An Effective Algorithm for Interest Aware Opportunistic Advertising by Mining Social and Consuming Information

Chia-Yu Lin*, Zhi-Feng Jiang†, Li-Chun Wang*, Bao-Shuh Paul Lin†
*Department of Electrical and Computer Engineering, National Chiao Tung University, Hsinchu, Taiwan
E-mail: sallylin0121@gmail.com, lichun@g2.nctu.edu.tw
†Department of Computer Science, National Chiao Tung University, Hsinchu, Taiwan
E-mail: gladiatorzf@gmail.com, bplin@mail.nctu.edu.tw

***Abstract*—Advertisements and coupon forwarding among mobile devices and social platforms become significant in recent years. However, when users are in the crowded places where the network connection is unstable such as shopping malls, forwarding of advertisements to target users in limited time is challenge. Thus, we propose an interest-aware opportunistic advertising by mining social and consuming information system (ISC) and algorithm. In ISC system, we combine social relationship and consuming information to find out the consumers who have similar interest. ISC algorithm adopts the result of ISC system to reduce the delay of broadcasting advertisement and increase the advertisement effect. We also implement and evaluate the performance of ISC system and algorithm on mobile devices and the ONE simulator. Our experiment results show that ISC algorithm is cost effective and intensively magnify the advertising effeteness with many customers under uncertain network and time-limited environments.**

***Keywords*-opportunistic advertising, social and consuming information, data mining**

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I. INTRODUCTION

Advertisements are ubiquitous in our life. Owing to the rise of smartphones and social platforms, advertisements and coupon forwarding among mobile devices and social platforms become significant. [1]–[3] integrate and implement advertising on mobile and social platforms. However, these research assume the targeted users are constantly connect to the network and the advertisements forwarding are not time sensitive. This assumption are not suitable for the crowded places where the network connection is unstable such as shopping malls or train stations. Especially in shopping malls, the advertisements should be received by the target consumers to increase the desire of consumption before they leave malls.

Opportunistic networking technique is an attractive option to forward message under intermittently connected network. In addition, socially-related people tend to be co-located quite regularly. Thus, [4]–[7] use social information such as the users social rank and social interaction on opportunistic networking environment to reduce the forwarding cost to reach a single or group destinations. In these research, high computation, storage capacities as well as the full cooperation of forwarding nodes are needed and the performance are not good during increasing number of users. Therefore, [8] propose IPeR, a fully distributed interest aware social-based algorithm to enable soft real-time opportunistic advertisement delivery in mobile networks. The similarity of user interest and advertisement specialization interest is computed and is used to magnify a nodes social rank if a given node and its friends are interested in a given message or advertisement. IPeR is unnecessary full cooperation of forwarding nodes and enhance the scalability owing to the distributed computation of each node.

However, the computation complexity of IPeR is $O(n^3)$, which is heavy load for mobile devices. Besides, according to [9] and [10], the social and consuming information such as the products which consumers have bought and the shops which consumers are interested should be integrated to precisely find out consumers' interest. In IPeR, the authors cannot precisely find out the potentially interested consumers and cannot magnify the effect of advertisement by only considering social data. Therefore, we propose an interest-aware opportunistic advertising by mining social and consuming information system (ISC) and algorithm. In ISC system, we combine social relationship and consumer information to find out the consumers who have similar interest. The similar consumers will be the possible propagators of advertisements.

We design four components in ISC system. Data collector collects consumers' information and shops' information. Attribute layer defines the attributes of every shop. Social layer connects the friends of consumers and compare the similarity of consumer behavior. Shop layer computes the relation between shops and use shops' information to find the similarity of consumer behavior. We not only develop four components but also propose ISC algorithm, which is a fully distributed interest-aware forwarding algorithm by mining social and consuming information. ISC algorithms can reduce the cost of broadcasting advertisement and increase the advertisement effect. From the experiments, we can see that the ISC algorithm is not only more light-weight and more suitable for mobile devices than IPeR but also achieve greater advertisement effect and spend four times delay time less than IPeR to deliver advertisements to target customers.

