Content Messenger Selection and Wireless Energy Transfer Policy in Mobile Social Networks

Dusit Niyato[1], Ping Wang[1], Dong In Kim[2], and Zhu Han[3]

[1] School of Computer Engineering, Nanyang Technological University (NTU), Singapore

[2] School of Information and Communication Engineering, Sungkyunkwan University (SKKU), Korea

[3] Department of Electrical and Computer Engineering, University of Houston, Texas, USA

***Abstract*—In mobile social networks, mobile users can help each other to disseminate and deliver contents utilizing social relationship (e.g., physical contact). In this paper, we consider content delivery in mobile social networks, where a mobile user (i.e., a content source) transfers not only content, but also energy to an intermediate user (i.e., a mobile content messenger). The messenger uses this energy to store, carry, and forward the content to the destination (i.e., a sink). We particularly address the content messenger selection and wireless energy transfer problem of the content source to determine which messenger to deliver the content and the amount of energy to be transferred to the messenger. We formulate a Markov decision process (MDP) to obtain the optimal policy. The numerical results show clearly the improved performance in terms of higher throughput as compared with a baseline static policy.**

***Index Terms*—Wireless energy transfer, mobile social networks, Markov chain**

I. Introduction

One of the services in mobile social networks is content dissemination and delivery [1]. A source generates and transfers content to other nodes, also called messengers. These messengers store, carry, and forward the content to other nodes when they move and meet each other until the content reaches the destination. While the major research issue of the content dissemination and delivery in mobile social networks is routing [2], resource allocation and sharing is also equally important [3]. Especially, to disseminate and deliver a content, mobile nodes have to spend energy and hence they may restrict their participation in the content delivery service to conserve their energy. Therefore, to motivate a mobile node to deliver a content, the content source can transfer energy to the mobile node, which is doable using wireless energy transfer technique [4]. However, there are couple of issues arising due to the content and energy transfer. Since the energy resource is limited, the content source must carefully choose the mobile node to transfer the content to, depending on the possibility of meeting the sink. Moreover, the amount of energy to be transferred has to be determined considering the tradeoff between content delivery performance and energy usage.

This paper addresses above issues by introducing an optimization model to obtain an optimal content messenger selection and wireless energy transfer policy. Specifically, we consider the mobile social network in which the content source can transfer content and energy to the messengers. The messenger uses that energy to maintain the content and deliver it to the content sink when they meet. We formulate a Markov decision process (MDP) to model the contacts among the source and messengers and energy charging from a charger. The optimal policy is obtained to maximize the utility of the content source which is defined as the throughput (i.e., the number of successful delivered contents per unit of time) minus the energy cost. We perform an extensive performance evaluation which shows that the optimal policy outperforms a baseline static policy.

II. Related Work

The concept of wireless energy transfer using mobile nodes is adopted in wireless sensor networks. For example, [5] introduced the concept of using a mobile charging vehicle traveling around to supply energy wirelessly to sensor nodes. The optimization to maximize the ratio of vacation time of the wireless charging vehicle over the cycle time was proposed to obtain an optimal traveling path. The similar concept was considered in [7] to allow multiple robots to meet and transfer energy among each other so that the mission of a group of the robots can be achieved. [8] studied a charging schedule for mobile chargers to supply energy to mobile robotic sensor networks. The optimal solution of the schedule was obtained considering the energy state of the robot.

With wireless energy transfer capability, the cooperation among wireless nodes to perform relay transmission can be motivated by energy sharing. For example, a data source can transfer energy wirelessly to relays and the relays use that energy to perform cooperative transmission. In [9], the transmit power allocation and energy transfer policies were jointly optimized to maximize the sum-rate in a two-hop communication. Similarly, [10] considered the scenario that different users can transfer energy wirelessly among each other so that the relay transmission can be performed using the received energy. [10] optimized energy management policy for relay channel, two-way channl, and multiple access channel with the objective to maximize the system throughput. In [11], the authors considered the cognitive radio network in which a secondary user relays data transmission of a primary user. In

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return, the primary user supplies energy and offers spectrum opportunity to the secondary user. The wireless information and energy transfer schemes were developed to maximize the total rate of both primary and secondary users.

However, all the works in the literature did not consider content delivery in the mobile social networks based on wireless energy transfer. Furthermore, the data relay/messenger selection and energy transfer policy was not optimized and this is the focus of this paper.

