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CYCLIC DELIVERY SCHEDULING TO CUSTOMERS WITH DIFFERENT PRIORITIES

Katarzyna Zofia Gdowska, Roger Książek
AGH University of Science and Technology, Krakow, Poland

ABSTRACT. Background: In this paper a cyclic delivery scheduling problem for customers with different priorities is presented. Shops, which are provided with deliveries, are occasionally located in places which are crucial for the proper flow of traffic. In such places coordination of deliveries is crucial; therefore it allows to completely eliminate the phenomenon of the simultaneous arrivals of suppliers.
Methods: In this paper the cyclic delivery scheduling problem for customers with different priorities was presented. To this theoretical problem a mix integer programming model was developed. Specific approach to the cyclic delivery scheduling problem is inspired by timetabling problem for urban public transport.
Results: Mixed integer programming model was employed for solving four cases of cyclic delivery scheduling problem for customers with different priorities. When the value of the synchronization priority assigned to a single customer raised then the total number of synchronizations in the whole network decreased. In order to compare solutions a synchronization rate was utilized. A simple factor was utilized - the proportion of number of synchronizations of deliveries to a given customer to the total number of synchronizations obtained for the whole network. When the value of synchronization priority raised then the value of synchronization rate of this customer improved significantly.
Conclusions: The mixed integer programming model for the cyclic delivery scheduling problem for customers with different priorities presented in this paper can be utilized for generating schedules of serving customers located in places where only one delivery can be received and unloaded at one go and where there is no space for other suppliers to wait in a queue. Such a schedule can be very useful for organizing deliveries to small shops united in a franchising network, since they operate in a way that is very similar to the network presented in this paper. Moreover, in a franchising network it is possible to implement and control coordination between deliveries.

Key words: cyclic delivery scheduling problem, mixed-integer programming, optimization, time windows.

INTRODUCTION

In this paper a cyclic delivery scheduling problem for customers with different priorities is presented. This issue seems to be a very significant problem in the field of city logistics, especially when cyclic deliveries to small shops in the city center are considered. Small restaurants and small shops, where people do food and grocery shopping, are located one next to another in narrow, crowded and sometimes one-way streets of residential areas and city centers. Such shops and restaurants need to be cyclically supplied: firstly, they offer fresh products which need to be replaced no later than their best before date and, secondly, they usually are short of storage facilities. Nevertheless, more and more often such shops are united in a franchising network, so that deliveries to all of them are organized and coordinated by a regional center; it is very

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useful as far as deliveries of such good as pastry or dairy product are concerned. Suppliers-wholesalers cyclically provide their customers-shops with subsequent lot of fresh goods. Due to the fact that the frequency and number of deliveries is significantly high, uncoordinated arrivals of the suppliers' vehicles may interfere in a negative way the flow of the traffic in the given area. Therefore there is a need to introduce coordination of cyclic deliveries by setting a schedule for all the suppliers and customers. If there is no coordination of suppliers' arrival, we can observe a situation which we know very well by experience of our everyday lives - two or three suppliers' cars arrive at the same time to a given customer and they have to wait until the previous ones in the queue are unloaded. These cars frequently block a street in which the shop is located and, as a result, they hamper the flow of traffic. Furthermore, it should be emphasized, that shops to which this paper is referred are occasionally located in places which are crucial for the proper flow of traffic. In such places coordination of deliveries is crucial, since it allows to eliminate completely simultaneous arrivals of suppliers. The customers know the demand for goods they offer, therefore, they are able to determine time between consecutive deliveries, so that their shops never run out of products. Similarly, the suppliers know locations of all the customers they serve, as well as travel times between a wholesaler's warehouse and the location of a shop-customer, hence, suppliers also are able to determine a route for their cars; such a route is defined by the order of customer to be visited one after another. Certainly, specific conditions connected to both suppliers and customers should be taken into account in the structure of the delivery schedule.

In this paper the cyclic delivery scheduling problem for customers with different priorities was presented as a theoretical problem for which a mix integer programming model was developed. The model was employed for solving a small possible situation – computational experiment is presented and results are reported.

