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A Novel Incentive Framework to Delay Tolerance for Mobile Traffic Offloading

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ABSTRACT

Cellular networks (e.g., 3G) are currently facing severe traffic overload problems caused by excessive traffic demands. Offloading part of the cellular traffic through other forms of networks, such as Delay Tolerant Networks (DTNs) and WiFi hotspots, is a promising solution. However, since these networks can only provide intermittent connectivity to mobile users, utilizing them for cellular traffic offloading may result in a no negligible delay. As the delay increases, the users' satisfaction decreases.

In this paper, we investigate the tradeoffs between the amount of traffic being offloaded and the users' satisfaction. We provide a novel incentive framework to motivate users to leverage their delay tolerance for cellular traffic offloading. To minimize the incentive cost given an offloading target, users with high delay tolerance and large offloading potential should be prioritized for traffic offloading.

To effectively capture the dynamic characteristics of users' delay tolerance, our incentive framework is based on reverse auction to let users proactively express their delay tolerance by submitting bids. We further illustrate how to predict the offloading potential of the users by using stochastic analysis for both DTN and WiFi cases. Extensive trace-driven simulations verify the efficiency of our incentive framework for cellular traffic offloading.

INTRODUCTION

The recent popularization of cellular networks (e.g., 3G) provides mobile users with ubiquitous Internet access. However, the explosive growth of user population and their demands for bandwidth-eager multimedia content raise big challenges to the cellular networks. A huge amount of cellular data traffic has been generated by mobile users, which exceeds the capacity of cellular network and, hence, deteriorates the network quality. To address such challenges, the most straightforward solution is to increase the capacity of cellular networks, which however is expensive and inefficient. Some researchers studied on how to select a small part of key locations to realize capacity upgrade, and shift traffic to them by exploiting user delay tolerance. Remaining the capacity of cellular networks unchanged, offloading part of cellular traffic to other coexisting networks would be another desirable and promising approach to solve the overload problem. Some recent research efforts have been focusing on offloading cellular traffic to other forms of networks, such as DTNs and WiFi hotspots and they generally focus on maximizing the amount of cellular traffic that can be offloaded. In most cases, due to user mobility, these networks available for cellular traffic offloading only provide intermittent and opportunistic network connectivity to the users, and the traffic offloading hence results in no negligible data downloading delay. In general, more offloading opportunities may appear by requesting the mobile users to wait for a longer time before actually downloading the data from the cellular networks, but this will also make the users become more impatient and, hence, reduce their satisfaction.

What is Mobile Computing?

Mobile computing is the discipline for creating an information management platform, which is free from spatial and temporal constraints. The freedom from

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these constraints allows its users to access and process desired information from anywhere in the space. The state of the user, static or mobile, does not affect the information management capability of the mobile platform. A user can continue to access and manipulate desired data while traveling on plane, in car, on ship, etc. Thus, the discipline creates an illusion that the desired data and sufficient processing power are available on the spot, where as in reality they may be located far away. Otherwise Mobile computing is a generic term used to refer to a variety of devices that allow people to access data and information from where ever they are.

Structure of mobile computing

Different types of devices used for the mobile computing:

1. Personal digital assistant/enterprise digital assistant
2. Smartphones
3. Tablet computers
4. Netbooks
5. Ultra-mobile PCs
6. Wearable computers
7. Palmtops/pocket computers

Applications of Mobile Computing:

Vehicles:

Tomorrow's cars will comprise many wireless communication systems and mobility aware applications. Music, news, road conditions, weather reports, and other broadcast information are received via digital audio broadcasting (DAB) with 1.5 M-bits/s. For personal communication, a global system for mobile communications (GSM) phone might be available offering voice and data connectivity with 384 k-bits/s. For remote areas satellite communication can be used, while the current position of the car is determined via global positioning system (GPS). Additionally, cars driving in the same area build a local ad-hoc network for fast information exchange in emergency situations or to help each other keeping a safe distance. In case of an accident, not only will the airbag be triggered, but also an emergency call to a service provider informing ambulance and police. Cars with this technology are already available. Future cars will also inform other cars about accidents via the ad hoc network to help them slow down in time, even before a driver can recognize the accident. Buses, trucks, and train are already transmitting maintenance and logistic information to their home base, which helps o improve organization (fleet management), and thus save time and money.

Emergency:

Just imagine the possibilities of an ambulance with a high quality wireless connection to a hospital. After an accident, vital information about injured persons can be sent to the hospital immediately. There, all necessary steps for this particular type of accident can be prepared or further specialists can be consulted for an early diagnosis. Furthermore, wireless networks are the only means of communication in the case of natural disasters such as hurricanes or earthquakes.