III. SYSTEM MODEL

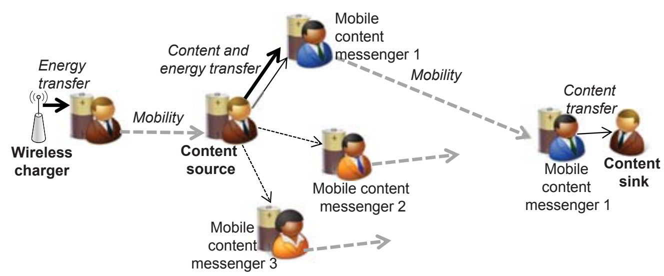

Fig. 1. System model of mobile social networks with a mobile power bank.

We consider a mobile social network composed of mobile users as shown in Fig. 1. The users can be a content source, messengers, and sink. The content source moves and visits a charger to receive energy (e.g., through wireless charging). The content source generates content and the content is stored in its buffer. When the content source meets a messenger, the source can ask the messenger to deliver the content to the sink. The content delivery by the messenger is via mobility. Specifically, the messenger with the content from the source moves and when it meets with the sink, the content will be transferred. However, for the messenger to deliver the content, the content source must also transfer energy (e.g., again using wireless energy transfer) to the messenger. The messenger uses this energy to maintain and transfer the content to the sink. The messenger consumes a certain amount of energy (i.e., transferred from the source) per unit of time to keep the content. If the transferred energy is depleted before meeting the sink, the messenger will discard the content.

The content source generates a content with the probability α in a time period (i.e., a time slot). The maximum capacity of the content buffer (i.e., a data queue) is Q. The content source has an energy storage (i.e., a battery) with the maximum capacity of E units of energy. The source consumes one unit of its own energy stored in the battery with the probability σ (e.g., to run its local application). When the content source visits the charger, it can receive one unit of energy per time slot with the probability γ and this incurs the cost of μ (e.g., charging price) to the source. The set of available messengers to deliver the content to the sink for the content source is denoted by $\mathcal{M}$ and $M = |\mathcal{M}|$. One messenger is selected by the content source to deliver its content, and the source can transfer δ units of energy to the messenger. Given $\delta \in \{1, 2, \ldots, A-1, A\}$ units of energy transferred from the content source, the probability that the messenger m will meet and be able to transfer the content to the sink before the energy is depleted is denoted by $\beta_m(\delta)$.

We define a contact state of the content source. The contact state corresponds to the event where the content source meets with the charger, any messengers, or none of them (i.e., being alone). If the contact state is meeting with the charger, the content source can receive energy. If the contact state is meeting with any messenger, the content source can transfer a content and energy to the messenger. If the contact state is being alone, the content source will do nothing. Let the transition matrix of the contact state of the content source be denoted by $\mathbf{C}$, and it is defined as follows:

$$\mathbf{C} = \left[\begin{array}{cc|ccc} C_{0,0} & C_{0,1} & \cdots & C_{0,m} & \cdots \\ C_{1,0} & C_{1,1} & \cdots & C_{1,m} & \cdots \\ \hline \vdots & \vdots & & \vdots & \\ C_{M,0} & C_{M,1} & \cdots & C_{M,m} & \cdots \end{array}\right] \begin{array}{l} \leftarrow \text{with charger} \\ \leftarrow \text{being alone} \\ \vdots \\ \leftarrow \text{with messenger } M \end{array} \quad (1)$$

where each row of the matrix $\mathbf{C}$ corresponds to the contact state, and $C_{c,c'}$ denote the probability that the content source changes its contact state from c to state c'. 0 and 1 are the state "with charger" and "being alone", respectively. The contact state m is when the content source is meeting with messenger $m \in \mathcal{M}$.

