OPTIMIZING CELLULAR NETWORK PERFORMANCE: AN INCENTIVE-BASED FRAMEWORK FOR TRAFFIC OFFLOADING

#1BANDARI POOJITHA,
#2BIGULLA VENKATESH,
#3K.CHANDRASENA CHARY, ***Associate Professor,***
Department of Computer Science and Engineering,
SREE CHAITANYA INSTITUTE OF TECHNOLOGICAL SCIENCES, KARIMNAGAR, TS.

ABSTRACT: Wireless network congestion is increasing on 4G and other networks. Moving some mobile phone traffic to WiFi and DTNs is appealing. Cellular traffic to these networks may be latency-prone since mobile users may not always be connected. Longer wait times lower customer satisfaction. This study examines the conflict between labor outsourcing efficiency and client satisfaction. We propose a novel incentive to encourage consumers to leverage cellular networks' data delivery tolerance. Clients with a high tolerance for delays and unloading potential are prioritized, reducing dumping incentive costs. Users can participate in our incentive strategy by bidding on their maximum delay tolerance. This method can track consumers' changing delay tolerance. Additionally, we show how to employ random analysis to estimate WiFi and delay-tolerant networking (DTN) users' offloading options. Trace data-based large-scale simulations confirm our incentive model for cellular traffic management.

KEYWORDS: Traffic Offloading, Incentive-Based Framework, Monetary Rewards, Data Bonuses

1. INTRODUCTION

Cellular networks like 4G give mobile users uninterrupted Internet access. Cellular networks are straining due to exponential user growth and demand for bandwidth-intensive multimedia content. As mobile data transmission and reception has increased, cellular networks have become less effective. Additional cells in the cellular network can easily fix the concerns mentioned above. Remember that this strategy is costly and inefficient. The researchers investigated delay tolerance as a way to efficiently distribute traffic to nodes that need it. Cell phone traffic will be diverted to other networks to reduce network overload. A recent study examines the best ways to transfer cellular data loads to WiFi access points and delay-tolerant networks. This study seeks to determine cellular traffic's maximum unloading capacity. In intercepted cellular networks, data download times sometimes exceed ideal. This is because mobile users need intermittent and flexible network connections. Despite the benefits of outsourcing, cellular network data transfer delays may annoy mobile users.

A novel strategy for motivating users to indicate traffic unloading delay tolerance is presented in this study. We also examine the fundamental performance-user satisfaction tradeoff. Patients who wait for data restoration will get a lower monthly membership fee. After the delay period, the user should trust the cellular network to deliver the remaining data. At that time, some cellular data traffic will likely be redirected to the networks. An incentive program's principal goal is to lower cellular network provider incentive costs. This document describes mobile users' overall reduction for projected traffic volume. Consumer patience and waiting tolerance must be considered to achieve this. Priority should go to patient clients with several mobile traffic shift chances.

Due to the opportunity cost of discontent, patient customers choose a cheaper price at first. This study suggests utilizing a reverse auction incentive mechanism to create a pricing structure that accounts for customers' delay tolerance. This method has been carefully tested to assure fair pricing. As sellers, users must submit bids with the required discount and waiting period. The term coupon will henceforth refer to these consumer-specific savings. User latency is set by the network provider, the supplier.

Clients that dump data may handle more data faster. Users who often request popular data can lessen their workload by obtaining data fragments from peers during the delay. Visitors to cafes and other public places may benefit from unloading. Two reliable prediction models are shown for DTN and WiFi. These models explain consumer unloading.

Before choosing the best auction outcome for an offloading purpose, clients must define their maximum tolerance for lateness. The winning bidders negotiate with the network operator to establish their wait time and coupon type after an auction. Users who did not win the auction can use mobile networks at the usual fee. This study makes three unique contributions:

The reverse auction-based Win-Coupon incentive program is introduced. Users leverage their tolerance for delays to send mobile data. This framework's simplicity, autonomy in decision-making, and applicability are its strengths. This study proposes using stochastic analytic methods to evaluate outsourcing in delay-tolerant networking. User mobility and access habits are key to assessing this potential. A Semi-Markov chain architecture is used to develop a WiFi prediction model that accounts for WiFi access point spatial distribution and human mobility.

The following sections explain paper organization. Next, a complete summary of the prior work is given. This section summarizes the study's design technique and contextual elements. Section 4 stresses our incentive structure, which requires a detailed explanation. Section 5 evaluates the Win Coupon using trace-driven models, whereas Section 6 tackles research gaps. The document concludes in Section 7.

