International Journal of Scientific Research in Science, Engineering and Technology
Print ISSN: 2395-1990 | Online ISSN : 2394-4099 (www.ijsrset.com)
doi : https://doi.org/10.32628/IJSRSET207512

A Low-latency Strategy with dynamic Duty-Cycle in Opportunistic Mobile Crowdsensing Scenario

Hongsheng Yang[1], Jianwei Liu*[2]
[1]Guangdong Power Grid Co. Ltd., Zhongshan Torch Power Supply Branch, Guangdong, Guangzhou, China
*[2]Pidu sub Branch, China Construction Bank, Chengdu, Sichuan, China

Article Info
Volume 7 Issue 5
Page Number: 117-123
Publication Issue :
September-October-2020

Article History
Accepted : 01 Sep 2020
Published : 12 Sep 2020

ABSTRACT

In Mobile Crowdsensing Scenario (MCS), most of the mobile devices transfer data to each other relay on encounter opportunities. MCS energy consumption and latency are the key indicators of networks under the application scenarios. On one hand, the neighbor idle scanning and listening mechanism of mobile devices usually consumes the energy that could be saved. Therefore, keeping devices to work in a low duty cycle can avoid this part of energy waste effectively, but it will bring serious network latency. Aim to this, the duty cycle strategy with a lower latency strategy is focused to discuss in this paper. A method, named Low latency Duty Cycle (DC) with MSFO, is proposed to reduce network latency which mainly compares the size of data packets to be transmitted by the device. Besides, small data packets have priority in the transmission queue for enhanced network performances. Extensive simulation results show that the proposed method can significantly reduce network latency in terms of MCS with a duty cycle strategy.

Keywords: Mobile Crowdsensing, Low Latency, Duty Cycle, Transmission Queue

I. INTRODUCTION

Mobile Crowdsensing Scenario takes advantage of the mobility of mobile devices and collects data with mobile nodes which include user phones, smartwatches, or vehicles, etc. This data transmitting strategy is relayed on the encounter of mobile objects which have mobility in city environments. It has been widely discussed in the Internet of Things (IoT) and Device-to-Device communications (D2D) research fields [1]. This emerging network has many advantages in the urban environment. For instance, the data collection system can rapidly network without any communication infrastructure. And the sensing solutions are various and flexible in the ultra-density mobile devices areas. But there are two major challenges in mobile crowdsensing scenarios. First, the power of mobile devices is constraint due to the movability of devices, therefore, some mobile nodes will knock off due to the exhausting energy. Second, the data transmission occurred by the encounter of two nodes, the limiting meeting results in high latency data delivery time. The energy is exhausted in crowdsensing networks, and the node density will decrease. The network performance will also be decreased because of the lower encounter opportunity. Besides, low latency also can affect the performance of the application system, which is designed based on crowdsensing technology [2]. Aim to this, this paper proposed a low-latency approach with dynamic duty cycle strategy MSFO, which is designed with the encounter probability based on the social contact law prediction. This approach effectively improves energy efficiency, and it can decrease the data transmitting average latency in crowdsensing networks.

The organization of this paper is as follows. In Section II, we discussed related works of crowdsensing energy efficiency. In Section III, we give the details of the application scenario and our proposed strategy. And numeral simulations are carried out, the results are given in section IV. Section V gives a conclusion.