The messenger m consumes the energy transferred from the content source with the rate of ν_m for maintaining the transferred content from the source. Therefore, per one unit of transferred energy, the messenger will keep the content with duration $1/\nu_m$. This is referred to as the energy depletion time of the messenger. Moreover, we assume that the time duration from when the messenger receives the content from the content source to when it meets the content sink is random and modeled as a phase-type distribution [12]. We adopt the phase-type distribution since it is a relatively general model. For example, exponential and hyper-exponential distributions can be modeled by the phase-type distribution. For messenger m, the parameters of the phase-type distribution are an initial probability row vector $\boldsymbol{\psi}_m$ and a subgenerator matrix $\mathbf{S}_m$. The probability that the messenger m will successfully transfer the content to the sink after it receives the content from the source is the probability that the messenger will meet with the sink before its transferred energy is depleted, i.e.,

$$\beta_m(\delta) = 1 - \boldsymbol{\psi}_m e^{\delta/\nu_m \mathbf{S}_m} \vec{\mathbf{1}} \quad (2)$$

where $\vec{\mathbf{1}}$ is a vector of ones with an appropriate size.

Given the above system model of the mobile social network, the content source faces the decision making problems. Firstly, when the source meets the messenger, the source has to determine whether to request this messenger to deliver its content to the sink or not. Secondly, if the source decides to do so, the source has to determine the amount of energy to be transferred to the messenger.

IV. Wireless Energy Transfer and Content Messenger Selection Policy

In this section, we present the MDP formulation to obtain the messenger selection and energy transfer policy. Firstly, we define the state and action spaces. Then we derive the transition matrices and reward function. The optimization formulation is presented afterward.

A. State and Action Spaces

The state space of the content source is defined as follows:

$$\Theta = \Big\{(\mathscr{C}, \mathscr{E}, \mathscr{Q}); \mathscr{C} \in \{0,1\} \cup \mathcal{M}, \mathscr{E} \in \{0,1,\ldots,E\}, \mathscr{Q} \in \{0,1,\ldots,Q\}\Big\} \quad (3)$$

where $\mathscr{C}$ is the contact state, $\mathscr{E}$ is the energy level of the battery (i.e., energy state), and $\mathscr{Q}$ is the number of contents in the queue (i.e., queue state). The state can be defined as a composite variable $\theta = (c, e, q) \in \Theta$, where c, e, q are the corresponding variables of $\mathscr{C}$, $\mathscr{E}$, and $\mathscr{Q}$, respectively.

The action space of the content source is defined as $\Delta = \{0, 1, \ldots, A-1, A\}$. Let $\delta \in \Delta$ denote the action variable. $\delta = 0$ indicates that the content source will not transfer a content to the messenger. The content source can transfer a content with $\delta > 0$ units of energy to the messenger when they meet each other (i.e., contact state is $c \in \mathcal{M}$).

B. Transition Matrices

We first consider the queue state transition. There are two cases, i.e., the queue state can only increase or remain the same, and the queue state can increase, decrease, and remain the same. The former happens when the content source does not have a contact with any messenger or it decides not to transfer a content. We have the transition matrix for this case defined as follows:

$$\mathbf{Q}^{\mathrm{ic}} = \begin{bmatrix} \alpha' & \alpha & & \\ & \ddots & \ddots & \\ & & \alpha' & \alpha \\ & & & 1 \end{bmatrix} \quad (4)$$

where $\alpha' = 1 - \alpha$. Alternatively, if the content source meets a messenger m and decides to transfer a content and energy (i.e., $\delta > 0$), the number of contents in the queue can decrease. The transition matrix for this case is expressed as in (5), where $\beta'_m(\delta) = 1 - \beta_m(\delta)$.

Then we consider the queue state transition with energy state. There are three cases, i.e., the content source is meeting with a charger, with a messenger, and without any contact with a charger or messenger. For the first case, the energy state can increase due to charging and decrease due to content source's self-consumption. The transition matrix is expressed as follows:

$$\mathbf{E}^{\mathrm{ch}} = \mathbf{Q}^{\mathrm{ic}} \otimes \begin{bmatrix} \gamma' & \gamma & & & \\ \gamma'\sigma & \gamma'\sigma' + \gamma\sigma & \gamma\sigma' & & \\ & \ddots & \ddots & \ddots & \\ & & \gamma'\sigma & \gamma'\sigma' + \gamma\sigma & \gamma\sigma' \\ & & & \gamma'\sigma & 1 - \gamma'\sigma \end{bmatrix} \quad (6)$$

where $\otimes$ is the Kronecker product and $\gamma' = 1 - \gamma$.

