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Mobile Offloading for Maximum Utility at Minimum Cost

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Abstract:
The new generation mobile devices appear along with an increase in cellular traffic speed. Nowadays cellular network operator's aim is to offload cellular traffic by using Wi-Fi networks. Due to the poor coverage of the present Wi-Fi networks it is difficult to satisfy both operators and mobile users. Thus to solve the poor coverage problem and also for a successful mobile data offloading Wi-Fi tethering has been introduced ,it is a way of providing Wi-Fi networks .This paper suggests a mobile tethering based cooperative network .Using this technology different users can gain certain profits after their participation in tethering activity. In the first step of our system ,each user's cellular traffic demand is allocated to other users .In order to minimize the total cellular traffic cost, which is an optimal resource allocation method, by this method tethering price can be determined to maximize the total utility of all the participated users. In simulation result we can observe the reduction of total cellular traffic cost and found various optimal tethering prices versus different traffic demands.

Key words: *Mobile Data offloading, Wi-Fi tethering, Cooperative network*

1. Introduction

The sudden increase of new generation mobile devices like tablets, Smartphone, ultra books and various other mobile devices helps in the building of different mobile networks between wireless devices through multiple network interfaces. Nowadays almost all present tablets and Smartphone have Wi-Fi interfaces and Bluetooth, most of these devices also can be connected with3G and 4G cellular networks. Some manufacturers make what they call *mobile broadband routers* that receive a 3G (or, in some instances, 4G) mobile signal and then convert it into Wi-Fi and all of Wi-Fi-enabled devices can connect to it to access the Internet.[6]This addresses two problems in different aspects. Firstly in the view of cellular network operators, very large amount of mobile data traffic will swarm into the cellular networks. Hence a proper controlling of mobile data traffic is needed. Secondly in the view of users ,a complex connectivity in different mobile networks encourages to optimize the payment plans because of increased payment charges of network usage, For example some latest and recent Smartphone can connect to 4G cellular networks, but when compared with 3G cellular networks it leads its users to pay even more. In a situation where a user is roaming abroad, his roaming data might require a very high expensive payment plan.

Among the latest different suggestions to solve these problems (*e.g.*, traffic engineering, upgrade of backhaul networks, use of advanced cellular infrastructure technologies, fine grained user traffic planning with time dependent pricing) there is a common option, mobile data offloading which is a cost effective solution to solve both the problems .Mobile data offloading is a type of complex networking technology .Its purpose is to leverage mobile data traffic over cellular networks. The most viable solution for operators to alleviate network congestion quickly, and adequately meet the capacity needs of their mobile broadband customers.[1]Latest studies show that mobile data offloading is a best and promising solution in business field and technical contexts.[2]Now the current mobile data offloading research focuses on macroscopic construction of offloading the infrastructure which needs cellular operators to invest a strong and solid amount of capital additionally. Even though mobile data offloading give users less costly alternative payment plans, but small or less coverage and poor mobility via fixed Wi-Fi solution may not satisfy the mobile users.

Also the present payment plans for Wi-Fi offloading by the cellular operators are valid only in a particular operator, without competition the given options for the users to optimize network payment plans are restricted.

Most of the present generation mobile devices are equipped with Wi-Fi network interface due to the ubiquity of Wi-Fi access points, thus due to this facility many of the mobile devices can act as a mobile access point or as a mobile hotspot in order to share internet connectivity via another network interfaces, these Wi-Fi network interfaces is mainly and primarily used to connect to access points.[4]For example, android platforms serve the function in the name of mobile tethering along with a small platform level modification ,mobile devices can use both the WiFi and cellular network interfaces simultaneously. In a locally neighboring group of mobile devices constructing a mobile tethering based cooperative network will reduce the network payments.

There is a proposed system which can minimize the cellular network traffic with the presence of a Wi-Fi access point.[3]It is also possible to constitute an ad-hoc network with many of the mobile devices even if there is no Wi-Fi access points.[3]In the cellular traffic offloading each user connects to cellular network and other users through an internal ad hoc network jointly ,but there is limitation in the situation where there is only one cellular network operator, but there can be many and different cellular or mobile network operators .In real time many cellular network operators do exist and various different network payment plans may bring out little problems in the two works. We have considered the cellular traffic prices based on the users mobile data usages. Here the users having low cellular traffic price resells mobile data to the mobile user with a high price. We have described a scheme with using multiple paths to mobile devices. [5]We have proposed a technique to improve the throughput in video streaming.