II. RELATED WORKS

Energy efficiency plays a key role in crowdsensing research fields. In urban crowdsensing environments, the mobile devices are carried by people, then, the communicable nodes show social characteristics in mobility pattern. Therefore, human contact law is a pivotal factor in the data transmitting design. In the prior work, Jianwei L. et al. proposed the self-adaptive duty cycle approach, which is discussed in the social contact scenario. This self-adaptive approach can obtain relatively high energy efficiency in a crowdsensing scenario. And the main indicators of network performance can maintain a period of time compared to the instant duty cycle method and routing without duty cycle sleeping strategies [3]. But, the latency of the network is not ideal in the application system. As far as we know, network performance is important in crowdsensing applications. Wenzao L. et al. also discussed the duty cycle schedule with geographic characteristics of human mobility. The mobile nodes adopt various duty cycle periods depend on the contact probability of each designed grid area. Then, the also compare with the energy efficiency and network performances for further discussion [4]. But it also ignores the queue issue design in the crowdsensing environment. According to many types of research in multi-hop networks, there are three main techniques: queue management, forwarding, and replication [5]. We can observe that the queue management can affect network performance. And it is also a complex issue in such crowdsensing or Delay Tolerant Networks (DTN) [6]. Although there are many routings in these research fields. The contact law of mobile nodes is based on the human or carrier's mobility pattern. Therefore, the mobility pattern can hugely influence network performance. In urban environments, there are many types of moving objects, such as a vehicle, human, subway, etc [7]. Thus, the epidemic method is the simplest and most effective way to adapt to the data transmitting system [3, 4].

From the above, the state-of-the-art researches mainly focus on the network performance of crowdsensing networks. The key indicators include data delivery ratio, average latency, and network overhead ratio. Meanwhile, the proposed energy efficiency approach ignores the queue management strategy. Aim to this, we adopt a moving average value of a nodes' time period to dynamic select duty cycle ratio and with a new queue management strategy. Which can obtain more prior latency and maintain acceptable energy efficiency in a crowdsensing environment.

III. CROWDSENSING SYSTEM MODEL AND LOW LATENCY DC WITH MSFO

Crowdsensing, as an emerging architecture, is widely discussed in the urban environment. As is shown in the report of Gray Davis of McAfee Inc. The number of connected devices is predicted to hit 50 billion in 2020. The huge number of IoT devices create very good conditions to establish a crowdsensing system, which can monitor or sense wide areas at a lower cost.

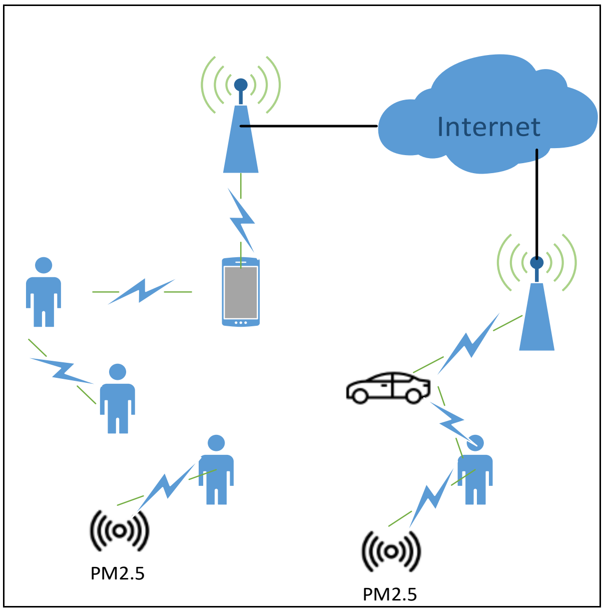

Figure 1: A Crowdsensing scenario for data collection

As shown in Figure 1, the crowdsensing networks consist of a variety of mobile nodes. Such as Sink station (The destination of sensing data), human carried smart devices, on-board computer, and PM 2.5 monitoring sensors, etc. The sensing data is transmitted by multiple-hop among these mobile nodes due to the mobility of devices. It can be considered as the overlay network of the traditional network. Obviously, the network performance can greatly affect the application system based on crowdsensing technology. The duty cycle approach is an effective approach to enhance energy efficiency due to the constraint power of each mobile device. However, when a node is in a non-working cycle, neighbour nodes cannot be discovered. Therefore, the unsuitable sleeping schedule will degrade network performance, especially in such an opportunistic network.