For the second case, the energy state can decrease due to energy transfer to messenger m and cannot increase. The transition matrix is expressed as follows:

$$\mathbf{E}^{\mathrm{ms}}_m(\delta) = \left[\begin{array}{ccccc} \mathbf{Q}^{\mathrm{ic}} & & & & \\ \sigma\mathbf{Q}^{\mathrm{ic}} & \sigma'\mathbf{Q}^{\mathrm{ic}} & & & \\ & \ddots & \ddots & & \\ & \sigma\mathbf{Q}^{\mathrm{ic}} & \sigma'\mathbf{Q}^{\mathrm{ic}} & & \\ \hline \mathbf{Q}^{\mathrm{dc}}_m(\delta) & \cdots & \mathbf{0} & & \\ \hline \sigma\mathbf{Q}^{\mathrm{dc}}_m(\delta) & \sigma'\mathbf{Q}^{\mathrm{dc}}_m(\delta) & \cdots & \mathbf{0} & \\ & \ddots & \ddots & & \ddots \\ & \sigma\mathbf{Q}^{\mathrm{dc}}_m(\delta) & \sigma'\mathbf{Q}^{\mathrm{dc}}_m(\delta) & \cdots & \mathbf{0} \end{array}\right] \quad (7)$$

for $\delta > 0$. For $\delta = 0$, all $\mathbf{Q}^{\mathrm{dc}}_m(\delta)$ will be replaced by $\mathbf{Q}^{\mathrm{ic}}$. That is, the queue state cannot decrease. The matrix $\mathbf{E}^{\mathrm{ms}}_m(\delta)$ is divided into three parts.

- The first part is from row 1 to row δ, which correspond to the energy states $0, \ldots, \delta - 1$. As the content source takes the action to transfer δ units of energy, but in this first part, it does not have enough energy. Therefore, the energy state can decrease one unit only due to self-consumption.
- The second part is at row $\delta + 1$, which corresponds to the energy state δ. At this state, there is enough energy to be transferred. However, the content source cannot have self-consumption. Therefore, the energy state decreases to zero.
- The third part is from row $\delta + 2$ to row $E + 1$, which correspond to the energy states $\delta+1, \ldots, E$, where again E is the maximum capacity of the energy storage. In this case, there is enough energy for the content source to be transferred and for self-consumption, and hence the energy state decreases by δ and $\delta + 1$ units, respectively.

In the first two parts, the number of contents in the queue cannot decrease. Therefore, $\mathbf{Q}^{\mathrm{ic}}$ is applied. By contrast, in the third part, the number of contents can decrease due to successful delivery by the messenger. Consequently, $\mathbf{Q}^{\mathrm{dc}}_m(\delta)$ is applied.

For the third case, the energy state can decrease due to self-consumption only. The transition matrix is expressed as follows:

$$\mathbf{E}^{\mathrm{fr}} = \mathbf{Q}^{\mathrm{ic}} \otimes \begin{bmatrix} 1 & & & \\ \sigma & \sigma' & & \\ & \ddots & \ddots & \\ & & \sigma & \sigma' \end{bmatrix}. \quad (8)$$

$$\mathbf{Q}_m^{\mathrm{dc}}(\delta) = \begin{bmatrix} \alpha' & \alpha & & & & \\ \beta_m(\delta)\alpha' & \beta'_m(\delta)\alpha' + \beta_m(\delta)\alpha & \beta'_m(\delta)\alpha & & & \\ & \ddots & \ddots & \ddots & & \\ & & \beta_m(\delta)\alpha' & \beta'_m(\delta)\alpha' + \beta_m(\delta)\alpha & \beta'_m(\delta)\alpha \\ & & & \beta_m(\delta)\alpha' & 1-\beta_m(\delta)\alpha' \end{bmatrix} \quad (5)$$

$$\mathbf{P}(\delta) = \left[\begin{array}{cc|ccccc} C_{0,0}\mathbf{E}^{\mathrm{ch}} & C_{0,1}\mathbf{E}^{\mathrm{ch}} & \cdots & C_{0,m}\mathbf{E}^{\mathrm{ch}} & \cdots & C_{0,M}\mathbf{E}^{\mathrm{ch}} \\ C_{1,0}\mathbf{E}^{\mathrm{fr}} & C_{1,1}\mathbf{E}^{\mathrm{fr}} & \cdots & C_{1,m}\mathbf{E}^{\mathrm{fr}} & \cdots & C_{1,M}\mathbf{E}^{\mathrm{fr}} \\ \hline \vdots & \vdots & & \vdots & & \vdots \\ C_{M,0}\mathbf{E}_M^{\mathrm{ms}}(\delta) & C_{M,1}\mathbf{E}_M^{\mathrm{ms}}(\delta) & \cdots & C_{M,m}\mathbf{E}_M^{\mathrm{ms}}(\delta) & & C_{M,M}\mathbf{E}_M^{\mathrm{ms}}(\delta)\cdots \end{array} \right] \quad (9)$$

Finally, we consider the queue state and energy state transition with the contact state transition. The transition matrix for action δ is expressed as in (9) where $C_{c,c'}$ is as explained in (1).