The rest of the paper is organized as follows. Section II describes related works for social-based forwarding algorithm in the opportunistic networking. Section III details

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the proposed interest-aware opportunistic advertising by mining social and consuming information system (ISC) and algorithm. Section IV shows the experiment result of ISC algorithm on mobile devices and the ONE simulator. We give our concluding remarks in Section V.

II. Related Work

Many social-based forwarding algorithms are proposed in the opportunistic networking community targeted towards specific destinations or towards general profile matches. PeopleRank [4], HiBOp [11], BubbleRap [6] and SimBet [5] were the social-based forwarding algorithm which were targeting specific destinations. But these algorithms exchange context information periodically and produce high network overhead [12]. Thus, IPeR [8], which is a fully distributed interest-aware forwarding algorithm are proposed. IPeR reduced the overall cost and delay by reducing the number of contacted uninterested candidates. The authors designed IPeR to deliver advertisements to potentially interested consumers within a given proximity and within a specified short-duration, whether these consumers were connected to the network or not. The authors collected users' social profiles, and integrated it with social-based opportunistic forwarding algorithms. However, the computation complexity of IPeR is $O(n^3)$, which is not suitable for mobile devices and the social data are not enough to find out the potentially interested consumers.

In the market-based recommendation system, [9] and [10] not only used social but also consuming information to find out consumers' interest and recommend products. [13] and [14] used users' consuming information to predict users' navigation patterns and preference in E-commerce. From previous research, we can know that combining social and consuming information can analyze consumers' consuming pattern and interest more accurately. Therefore, we propose an interest-aware opportunistic advertising by mining social and consuming information system (ISC) and algorithm to find out the potentially interested consumers as the relay users in the opportunistic advertising network. ISC can not only find the most suitable relay users to increase the advertising effectiveness but also make the computation complexity be $O(n^2)$. ISC executes efficiently for mobile devices.

III. System Design

In this section, we introduce the proposed interest-aware opportunistic advertising by mining social and consuming information system (ISC) and algorithm. Fig. 1 shows the system architecture of ISC. There are four components in ISC system. The input data includes consumers' information and shops' information will be collected by data collector. Attribute layer defines the attributes of every shop. The attributes of shops will be the input of social layer. Social layer shows the consumers' friend lists and compare the similarity of consumer behavior. Shop layer computes the relation between shops and use shop information to find the similarity of consumer behavior. The detail of every layer is described as followed.

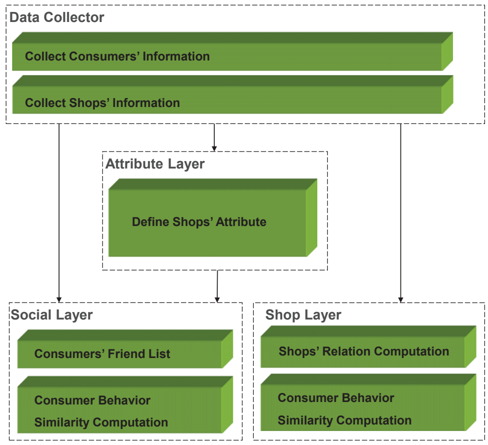

Figure 1. The system architecture of ISC.

A. Attribute Layer

Attribute layer defines the attributes of shops. There are A kind of attributes. Every shop can have more than one attributes $a_i \in A$. For example, the attributes of 'McDonald' are "restaurant," "coffee shop" and "fast-food." The attributes of shops are the input of social layer.

B. Social Layer

In social layer, we can get the consumers' social friend lists and compare the consuming behavior with their friends. There are two steps in the consumer behavior similarity computation. First, we use tables which are called consuming attribute table to collect the attributes of shops which the consumer has been spent money in. Table I is the example of the arrays. The column shows the list of consumers. The row presents the attribute of shops. For example, the consumer has been shop A. The attributes of shop A are "a_1, a_2, a_4". The value in the field of a_1, a_2, a_4 will plus one. Thus, we can get a value list corresponding to every shop attribute for every consumer. Second, we compute the cosine similarity (Equation 1) of attribute lists to compare the consuming behavior similarity between the consumer and their friends. If the result value is close to 1, it means the consuming behavior of two consumers are similar. After the cosine similarity computation, the result value will be multiplied by a weight value which presents the relation degree between two consumers in the social network since we believe that friends have some influence on consuming decision. For example, when you are hesitant to buy a product, some friends give you recommendation of this product. Then, you may decide to buy it. This is social effect on consuming behavior.

