Delay Tolerant Networks and Wi-Fi Frameworks for Cellular Traffic Offloading

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Abstract

3G Cellular networks are presently facing severe traffic overloading issue caused due to excessive traffic demands from mobile users. The existing networks can only be providing intermittent connectivity to the users. Non-negligible delay may result by utilizing them for traffic offloading. This delay will not make mobile users satisfy. Offloading part through Delay Tolerant Networks and Wi-Fi hotspots is a best suited solution. Keeping mobile users satisfaction in view, there is need to provide an incentive framework to leverage delay tolerance for cellular traffic offloading. Our study has identified that by minimizing the incentive cost, users with high delay tolerance and large offloading potential should be given higher priority. In this paper, we investigated an incentive framework which works on reverse auction in which user proactively express their delay tolerance through bids submission. We further analysed how both DTN and WiFi hotspots can predicts the offloading potential of the users.

Keywords: *Cellular Networks, Cellular Traffic Offloading, Delay Tolerant Networks, Traffic Overloading, Wi-Fi Hotpot.*

1. Introduction

Due to the revolutionary change in the technology and invention of 3G cellular networks, the mobile users are providing with ubiquitous Internet access. Moreover, an explosive growth of mobile user and their data demands raise big challenging issues to the cellular network service providers. A huge amount of data traffic has been generated by users, which exceeds the cellular networks capacity and deteriorates the quality of the network. To address such challenges, the most suitable solution is to increase the cellular networks capacity. However it found expensive and inefficient in implementation. Researchers identified how to select key locations to realize capacity up grading, and shifting traffic to them by utilizing user delay tolerance. Keeping the cellular networks capacity unchanged, and moving offloading part of traffic to other coexisting cellular networks would be another promising and desirable approach to solve the overload problem.

Cellular networks provide users with incentives in the form of discounts if they are willing to wait even longer sometimes for data downloading. During the delay, some part of the data traffic may be diverted to other networks like DTN and Wi-Fi, and the user is assured to receive the remaining unloaded data part if any via cellular network after the delay period ends. To achieve this goal, two major factors like delay tolerance and offloading potentials of the users should be taken into account. While giving priority discounts to users with large offloading and high delay tolerance.

First, with the same delay period, the users with higher delay tolerance should compensate their satisfaction loss by providing fewer discounts. We studied an incentive mechanism which works on reverse auction to conduct a justification pricing to the users facing higher delay time. In this mechanism, the users sends bids as sellers by including how much delay they are willing to experience and the compensatory discount to obtain. In this case, the cellular network operator acts as the buyer to buy the amount of delay tolerance from the users.

Second, with the same delay period, users with larger offloading potential are able to unload more data traffic. To capture the offloading potential of the users effectively, we studied two accurate prediction models to consider both users delay tolerance and offloading potential which contributes to incentive cost minimization and to give an offloading target.

In this paper, we investigated the gap between the traffic amount being offloaded and the users' satisfaction. We studied a novel incentive framework to hold their delay of tolerance for traffic offloading.

2. Preliminary Study

Researchers recently made some efforts to focus on offloading cellular traffic by diverting to other forms of interrelated networks, such as DTNs and Wi-Fi hotspots. They generally focused on maximize cellular traffic amount that can be unloaded. In many cases, due to user

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mobility, these cellular traffic networks available for offloading may only provide users intermittent and opportunistic network connectivity, and the traffic offloading results in non-negligible data downloading delay. In general, mobile users are requested to bare the waiting period for downloading data which can be compensated by discounts, But with this scenario, some users become more impatient and hence, their satisfaction is reduced.

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

- Considered the satisfaction loss of the users when a longer delay is caused by traffic unloading.
- They only provide intermittent and opportunistic network connectivity to the users.
- Non-negligible data downloading delay.