A. A Moving Average Node Encounter Prediction Strategy

The mobile node has individual characteristics in urban areas. The communicable devices have a human mobility pattern due to it is carried or controlled by a human being. We can give some definition to express the mobility pattern of mobile devices. If the $En^i(T)$ denotes the node i encounter times of the other communicable devices. It can be express as equation (1)

$$En^i(T) = \sum_{t=0}^{T} x^i(t) \tag{1}$$

Where the $x^i(t)$ follow the distribution of 0,1. In social networks, the encounter characteristic can be expressed by equation (1).

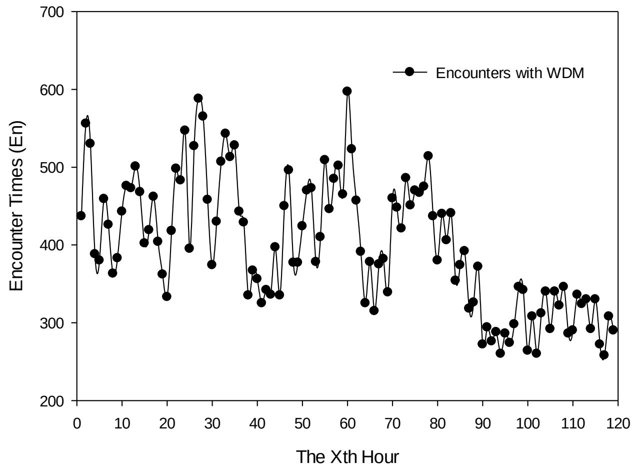

Figure 2: A encounter distribution under WDM model for the whole nodes

The Working Day Movement Model (WDM) is the closest to the real social mobility model. The En means whole nodes in crowdsensing encounter times for one hour in such a scenario.

$$En(T') = \sum_{i=1}^{m} \sum_{0}^{T'} x^i(t) \tag{2}$$

Where the m represents the node number of crowdsensing, and the T' denotes the length of the time slice. The result of En can be seen in Figure 2, The number of encounters fluctuates greatly in a different time slice. It reflects the human move way in different time. Obviously, a person goes to work in the morning, stays at the office (relatively narrow space) for work, and goes shopping after work, etc. The encounter behaviour usually occurred during the long trip of a node. Then, the encounter law can be express by equation (3)

$$En^i(t) = f\left(T + En^i(t)\right) \quad (3)$$

where the T denotes a period time of movement node i. Besides, we can know it can be used for the encounter prediction of a node. An important rule is the encounter behavior begins, and it will last for a while. This is easy to understand because the encounter must occur when the node is moving.

B. Duty Cycle based on the Encounter Prediction

DC approach is an effective way in Wireless Sensor Networks (WSN), And it can work well in such crowdsensing networks [4].

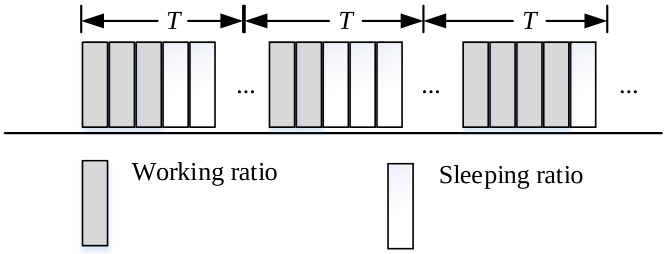

Figure 3: The DC of a node in the crowdsensing network

As discussed above, the characteristics of each node's encounter are different, so each node has its own different DC law. Assume the energy consumption follow the uniform distribution at the time scale. The DC ratio can be changed in each period T, which is shown in Figure 3. The saving energy $E_S^{(i)}$ of node i can be expressed as equation (4)