2. RELATEDWORK

Traffic rerouting via Delay-Tolerant Networks (DTNs) may prevent excessive cell phone use, according to some researchers. After establishing a reliable Delay-Tolerant Networking (DTN) connection, the operator can tell users to transfer interfaces and receive data from another peer group. Ristanovic's Mix-Zones technology is simple for cellular networks. Push-and-Track, a data management system by Whit Beck et al., uses Delay-Tolerant Networks (DTNs) to determine how many copies to send and to whom. Please outline three simple ways to use delay-tolerant networks (DTNs) to improve mobile user information delivery and reduce network congestion. Research focuses on Delay-Tolerant Networks (DTNs) information access latency. Authors examine information transmission from static and dynamic theoretical viewpoints. In recent initiatives, people have used mobile social networks to spread information. This study provides a realistic model for delay-tolerant network traffic, which advances our system. Public WiFi can block mobile phone interference. Hot Zones are created using WiFi hotspot locations and user mobility. Thus, users can only activate WiFi modules when they are sure they can connect. The researchers test public hotspots using GPS data. Lee et al. study synchronous and asynchronous WiFi offloading in mobile scenarios. Several research have predicted when WiFi technology will be commercially available to facilitate offloading strategy development. Researchers schedule mobile device data transfers during WiFi-faster times of day. The SALSA approach estimates the optimal energy-delay tradeoff for mobile devices with WiFi and cellular network interfaces using the Lyapunov framework. This study introduces a new way for accurately predicting WiFi hotspot network traffic drops while mobile users wait a defined duration.

Prior traffic discharge studies did not examine how long wait times affect customer satisfaction. Our auction-based incentive program makes it easier for others to get cellular data to encourage consumers to endure wait times. Network design has extensive auction experience. Spectrum leasing is a famously successful bidding example. Recent discussions have focused on selling wireless spectrum. A decade ago, the FCC aggressively auctioned idle radio frequencies. Data-hungry nodes have been pushed to auction their data to more willing nodes. There are no auctions to reduce cell phone traffic yet.

Earlier studies promoted Delay-Tolerant Networks (DTNs) to alleviate cellular network congestion. This study considerably expands on the prior one. The WiFi and delay-tolerant network architecture described in this study is generic. We test our model's ability to anticipate WiFi users' outsourcing behavior using trace-driven simulations. To better evaluate our methodologies, we altered the data query model to imitate a Zip code distribution. As an example. The user's text is scholarly, thus no changes are needed. Main idea of Win-Coupon.

3. OVERVIEW

TheBigPicture

This section examines Win-

Win-Coupon encourages mobile data traffic dumping using a reverse auction-like incentive system. Figure-based visual representation. The goal is to determine how X affects Y. 2 Provider networks are like businesses that give discounts to patient flow controllers in exchange for patient business. Data requests to the network provider should include bids. People that express interest in a transaction define how long they will wait and how much discount they desire for a coupon. This lets network administrators set customer latency tolerance. When choosing how to finish an auction, consider the participants' selling power. Network modeling can predict system metrics like user trends and data access patterns. This data can be used to make educated estimations about how much people can reduce their obligations. Enter the access point range or contact friends who have stored the necessary data. To u1, the cellular network will deliver the remaining data bits once the timeout runs out. Figure 1 shows u3, the penultimate bidder, obtaining base pricing information via a cellular network.

User DelayTolerance

Given that download delays decrease enjoyment, people may have a high tolerance for waiting. A satisfaction function S(t) measures consumers' adaptability to delays and falls monotonically with delay t. User willingness to wait for data service. User preferences, information requested, and other contextual factors affect satisfaction. This study hypothesizes that customers have a threshold for information waiting periods. Internet users who are unhappy may cease paying. Figure 2 illustrates the user satisfaction function S(t) using data. User patience for data retrieval is represented by tbound. The graph shows the relationship between the user's perceived data value and the service's basic charge (p), rising as waiting times grow. The delay (t1) from p to p1 diminishes the user's desire to pay. P1 represents the pleasure decrease caused by delay t1.

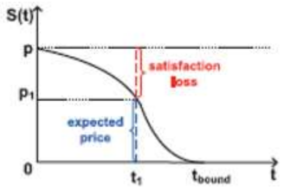

Fig.2.Satisfactionfunction.

Auctions

Academic researchers use the satisfaction function to quantify and assess people's or groups' contentment in different circumstances.

Economics often uses auctions to determine the market value of a product or service. Many businesses employ this strategy. Most auctions are forward auctions, with one seller and many bids. A reverse auction has one buyer and numerous vendors. Purchasing administrators evaluate supplier proposals and execute purchases. First, define some important words. I bid $bi on the auction item. The private price bidder I is willing to pay for resources is (xi). Only I can use this phone number. Pi represents the purchasing price in the market. Recommended cost keeps pace stable.

A bidder's utility is calculated by comparing their private evaluation of a resource (xi) to its market price (pi), including expenses. Auction participants are expected to make good decisions and limit risk. Many auctions assume bidders will behave.