C. Optimization Formulation

We aim to obtain the action δ which indicates whether to transfer a content or not and how much energy to be transferred to a messenger. The policy π is defined as the action to be taken at a given state (i.e., contact state, energy state, and queue state). The optimal policy is obtained to maximize the utility. The utility is defined as the throughput of the content source (i.e., the number of successfully delivered contents) minus energy cost. The optimization problem based on an MDP is defined as follows:

$$\max_{\pi} \quad \mathscr{J}(\pi) = \lim_{t\to\infty} \inf \frac{1}{t} \sum_{t'=1}^{t} \mathbb{E}\left(\mathscr{U}(\theta_{t'}, \delta_{t'})\right) \quad (10)$$

where $\mathscr{J}(\pi)$ is the utility function. $\mathscr{U}(\theta_{t'}, \delta_{t'})$ is the immediate utility function given state $\theta_{t'} \in \Theta$ and action $\delta_{t'} \in \Delta$ at time t'. The immediate utility function is given as follows:

$$\mathscr{U}(\theta, \delta) = \begin{cases} \mathscr{T}_m(e, q, \delta), & c = m \in \mathcal{M} \\ -\mu, & (c = 0) \text{ and } (e < E) \\ 0, & \text{otherwise} \end{cases} \quad (11)$$

where $\mathscr{T}_m(e, q, \delta)$ is an immediate throughput function given energy state e, queue state q, and action δ, defined as follows:

$$\mathscr{T}_m(e, q, \delta) = \begin{cases} \beta_m(\delta), & (\delta > 0) \text{ and } (e \geq \delta) \text{ and } (q > 0) \\ 0, & \text{otherwise} \end{cases} \quad (12)$$

The immediate throughput is the probability of successful content delivery given that the content source meets one of the messengers (i.e., $c \in \mathcal{M}$), the content source decides to transfer a content and energy (i.e., the action is $\delta > 0$), there is enough energy (i.e., $e \geq \delta$), and there is a content in the queue (i.e., $q > 0$).

To obtain an optimal messenger selection and energy transfer policy π^*, we consider a randomized policy. The optimal policy can be obtained by solving the equivalent linear programming problem defined as follows:

$$\begin{aligned} \max_{\phi(\theta,\delta)} \quad & \sum_{\theta\in\Theta} \sum_{\delta\in\Delta} \phi(\theta, \delta) \mathscr{T}(\theta, \delta) & (13) \\ \text{s.t.} \quad & \sum_{\delta\in\Delta} \phi(\theta', \delta) = \sum_{\theta\in\Theta} \sum_{\delta\in\Delta} \phi(\theta, \delta) P_{\theta,\theta'}(\delta), \quad \theta' \in \Theta \\ & \sum_{\theta\in\Theta} \sum_{\delta\in\Delta} \phi(\theta, \delta) = 1, \quad \phi(\theta, \delta) \geq 0 \end{aligned}$$

where $P_{\theta,\theta'}(\delta)$ denotes the element of matrix $\mathbf{P}(\delta)$ where $\theta = (c, e, q)$ and $\theta' = (c', e', q')$. Let the solution of the LP problem be denoted by $\phi^*(\theta, \delta)$. The randomized policy of the content source is obtained as follows:

$$\pi^*(\theta, \delta) = \frac{\phi^*(\theta, \delta)}{\sum_{\delta'\in\Delta} \phi^*(\theta, \delta')}, \text{ for } \theta \in \Theta \text{ and } \sum_{\delta'\in\Delta} \phi^*(\theta, \delta') > 0. \quad (14)$$

If $\sum_{\delta'\in\Delta} \phi^*(\theta, \delta') = 0$, then $\pi^*(\theta, 0) = 1$.