$$cos(User_1, User_2) = \frac{(User_1 \bullet User_2)}{|User_1||User_2|} \tag{1}$$

C. Shop Layer

In the shop layer, we want to find out the relation between shops and use this kind of relationship to compare consumers' consuming behavior. There are two steps

Table I
THE EXAMPLE OF CONSUMING TABLE

Consumers	a_1	a_2	a_3	a_4	...	a_A
Consumer 1	1	1	0	1	...	0
Consumer 2	0	0	1	1	...	1

Table II
THE EXAMPLE OF SHOP SET TABLE

Consumers	S_1	S_2	S_3	S_4
Consumer 1	3	1	2	2

computation. First, we use frequent pattern growth (FP-Growth), which is a famous data mining algorithm to analyze the association rules of data to find out the relation between shops and we put the relative shops in the same set S_i. We define S kind of sets. $S_i \in S$. Every shop is not limited to one set. Second, we use tables which is called shop set table to classify the shops which the consumer has been spent money in. l_i represents every shop. For example, a customer has spent money in shop $l_1, l_2, l_4, l_7, l_8, l_{10}$. Then, we use FP-Growth to find out the sets of shops. $S_1 = l_1, l_4, l_7$,$S_2 = l_2, l_3$,$S_3 = l_4, l_7$,$S_4 = l_8, l_{10}$. After we find out the relation of shops, we can match customers' consuming information with these shop sets and fill in Table II. S_1 includes shop l_1, l_4, l_7, and consumer 1 has been to shop l_1, l_4, l_7. Thus, the value of S_1 is 3. Similarly, S_2 includes Shop l_2, l_3, and consumer 1 hasn't been to shop l_3. Therefore, the value of S_2 is 1.

After the computation of attribute, social and shop layer, Table I and II are stored at every consumer's smartphone. ISC algorithm will use these two tables to compute the social and consuming similarity between customers and choose the advertising forwarding mechanism.

D. ISC algorithm

Fig. 2 shows ISC algorithm, which is a fully distributed interest-aware forwarding algorithm. We use ISC algorithms to reduce the cost of broadcasting advertisement and increase the advertisement effect. There are three processes to decide how to broadcast advertisement to nearby consumers with mobile devices.

First, we check the number of nearby customers. If there are too few customers, we broadcast the advertisement to avoid the advertisement losing by insufficient advertisement propagators. Otherwise, we execute the second process. According to [5], customers who have same interest usually get together. Thus, we will find out the number of nearby customers who are interested in the advertisement in the second process. If the interested customers are more than β, we can send the advertisement to interested customers. If the interested customers are fewer than β, we execute the third process. In the third process, we want to find more possible interested customers to forward advertisements. Thus, we use Equation 1 and Table I and II of every customers to compute the interest and shopping behavior similarity of the current propagator and nearby customers. If we can find out sufficient similar customers, we forward the advertisement to similar customers. Otherwise, we broadcast the advertisement. By ISC algorithm, we can improve the effect of advertisement by forwarding the advertisement to interested customers and decrease the cost of forwarding the advertisement at the same time.

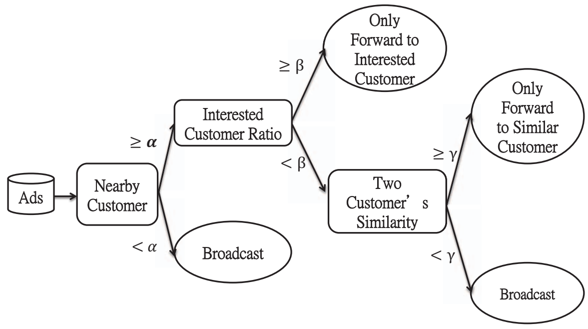

Figure 2. The ISC algorithm.