3. Present Study

In this paper, we mainly focus on investigating the balance between the traffic amount being offloaded and the satisfaction of the user. We studied a novel incentive framework to motivate users to adjust their delay tolerance in data download for traffic offloading. Users are provided with incentives like waiting period discounts based on the amount of waiting period. During the delay period, some part of the cellular data traffic may be opportunistically unloaded to other proportional networks such as DTN and Wi-Fi hotspots, and the user is assured to receive the remaining part of the data after ending the delay period. The present studied system

- Motivates the mobile users with high delay tolerance and large offloading potential for their offloading traffic to other consecutive connected networks.
- Captures the dynamic properties of users' delay tolerance.
- Predicts users' offloading potential.

3.1 Predicting User Delay Tolerance

Due to the increase of delay in downloading, the user's satisfaction decreases simultaneously, and reflects on users delay tolerance. To predict users' delay tolerance, we introduce a satisfaction function S(t), and decreasing delay function "t" to represent the price of pay for data service delay. The satisfaction function S(t) is determined by the user by himself based on his requested data, and other environmental factors.

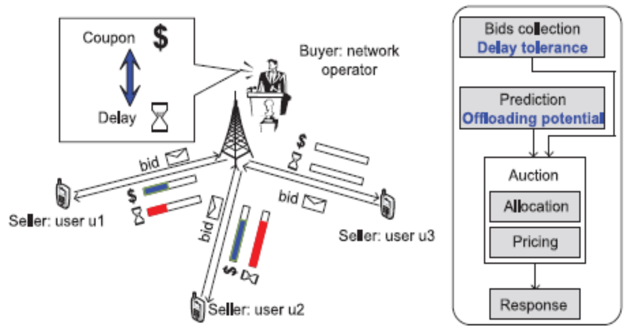

Fig. 1 Novel Incentive Framework Model

We assume that individual user has an upper bound of delay tolerance for each service. Once the delay reaches its bound, the user's satisfaction automatically becomes zero, indicating that no pay will be made to the user for the data service. Fig. 2 shows an example of this scenario of a specific user for a specific data.

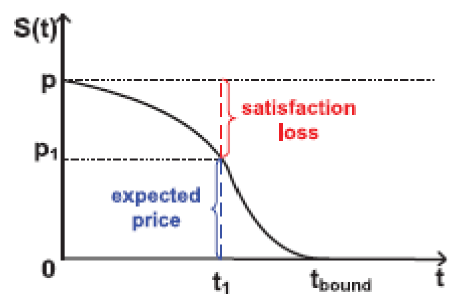

Fig. 2 Satisfaction Function S(t)

3.2 Reverse Auction Mechanism

In this section, we studied how the novel approaches are implemented to determine the amount of delay tolerance has been experienced and the compensatory discounts to the given by the help of algorithms.

Algorithm 1: Win-coupon-Allocation $(\mathcal{N}, \mathcal{B})$

for $v = 0$ *to* $\hat{v}_0$ **do**
  $\mathcal{T}^v_{\mathcal{B}_1} = \{T^v_1\}$;
  $\mathcal{C}^v_{\mathcal{B}_1} = C^v_1$;
for $i = 2$ *to* $|\mathcal{N}|$ **do**
  for $v = 0$ *to* $\hat{v}_0$ **do**
    $s* = arg\min_{s \in [0,v]} \{\mathcal{C}^s_{\mathcal{B}_{i-1}} + C^{v-s}_i\}$;
    $\mathcal{T}^v_{\mathcal{B}_i} = \mathcal{T}^{s*}_{\mathcal{B}_{i-1}} \cup \{T^{v-s*}_i\}$;
    $\mathcal{C}^v_{\mathcal{B}_i} = \mathcal{C}^{s*}_{\mathcal{B}_{i-1}} + C^{v-s*}_i$;
return $\mathcal{T}^{\hat{v}_0}_{\mathcal{B}}, \mathcal{C}^{\hat{v}_0}_{\mathcal{B}}$;

