysis and ample simulation results using real trajectory dataset demonstrate the comprehensive advantages of the PERIO framework over the existing schemes in typical scenarios [58].

JiangtianNie proposed two-stage game theory by analyzing backward induction. At first stage Crowdsensing Service provider decides the incentives for the participants and in the second stage the MUs selects the participation level according to the observed reward. They proposed Optimal Incentive Mechanism for optimal reward. The evaluated results show improved increasing participation level and CSP revenue. Future work plan is to obtain multiple CSP competition to increasing the monopoly [59].

Zhang proposed Incentive Mechanisms based on two models of optimization one for the optimal maximization of user cardinality and other one defined the sensing utility functions for the whole sensing area of each region. Incentive mechanism is based on Reverse Auction model in which maximize the service of quality within a recruited budget and get the preferable properties i.e. truthfulness, computational efficiency, budget feasibility and good competitiveness It evaluates the results on the basis of real world geographical traffic dataset T-drive compared with Ugreedy [60].

Total Cost for recruiting workers should be within the limit of budget for the coverage area. It is important issue how effectively monitoring the sensing area and also the Feasible Budget in the mobile crowdsensing System. These issues open door for research area. Zhenzhe Zheng proposed an incentive mechanism Budget fEAsible for weighted Coverage maximizatioN (BEACON), based on two parts: Sensing Task Allocation and Compensation Determination. GDY-MAX allocation algorithm is used to select task. Evaluation results shows that BECON incentive mechanism proof better performance for valuation, winner and coverage ratio [61].

It became challenging now to prevent sensing data from malicious attack or also ensures the correctness of data in mobile crowdsensing system. In this respect many incentive schemes modeled but still failed to provide high quality data assurance. Bowen Zhao presented Privacy-Preserving and Data-Quality Aware incentive scheme (PACE) to overcome issues regarding quality and privacy of sensing data. This scheme is based on zero-knowledge model for estimated reliability of data and distributes incentives among the participants [62].

Dan Peng presented an incentive mechanism for the quality of data in mobile crowdsensing. Qualities of data ensured by approximation matrix effort of each participant and then pay rewards on the basis of how much quality of sensing data is effective. In this way participants motivated to perform the task in an efficient manner [63]. Dejun Yang presented an incentive mechanism based on two different models with respect to two different views of points: Platform Centric Stackelberg Game, User-centric model MSensing based on auction incentive mechanism. Participant cannot get different prices from the total cost by asking to increase the utility [19].

2.3 Comparison of MCS Incentive Mechanism Schemes

In this section, it is analyzed that different related existing schemes of Mobile crowdsensing Incentive Mechanisms and highlighted the advantages and limitations. Existing schemes investigated different challenging issues of Mobile crowdsensing and proposed scheme for better performance, improvement and deployment but still there are some problems regarding these factors such as paying rewards, participation of users, difficulty level of tasks, quality and privacy of data etc. Table 2.3 shows the comparison of different incentive mechanisms of mobile crowdsensing system.

Table 2.3: Analysis of Incentive Mechanism Schemes

Scheme	Basic Idea	Mechanism	Advantages	Limitations
YatongChen proposed Mobile Crowdsensing with Intermediaries [10].	Designed three layered network model including social network applications to get through the users' overlapping problem.	Auction-based Incentive Mechanism Mobile crowdsensing	1. Data is guaranteed for long term period. 2. Large number of users participated. Compatible, Rational and efficiently low cost.	1. Participants are paid on the bases of consumption of physical resources. 2. Participant may be fail to complete the task within a given time period.
Guoliang Ji presented Incentive Mechanism [34].	Recruiting potential candidates and detained candidates on the basis of their adequacy in performing task.	Reverse Based Auction Incentive Mechanism	1. Potential Participants selected for sensing tasks. 2. Detained participants with awarding inner lottery to maintain participation rate.	Total cost of participants for sensing tasks is fixed.
Abdul Razaque proposed Incentive Mechanism for MCS [18].	Designed algorithms of User Selection Mechanism and Payment Determination Mechanism	Reverse–Auction based Incentive mechanism and virtual credits.	1.Ensured participants through Determination of payments 2. Quality of tasks improved for higher credits of users.	Don't handle the situation of dynamic changes regarding allocation of tasks etc.

DiogoCalado presented Tamper-proof Incentive Mechanism [35].	Users participated in both ways manually and automatically for sensing tasks.	ThisforThat Incentive mechanism based on tamper-proof	1. Blockchain approach used to save the previous record of users. 2. Participants paid in one community cannot be entertained in the community. 3. Participants' personal information secured.	Blockchain approach is used at server level nodes.
Guang Yung proposed Social Incentive Mechanism [39].	Incentivize participants through social friends'.	Novel based approach Incentive mechanism	1. It is cost-efficient to encourage participants. 2. It grants optimal solution for social mechanism.	Introduces framework for further real world implementati on.
Jose Auza proposed Local Information incentive mechanism for MCS [42].	Model shows the behaviour and response of participants in sensing platform and assigned different incentive values to the participants on the basis of identical features.	Novel incentive Mechanism	1. Individual participant information is considered. 2. Offered different incentive values to the participants which saves the systems' total cost.	Performance of incentive mechanism including human mobility approach. Budget of Sensing platform should be considered.
Jiahui Hai presented Demand-Driven Dynamic Mechanism [43].	In each round of sensing task rewards changed Dynamically to increase the participation.	Incentive mechanism based on Demand-Driven Dynamic	1. Dynamically reward change makes it possible to complete the task before finish time. 2. In a distributed procedure, tasks selected by the users.	It is only location depend incentive mechanism.
JiaXu proposed Multiple Cooperative Tasks with	Users are grouped by using neural	Truthful Auction based	1. It is Cost truthful, efficient and individual rationality model.	Designing different models using different

Compatible Users in Mobile Crowdsensing via Online Communities [45].	network model and clustering Algorithm. Two models proposed MCT-S and MCT-M.	Incentive Mechanism	2. Avoid the participation of irrational users. 3. It reduces the social cost with less grouping time.	indicators such as geographical distance, user quality for some specific MCS applications and creating users' groups on the basis of learning based model.
JiangtianNie proposed Socially-Aware Incentive Mechanism [59].	Developed game theoretic model which consists of two stages. The Provider sets the mechanism in first stage and Mobile Users decide the level of participation. Rewarding the participants discriminatory or uniformly under complete information scenario	Optimal Incentive Mechanism	1. Rewarding the participants discriminatory or uniformly under complete information scenario. 2. Discriminatory reward mechanism helps the CSP to achieve greater revenue gain.	1. Monopoly CSP setting to a multiple CSP competition. 2. Spatial/temporal into reward mechanisms for the Crowdsensing
Zhenzhe Zheng proposed BEACON [61].	Budget fEasible for weighted Coverage maximization	Deterministic Mechanism GDY-Max algorithm select the task for participants	1. Satisfied compatibility of incentives, individual rationality.	On different winning positions participants have different threshold bids which are difficult to bind with the limited budget.
Zhang, Xinglin designed Incentive Mechanisms for Mobile Crowdsensing	To achieve standardized service and maximizing the recruited users in sensing area	Incentive Mechanism for Cardinality Maximization	1. It is feasible within budget. 2. It achieves computational efficiency, individual	It is for heterogeneous sensing costs users for different ROIs.

