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Research on Online Scheduling Strategies for Environmental Sanitation Vehicles

Yang Luo

School of Chongqing Jiaotong University, Chongqing 400074, China.

2567955367@qq.com

Abstract

At present, garbage removal is one of the key issues of environmental protection work, and the problem of garbage removal is particularly important. Generally, the cost of garbage removal accounts for 60% -80% of the total garbage treatment cost. Therefore, the problem of scheduling sanitation vehicles with the goal of cost minimization has become a hot topic. Most of the existing research on this problem is based on static demand, and finally calculates the offline optimal scheduling of sanitation vehicles. Therefore, taking into account the dynamic changes in demand, an online scheduling strategy for urban sanitation vehicles, namely an induction strategy, was designed, and the competitive performance ratio under different strategies was proved.

Keywords

Environmental Sanitation Vehicles; Scheduling strategy; Competitive ratio.

1. Introduction

With the continuous development of China's economy, the production of urban household waste in China ranked first in the world in 2014, and rapidly increased at an annual growth rate of 8% -10%[1]. Garbage removal is one of the most crucial links in the entire garbage treatment system. According to research data from the Environmental Sanitation Technology Network, the cost of garbage removal in China accounts for 60% -80% of the entire garbage treatment system. Therefore, a large number of scholars have begun to study the scheduling problem of urban sanitation vehicles. Li Xin, Pan Wangyang, and others considered the dynamic changes in garbage volume when studying the scheduling strategy of urban sanitation vehicles, and finally used the Dijkstra algorithm to solve the scheduling problem[2]. Ma Junping and Xu Yinfeng et al. used online algorithms to study the online scheduling problem of express delivery vehicles[3].

2. Research on Online Scheduling Strategies

2.1. Problem description

Given a simple city directed connected network graph G (V, E), which includes all routes for sanitation garbage truck transportation, V is the node set that includes all vertices in the graph, E is the road segment set that includes all road segments in the graph, and d (b, c) represents the weight from node b to node c, where. When carrying out tasks, the sanitation garbage truck plans to serve x garbage collection points, forming a demand sequence. The optimal transportation route is set in advance (the distance of the optimal route is). When the sanitation vehicle does not reach full load, there will be a penalty cost for non full load.

2.2. Related assumptions

All studies in this chapter are based on the following assumptions:

(1) The transportation network graph G is a connected graph;

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(2) Garbage collection points are independent of each other;

(3) Prioritize calling vehicles that have completed tasks but have not reached their rated load capacity.

2.3. Strategy design and proof

The induction strategy refers to the dispatch of n sanitation garbage trucks by the dispatch center to complete the cleaning tasks of each garbage collection point according to the optimal path. When z environmental sanitation garbage trucks have not completed all the garbage collection and transportation tasks, the information will be fed back to the dispatch center, which will then guide other vehicles to the demand point to complete the task.

Scenario 1: Only one sanitation vehicle has not completed the task and there is one remaining demand point that has not been processed.

Scenario 1-1: There are w sanitation garbage trucks that have completed their tasks but have not reached their rated load capacity. One of the n sanitation garbage trucks is not completing its task. At this point, there is exactly one available sanitation garbage truck on the road network. At this time, the transportation cost required for n sanitation garbage trucks to complete the demand sequence L is:

$$C_{\text{online}} = \sum_{i=1}^{n-2}(C_i d(O,L_1) + \sum_{j=1}^{x-1} C_i d(L_j,L_{j+1}) + C'_i d(L_x,O)) + Cd(O,L_1) + \sum_{j=1}^{s-1} Cd(L_j,L_{j+1}) + C'd(L_s,O) + Cd(O,L_1) + \sum_{j=1}^{x-1} Cd(L_j,L_{j+1}) + Cd(L_x,L_{x+1}) + C'd(L_{x+1},O) \tag{1}$$

Combining the offline formula and the ratio of maximum cost to minimum cost β， The following formula is established.

$$\frac{C_{online}(L)}{C_{opt}(L)} \le (1 + \frac{\lambda_{max} - 1}{n})\beta \tag{2}$$