Algorithm 2: Win-coupon-Pricing $(\mathcal{N}, \mathcal{B}, \mathcal{T}_{\mathcal{B}}^{\hat{v}_0}, \mathcal{C}_{\mathcal{B}}^{\hat{v}_0})$

for $i = 1$ *to* $|\mathcal{N}|$ **do**
  if *i is the winning bidder* **then**
    Win-Coupon-Allocation$(\mathcal{N} \setminus \{i\}, \mathcal{B} \setminus \{\mathbf{b}_i\})$;
    $p_i = \mathcal{C}_{\mathcal{B}\setminus\{\mathbf{b}_i\}}^{\hat{v}_0} - (\mathcal{C}_{\mathcal{B}}^{\hat{v}_0} - \sum_{k=1}^{t_i} b_i^k)$;
  else
    $p_i = 0$;
return p_i, *for all i*;

3.3 Prediction of Offloading in DTN Case

By motivating users to wait while providing data services for some time, part of the cellular traffic can be offloaded to other intermediate alternative available networks. Delay Tolerance Network (DTN) coexists generally with cellular networks, and does not rely on any cellular network infrastructure. Mobile users can share data via these DTNs by contacting with each other. In certain areas with higher mobile user density, users have many chances to contact with other users with their requested data. Large data service requests such as multimedia clips leads to consume most of the cellular network resources, and sometimes such requests can also tolerate delay. By offloading them through this network, the cellular network payload can be reduced significantly.

Due to high mobility of nodes, large data items are somewhat hard to complete transmission when two nodes contact together. During our study it has been proven that the Random Linear Network Coding techniques can improve significantly the data transmission efficiency, in situations when there is limited transmission bandwidth. This RLNC model is adopted to encode the original data into a group of coded packets. As long as the requester collects enough number of linearly independent coded packets if any of its requested data, then the data can be reconstructed. Besides, when the requested data item is very large, multi-generation network coding is adopted in general. To balance the data transmission efficiency, the transmission cost and the computational, to decide the generation size and to schedule their transmissions should need to be carefully considered.

3.4 Prediction of Offloading in Wi-Fi Case

Similar to the DTN case, mobile users are motivated to wait for certain time, so that part of their cellular network traffic may be redirected to WiFi hotspots when they contact some Wi-Fi networks. In few areas with wide deployment of Wi-Fi networks, offloading can significantly mitigate the problem of network overload.

Most of the mobile users have same commute path regularly, and thus we can use Markov model to formulate their mobility. Due to high node mobility, we even consider the limits of contact duration in the Wi-Fi case. It means large data items in a Wi-Fi hotspot may not be completely downloaded during nodes contacts. To estimate the offloading potential, it is necessary to consider both transient and steady behavior of node mobility.

3.5 Performance Evaluation

In this section, we investigated the evaluation process of Win-Coupon performance through trace-driven simulations for both Delay Tolerant Networks and WiFi cases. For each case, we considered first the simulation setup, and then performance evaluation of compensatory discounts under various system parameters. In the evaluation, the performance metrics such as total amount of offloading traffic, total incentive cost in terms of allocated coupon and average downloading delay time waited by the bidder are used.

4. Conclusion

In this paper, we studied a best suited novel incentive framework and can be implemented for cellular traffic offloading. The most basic intension is to motivate the network users facing high delay tolerance and large offloading potential to unload their traffic to other related intermittently connected networks like DTN or WiFi hotspots. We studied an incentive mechanism which works on reverse auction to capture the dynamic characteristics of users' delay tolerance. Our research has been proven that these mechanisms can guarantee truthfulness, low computational complexity and individual rationality. Moreover, we studied two accurate design models to predict the users offloading potential for both DTN and WiFi cases.

References

[1] Xuejun Zhuo, Wei Gao, Guohong Cao, and Sha Hua, "An Incentive Framework for Cellular Traffic Offloading", IEEE TRANSACTIONS ON MOBILE COMPUTING, VOL. 13, NO. 3, MARCH 2014.

[2] W. Gao, Q. Li, B. Zhao, and G. Cao, "Multicasting in Delay Tolerant Networks: A Social Network Perspective," Proc. ACM MobiHoc, 2009.

[3] A.J. Nicholson and B.D. Noble, "Breadcrumbs: Forecasting Mobile Connectivity," Proc. ACM MobiCom, 2008.