with Heterogeneous Sensing Costs [60].	for mobile crowd sensing application, proposed Effective-Budget limited incentive mechanism which is based on the reverse auctions.		rationality and truthfulness.	
Bowen Zhao PACE [62].	Based on Zero knowledge models.	Privacy preserving and quality data aware mechanism	1. Providing Quality data. 2. Motivate other task participants to 3. Limited to budget, it distributes quality-aware reward among participants.	It will merge in incentive design.
JinboXiongRong Ma presented PERIO [58].	Users' privacy level calculated through algorithm and then it is combined with the game theory.	Game-Based framework, encryption of data	1. Higher QoCS and individual privacy stable by using Nash equilibrium. 2. Data encryption maintains the integrity and real timeliness. 3. Sensing Users' utility maximized by directed the users to select optimal scheme.	Regarding privacy users have to participate in Spatio-temporal area which is complicated phenomenon.
Jian Lin Dejun Yang designed algorithms BidGuard and BidGuard-M [52].	Two different frameworks based on Single bid and multi bid model for maintain privacy.	Auction based incentive Mechanism based on two algorithms BidGuard and BidGuard-M.	1. Minimizing the social cost by using theoretically log function. 2. With function of log gain differential privacy. 3.Asymptomatic ally optimal models	Privacy leakages performance is different for both of the models, evaluating with linear and log function.

To a great extent Incentive Mechanisms is based on different perspectives e.g. participation of users, assignment of task, Sensing area, quality and privacy of data have been designed for the mobile crowdsensing. These mechanisms have some similarities and limitations. In [10], Incentive mechanism based on auction process aimed to motivate the users by using social application e.g. Instagram, Twitter, and Facebook etc. As the smart phone users are interested to use social media applications, therefore to increase the participations rate for sensing tasks, this type of mechanisms have been designed. But user may not be able to complete the task on time as it is based on online so there is limited time or resources.

In [34], [18], Scheme based on reverse auction incentive mechanism to increase the participation of users, but the users may leave the task for getting low rewards. Different user resources have been consumed for performing tasks and after that if the user cannot get rewards more than the total cost on performing tasks, this decrease the users to participate in the sensing area. In [35], ThisforThat mechanism proposed based on tamper proof where users participate between manually and automatically for sensing tasks. Blockchain approach is used to record the data of users but at server level nodes.

In [38], [42], Novel incentive mechanism presented to maintain the total cost of system by awarding different incentives to the users. In [43], [45], [59] [60], proposed scheme based on Truthful, Optimal, Demand-Driven, Cardinality maximization properties mechanism for individual information sharing by avoiding irrational participants and reducing the social cost by decline the grouping time. Rewarding the users discriminatory and uniformly under complete information scenario. In [61], BEACON deterministic mechanism within the feasible budget, satisfy the properties of individual rational and compatibility of incentives presented.In [62], PACE scheme proposed to motivate the users for sensing data based on the property of quality in order to get more rewards. In [58], PERIO framework based on game theory designed to increase the privacy of participated users by satisfying the QoCS requirements and designed algorithm of privacy measurement and preserve data privacy scheme.

2.4 Issues in Existing Schemes

There are adequate benefits of using the sensing devices that can help people in their daily life and make their life easy. For this, they need to enable the crowdsensing applications so that they remain cognizant of their surroundings. There are different bad marks attached with the sensing devices that they have bounded resources which emerge as challenges for crowdsensing as well. Mobile devices also have restricted resources even though they are provided more resources as compare to remote-class sensors [64], [65].

The goal of the upgrading of 4th generation 4G of cellular mobile data to 5th generation 5G is to support massive connectivity, higher data rates and lower latency. Many modifications in the architecture of 4G are seen. While high data rates were supported in 4G already. The use of mm frequency is of great help in 5G technology. In 5G technology the TTI (transmission time interval) is shorten which means shorter buffering [6]. A lot of existing schemes try to resolve many of highlighted problems but still in addition more deviceful schemes and solutions required to cope up with these challenges. To a certain scope, it is summarized that related challenges based on users' participation, rewards or payment for participants and quality of sensing data.

2.4.1 Users' Participation

To provide sufficient motivation to the participants, so that they may take part in crowdsensing, is most important existing challenge. It is difficult to compel people to participate in crowdsensing because it does not give enough benefit to them. If the information gathered by the users is not suitable for the sensing platform, then mobile crowdsensing system needs a large number of participants to fulfill their demands and to overcome the issue regarding information gathering and it allows the participants to collect high quality based information. Then, it becomes possible for the withdrawal of large amount of accurate data.

As the quantity of data is huge, so it requires more and more participants. But the willingness of these participants is not as same as always because it requires alot of energy which impacts on their daily activities. Therefore, incentive based mechanisms have been designed in order to motivate the users to participate. It will create challenges like low incentives for the participants or privacy breaches, uses of resources etc. Participation rate refers to the grouping of quality of data and its impartiality to conduct the contest. The mentioned factors influence the rate of participation in MCS and as a result a large number of data will be gathered [66].

Sensing task with small and light weight sensor cannot consume more energy and power which makes the user to participates for the task but heavy sensors consumed more which decreasing the participation rate of users. It will become an issue for the participants to take part in sensing task. Juong-Sik Lee presented novel Reverse Auction incentive mechanism based on dynamic price (RADP). Platform which allows participants to argued bids in exchange of data which results to energizing or motivating the participants[46].

To maximizing the users participation Dejun Yang presented incentive mechanism consists on platform centric model based on game Stackelberg where participants awarded rewards by the platform and user centric model based on reverse auction where the users have to follow the leaders [67]. JinboXiong presented MAIM multi attribute novel incentive mechanism which aimed to increase the users participation by considering multi attributes and participation analysis [68]. Furthermore, practical incentive schemes needed to maximize the users' participation by giving efficient incentives within budget constraint lowest usage of participants' resources.