Table III
SIMULATION ENVIRONMENT PARAMETERS

Parameters	Nominal Value	Range
No. of customers	25-175	20-300
No. of Advertisements	1-10	1-10
Set of Interests	0-9	0-10
Alpha	0.1	0-1
Beta	0.6	0-1
Gama	0.6	0-1
Interest-People Threshold	0.5	0-1
Wireless Range	10-100 m	10-100 m

IV. EXPERIMENT RESULT

In this section we implement ISC algorithm on mobile devices and the ONE simulator [15] to compare computation time, hop count and delay time of sending advertisements, etc with IPeR algorithm [8]. Mobile devices includes Android emulator and HTC Desire.

A. Environment Setup and Parameters

To compare the performance with IPeR, we set most of the environment parameters same with IPeR. The ONE simulator [15] simulates a mall environment. The range of the mall is 1000m x 1000m. Random source nodes generate random distributed advertisements to simulate advertisements forwarding to target customers. In addition, we use the Random Waypoint model (RWP) to simulate people walk in shopping malls.

We simulate many cases. The number of customers is 25 to 175, and 1 to 10 advertisements with 10 attributes will be sent. We also assume customers spend one hour shopping in the mall. Table III lists parameters we used in the ISC algorithm.

The mobile wireless range is 100m. Per square-meters population-density is more than average density. That is, there are many people here. Thus, we set the alpha value to 0.1. In order to judge whether there are lots of peoples walking around, we set beta and gama to 0.6. We generate random social profiles to each user and construct 20% covered friendship social graph.

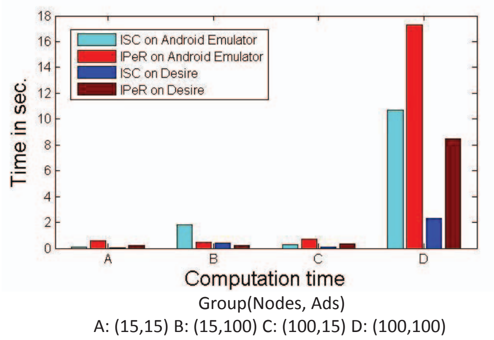

Figure 3. The computation time of ISC and IPeR on Android emulator and HTC Desire.

B. Evaluation Metrics

The goal of ISC algorithm is for advertisers to opportunistically reach the most relevant/interested users in the limited time and increase the advertisement effect. This goal should be attained while minimizing the overall cost, especially for users not interested in the advertisements. To evaluate the effectiveness of delivering on time advertisement within a shopping mall or train station, or an airport, we use the following metrics to measure the performance of ISC algorithm and compare with IPeR algorithm.

Computation Time: We measure the computation time of advertisement forwarding algorithms on Android emulator and HTC Desire. When the computation time is shorter, the algorithm is more light-weight for smartphones.

Hop count: We record the number of intermediate nodes of forwarding advertisements to target customers. The larger number of intermediate nodes represents more interested customers receive the advertisements. The effect of advertisements is larger.

Delay: We measure the time of forwarding advertisements to target customers. We assume customers spend one hour in the mall so we have 3600 seconds to forward advertisements. If the advertisements are not receive by target customers, the delay time is 3600 seconds.

C. Experiment 1

We implement ISC and IPeR algorithm on mobile devices include Android emulator and HTC desire. We have four cases in this experiment. In case A, there are 15 customers and we deliver 15 advertisements. In case B, we increase the number of sending advertisements. we send 100 advertisements. In case C, we increase the total number of customers to 100. In case D, there are 100 customers and we send 100 advertisements. Fig. 3 shows the computation time of ISC and IPeR of 4 cases. When there are many customers and many advertisements are sent, the computation time of IPeR is longer than ISC on Android emulator. In HTC Desire, the computation time of IPeR is four times as long as the computation time of ISC. In this experiment, we can find out that the complexity of ISC is much less than IPeR. That is, ISC is much light-weight and suitable for mobile devices.