$$E_S^{(i)} = \int_0^T \frac{To}{\Delta t} e_s(t) d_t, \quad (4)$$

where the Δt represents the duty period, the same to the T of Figure 3. And the To means the sleeping period. $e_s(t)$ denotes the energy consumption in a period. This formula calculates the energy saved by hibernation in such opportunity network. It can be simply seen from the formula that the longer the time allocated for the node in To, the more energy saved by such sleeping approach. The problem is that the longer sleep time for the node, the more transmission opportunities will lose. Therefore, the performance should maintain during this sleeping schedule. We divide the time scale to time slice as the t_{k-6}, t_{k-5}, t_{k-4}, t_{k-3}, t_{k-2}, t_{k-1}. We use the $Pr(t_k)$ as the value of encounter times for the next time slice. It can be described as equation (5)

$$Pr(t_k) = \frac{\sum_{i=1}^{6} w_{k-i} E(t_{k-i})}{6}, \quad (5)$$

The time slice is 10 minutes in our approach. The weight value can be calculated as equation (6)

$$w_i = \frac{e^i}{\sum_{j=1}^{6} e^j}, \quad (6)$$

where e represents the base of the natural logarithm. As time progresses, nodes continue to count the number of node encounters in t_k time period. When it is necessary to predict the number of node encounters in t_{k+1} time period, they continue to predict the number of node encounters in t_{k+1} time period based on the actual number of node encounters in the first 60 minutes. Then We can determine the DC ratio by equation (7).

$$DC_{t_n} = \begin{cases} a & if \quad Pr(t_n) \geq 1 \\ Pr(t_n) \rightarrow (a, b) & if \quad 0.1 < Pr(t_n) < 1 \\ b & if \quad Predict(t_n) \leq 0.1 \end{cases} \quad (7)$$

From the equation (7), the predicted probability value is the DC ratio. We should set a lower limit a to avoid full sleep. In a similar way, there is higher limit b to avoid full work. The setting of this interval is the empirical value of many experiments.

C. Queue Management Approach with the DC Strategy

In crowdsensing networking, the chance of encounter opportunity is extremely limited. The conventional sending buffer management is First In First Out (FIFO) strategy. The data transmission time Tr usually describe as equation (8)

$$Tr = \frac{Ds}{S^i p}, \quad (8)$$

where the Ds represents the data size which is waiting for transmitting. S^ip denotes the wireless data transmission speed. Obviously, the Tr is relatively short in the crowdsensing environment due to the mobility of nodes. The smaller Ds of the pending packet, the higher the probability of successful transmission. Then, we adopt the Minimum Size First Out (MSFO) strategy for queue management. When two nodes are covered by each communication range and both in the working cycle, the sending buffer is reordered in this proposed approach. The minimum packet should be exchanged firstly.

IV. SIMULATION AND RESULTS

We built the simulation scenario for further validation. We adopt the WDM model, which is near realistic urban environments. Five pedestrian groups are deployed, each group owns 40 people. Besides, there are five bus groups (2 for each) in this simulation scenario. four taxis and 5 sink stations are deployed in this scenario. The ONE simulator is as the simulation platform, and the key parameters are list as TABLE I

TABLE I

KEY SIMULATION PARAMETERS

PARAMETER NAME	VALUE
Simulation World Size	10000*8000 m
Simulation Time	216 hours
City Map	Helsinki
Buffer Size	5M
Packets Size	250k-500k
Warm-up Time	4300
a, b	0.2, 0.8

1) The encounter prediction time

We adopt the moving average method based on the encounter values of the first six states to predict the future encounter times. The Figure 3 is the comparation of real simulation value and predicted value.