2.4.2 Reward Maximization

Reward plays the most important role in MCS. It gives to the participants after performing the tasks efficiently. To increase the participation of users, it should be important to reward participants with the different amount of incentives on the basis of tasks performed by them. Therefore, rewards become key challenge in MCS. Xinglin Zhang presented different incentives strategies which are designed to motivate the users in exchange of incentives which are of entertainment, services and monetary incentives. Users motivated through rewards which should be based on performing tasks [13] .

In auction based monetary type of incentives are used. Luis G. Jaimes proposed an incentive mechanism based on reverse auction in order to maximize the participation of users by considering costs of users, constraints of budget, coverage area and integrating the RADP with recruitment mechanism and algorithm Greedy Budgeted with Maximum Coverage (GBMC) to design new algorithm Greedy Incentive Algorithm (GIA) [40]. Dan Peng designed quality based mechanism in which incentives are rewarded to the participants on the basis of their performance. The basic purpose of this mechanism is to pay the participants on the sensing quality of tasks [69]. Many of existing studies designed and work out for the maximization of rewards but still it is key challenge for MCS. Therefore, it is an open research challenge in MCS.

2.4.3 Assigning Tasks

Task allocation in mobile crowdsensing is significant issue as it increases the participation rate if it is assigned properly to the users. Some of the major problems regarding this issue are to complete it within time limit and quality. Zhibo Wang proposed privacy personalized task assignment framework for assigning tasks in an efficient way by hiding the personal information of the participating users [70]. Liang Wang presented novel framework for assigning tasks for optimizing, based on the repetitive patterns of mobility by using greedy algorithm [71]. Sri Ramakrishna presented iCrowd framework based on piggyback model of mobile crowdsensing for the allocation of task with variable incentives. It increased the delivery ratio of data and decreasing the data packets lost [72].

Mobile crowdsensing Platform recruit users to participate for the sensing task and have to upload quality data. Therefore, users have to commit their time and energy for sensing and uploading data in exchanging of incentives. But due to lack of knowledge and skills there may be a risk of unsatisfactory data which make platform to hesitate in recruiting users for the tasks. So there should be an efficient mechanism to allocating tasks for sensing quality data.

Battery resource is an important element during sensing the task, as if the battery consumed without completing the tasks, the requirements of the particular task will change which creates an issue. For resolving such type of problems Wang.J.Wang proposed cloud based model in which quality of data, sensing area, the state of sensing sensor is evaluated, and on the basis of power strength of sensor threshold value will be set. if the task announcer or position of sensor in network is changed then this change will be informed timely for relocating the task to completing normally [73]. Assigning tasks appropriately still a big challenge in mobile crowdsensing as many factors from the users' or system point of view still creating problems which needs to be addressed more efficiently and effectively.

2.4.4 Quality of Data

Information has been always being a concern and its assessment of its quality is even more important. Data credibility has grown into a concern and it is always important due to insufficient users' involvement in assigned task and divergence of devices. A user, if interested is suggested to opt a deep analysis which will cover the main scope of the study. Few researchers have focused on recruitments frameworks with quality of data however any formwork without considering quality of data is not effective. Thus, it is important to consider quality and quantity both at times of design procedure [66].

Sometimes due to noisy sensing data may be incomplete in mobile crowdsensing which affected the quality of data. It also poses threat to the privacy and security of an individual due to which they do not go for using the sensing devices.

That is why, it is necessary to preserve and secure the data of the users. Another issue that is being faced is that the challenge of improving the quality of data along with reducing resource consumption. It has become a challenge because the sensed data contains multifaceted attributes and it also consumes resources that create hurdle in improving data quality with low consumption of resource. Another big issue is to trace out the data that is redundant because it consumes alot of resources.

To tackle with this issue, it is necessary to remove the redundant data that will ultimately result in reduction of resource consumption and cost. There another issue remains, which arises even though the redundant data is reduced. The problem is the reduced quality of data that comes out of the process of crowdsensing. So, it becomes a challenge to retain and maintain the quality of data. Inconsistency also degrades the quality of data like at the same time different user's sense the same event concluded the different results and makes the data inconsistent. To detecting redundant data in the mobile crowdsensing is the key challenge for the researchers [74]. Fazlullah Khan presented a survey and highlights different challenges regarding the Mobile crowdsensing system and also gives some suitable solutions to tackle with these challenges. However, further more studies required to cope up with the different challenges of MCS in order to enhance the efficiency of users' participation, maximizing rewards and personal privacy security of participants [75].

2.4.5 Rationality

In MCS, rationality plays a vital role as it minimizes the chance of not including people as contributor. This simply refers to the equity between multiple participants during task assignment. This helps in classifying incentive mechanism for participants. However, there is still need to consider quality of data, quantity of data along with fairness to create dense MCS circumstances [66].

For the collection of large amount of data, mobile crowd sensing is one of the effective, efficient way out. But, the issue of trustworthiness of the gathered data with the help of smartphones sensor is still challenging. The main reason behind this challenge is the cost of sensors used in phones and the other one is its inability to perform as the specialized sensors. Contrarily, the amount of data and data sender are exponentially growing which is difficult to manage and halt. So there is a need to extract algorithms that can run faster and effective and with high performance. Absence of high quality embedded sensors which create the problems of the trustworthiness of sensing data. A large amount of data is generated by sensors or participants and this data needs to be processed [76].

Roadmap to solution of challenges should be universally accepted, sensors for smartphone and a huge storage needs to be taken to store the bulky information. For timely decisions, high processing and effective algorithms need to be upgraded.

2.4.6 Privacy

In wireless networks and MCS environment, it is important to work on privacy as most of the devices collect sensitive data. Data collected from users is done for reliability of data and trustworthiness. Few platforms collect global positioning system (GPS) route of devices. Even some of the frameworks collect data during logging in procedure which is against the user privacy policy in the name of better user experience [66]. JinboXiong proposed data aggregation scheme for privacy preserving by allowing participants to provide noise data and encrypted it with the homomorphic encryption process. Mediator received this encrypted data in the form of ciphertext. A novel mechanism based on game theory is presented for the privacy of data which ensures the personal privacy from the mediator [53].

When participants share bids then their personal information will have shared with others. Haiming Jin presented differentially private incentive mechanism by hiding the bids information from the others. It is consist of single minded reverse combinatorial auction [77]. Jian Lin designed two models for privacy preserving Bid-Guard and BidGuard-M mobile crowdsensing incentive mechanism by achieving individual rationality, computational efficiency and truthfulness [52].