The paper is organized as follow: the first paragraph is devoted to general description of the cyclic delivery scheduling problem for customers with different priorities. In the second paragraph a mixed integer programming model for the cyclic delivery scheduling problem for customers with different priorities is presented. In two subsequent paragraphs utilization of the MIP model is presented and results obtained in computational experiments are reported. The final paragraph provides recapitulation of the presented problem and suggests directions for further research.

CYCLIC DELIVERY SCHEDULING PROBLEM FOR CUSTOMERS WITH DIFFERENT PRIORITIES

The problem of planning and realizing deliveries from suppliers to customers include the whole spectrum of issues referred to transportation, scheduling and synchronization. Particular problems were defined in different ways, depending on the aspects of the problem that were selected to be included and represented in the model. Transportation problems include numerous different problems, amongst others, vehicle routing problem [Toth and Vigo 1992, Ambroziak and Jachimowski 2011], travelling salesman problem [Laporte 1992, Takei et al. 2010], scheduling problem [Castelli et al. 2004] and timetabling problem [Ceder et al. 2001, Ibarra-Rojas and Rios-Solis 2012, Eranki 2004, Gdowska and Książek 2012a, 2012b]. Furthermore, the area of cyclic deliveries is also well explored. Amongst main problems may be listed: periodic service scheduling [Kazan et al. 2012], minimizing the number of vehicles [Campbell et al. 2005], seasonal deliveries [Ching-Ter and Hsiao-Ching 2013], manufacturing and distribution scheduling with fixed delivery departure dates [Leunga and Chen 2013] or with time windows [Ullrich 2013], cost optimization [Nidhi and Anil 2011] and issues referring to quality, safety and sustainability of distribution [Akkerman et al. 2010]. The reasons for the great number of formulations of transportation problems are, on one hand, criteria and goals to be fulfilled by the obtained solution and, on the other hand, specific organizational conditions of realizing deliveries.

In this paper utilization of a mixed integer programming model for the cyclic delivery scheduling problem with time windows for customers with different priorities is presented. The scope of the model is to obtain a schedule of synchronized deliveries, so that all the customers' receiving points are evenly loaded. Such an approach to the cyclic delivery scheduling problem is inspired by timetabling problem for urban public transport. The definition of synchronization and variables utilized in the model presented in this paper were taken from The Bus Synchronisation Timetabling Problem (BTP) [Ibarra-Rojas and Rios-Solis 2012]. As a result a model for the cyclic delivery scheduling problem was developed.

As it was mentioned before, every customer is characterized by specific conditions of delivery unloading; therefore, the priority of synchronization of deliveries' arrivals was assigned to every customer. According to the approach presented in this paper synchronization between deliveries is understood as a situation when deliveries from two suppliers arrive at a given customer's one after another and the required interval between their arrivals is kept. The customers achieve different values of synchronization priority, according to the following rule: the more important synchronization of deliveries at a given customer's is, the higher value of the synchronization priority is assigned to him. In result, deliveries to the crucial customers are synchronized, since they are awarded high value of the synchronization priority.

MIXED INTEGER PROGRAMMING MODEL FOR THE CYCLIC DELIVERY SCHEDULING PROBLEM FOR CUSTOMERS WITH DIFFERENT PRIORITIES

A mixed integer programming model was developed for the cyclic delivery scheduling problem for customers with different priorities. In the model following sets, variables and parameters were utilized: I - set of suppliers, B - set of customers, for each supplier there is a defined set of deliveries to be realized from the i-th supplier's warehouse (F_i), T – parameter, planning horizon, that is the period during which all the deliveries must departure from suppliers' warehouses, but it is not necessary for them to be delivered and unloaded at customers', f_{ri} - parameter, number of the last delivery to be realized from the i-th supplier's warehouse (i-th supplier provides all his customers with the same number of deliveries), h_i - parameter, minimal interval between departures of consecutive deliveries from the i-th supplier's warehouse (minimal headway time), H_i - parameter, maximal interval between departures of consecutive deliveries from the i-th supplier's warehouse (maximal headway time), t_{ib} - parameter, travel time between the i-th supplier's warehouse and the b-th customer's warehouse, w_b - parameter, desirable minimal interval between arrivals of consecutive deliveries in the b-th customer's. Parameter J_{ij} yields the value 1, if i-th and j-th suppliers have at least one common customer, and the parameter S_{ijb} yields the value 1, if i-th and j-th suppliers serve the b-th customer, which means that their deliveries may be synchronized according to the b-th customer's requirements.