Scenario 1-2: When a sanitation garbage truck fails to complete its task and there is one remaining garbage collection point, there are w available sanitation trucks. At this time, one of the sanitation trucks serves the demand point, while the other vehicles return not fully loaded. The transportation cost required to complete the demand sequence L at this time is:

$$C_{online} = \sum_{i=1}^{n-1-w}(C_i d(O,L_1) + \sum_{j=1}^{x-1} C_i d(L_j,L_{j+1}) + C'_i d(L_x,O)) + Cd(O,L_1) + \sum_{j=1}^{x-2} Cd(L_j,L_{j+1}) + C'd(L_{x-1},O) + Cd(O,L_1) + \sum_{j=1}^{x-1} Cd(L_j,L_{j+1}) + Cd(L_x,L_{x+1}) + C'd(L_{x+1},O) + \sum_{i=1}^{w-1}(C_i d(O,L_1) + \sum_{j=1}^{x-1} C_i d(L_j,L_{j+1}) + C_i d(L_x,O)) \tag{3}$$

Combining the offline formula and the ratio of maximum cost to minimum cost β， The following formula is established.

$$\frac{C_{\text{online}}(L)}{C_{\text{opt}}(L)} \le (1 + \frac{\lambda_{\max} - w + (w-1)\partial_{\max}}{n})\beta \tag{4}$$

Scenario 2: There are z sanitation garbage trucks that have not completed their tasks, and there are still y demand points that have not been processed.

Scenario 2-1: There are w available sanitation vehicles. The number of remaining garbage collection points is equal to the number of available sanitation vehicles. The transportation cost required to complete the demand sequence L at this time is:

$$C_{online} = \sum_{i=1}^{n-z-w}(C_i d(O,L_1) + \sum_{j=1}^{x-1} C_i d(L_j,L_{j+1}) + C'_i d(L_x,O)) + \sum_{i=1}^{z}(C_i d(O,L_1) + \sum_{j=1}^{s-1} C_i d(L_j,L_{j+1}) + C'_i d(Ls,O)) + \sum_{i=1}^{y}(C_i d(O,L_1) + \sum_{j=1}^{x-1} C_i d(L_j,L_{j+1}) + C_i d(L_x,L_{x+1}) + C'_i d(L_{x+1},O)) \tag{5}$$

Combining with the offline formula, the following equation holds.

$$\frac{C_{online}(L)}{C_{opt}(L)} \le (1 + \frac{y\lambda_{max} - w}{n})\beta \tag{6}$$

Scenario 2-2: There are w available sanitation vehicles. The number of remaining garbage collection points is less than the number of available vehicles. The transportation cost required to complete the demand sequence L at this time is:

$$C_{online} = \sum_{i=1}^{n-z-w}(C_i d(O,L_1) + \sum_{j=1}^{x-1} C_i d(L_j,L_{j+1}) + C'_i d(L_x,O)) + \sum_{i=1}^{z}(C_i d(O,L_1) + \sum_{j=1}^{s-1} C_i d(L_j,L_{j+1}) + C'_i d(Ls,O)) + \sum_{i=1}^{y}(C_i d(O,L_1) + \sum_{j=1}^{x-1} C_i d(L_j,L_{j+1}) + C_i d(L_x,L_{x+1}) + C'_i d(L_{x+1},O)) + \sum_{i=1}^{w-y}(C_i d(O,L_1) + \sum_{j=1}^{x-1} C_i d(L_j,L_{j+1}) + C_i d(L_x,O)) \tag{7}$$

Combining with the offline formula, the following equation holds.

$$\frac{C_{online}(L)}{C_{opt}(L)} \le (1 + \frac{y\lambda_{max} - w + (w-y)\partial_{max}}{n})\beta \tag{8}$$

In summary, the competition that adopts an inducement strategy is shown in the table1.

Table1 Competitive Ratio Table for Inducing Strategies

Scenario1		Scenario2	
Scenario1-1	Scenario1-2	Scenario2-1	Scenario2-2
$(1+\frac{\lambda_{max}-1}{n})\beta$	$(1+\frac{\lambda_{max}-w+(w-1)\partial_{max}}{n})\beta$	$(1+\frac{y\lambda_{max}-w}{n})\beta$	$(1+\frac{y\lambda_{max}-w+(w-y)\partial_{max}}{n})\beta$
The competitive ratio of inducement strategy is: $(1+\frac{y\lambda_{max}-w+(w-y)\partial_{max}}{n})\beta$			

3. Conclusion

Based on online algorithms and competitive strategies, the online scheduling problem of sanitation garbage trucks under incomplete information was studied. With the goal of minimizing the total transportation cost of sanitation garbage trucks, an induction strategy was designed, and the strategy competition ratio in each scenario was proved to be abc. When the task is not completed, the dispatch center can execute this strategy in the face of real-time updated information feedback from the sanitation garbage truck.

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