Humans are always the fundamental part of mobile crowd sensing systems where they are liable to error, or false data can be inserted into the system. False data can contaminate the sensed data. By analyzing different mechanisms, it is concluded that still there are several issues become challenging for mobile crowdsensing that should be resolved properly to make it more efficient and effective.

2.5 Summary

Different incentive mechanisms of Mobile crowdsensing System, based on Auctions, Reverse-auctions, Game theory have been studied. For these schemes, some important issues are highlighted. The existing studies extending to improve the Users participation, Task performing level and paying rewards in Mobile Crowdsensing System. Different challenges have been discussed, which will open the doors for the research area of mobile crowdsensing system. A lot of research work has been done in this area but still some more work is needed to be explored

CHAPTER 3

METHODOLOGY

3.1 Overview

In this chapter, methodology is discussed to defining the Incentive Mechanism for Cooperative Tasks which is based on reverse auction process for the Mobile Crowdsensing. The main aim of this work is to increase the interest of participants also for difficult level of tasks through awarding them according to the difficulty level of task. The first step is the announcement of task by the platform then, the system finds the required number of potential candidates from the existing team workers, if the number of candidates are insufficient then new workers recruit for performing tasks. The second step after completion of task winners declared by the system.

3.2 Operational Framework

The operational framework is based on different st-eps. Firstly, the system announced a task on the system platform then the platform checks the availability of workers by considering their location. And if the numbers of candidates are sufficient for the task completion then the system performs Reverse-Auction Process. But if the workers are insufficient for the completion of task than the System platform finds new potential candidates through Recruiting Process. After completing the tasks, winners announced by the System platform as shown in Figure 3.1.

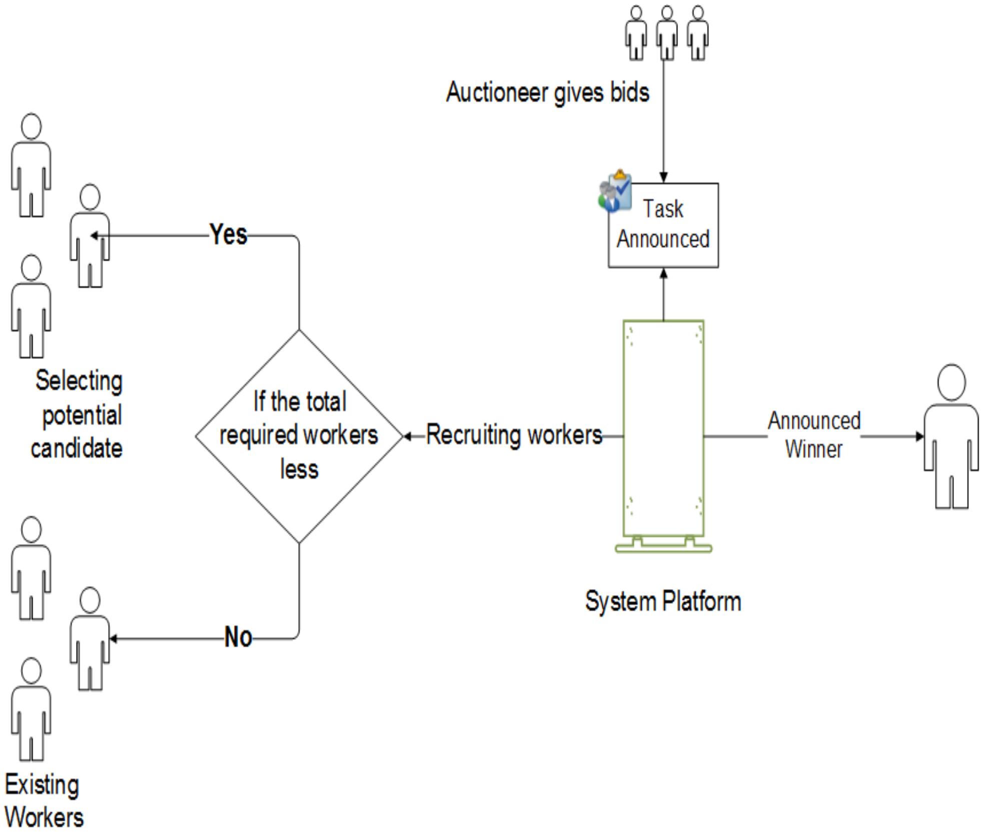

Figure 3.1: Operational Framework of Incentive Mechanism for Mobile Crowdsensing

3.3 Research design and Development

Solutions of identified issues are introduced, which consist of three phases: In the first phase collects data for the participation of users in performing task. Second phase consists on the process of Reverse Auction and the in the last phase of the model winners declared by the system.

3.3.1 Selection of Potential Candidate

First of all, system select the potential candidates for the task from the existing team of workers, if the number of candidates are insufficient then new workers recruit for performing the task. After completion of task, the System platform announced the winners. Recruiting a new potential candidate in which NS $_{i,k}$ is the Set of Newly Recruited worker, C_k : PC $_k$ is the Set of Potential candidates ,C_k : EL $_k$ is the No. of Expected worker , TH_w is the Set of threshold for willingness. Compute their Effective Coverage Level (ECL) for recruiting process. Give Ranks to the candidates in the descending order according to their ECL. If the Willingness of the worker is greater than Threshold, add this potential candidate to the Set of Newly Recruited Worker. Flow chart for this process is shown in Figure 3.2.