From the optimal solution of the equivalent linear programming (LP) problem, i.e., $\phi^*(\theta, \delta)$, we can obtain the average throughput as follows:

$$\tau = \sum_{c\in\mathcal{M}} \sum_{\delta=1}^{A} \sum_{e\geq\delta} \sum_{q>0} \beta_m(\delta) \phi^*(\theta, \delta). \quad (15)$$

Similarly, the average amount of energy transferred to messenger m is obtained from

$$\overline{e}_m = \sum_{c=m} \sum_{\delta=1}^{A} \sum_{e\geq\delta} \sum_{q>0} \delta \phi^*(\theta, \delta). \quad (16)$$

V. Performance Evaluation

A. Parameter Setting

We consider a content source in the mobile social network. There are three content messengers in the network. The phase-type distribution of the time to meet the content sink of the content source is given as follows:

$$\boldsymbol{\psi} = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}, \quad \mathbf{S} = \begin{bmatrix} -\lambda & \lambda & \\ & -\lambda & \lambda \\ & & -\lambda \end{bmatrix} \quad (17)$$

and hence $\mathbf{S}^0 = \begin{bmatrix} 0 & 0 & \lambda \end{bmatrix}^\top$, where $\lambda = 1, 1.1, 1.2$ for content messengers 1, 2, and 3, respectively.

Unless otherwise stated, we use the following parameter setting for the performance evaluation. The content queue has the maximum capacity of 10 contents and the energy storage has the maximum capacity of 20 units of energy. The content generation rate is 0.04 contents/hour. One unit of energy transferred to the content messenger can be used to carry the content for two hours for all messengers. The content source transfers the maximum of 4 units of energy to a messenger. The probability of successful energy transfer is 0.99 and the content source consumes its energy with the probability of 0.01. The cost incurred to the content source when receiving energy from a charger is 0.01. The content source is at the charger with the probability of 0.1111, while it meets with each messenger with the probability of 0.2222 and stays alone also with the probability of 0.2222.

B. Numerical Results

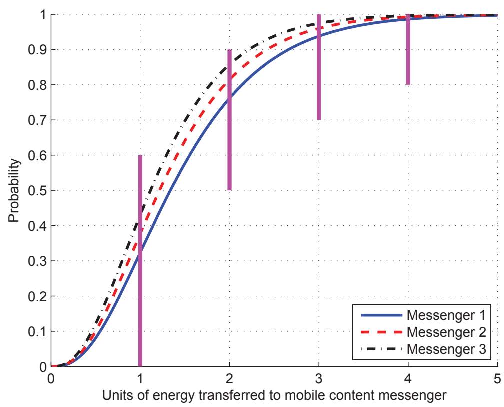

Fig. 2. Cumulative probability distribution of phase-type distribution.

Figure 2 shows the cumulative probability distribution of the phase-type distribution. We observe that as the amount of energy transferred to the content messengers increases, the probability that the messenger will successfully deliver the content to the sink is higher. Additionally, with different parameters of the phase-type distribution, this probability is different for different messenger. For example, since the travel rate of the messenger 3 is the largest, it has the highest probability to successfully deliver a content with the same amount of energy. Based on this fact, to achieve an optimal throughput performance the content source has to optimize not only the messenger to deliver its content, but also the amount of energy to be transferred.

Figure 3 shows the throughput of the content source under different content generation rate. Clearly, when the content generation rate increases, the throughput first increases and later becomes saturated. The saturation is due to the limited energy supply from the charger. We also compare the optimal policy with the static policy where a fixed amount of energy

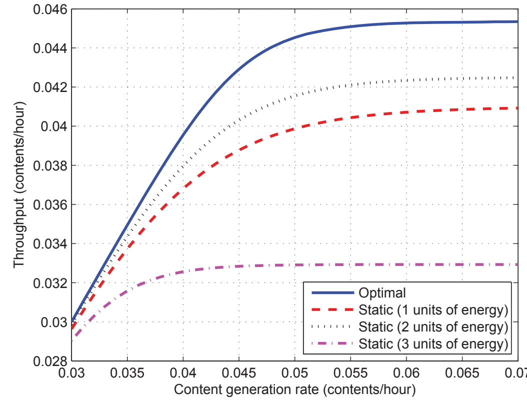

Fig. 3. Throughput under different content generation rate.

is transferred when the content source meets any messenger. We observe an interesting result that when the amount of transferred energy is small (i.e., 1 unit), the throughput is small, which is expected since the probability of successful content delivery is small. However, when the amount of transferred energy is large (i.e., 3 units), the throughput is also small. This is from the fact that much energy is used needlessly per one content. In this case, only two fixed units of transferred energy yield the highest throughput. However, all the throughput of the static policy is significantly lower than that of the optimal policy. This result proves the necessity of having an optimization for the messenger selection and energy transfer.