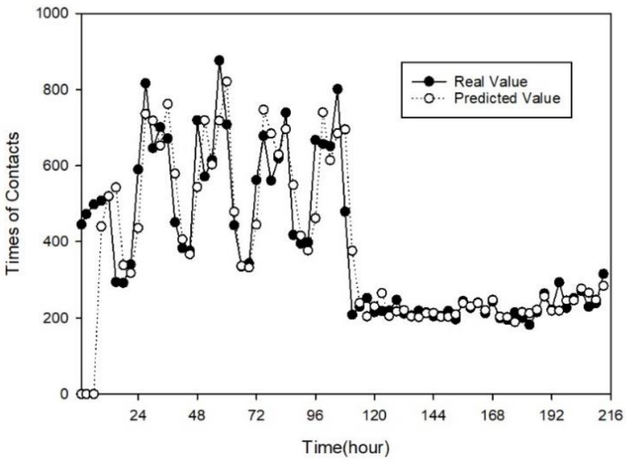

Figure 3: A comparation of real simulation value and predicted value

We can seem from Figure 3 that, the prediction approach is effective. The real simulation value is near the predicted value. As the true value falls, the predicted value drops sharply immediately.

2) The network performance

The DC can effectively improve the energy efficiency of the network, which has been discussed above. Due to the energy consumption problem is considered as uniformly distributed in this crowdsensing scenario. Then we mainly focus on the network performance with low DC strategy. The key indicators are the delivery ratio, latency and the network overhead ratio.

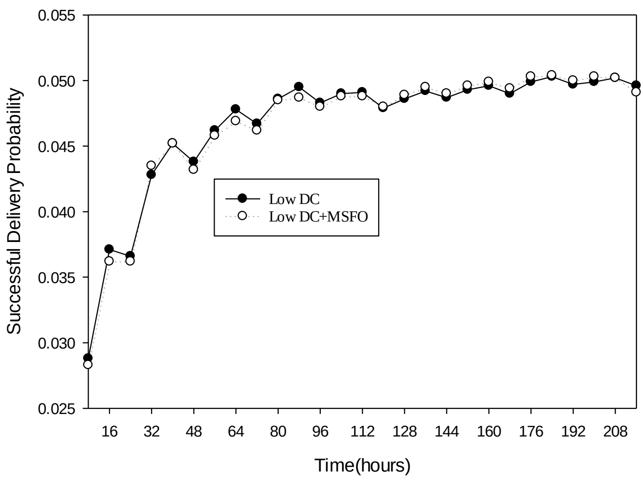

Figure 4: A comparation of delivery ratio between Low DC and Low DC with MSFO

From Figure 4, the addition of the MSFO strategy does not affect much more overall delivery performance. After the network is stabilized, the delivery performance of the new policy is slightly improved.

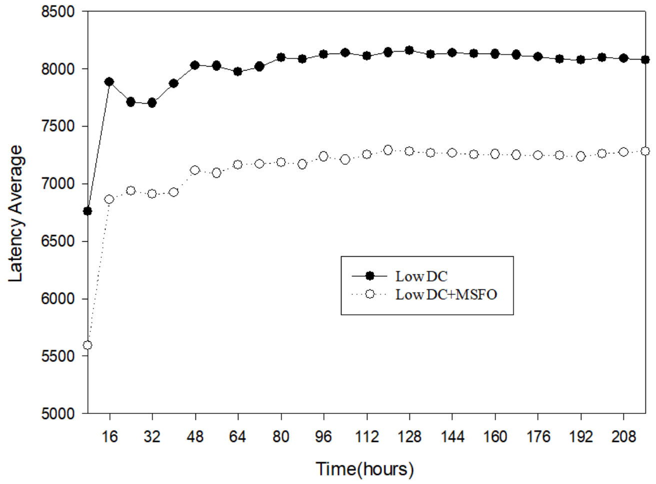

Figure 5: A comparation of delivery latency between Low DC and Low DC with MSFO

As can be seen from Figure 5, this method significantly reduces the average delivery delay under this DC strategy. Under this buffer management strategy, the average delivery latency can be reduced by 13%.