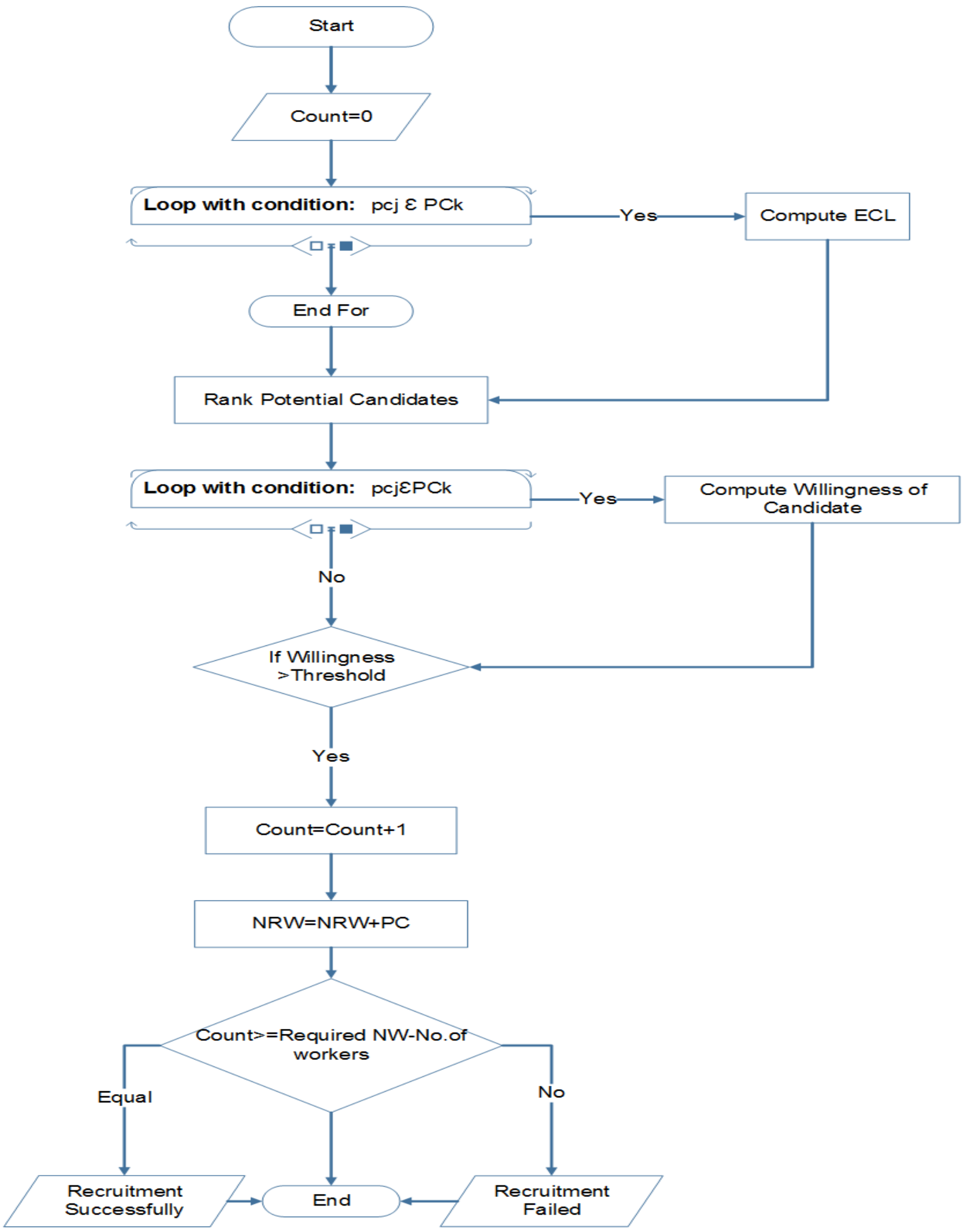

Figure 3.2: Flowchart for Recruitment Process

3.3.2 Assigning Tasks

In this step, tasks announced by the system platform for sensing the data. Auctioneer gives different bids for sensing the tasks and the system platform selects the smallest bidder. Tasks have different levels such as L1, L2, L3 and L4 as the level increases tasks become more difficult. Then the tasks assigned to the users.

3.3.3 Declare Winners

After the completion of tasks, winners announced by the system and awards them incentives on the basis of their level of tasks. Users for performing tasks distributed in the cells having Cell-Ids. The data analyzed by the system platform and perform Reverse Auction Process for finding the smallest bidders. On the basis of difficulty level rewards distributed among the winners.

3.4 Simulation Framework

The simulation framework has been framed in the accordance with the described Incentive mechanism of mobile crowdsensing. Simulation tool is used to validate the performance of IMCT as compared to base schemes.

3.5 Summary

The implementation of incentive mechanism for cooperative tasks in mobile crowdsensing can be effective as it can increase the level of participation. Users are rewarded according to the level of tasks, which increased the interest of users to perform difficult level of tasks also.

CHAPTER 4

REVERSE-AUCTION BASED DYNAMIC PRICING INCENTIVE MECHANISM FOR COOPERATIVE TASKS

4.1 Overview

The performance of workers neglected in recruiting new workers or terminating existing workers which lacks the existence of worker. The main problem is that total cost of task performed by particular participant is fixed whether the task is easy or extensive. It arises the interest of participants to earn same amount with easy task and avoiding the extensive tasks which results in less competition due to less number of participants for extensive task. In this Chapter, the system model for the incentive mechanism scenario is presented where different types of entities are explored that interact in the system. In incentive mechanism the users behaved according to the requester of mobile crowdsensing platform. Sensing Tasks is given to the users of mobile devices, smartphones etc. to the large group of crowd for collecting a data. After completing the task, reward in the terms of payment is given to the participants of the task performer. The System Model incentive mechanism has three modules as shown in Figure 4.1.

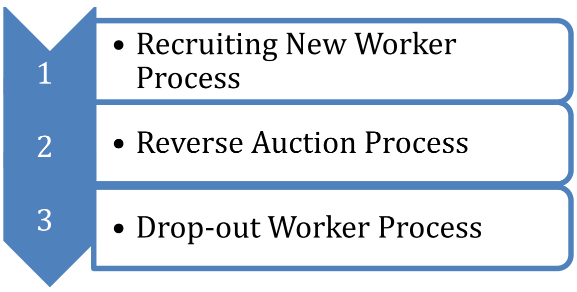

Figure 4.1: Tasks of Reverse-Auction Based Incentive Mechanism

4. 2 System Model

The incentive mechanism system model comprises of four types of entities including Task Requester, System Platform, Workers, and Potential Candidates. Workers are those participants which had already performs the sensing task in the system while potential candidates having the interest to join the system and are outside from the system. Firstly, the Task requester announced a sensing task on the system platform then the platform checks the availability of workers by considering their Position of Interests (POIs) meets the sensing task location. After that if the numbers of workers are sufficient for the task completion then the system performs Reverse-Auction process. But if the workers are insufficient for the task completion than the system platform finds new potential candidates through recruiting process. The Reverse-Auction Based Incentive Mechanism System Model consists of three modules: Recruitment of New Workers, Reverse-Auction and Drop-out Control.

4.2.1 Recruiting New Worker Process

In this module, first of all find the potential candidate, when the number of participants are insufficient to perform the task then the system recruits the new worker on the basis of willingness of their potential according to the equation (4.1)

$$W_j\left(pc_j\right) = 1 - exp\ exp\ (-\gamma_j.(lry_j - co_j)) \tag{4.1}$$

where γ_j represents the consideration of lottery, lry_j represents the lottery given to the potential candidate and co_j is the total cost of potential candidate in completing the assigned task [34]. Coverage level of the potential candidate is calculated in his POIs with the existing workers POIs using the equation (4.2)

$$CL(C_k, EL_k) = \{exp[(EL_k - M_k)/\lambda] \quad if M_k > EL_k\ 1 - \eta.exp[(EL_k - M_k)/\lambda] \quad else \tag{4.2}$$

where λ and η represents constants. In this equation there are two parts; upper part of the equation will be evaluated to stop more workers when there are enough workers are available for the given task otherwise for more new workers, lower part of the equation will be evaluated to meet the required number of workers for sensing task [34]. Algorithm for recruiting a new potential candidate as shown in Figure 4.2, in which $NS_{i,k}$ is the Set of Newly Recruited worker, C_k : PC_k is the Set of Potential candidates ,C_k : EL_k is the No. of Expected workers , TH_w is the Set of threshold for willingness of participants.