We have proposed this paper by constructing a mobile tethering cooperative network. Before the construction of the system it is necessary to collect all users information about their cellular traffic price, traffic demand and traffic capacity. Then every user's cellular traffic demand is allocated to other users as a method to minimize the total cellular cost. Based on the optimal traffic loading, the optimal tethering market price which can maximize the total utility of all the users also can be determined. So in our system all the users are both the buyers as well as the sellers of cellular data .This shows and reflects the cooperative relationship among the users in the mobile tethering based network. The current and new generation tablets and Smartphone do not allow this in order to better the battery life. Even not so complicated platform level modifications also still enables and allows developers to implement this method with commercially readymade mobile devices.

Some of the contribution of the paper is mainly summarized into three aspects as follows.

- We have provided a mobile tethering based cooperative network system which can increase the full utility of users in the system through the tethering market operations,
- We have specified systematically and also have solved the utility maximization problem in terms of resource allocation and also with regard to market price.
- We have evaluated the performance of mobile tethering based cooperative network system using numerical analysis.

2. Motivation

In this particular section we describe the importance and necessity of cooperative network system with regard to marginal profit which is generated from the tethering market. In tethering market users are divided into four groups based on the tethering market price, cellular traffic price and accessibility to the cellular network. The first group consists of users with lower cellular traffic prices when compared to tethering market price. These users gain their profits by selling their cellular traffic bandwidths in the tethering market. Second group consists of users whose cellular traffic prices are higher than the tethering market price, thus they prefer to buy other user's cellular traffic bandwidths so that they can lower their cellular traffic costs. Based on these two conditions, the profit gained by the user is proportional to differences between the user cellular traffic price and tethering market price. The third group of users is those who have identical cellular traffic prices with respect to the tethering market price. This type of users gain nothing in the market of tethering, this situation is very rare and does not cause much problem because of the metabolic nature of the tethering prices in the market with regard to inflow and outflow of users traffic .The last group of users has some Wi-Fi version's mobile devices. In the current system model this group of users also gain little profits as other users .This is done by buying cellular traffic bandwidth from the market of tethering .From the analysis all users who have participated in the tethering market gains non negative profits.[4]Power consumption and delay problems is ignored .This mobile tethering based cooperative network system is of great usage to users who are little sensitive to the cost of network traffic or in the lack of a cellular interface.

3. Cooperative Network Model

Cooperative networking is a network design strategy which is used for wireless networks .In this networking individual network nodes is able to cooperate to implement network goals in a coordinated way .They can prompt the development of advanced wireless networks to cost effectively provide multimedia services.

3.1. General Construction

Many present mobile devices have minimum two network interfaces, one is for cellular network, and another is for Wi-Fi network. Simultaneously users can participate in the tethering activity using these two interfaces .To gain profits the users can either be a buyer or a seller.

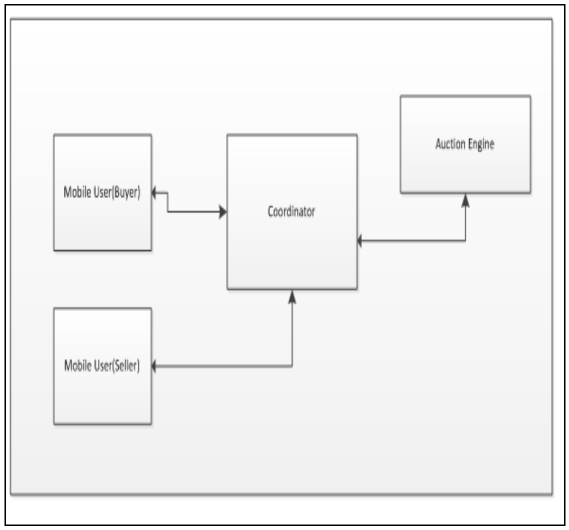

Figure 1: System Architecture

In fig1 shows, mobile tethering based cooperative network system .As the starting process every users in the cooperative network system broadcasts the information of their traffic demand, external traffic price for each unit, and traffic capacity to form a group .Every group becomes a temporary union which is the unit group of a cooperative network system .After the temporary union construction, a coordinator is chosen randomly among the users .Then that particular chosen user plays the role of a coordinator and also plays the role as a user until the end of the process. The coordinator minimizes the payment plan for the users by allocating traffic loads with broadcasted data, and also maximizes the complete utility by finding an optimal market price as the end of the process the tethering market will be closed when all traffic transaction in the market is over. This procedure is repeated until there is no presence of a user in the cooperative network system.