In this model two types of variables were utilized: X_{ip} - departure time of the p-th delivery from the i-th supplier's warehouse, Y_{ijbpq} - presence or absence of synchronization between every pair of deliveries that arrive in the b-th customer's. Complete notation utilized in the model is presented in the table 1.

The original BTP model was modified in order to adjust it to the cyclic delivery scheduling problem. First of all, the objectivity function was changed: we maximize the total number of synchronizations augmented by the total sum of payments (priorities) earned thanks to obtained synchronizations. As it was already said, synchronization between deliveries is understood here as a situation when deliveries from two suppliers arrive at a given customer's one after another and the required interval (parameter w_b) between their arrivals is kept.

Table 1. Notation
Tabela 1. Oznaczenia przyjęte w modelu

Sets:	
I	set of suppliers
B	set of customers
F_i	set of deliveries to be realized from the *i*-th supplier's warehouse
Variables:	
X_{ip}	(integer veriable) departure time of the *p*-th delivery from the *i*-th supplier's warehouse
Y_{ijbpq}	Y_{ijbpq} = 1, if the *p*-th delivery from the *i*-th supplier arrives in (and is unloaded) the *b*-th customer's warehouse before the *q*-th delivery from the *j*-th supplier, otherwise Y_{ijbpq} = 0.
Parameters:	
T	planning horizon
H_i	maximal interval between departures of consecutive deliveries from the *i*-th supplier's warehouse (maximal headway time)
h_i	minimal interval between departures of consecutive deliveries from the *i*-th supplier's warehouse (minimal headway time)
w_b	upper limit of the time window during which only one supplier should be unloaded at the *b*-th customer's
t_{jb}	travel time between the *i*-th supplier's warehouse and the *b*-th customer's warehouse (time of unloading at every the customer's preceding the *b*-th customer on the *i*-th supplier's trip is included)
M	big number
J_{ij}	J_{ij} = 1, if a delivery from *i*-th supplier is allowed to be synchronised with a delivery from *j*-th supplier; otherwise J_{ij} = 0
S_{ijb}	S_{ijb} = 1, j if a delivery from *i*-th supplier is allowed to be synchronised with a delivery from *j*-th supplier in the *b*-th customer's warehouse; otherwise S_{ijb} = 0
fr_i	number of deliveries to be realized from the *i*-th supplier's warehouse
k_b	synchronization priority of the *b*-th customer

Source: own work based on the BTP model [Ibarra-Rojas and Rios-Solis 2012].

Table 2. Mixed integer programming model for the cyclic delivery scheduling problem for customers with different priorities
Tabela 2. Model programowania całkowitoliczbowego mieszanego dla problemu harmonogramowania cyklicznych dostaw do odbiorców o różnych priorytetach