Set of newly recruited workers for the the task $DL_{t,i,k}$: $NW_{i,k} \leftarrow \emptyset$
Set of potential Candidates in C_k : PC_k
Expected Number of workers in C_k : EW_k
Threshold for Willingness: TH_w
Number of required new workers: $NAuc_{i,k} - M_k$
count ← 0
for $pc_j \in PC_k$ **do**
$ECL_n = \frac{\sum_{ck \in POI_n} CL_n(C_k, EW_k)}{|POI_n|}$ // Computing Effective Coverage level
End for
rank candidates ∈ PC_k in descending order of ECL
for $pc_j \in PC_k$ **do**
$W_j(pc_j) = 1 - \exp(-\gamma_j.(lry_j - co_j))$ // computing willingness of potential candidate
if $W_j(pc_j) > TH_w$ **then**
count ← $count + 1$
$NW_{i,k} \leftarrow NW_{i,k} \cup pc_j$
if count > $NAuc_{i,k} - M_k$ **then**
break
End if
else
continue
End if
End for
if count = $NAuc_{i,k} - M_k$ **then**
recruitment is successful
return : $NW_{i,k}$
else
recruitment failed
return ∅
End if

Figure 4.2: Algorithm for Recruiting New Potential Candidate

The first step is to check the required number of workers for performing the task, if there are not enough workers for the task completion then check the potential candidate who either belongs from the PC_k or not. Compute their Effective Coverage Level (ECL) for recruiting worker process. For this purpose, to select potential candidates give ranks to the candidates in the descending order according to their ECL. If the Willingness of the worker is greater than Threshold, then add this potential candidate to the Set of Newly Recruited Worker.

4.2.2 Reverse-Auction Process

In Reverse-auction module, the winners are announced on the basis of auctioneers' Effective Coverage Level and losers drop out on the contribution of their usefulness to the system. When the required numbers of workers recruit then the Auctioneers gives the bids for the task, the platform considers the smallest bidders but according to the Effective Coverage level of the user. System platform calculate the workers' bid by considering their ECL as given in equation (4.3) where θ is constant, b_n is the bid of the user and ECL_n is the Effective Coverage Level [34].

$$b'_n = b_n - ECL_n \,.\theta \tag{4.3}$$

Winners will be rewarded according to the DL_t difficult levels of different tasks. If the task is easy, the reward for the task RW_twill be L1 which has a basic amount BA. Basic amount assumes to be 100. If the task is less difficult, the reward for the task RW_t will be L2 which is double of basic amount 2* BA. Likewise, for the more difficult or hard task, rewards will pay. If the workers loose the task, he will likely to drop out from the system but in order to maximize the participation of the users the System Model gives inner lottery $InLry_n$ to worker u_n which is calculated according to the equation (4.4) [34].

$$InrLtry_n^r = \{InrLtry_n^{r-1} + ECL_n.\psi if u_n fails in r - 1 \quad 0 \quad else \tag{4.4}$$

where ψ is base lottery. If the Workers Return of Investment ROI is lower than a certain threshold TH_{ROI} he will be likely to drop out from the system. It will be calculated according to the equation (4.5) [34]. For Auction Process Algorithm is shown in Figure 4.3.

$$S_n^r = (e_n^r + \beta_n) \,/\, (p_n^r . co_n + \beta_n) \tag{4.5}$$

Selecting the level of task : DL_t
Set of workers for task $DL_{t,i,k}$ in the auction: $AS_{i,k}$
Initial Reward: RW_t = = BA
Basic Amount of level : BA = 100
Set of winners: Win ← θ
Set of auctioneers who are likely to drop out: Drop ← θ
Initial Threshold of ROI: TH_{ROI}
Required number of executions for task $DL_{t,i,k}$: $RN_{i,k}$
bid by auctioneer: u_n: b_n
for $u_n \in AS_{i,k}$ **do**
    $b'_n = b_n - ECL_n \, . \, \theta$
End for
rank u_n in ascending order of b'_n and add the first $RN_{i,k}$ workers to winner set
    Win
if DL_t == Easy
    RW_t = L1
    AL1= BA
else if DL_t = = Less Difficult
    RW_t = L2
    AL2= 2* BA
else if DL_t = = More Difficult
    RW_t = L3
    AL3 = 3* BA
else if DL_t = = Hard
    RW_t= L4
    AL4 = 4* BA
for $u_n \notin$ Win **do**
    give InLry_n to u_n
    $S_n^r = (e_n^r + \beta_n) \,/\, (p_n^r . co_n + \beta_n)$
    if $S_n^r < TH_{ROI}$ **then**
        Drop ← u_n ∪ Drop
    End if
End for
for $u_n \in$ Drop **do**
    $ES_n^{r+1} = (e_n^r + \phi_r + \text{InLry}_n + \beta_n) \,/\, ((p_n^r + 1) . co_n + \beta_n)$
    if $ES_n^{r+1} > TH_{ROI}$ **then**
        u_n *rejoin the system with a certain probability*
    else
        drop out finally
    end if
End for
update worker in each cell for the next round

Figure 4.3: Algorithm for Auction Process

The system keeps drop out worker through calculating the expected ROI (ES_n^r) for the (r+1) next round according to the equation (4.6) [34].

$$ES_n^r \ = \ e_n^r + \ \phi_r \ + \ InrLtry_n \ + \ \beta_n) \ / \ (\ (p_n^r + 1) \ . \ co_n + \beta_n) \qquad (4.6)$$

where ϕ_r is winner's maximum bid value for round r. If ES_n^r will greater than a certain threshold, the user u_n will rejoin the system with some specific probability.

4.2.3 Drop-Out Process

To maintaining the number of workers in the system, workers can be detained by awarding inner lottery. For this purpose, drop-out control process model is designed. The auctioneers likely to drop out from the system when the Return of Investment (ROI) is less than the Threshold value, which will be calculated by the equation (4.7) [34].

$$S_n^r = (e_n^r + \ \beta_n) / \ (P_n^r \ . co_n + \ \beta_n) \qquad (4.7)$$

where e_n^r represents the actual reward of the user in the round r, β represents the tolerance level of the user, P_n^r represents the number of participants in round r, co_n represents the minimum reward expected to give the user.