3.2. Design Assumptions

We have not considered the power consumption and delay cost in the tethering market in order to simplify the system model .As a limitation we only consider the constant cellular network bandwidth constraint of each user since this is considered as a restriction. No users in the tethering market will either break in or break away during a given period of tethering market time .All the users in the group follows the coordination of traffic and the tethering market price which the coordinator determined. Suppose if the user’s device is not able to connect to an external cellular network such as a WiFi versioned tablet, then we have to adjust his per unit external traffic cost as the maximum cost among all the users in the group also should set his traffic capacity to zero.

3.3. Tethering Activity

In a tethering market all the deals are done through a coordinator. For the tethering activity the tethering price is determined by the coordinator and conducts the deals in the direction of maximizing the total utility for all the users. Coordinator also plays the role of allocating every user’s traffic demand in order to minimize the total cellular traffic cost of the system by analyzing the traffic demand per unit external traffic price and also traffic capacity of each user which has been broadcasted. If the user is allocated with more traffic than their demand then the user can sell their traffic bandwidths to the coordinator, and in the opposite situation they can become the buyer.

4. Processing Flow Chart of Tethering

The flowchart of the proposed algorithm is given below

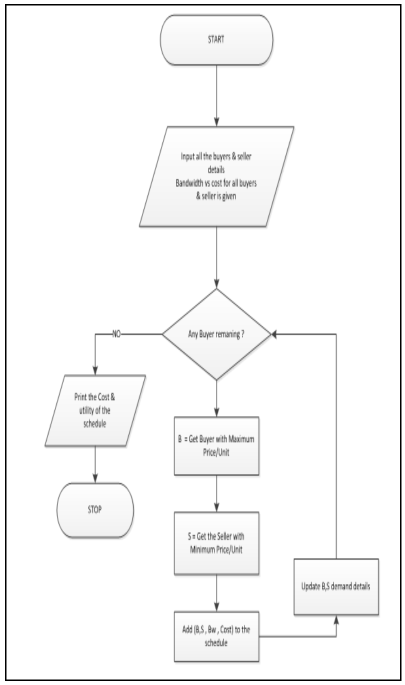

Figure 2: Flow Chart

In fig 2 we propose Max-Min algorithm for arriving at the schedule. The coordinator manages the dealings of both the buyer and the seller. Among all the buyers we select the buyer with maximum price per unit, and among all sellers we select the seller with minimum price per unit. Thus we can obtain offloading of mobile data with maximum utility and minimum cost.

5. Result Analysis

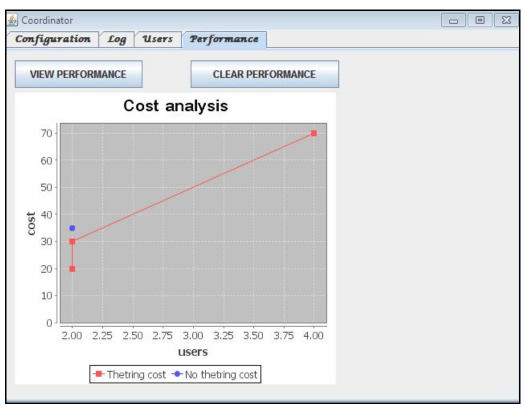

Figure 3: Performance Graph

In fig 3 shows the performance with respect to tethering and without tethering. The graph shows the cost analysis. The x axis shows the cost details, and y axis shows the user details. The effect of demand of each user is shown. We can observe that users with lower demand rarely increase the optimal price and surplus. It is because when supply is sufficiently large, higher demand increases the surplus and equilibrium price in the economic market. The impact of higher demand may reduce with respect to the number of nodes, which implies that a highly optimized cooperative network may not be optimized more though a user with higher demand and price comes to the network.

6. Conclusion

In this paper, we propose a mobile tethering-based cooperative network system that opens tethering markets where cellular traffic is being traded. There are two challenges in the tethering market: one is cost minimization of cellular networks and the other is sharing the surplus of the market, and we model the problem, as well as the utility function of a user, to solve challenges. We use mainly the tethering price as a tool for sharing surplus since per traffic profit is the difference of the tethering price and a cellular traffic price. When the tethering price maximizes the total utility of all users in the market then we optimize the tethering price. As we design the utility function as a concave function, maximizing total utility controls the situation that one user monopolizes the whole surplus of the system.

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