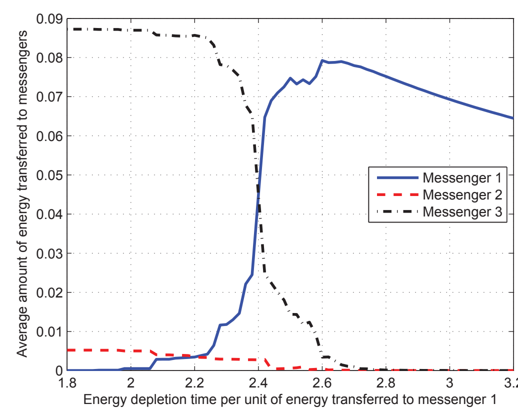

Fig. 4. Average amount of energy transferred to messengers when the energy depletion time per unit of transferred energy to messenger 1 is varied.

Next we investigate the impact of the time duration per unit of transferred energy that messenger 1 can maintain the content from the content source (i.e., energy depletion time). When this time increases, the messenger can keep the content longer, leading to higher probability to meet with the content sink before the transferred energy is depleted. Figure 4 shows the average amount of transferred energy to different messengers. Initially, the content source tends to rely mostly on messenger 3. However, as the energy depletion time of messenger 1 increases, the content source switches to this messenger, indicating by larger amount of transferred energy. Eventually, the content source will rely solely on the messenger 1 when its energy depletion time is much larger than those of other messengers. Additionally, we observe that as the energy depletion time increases, the content source transfers less energy to the messenger 1. This is due to the fact that only small amount of transferred energy is sufficient for this messenger to deliver the content. Therefore, the content source can save its energy for their own use or reduce energy supply from the charger which lowers its cost.

The result in Figure 4 suggests that the content source can rely on few messengers with large probabilities of successful content delivery per unit of transferred energy. We investigate this point further by varying the set of available messengers. Figure 5 shows the throughput of such evaluation. Note that in this case we consider the fourth messenger with parameter $\lambda = 1.3$, which yields the highest probability of successful content delivery.

When we remove messengers 1, 2, and 3, there is slight drop in throughput (Figure 5). By contrast, we notice significant lower throughput when the messengers 4, 3, and 2 are removed from the set of available messengers. This result confirms that the content source does not need to interact with all available messengers if their chance of successful content delivery is relatively low, avoiding creating unnecessary overhead. By relying on the social metrics and contact statistics, the content source can determine the set of messengers to optimize the energy transfer and messenger selection policy. This point will be further studied in the future work.

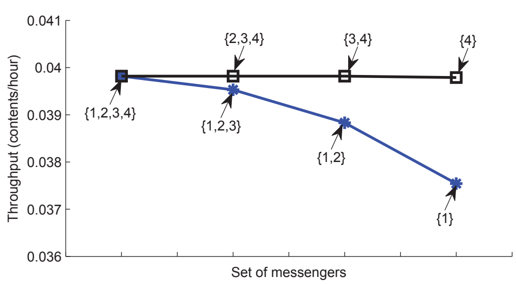

Fig. 5. Throughput under different set of available messengers.

VI. Summary

In mobile social networks, energy can be a crucial factor for people to help each other to disseminate and deliver content. In this paper, we have considered the mobile social network, where mobile messengers can help a content source to deliver a content to the content sink. The content source also transfers energy to the messenger to do so. We have studied the content messenger selection and wireless energy transfer problem. Specifically, we have formulated a Markov decision process to obtain an optimal messenger selection and energy transfer policy. The objective is to maximize the utility which is defined as the throughput of the content source minus energy cost. We have shown numerically that the amount of energy transferred to the messenger can significantly affect the throughput. Additionally, we have shown that the optimal policy from the proposed optimization outperforms baseline static policy.

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