Objectivity function:		
$\max \rightarrow \sum_{i\in I}\sum_{j\in I}\sum_{b\in B}\sum_{p\in F}\sum_{q\in F}(Y_{ijbpq} + Y_{ijbpq} * k_b) * J_{ij} * S_{ijb}$	$i,j\in I; b\in B; p\in F_i; q\in F_j$	
Subject to:		
$X_{i,1} \le H_i$	$i\in I$	(1)
$X_{i,fr_i} \le T$	$i\in I$	(2)
$T - H_i \le X_{i,fr_i}$	$i\in I$	(2a)
$h_i \le X_{i,p+1} - X_{ip}$	$i\in I;\ p \le F_i - 1$	(3)
$X_{i,p+1} - X_{ip} \le H_i$	$i\in I;\ p \le F_i - 1$	(3a)
$(X_{jq} + t_{jb}) - (X_{ip} + t_{ib}) \ge w_b - M(1 - Y_{ijpqb} J_{ij} S_{ijb})$		(4)
	$i,j\in I; b\in B; p\in F_i; q\in F_j$	
$Y_{ijbpq} J_{ij} S_{ijb} \le 1 - Y_{jibqp} J_{ji} S_{jib}$	$i,j\in I; b\in B; p\in F_i; q\in F_j$	(5)
$X_{ip} \in \{0,1,...T\}$	$i\in I;\ p \le F_i$	(6)
$Y_{ijbpq} \in \{0,1\}$	$i,j\in I; b\in B; p\in F_i; q\in F_j$	(7)

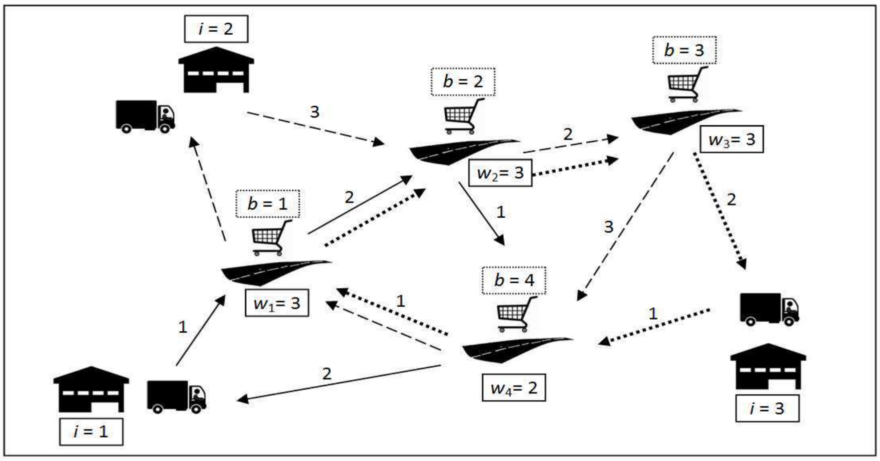
Source: own work based on the BTP model [Ibarra-Rojas and Rios-Solis 2012].

The constraint (1) of the model defines the latest possible departure time of the first delivery from the *i*-th supplier's warehouse; departure time equals to the maximal time between consecutive deliveries from the *i*-th supplier's warehouse (H_i). The constraints (2) and (2a) guarantee that all the deliveries will departure from suppliers' warehouses until the planning horizon T is over. The constraints (3) and (3a) assure that the required intervals between departures of consecutive deliveries from the i-th supplier's warehouse (parameters H_i and h_i) are kept. Synchronization of a pair of deliveries at the *b*-th customer's occurs only when the inequality in the constraint (4) is fulfilled, which means that the interval between arrivals of two deliveries at the same customers' is no lesser than the value of the parameter w_b. The constraint (5) represents valid inequalities introduced to the model which forces the proper value of the variable Y_{ijbpq} depending on the value of the value of the opposite one, Y_{jibqp}. When the *i*-th supplier comes to the *b*-th customer before the *j*-th supplier no matter if they are or are not synchronized, then it is impossible to synchronize at the same time the situation when the *i*-th supplier comes before the *j*-th one.

COMPUTATIONAL EXPERIMENTS - A CYCLIC DELIVERY SCHEDULING PROBLEM FOR CUSTOMERS WITH DIFFERENT PRIORITIES SOLVED WITH THE MIP MODEL

Three suppliers provide cyclic deliveries to four customers. Every supplier visits the customers in the same order, planned in advanced. The route of the supplier remains the same for every trip he performs, since it was recognized to be the most suitable (the most frequently the cheapest) for the supplier. Therefore, in this situation, it is hardly possible to change the order of customers to visit.