To protect individual reason, auctioneers must treat everyone fairly. Intelligent auctioneers prepare strategically to improve results. A weakly dominant strategy is N, the number of possible clients:

To weakly dominate user i, ui(i, i) must be greater than ui(i, i) for every i greater than or equal to i. The current variable i is an infinite series of numbers starting with 1.

|N| represents all bidders' proposals without bidder i. Planning and insight are lacking in the strategy.

This study will discover how to use variable I in bidding scenarios. Strategy-proofness states that an auction is fair if each bidder approaches setting their price at their own private value marginally.

The auctioneers, represented by i, must adopt a strategy that offers them a slight edge over their rivals.

In academic literature, xi is abbreviated xi. Market manipulation is rare because everyone is expected to be honest. Non-aggressive bidding reduces costs. This method optimizes resource allocation by rewarding ideas that match parties' interests. Many studies have examined Vickrey Clarke-Groves (VCG) auctions because to their transparency. However, the Vickrey-Clarke-Groves (VCG) process only ensures truthfulness after identifying the optimal allocation. Combine it with approximation methods to get imperfect results. Unfortunately, Win-Coupon selection is NP-hard. Current research shows that allocation techniques must follow the monotonicity principle to justify their claims. We recommend deterministic monotone approximation to maintain data precision and reliability. This shows that the current incentive system is robust, cognitively responsive, and computationally efficient.

4. MAINAPPROACHOFWIN-CUPON

This study uses various examples to describe Win-Coupon's operations. In a Win-Coupon reverse auction, the network operator gives the winning bidder a discount for users' patience. The study includes mobile phone owners prepared to sacrifice delay tolerance for incentives. Right-hand schematic of Win-Coupon technique in Figure 1. The network operator solicits bids to determine if bidders will accept delays and dumping procedures. A price strategy and inventory distribution are then made using the data. After the auction, the system administrator notifies the winners. Tendering must be addressed first. This conversation will be about auctions. First, describe what makes a given auction procedure exceptional. This section analyzes WiFi and DTN bids' predicted offloading capacity hypothetically.

Bidding

User is still unhappy after t seconds. Given that the delay affects the user's private value, the user chooses a coupon with a value greater than or equal to p S(t) for t. For each delay t, S(k) increments the user's secret number by xk (where k is an integer greater than 1). 1) The decrease is -S(k). Figure 3 shows a customer searching for an x-priced buy.

The wait lasts x1–x2–x3 seconds. User bids are often changed. By showing that each participant bids their own private value, bk = xk for each k, we can prove the Win-Coupon auction is genuine.

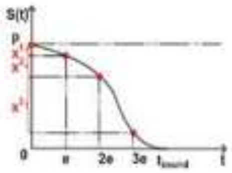

Fig.3.Privatevalue.

self-worth.Win-Coupon rounds occur in each negotiating round. Interested parties would wait too long for the auction to end. This contrasts with long-term situations like FCC spectrum leases when many individuals need cellular data connectivity at once. Because bidders are patient, auction delays may have little impact. Then we'll discuss the auction's most significant elements: the objects for bid and the bidding process.

AuctionAlgorithms

Win-Coupon rounds occur in each negotiating round. Interested parties would wait too long for the auction to end. This contrasts with long-term cases like an FCC spectrum lease, where multiple customers may need cellular data connectivity at once. Since bidders are expected to be patient, auction delays may be overlooked. Auctions have two basic parts: the object for sale and the bidding system.

Allocation

Every bidding round has a Win-Coupon round. Prospective buyers would have to wait too long to finish the auction. In contrast, long-term arrangements like the FCC spectrum lease allow many users to request mobile data access. Auction delays are often overlooked since bidders are expected to be patient. Auctions feature the object for sale and the bidding process. For each offloading goal, we explore the optimum strategy to reduce incentive cost.

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· , t|N|}

whichminimizesthetotalincentivecost,subjectt o a givenoffloadingtarget.

$$\min_{t_i} \sum_{i\in N}\sum_{k=1}^{t_i} b_i^k \quad (1)$$

$$s.t. \sum_{i\in N} V_i^{d_i}(t_i) \geq v_0 \quad (2)$$

$$\forall i,\ t_i \in \{0,1,2,\ldots,\bar{t}_i\} \quad (3)$$

Eq. (1) shows the amount the network operator must pay bidder I for the coupon.