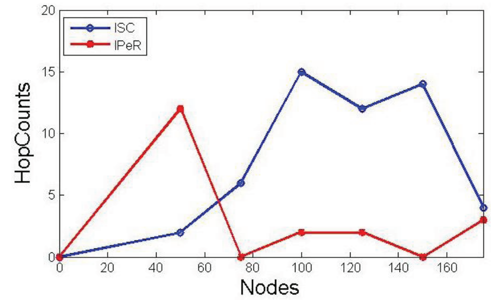

Figure 4. The hop count of ISC and IPeR by sending one advertisements.

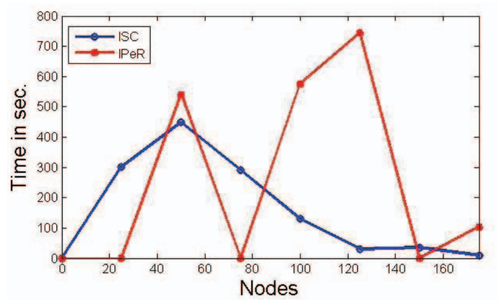

Figure 5. The delay time of ISC and IPeR by sending one advertisements.

D. Experiment 2

We not only implement ISC and IPeR on mobile device, but also simulate the ISC on the ONE simulator, which is the simulator for delay-tolerant networking (DTN) protocol evaluation. We have two cases in this experiment. In case A, we send only one advertisement to one target customer. In Fig. 4, we can see that the ISC can finds more interested customers. The more interested customers forward the advertisement, the greater effect of the advertisement. Also, we can find out that while the number of customers are increasing, the hop count of IPeR is zero. The zero value represents IPeR cannot deliver the advertisement to the target customer. Besides, few numbers of customers will cause the data non-valuable because of data sparsity. Therefore, the hop count of IPeR may higher than ISC. Fig. 5 shows the delay time of ISC and IPeR. We can see that the delay time of ISC is under 500 seconds and the delay time of IPeR is up to 3600 seconds in many situations. That is, IPeR cannot sends the advertisement to the target customer in many situations. Thus, ISC can not only finds more possible interested customers to forward the advertisement and intensively increase the effect of the advertisement but also spend less time to deliver the advertisement to the target customer.

In case B, we send ten advertisements to ten target customers. In Fig. 6, the hop count of ISC algorithm still much higher than IPeR. Fig. 7 shows that the delay time of sending ten advertisements. We can find out that while sending more advertisements, the delay time of IPeR is shorter than sending one advertisements. But the overall delay time of IPeR is still higher than ISC. When more

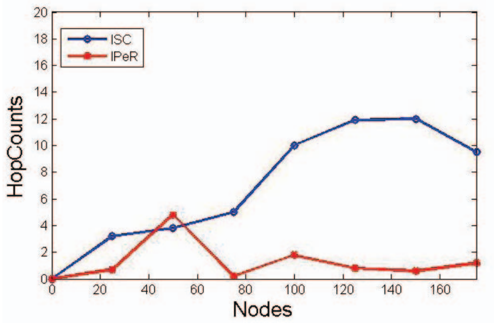

Figure 6. The hop count of ISC and IPeR by sending ten advertisements.

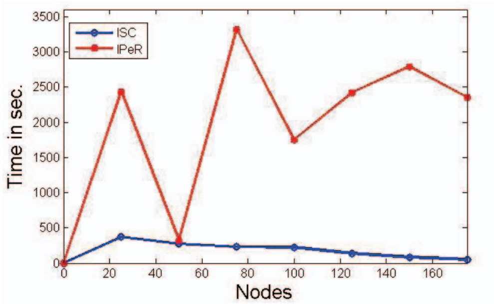

Figure 7. The delay time comparison of ISC and IPeR by sending ten advertisements.

advertisements are sent, ISC algorithm still can maintain greater effect of advertisements than IPeR. From two experiment results, we can obtain that ISC algorithm is more light-weight, spending less time and creating greater advertisements effect than IPeR algorithm.