During the week time every supplier (i) has to provide every customer b with a certain number of deliveries, f_{ri}. For every supplier (i) minimal (h_i) and maximal (H_i) intervals between departures of consecutive deliveries from his warehouse are defined. To every customer (b) is assigned a certain priority of synchronization (k_b). In result, the higher is the value of the priority of synchronization (k_b) assigned to the *b*-th customer, the more important is to synchronize deliveries arriving in the *b*-th customer's. It is because when the *p*-th delivery from *i*-th supplier arrives in the *b*-th customer's before the *q*-th delivery from *j*-th supplier and the interval between their arrivals is no lesser than the value of the parameter w_b, then the variable Y_{ijbpq} yields the value 1 and the objectivity function is augmented of the value k_{b+1}.



Source: own work

Fig. 1. Scheme of a problem of the cyclic delivery scheduling problem for customers with different priorities
Rys. 1. Schemat przykładowego problemu harmonogramowania cyklicznych dostaw do odbiorców o różnych priorytetach

In order to make it easier to schedule deliveries the following assumption was adopted: every customer works six days a week, ten hours a day. During working time a customer is ready to receive and unload one delivery at the same time. Therefore a 60-hour planning horizon T can be utilized in computations. What is more, it was assumed that time of delivery receiving and unloading is so short that it may be neglected.

In order to eliminate queues of vehicles waiting for unloading the model presented in the previous paragraph of this paper was utilized for the problem, since as a solution the model we obtain an optimal weekly delivery schedule. Directly from the model we achieve departure time of every delivery from the supplier's warehouse. On that basis we can compute the arrival time of each delivery at customer's. The scheme of this problem is presented in the Fig. 1.

In the table 3 data utilized in computational experiments are presented. First of all, the order of deliveries is known and unchangeable. The number of deliveries to departure from every supplier's warehouse during the planning horizon (60 hours) is defined. In the table maximal and minimal intervals between departures of consecutive deliveries from the i-th supplier's warehouse are also given. This table also provides information of travel times t_{jb} between every supplier's warehouse and every customer is also provided; travel time between a supplier's warehouse and a customer was estimated as average travel time of driving along the route approved by the *i*-th supplier.

In table 4 routes of deliveries are presented as travel times between the *i*-th supplier's warehouse and the first customer on the route, and then travel times between every pair of customers visited consecutively by the *i*-th supplier. In this table information of desirable minimal interval between arrivals of consecutive deliveries in the *b*-th customer's (w_b) is provided.

Table 3. Data utilized in the computational experiment
Tabela 3. Dane wykorzystane w przykładowym zadaniu

	Order of deliveries / travel time t_{jb} [h]				Maximal time between consecutive deliveries from the *i*-th supplier's warehouse h_i [h]	Minimal time between consecutive deliveries from the *i*-th supplier's warehouse H_i [h]	Number of deliveries to be realised
	Customer						
	1	2	3	4			
Supplier 1	1/1	2/3	–/–	3/4	18	20	3
Supplier 2	4/9	1/3	2/5	3/8	12	15	4
Supplier 3	2/2	3/4	4/6	1/1	10	12	5

Source: own work

Table 4. Data - travel times between customers [h]
Tabela 4. Dane - czas przejazdu pomiędzy odbiorcami [h]

	Customer 1	Customer 2	Customer 3	Customer 4	Upper limit of the time window w_b
Supplier 1	1	-	-	-	-
Supplier 2	-	3	-	-	-
Supplier 3	-	-	-	1	-
Supplier 1	-	2	-	1	5
Supplier 2	2	-	2	1	5
Supplier 3	-	2	-	3	5
Supplier 4	1	1	3	-	7

Source: own work

The goal of the conducted computational experiment was to utilise a mixed integer programming model for solving four cases of cyclic delivery scheduling problem for customers with different priorities and to compare obtained results. Each of these four problems was formulated for data presented in tables 3 and 4. The only difference between them was different value of the synchronization priority assigned to the Customer 4. All the three suppliers provide customers with deliveries according to assumptions presented in the beginning of this paragraph (see Fig. 1.). In every case following values of the synchronisation parameter k_b were assigned (values of all the other parameters remain the same in every case - see tables 3 and 4):