If the worker fails the task in the last round (r-1) then he will be rewarded by inner lottery which is evaluated according to the equation (4.8) where $InrLtry$ represents the inner lottery of the worker, ψ represents the base value of the lottery [34].

$$InrLtry_n^r = \{InrLtry_n^{r-1} + \ ECL_n . \psi \qquad if \ \ u_n fails \ in \ r - $$
$$1 \ 0 \qquad else \qquad (4.8)$$

The cost of the auction with respect to the platform is evaluated by the equation (4.9) where Win represents the set of winner in auction, b_n represents the bid of the user [34].

$$C_{Auc} = \sum_{u_n \in Win} \quad (b_n + InrLtry_n) \tag{4.9}$$

4.3 Summary

The IMCT System Model work is based on reverse auction process. It has three modules; Recruiting New Workers, Auction Process and Drop-out Process. Recruiting New Workers algorithm recruited potential candidate if the platform has insufficient competent workers for the task. Tasks performed by the participants depended on the level of tasks. If the task level is difficult then participants will be awarded by the higher reward and vice versa. If the participants loss the task to win then it will be dropped out by inner lottery to maintain the number of participants in the system.

CHAPTER 5

RESULTS AND ANALYSIS

5.1 Overview

In this chapter, results are compared with existing Mobile Crowdsensing Reverse Auction Incentive Mechanism schemes with the help of different graphs. In total cost, auction and recruitment cost graph the Total cost of performing task and recruitment cost will be compared with the RAB (Reverse Auction Based) incentive mechanism. The Dynamic price of total cost for performing the task will increase the interest of participants which will also show with the help of graphs.

5.2 Simulation Environment

For simulation, it has been framed according to the system model shown is Figure 3.1. ASP.Net and C# use for develop testbed by deploying WCF services on Windows Azure Cloud. A mobile application also developed for android and iPhone devices by using Xamarin. Table 5.1 explores simulation parameters.

Table 5.1: List of Parameters for Simulation

Parameter Variables	Values
Coverage Area	1000m*1000 m

Tasks Announced	100-300
No of Workers	40-80
Minimum Value QoD	0.5
Level of Task	1-4
Reward	20000-120000

5.3 Comparison with RAB Incentive Mechanism

The System Model incentive mechanism with dynamic pricing on the basis of Tasks' level compared with RAB Incentive mechanism where the cost of potential candidate is fixed without considering the level of task. In total cost, auction and recruitment cost graph the Total cost of performing task and recruitment cost will be compared with the RAB (Reverse Auction Based) incentive mechanism. The Dynamic price of total cost for performing the task will increase the interest of participants which will also show with the help of graphs.

5.3.1 Workers on the basis of level of task

In IMCT System Model ratio of recruiting workers is much more than the existing mechanism as because of level of task which incentivize the users to particpate more in performing the tasks. Figure 5.1 shows as the level of task increased the number of participants increased but in RAB No of workers are decreasing as the task becomes difficult. For example level of task is 3, no of willing particpants are 40 to 45 in RAB but in IMCT System Model number of willing participants more than 40.

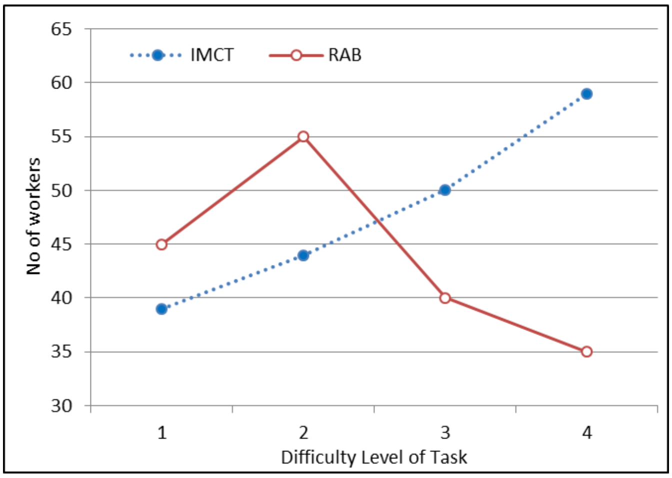

Figure 5.1: Number of workers for different Levels of Task

5.3.2 Recruiting Workers in Cell

In RAB Incentive Mechanism ratio recruiting workers is less than as compared to system model. Red squares show the No of workers recruited in each sensing cell by RAB Incentive Mechanism contrary to IMCT System Model blue triangles show the recruited workers which shows more participation of users. Figure 5.2 explores that IMCT System Model has better effect for recruiting workers on the basis of level of task. In RAB mechanism for the cell-id 30 no of workers are 20 to 30 whereas in system model for the same id No of workers is35 to 45.

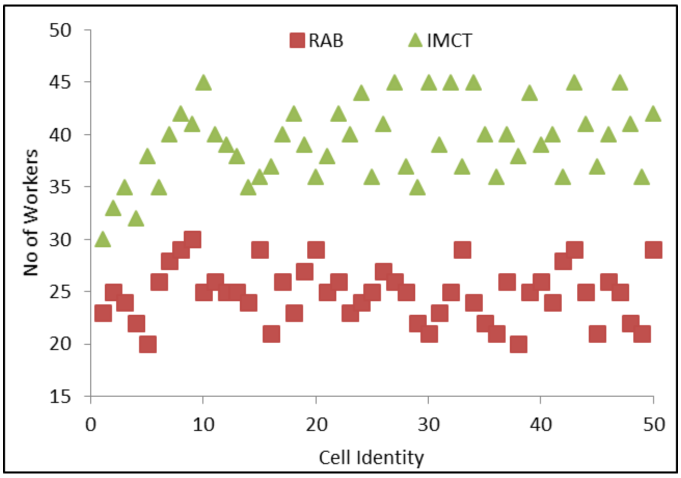

Figure 5.2: Workers in each cell

5.3.3 Rewards on the basis Level of Task

In existing mechanism, rewards for the workers are not according to the difficulty level of task. Rewards will be same for all the tasks but in the IMCT System Model, workers get their rewards according to the level of task. Figure 5.3 shows that as the level of task increases reward of workers becomes higher. When the level of task is 1 the reward for that specified task will be low as compared to other levels, it will be between the ranges of 20,000 to 25,000. But when the level of task increases its reward will be increased as level 4 tasks rewards is more than 100,000.