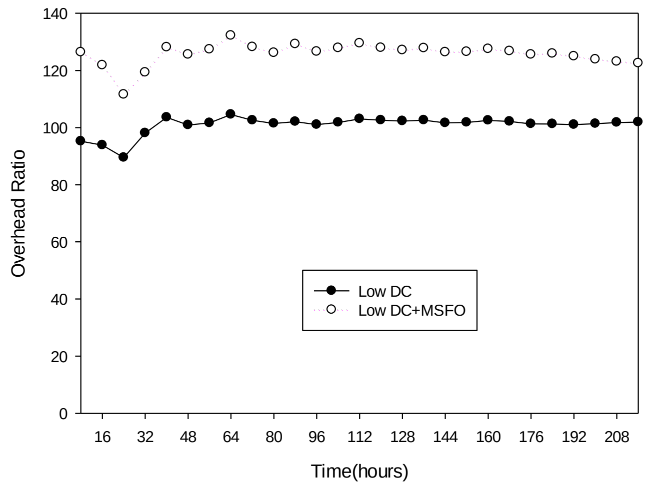

Figure 6 : A comparation of overhead ratio between Low DC and Low DC with MSFO

The network overhead ratio is one of the core indicators in the network. The higher value means more network pressure in crowdsensing networks. As it is shown in Figure 6, Low DC with MSFO is worse than strategy without any queue management protocol. That's because smaller copies of packets get more transmission opportunities, resulting in a larger number of copies of these packets.

From the numeral results of network performance, the DC approach with MSFO can enhance network performance. Especially, the average latency decreases in the crowdsensing network. Thus, MSFO can be used to effectively reduce the transmission delay in applications with certain delay requirements.

V. CONCLUSION

Crowdsensing network plays an important role as a low-cost coverage network under the background of future IoT and 5G. Energy efficiency and transmission latency greatly affect the popularity of related applications. Therefore, this paper proposes the low latency DC with MSFO strategy which is designed based on the encounter prediction and queue management. It can optimize crowdsensing network performance to some extent, especially in network average latency. But the low delivery performance and fixed periodic sleep strategy will have a great capacity for improvement, which will be the future research.

VI. REFERENCES

[1]. Zhang R , Jia S , Ma Y , et al. Social-Aware D2D Video Delivery Method based on Mobility Similarity Measurement in 5G Ultra-Dense Network[J]. IEEE Access, 2020, PP(99):1-1.

[2]. Jung Y , Baek Y . Multi-hop data forwarding method for crowd sensing networks[J]. Peer-to-Peer Networking and Applications, 2016, 9(4):628-639.

[3]. Liu J., Li W., Wen Z , et al. An Energy Efficiency Approach via Self-Adaptive Duty-Cycle in Social Contacts Scenario[C]// 2019 IEEE 25th International Conference on Parallel and Distributed Systems (ICPADS). IEEE, 2020.

[4]. Li W, Liu J, Wu X, et al. A Location-Aware Duty Cycle Approach toward Energy-Efficient Mobile Crowdsensing[C]. international conference on parallel and distributed systems, 2019.
[5]. Massri K, Vernata A, Vitaletti A, et al. Routing protocols for delay tolerant networks: a quantitative evaluation[C]. acm workshop on performance monitoring and measurement of heterogeneous wireless and wired networks, 2012: 107-114.
[6]. Leguay, Jérémie, Friedman T , Conan V . DTN Routing in a Mobility Pattern Space[J]. Computer Science, 2005:276-283.
[7]. Ekman F., K. A., Karvo J., et al. Working day movement model[C], Acm Sigmobile Workshop on Mobility Models. ACM, 2008:33.

Cite this article as :

Hongsheng Yang, Jianwei Liu, "A Low-latency Strategy with dynamic Duty-Cycle in Opportunistic Mobile Crowdsensing Scenario", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 7 Issue 5, pp. 117-123, September-October 2020. Available at doi : https://doi.org/10.32628/IJSRSET207512
Journal URL : http://ijsrset.com/IJSRSET207512