Business:

Today's typical traveling salesman needs instant access to the company's database: to ensure that the files on his or her laptop reflect the actual state, to enable the company to keep track of all activities of their traveling employees, to keep databases consistent etc., with wireless access, the laptop can be turned into a true mobile office.

Benefits of Mobile Computing:

- Improve business productivity by streamlining interaction and taking advantage of immediate access

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- Reduce business operations costs by increasing supply chain visibility, optimizing logistics and accelerating processes
- Strengthen customer relationships by creating more opportunities to connect, providing information at their fingertips when they need it most
- Gain competitive advantage by creating brand differentiation and expanding customer experience
- Increase work force effectiveness and capability by providing on-the-go access
- Improve business cycle processes by redesigning work flow to utilize mobile devices that interface with legacy applications.

EXISTING SYSTEM

Existing offloading studies have not considered the satisfaction loss of the users when a longer delay is caused by traffic offloading.

DISADVANTAGES OF EXISTING SYSTEM:

- Not considered the satisfaction loss of the users when a longer delay is caused by traffic offloading.
- Only provide intermittent and opportunistic network connectivity to the users.
- Non-negligible data downloading delay.

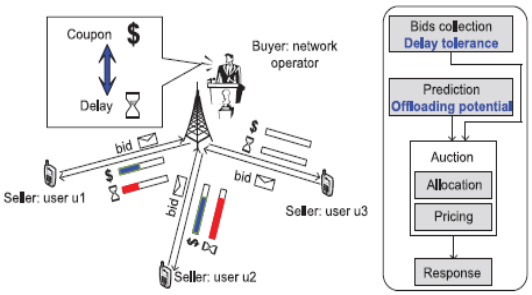
PROPOSED SYSTEM

In this paper, we focus on investigating the trade-off between the amount of traffic being offloaded and the users' satisfaction, and propose a novel incentive framework to motivate users to leverage their delay tolerance for traffic offloading. Users are provided with incentives; i.e., receiving discount for their service charge if they are willing to wait longer for data downloading. During the delay, part of the cellular data traffic may be opportunistically off-loaded to other networks mentioned above, and the user is assured to receive the remaining part of the data via cellular network when the delay period ends.

ADVANTAGES OF PROPOSED SYSTEM:

- To motivate the mobile users with high delay tolerance and large offloading potential to offload their traffic to other intermittently connected networks such as DTN or WiFi hotspots.
- To capture the dynamic characteristics of users' delay tolerance.
- To predict users' offloading potential based on their mobility patterns and the geographical distribution of WiFi hotspots in the WiFi case.

SYSTEM ARCHITECTURE:



IMPLEMENTATION MODULES:

1. Network Model.
2. Reverse auction.
3. Prediction of Offloading Potential: The DTN Case
4. Prediction of Offloading Potential: The WiFi Case

MODULE DESCRIPTION:

Network Model

In this module, focusing on offloading cellular traffic to other forms of networks, such as DTNs and WiFi hotspots and they generally focus on maximizing the amount of cellular traffic that can be offloaded.

Reverse auction

In this module, we use a novel incentive framework, Win-Coupon, based on reverse auction, to motivate users to leverage their delay tolerance for cellular traffic offloading; Auction has been widely used in

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network design. Applying auction in the spectrum leasing is one of the most practical applications. Federal Communications Commission (FCC) has already auctioned the unused spectrum in the past decade, and there are a large amount of works on wireless spectrum auctions. Moreover, auction has also been applied for designing incentive mechanism to motivate selfish nodes to forward data for others. However, none of them has applied auction techniques to cellular traffic offloading.

Prediction of Offloading Potential: The DTN Case

Mobile users can share data via DTNs by contacting each other. In urban area with higher user density, mobile users have more chances to contact other users who have their requested data. Large data requests such as video clips tend to drain most of the cellular network resource, and such requests can also tolerate some delay. By offloading them via DTNs, the payload of cellular network can be significantly reduced.

Prediction of Offloading Potential: The WiFi Case

In this module, we model node mobility by a Semi Markov Process, in which arbitrary distributed sojourn times are allowed. To avoid state space explosion, each Markov state represents a geographical area with a fixed size. The process of a user moving from a geographical area to another is modeled as a transition of Markov processes between two states.

CONCLUSION

In this paper, we proposed a novel incentive framework for cellular traffic offloading. The basic idea is to motivate the mobile users with high delay tolerance and large offloading potential to offload their traffic to other intermittently connected networks such as DTN or WiFi hotspots. To capture the dynamic characteristics of users' delay tolerance, we design an incentive mechanism based on reverse auction. Our mechanism has been proved to guarantee truthfulness, individual rationality, and low computational complexity. Moreover, we design two accurate models to predict the offloading potential of the users for both DTN and WiFi cases. Extensive tracedriven simulations validate the efficiency and practical use of our incentive framework.

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