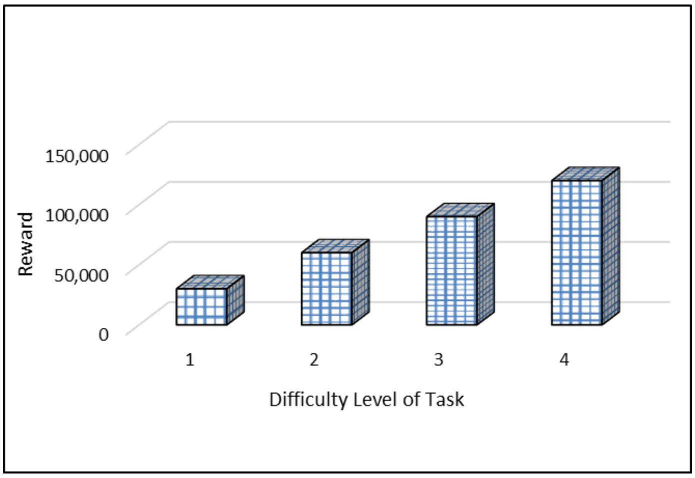

Figure 5.3: Rewards for different level of tasks

5.3.4 Estimated Budget at Different Levels of Task

In RAB estimated total cost for the task is increased slowly which may be insufficient for the complete auctioneer process but in IMCT System Model incentive mechanism estimated total budget will be increased as the level of tasks step towards higher which will be enough for the complete process as shown in Figure 5.4. For example, level of task 4 has higher estimated cost as compared to other levels. Estimated amount of budget for the level 1 is between 200,000 to 250,000 but as the level of tasks increases the total estimated amount of budget also increased level 4 estimated budget amounts is 400,000.

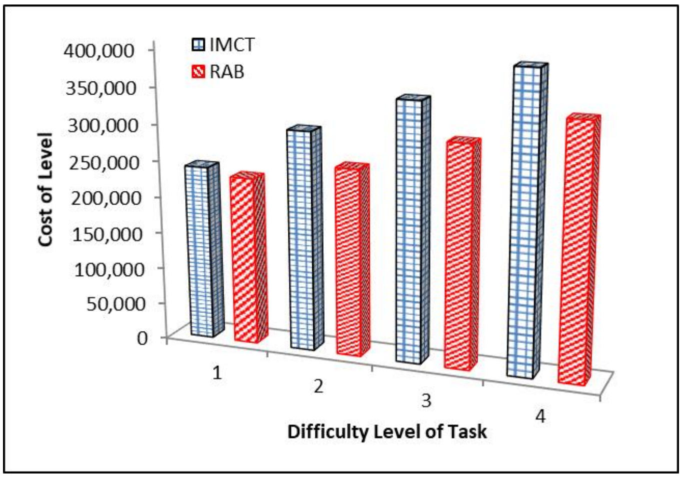

Figure 5.4: Estimated Budget

5.3.5 Ranked based on Completion of Task

IMCT System Model ranked the users on the basis their honesty and dishonesty in providing data. If the data sensed by participants is unfair or fake, system decrease the rank of users and it also create the problem to revive the user. Figure 5.5 shows that the on dispensing fair data the users ranked downward on the other hand if the users provide fake data, it decreases the rank in upward. It is assumed that for entry of each new user positioned the rank of 0.5.

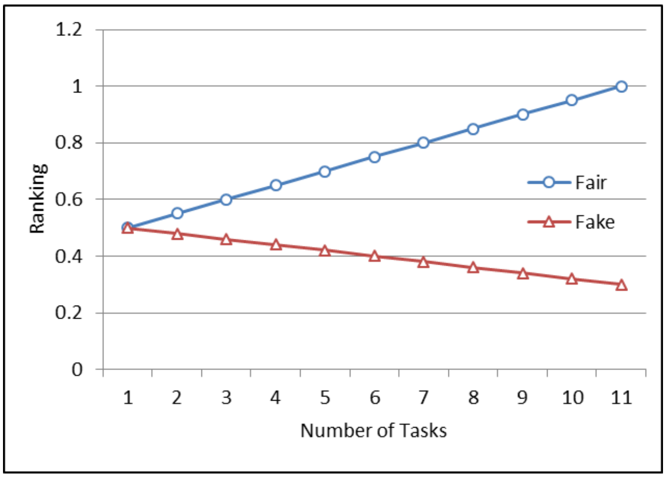

Figure 5.5: Ranked Users on the basis of providing Data

5.4 Summary

After the Simulation results compared with the RAB incentive mechanism scheme it is concluded that System Model shows better performance than the existing schemes. On the whole, it motivates the users to participate in difficult tasks as well. Different parameters are used for comparison such as Users Participation, Total cost, Estimated Budget amount, Rewards for participants and Rank of Users.

CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1 Overview

Incentive mechanism based on Reverse-Auction with Dynamic Pricing for the difficulty level of tasks in mobile crowdsensing system are presented in which the total cost of performing task is different and the potential candidate is selecting on the basis of their contribution to the system. Firstly, the auctioneer gives bids then the platform selects the lowest bidder. In this design existing workers are awarded with rewards in the form of lottery or bonus and inner lottery to the terminating workers on the basis of their contributions to the system.

6.2 Conclusion

In this research work, a reverse auction based incentive mechanism for mobile crowdsensing framework has designed to contribute different incentives to the participants. For this purpose, tasks divided into different levels on the basis of their difficulty. Existing schemes cannot facilitate the participants according to the level of tasks which results less participation for sensing the task. System model results show that the participation of users increased as the rewards based on the difficulty level of tasks. It also especially focused on the rewards of participants. If the tasks performed by users are difficult, so the rewards are according to the level and vice versa. It also

increases the quality of sensing data due to good performance of the users. The algorithm recruited new workers on the basis of their willingness and detained the participants with inner lottery, which maintains the number of participants in the system. When the rewards are based on level of tasks, users show much interest to perform difficult level of tasks. Because of such beneficiary practices, it is observed that workers performed more efficiently.

6.3 Future Work

In the future, strong efforts are required to design the ideal mechanism based on the difficulty level of task implementation for rewarding the workers on the basis of their sensing difficulty level of task. Furthermore, there is a need to focus on the coverage area of sensing data and quality of data.

6.4 Summary

In Mobile Crowdsensing system, motivating the participants for performing sensing tasks is the most important challenging factors. The examination of different features of Mobile Crowdsensing is done in depth to tackle challenge of maximizing participants. System model is based on reverse auction mechanism, will facilitate users through rewarding different incentives on the basis of their difficulty level of sensing task and ranked the users on the basis of quality of data.

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