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Perform initialization phase of algorithm 2 (lines 1–4);
ξ ← 4; θ ← 16;
δ ← ⌊min{N/ξ, θ/ξ}⌋;                         ▷ Initialize threshold δ
while |I| > 0 do
    ε ← θ/(ξ+1);
    while |I| > δ do
        Perform bidding and assignment phase of algorithm 2 (lines 9–15);
        ε ← ε · ξ;
    end while
    δ ← δ/ξ; θ ← θ · ξ;
end while
```

You may request a temporary postponement. Buyer i will tolerate delay t after receiving data set d. The equation considers this. (2) shows how much traffic can be redirected. The paper discusses DTN in Section 4.3 and WiFi in Section 4.4. Both sections detail the V di (t) forecast. We may assume that each bidder would only be interested in one set of data during a bidding round, thus we can build a one-to-one relationship between each bidder (i) and a set of data (d). Offloading target v0 must always exceed the threshold. The third equation prevents li from exceeding its tolerance. If li = 1 for every i, the distribution problem becomes the 0-1 knapsack problem. As with the 0-1 knapsack issue, ours is NP-hard. Dynamic programming determines the best approach for the new job.

Auctionalgorithm

An economic equilibrium condition like the assignment problem is provided to explain auction operations. Consider this scenario. Everyone behaved like smart businesses, and the market process allocated people and things. P represents Object j's cost. The recipient must pay this. For an item j to have value for an individual I, where j is a positive integer between 1 and n, the product of the j-th vector ai element and the j-th vector pi element must match the maximum value of the j-th vectors aij multiplied by the negative of the pi element. Thus, I want supervision of the priceless relic, ji.

All stakeholders will be satisfied if the lowest bidder wins based on the submitted offers. In this case, prices that demonstrate buyers' willingness to wait and sell for less matter. ti represents bidder i's projected delay, while fti represents the allocation procedure. Because each customer's waiting time is constant, the waiting period is always integer. Bidder loses only when ti is zero. Pricing and assignments balance if this is met. This resolves the Win-Coupon distribution issue. Economists must evaluate equilibrium assignments and pricing since they are interconnected with the assignment problem. Maximizing total benefit while addressing the assignment problem is a balanced assignment. Similarly, the values solve a dual optimization issue. The duality theorem, a basic linear programming concept, makes sense here. Check out the natural system equilibrium pathways. The approach will be called the naive auction algorithm due to a major weakness that will be explained shortly. Recognizing this flaw will generate a more reliable and full plan.

The basic auction process begins with any task and price combination and continues through iterations. A pricing list and task are set for each iteration. Once the issues are resolved, the process will finish. Someone who will be disappointed if not chosen. Imagine a person named i conducting a high-value market transaction. They encounter ji. by chance on their way.

ji maxj = 1,...,n aij - pj only if a) Ji negotiates with each player at the start of the round and b) Ji decides that the ideal item (jI) is worth the same as the second-best item at pji.

The equation i = vi + wi and the sentence pji = pji + i exist.

The formula vi=maxj aijpj indicates an item's higher worth. Also, wi=maxj6=ji aijpj represents the object's second-highest value.

Traditional reverse auction distribution is primarily based on submitted offers. The lowest bidder always wins because of this. However, bids alone indicate how long purchasers are willing to wait, so additional factors must be considered. Price-lowering providers must be assessed. Let fti be the allocation procedure and ti the network operator's delay request from bidder I. Because each customer's waiting time is constant, the waiting period is always integer. Bidder loses only when ti is zero. The Win-Coupon allocation dilemma is mathematically understandable.

Pricing

Forward transactions with a single vendor with limited financial resources employ VCG pricing.

Price matters with so many buyers. This approach encourages genuine bidding by compelling the top bidder to pay for the opportunity cost paid by the other bidders (2). The highest bidder (i) should receive a voucher under our pricing method (see reference). This coupon represents other bidders' opportunity cost for bidder I's involvement.

5. DISCUSSIONS

This study focuses on downloading, which accounts for most cellular traffic. We also analyze the Win-Coupon configuration without WiFi and DTN factors. Our architecture can handle many eventualities. Win-Coupon relies on forecasts and auction-based incentives. If the expected amount of offloaded traffic V di (t) can be estimated, the incentive mechanism can be used for coupon distribution and pricing in many cases including downloading, uploading, DTN alone, WiFi alone, or both. Only prediction changes with adjustments.

6. CONCLUSION

This paper proposes a novel incentive strategy to reduce cell traffic. This encourages mobile customers who can offload and have a high tolerance for delay to divert some of their data traffic to intermittent networks like WiFi hotspots and Delay-Tolerant Networking. In this study, we suggest a reverse auction-based incentive system to reflect consumers' dynamic delay tolerance. Our technique is valuable because of its integrity, psychological soundness, and computational simplicity. Our two powerful models predict people offloading data in Delay-Tolerant Networking (DTN) and WiFi scenarios. Detailed trace-driven simulations have proved our reward paradigm's efficacy and worth.

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