V. Conclusion

In this paper, we proposed interest-aware opportunistic advertising system and algorithm (ISC) algorithm, which combined social and consuming information to find interested users efficiently and forward advertisements under uncertain network and time-limited environments. ISC system included three layers. Attribute layer defined shop attributes. Social layer considered the social impact of friends during shopping. Shop layer found out the relation between shops. The proposed three layers could find out customers who have interest to advertisements. ISC algorithm adopted the result of ISC system to reduce the delay of broadcasting advertisement and magnify the advertising effeteness. We also implemented ISC system and algorithm on smartphones and the ONE simulator to evaluate the performance. The experiment results showed that ISC is light-weight, suitable for mobile devices, increasing advertisement effect and spending less delay time to deliver advertisements. For future work, we plan to display our system on real shopping malls. We hope ISC can actually help stores increase the business benefit.

References

[1] E. D. Spiegler, C. Hildebrand, and F. Michahelles, "Social networks in pervasive advertising and shopping," in *Pervasive Advertising*. Springer, 2011, pp. 207–225.

[2] H. Haddadi, P. Hui, T. Henderson, and I. Brown, "Targeted advertising on the handset: Privacy and security challenges," in *Pervasive Advertising*. Springer, 2011, pp. 119–137.

[3] J. Wais and E. Clemons, "Understanding and implementing mobile social advertising," *International Journal of Mobile Marketing*, vol. 3, no. 1, pp. 12–18, 2008.

[4] A. Mtibaa, M. May, and M. Ammar, "Social forwarding in mobile opportunistic networks: A case of peoplerank," in *Handbook of Optimization in Complex Networks*. Springer, 2012, pp. 387–425.

[5] E. M. Daly and M. Haahr, "Social network analysis for routing in disconnected delay-tolerant manets," in *Proceedings of the 8th ACM international symposium on Mobile ad hoc networking and computing*. ACM, 2007, pp. 32–40.

[6] P. Hui, J. Crowcroft, and E. Yoneki, "Bubble rap: Social-based forwarding in delay-tolerant networks," *Mobile Computing, IEEE Transactions on*, vol. 10, no. 11, pp. 1576–1589, 2011.

[7] P. Costa, C. Mascolo, M. Musolesi, and G. P. Picco, "Socially-aware routing for publish-subscribe in delay-tolerant mobile ad hoc networks," *Selected Areas in Communications, IEEE Journal on*, vol. 26, no. 5, pp. 748–760, 2008.

[8] S. Al Ayyat, K. A. Harras, and S. G. Aly, "Interest aware peoplerank: Towards effective social-based opportunistic advertising," in *Wireless Communications and Networking Conference (WCNC), 2013 IEEE*. IEEE, 2013, pp. 4428–4433.

[9] Y. Z. Wei, L. Moreau, and N. R. Jennings, "A market-based approach to recommender systems," *ACM Transactions on Information Systems (TOIS)*, vol. 23, no. 3, pp. 227–266, 2005.

[10] Y. Z. Wei, L. Moreau, and N. Jennings, "Learning users' interests by quality classification in market-based recommender systems," *Knowledge and Data Engineering, IEEE Transactions on*, vol. 17, no. 12, pp. 1678–1688, 2005.

[11] C. Boldrini, M. Conti, and A. Passarella, "Exploiting users social relations to forward data in opportunistic networks: The hibop solution," *Pervasive and Mobile Computing*, vol. 4, no. 5, pp. 633–657, 2008.

[12] H. A. Nguyen and S. Giordano, "Context information prediction for social-based routing in opportunistic networks," *Ad Hoc Networks*, vol. 10, no. 8, pp. 1557–1569, 2012.

[13] V. S. Tseng, J.-C. Chang, and K. W. Lin, "Mining and prediction of temporal navigation patterns for personalized services in e-commerce," in *Proceedings of the 2006 ACM symposium on Applied computing*. ACM, 2006, pp. 867–871.

[14] N. Abdullah, Y. Xu, S. Geva, and J. Chen, "Infrequent purchased product recommendation making based on user behaviour and opinions in e-commerce sites," in *Data Mining Workshops (ICDMW), 2010 IEEE International Conference on*. IEEE, 2010, pp. 1084–1091.

[15] A. Keränen, J. Ott, and T. Kärkkäinen, "The one simulator for dtn protocol evaluation," in *Proceedings of the 2nd International Conference on Simulation Tools and Techniques*, 2009.