[4] M.R. Ra, J. Paek, A.B. Sharma, R. Govindan, M.H. Krieger, and M.J. Neely, "Energy-Delay Tradeoffs in Smartphone Applications," Proc. ACM MobiSys, 2010.
[5] P. Cramton, "Spectrum Auctions," Handbook of Telecommunications Economics, pp. 605-639, Elsevier Science, 2002.
[6] P. Xu, S. Wang, and X. Li, "SALSA: Strategyproof Online Spectrum Admissions for Wireless Networks," IEEE Trans. Computers, vol. 59, no. 12, pp. 1691-1702, Dec. 2010.
[7] X. Zhou, S. Gandhi, S. Suri, and H. Zheng, "Ebay in the Sky: Strategy-Proof Wireless Spectrum Auctions," Proc. ACM MobiCom, 2008.
[8] M. Reardon, "Cisco Predicts Wireless-Data Explosion," http://news.cnet.com/8301-30686_3-10449758-266.html, 2013.
[9] I. Trestian, S. Ranjan, A. Kuzmanovic, and A. Nucci, "Taming the Mobile Data Deluge with Drop Zones," IEEE/ACM Trans. Networking, vol. 20, no. 4, pp. 1010-1023, Aug. 2012.
[10] B. Han, P. Hui, V. Kumar, M. Marathe, J. Shao, and A. Srinivasan, "Mobile Data Offloading through Opportunistic Communications and Social Participation," IEEE Trans. Mobile Computing, vol. 11, no. 5, pp. 821-834, May 2012.
[11] K. Lee, I. Rhee, J. Lee, S. Chong, and Y. Yi, "Mobile Data Offloading: How Much Can WiFi Deliver?" Proc. ACM Sixth Int'l Conf. Emerging Networking Experiments and Technologies (CoNEXT), 2010.
[12] A. Balasubramanian, R. Mahajan, and A. Venkataramani, "Augmenting Mobile 3G Using WiFi," Proc. ACM MobiSys, 2010.
[13] N. Ristanovic, J.-Y.L. Boudec, A. Chaintreau, and V. Erramilli, "Energy Efficient Offloading of 3G Networks," Proc. IEEE Eighth Int'l Conf. Mobile Ad-Hoc and Sensor Systems (MASS), 2011.
[14] J. Whitbeck, Y. Lopez, J. Leguay, V. Conan, and M.D. Amorim, "Relieving the Wireless Infrastructure: When Opportunistic Networks Meet Guaranteed Delays," Proc. IEEE Int'l Symp. a World of Wireless, Mobile and Multimedia Networks (WoWMoM), 2011.
[15] C. Boldrini, M. Conti, and A. Passarella, "Modelling Data Dissemination in Opportunistic Networks," Proc. ACM Third Workshop Challenged Networks (CHANTS), 2008.
[16] P. Costa, C. Mascolo, M. Musolesi, and G. Picco, "Socially Aware Routing for Publish Subscribe in Delay-Tolerant Mobile Ad Hoc Networks," IEEE J. Selected Areas in Comm., vol. 26, no. 5, pp. 748- 760, June 2008.
[17] L. Anderegg and S. Eidenbenz, "Ad Hoc-VCG: A Truthful and Cost-Efficient Routing Protocol for Mobile Ad Hoc Networks with Selfish Agents," Proc. ACM MobiCom, 2003.
[18] W. Wang, X. Li, and Y. Wang, "Truthful Multicast in Selfish Wireless Networks," Proc. ACM MobiCom, 2004.
[19] X. Zhuo, W. Gao, G. Cao, and Y. Dai, "Win-Coupon: An Incentive Framework for 3G Traffic Offloading," Proc. IEEE Int'l Conf. Network Protocols (ICNP), 2011.
[20] D.P. Bertsekas, D.A. Castanon, and H. Tsaknakis, "Reverse Auction and the Solution of Inequality Constraned Assignment Problems," SIAM J. Optimization, vol. 3, pp. 268-299, 1993.
[21] W. Vickrey, "Counterspeculation, Auction and Competitive Sealed Tenders," J. Finance, vol. 16, pp. 8-37, 1961.