- Case 1: k_1=0, k_2=0, k_3=0, k_4=0; (equal synchronization priorities),
- Case 2: k_1=0, k_2=0, k_3=0, k_4=1; (low synchronization priority assigned to the Customer 4),
- Case 3: k_1=0, k_2=0, k_3=0, k_4=10; (medium synchronization priority assigned to the Customer 4),

– Case 4: k_1=0, k_2=0, k_3=0, k_4=100; (high synchronization priority assigned to the Customer 4).

The goal of the conducted computational experiment was to solve these problems formulated as mixed integer programming models for the same set of data with the GLPK Solver (GNU Linear Programming Kit ver. 4.3). Computations were conducted with a computer equipped with a processor Intel® Core™2 Duo 2.00 GHz and 4 GB RAM. Searching for a solution was limited in advance by time limit that was equal 600 seconds. This amount of time was enough to obtain optimal solution for every problem.

RESULTS OBTAINED IN COMPUTATIONAL EXPERIMENTS

After solving four cases of cyclic delivery scheduling problem for customers with different priorities we obtained results which are to be found in the table 5. All the solutions are optimal from the perspective of the value of the objectivity function introduced in the utilised model. The value of the objectivity function equals the total number of synchronizations augmented by the total sum total number of synchronizations at the Customer 4 multiplied by priority of synchronization k_4. Priorities of synchronization have different values in every case, therefore there is no need to compare the quality of obtained solutions by comparing values of the objective function. Nevertheless, it is to be observed that solution obtained in Case 3 (medium synchronization priority assigned to the Customer 4) and in Case 4 (high synchronization priority assigned to the Customer 4) have the same the total number of synchronizations as well as the total number of synchronizations at the Customer's 4. Hence, attention should be paid to the total number of synchronizations obtained in every case. When the value of the synchronization priority assigned to the Customer 4 raised the total number of synchronizations in the whole network decreased. There was a following reason: by giving higher value of synchronization priority to the Customer 4 we forced the solver to search for the higher possible number of synchronizations for this customer and it made it more difficult to find synchronizations for other customers, so the total number of synchronizations was reduced but the value of the objectivity function rose.

Table 5. Results of computational experiments
Tabela 5. Wyniki eksperymentu obliczeniowego

		Priority assigned to the Customer 4			
		0	1	10	100
	Value of the objective function	146	185	552	4242
	Total number of synchronisations	146	145	142	142
Number of synchronisations	Customer 1	43	42	43	42
	Customer 2	45	45	42	42
	Customer 3	19	18	16	17
	Customer 4	39	40	41	41
Synchronisation rate	Customer 1	29,5 %	29,0%	30,3%	29,6%
	Customer 2	30,8 %	31,0%	29,6%	29,6%
	Customer 3	13,0 %	12,4%	11,3%	12,0%
	Customer 4	26,7 %	27,6%	28,9%	28,9%

Source: own work

According to assumptions adopted, quality of solutions can be evaluated by comparing obtained delivery schedules. In order to compare obtained optimal solutions the synchronization rate was developed. Synchronization rate is a proportion of number of synchronizations at a given customer's to the total number of synchronizations obtained for the whole network. As it was to be expected, when the value of synchronization priority assigned to the Customer 4 raised then the value of synchronization rate of this customer improved by ca. 2%. At the same time synchronization rate of other customers their synchronization rates worsened. The size of improvement of the delivery schedule may not seem significant; however, obtaining one or two synchronizations extra in such a small network is not easy.

CONCLUSIVE REMARKS

The mixed integer programming model for the cyclic delivery scheduling problem for customers with different priorities presented in this paper can be utilized for generating schedules of serving customers located in places where only one delivery can be received and unloaded at one go and where there is no space for other suppliers to wait in a queue. Such a schedule can be very useful for organizing deliveries to small shops united in a franchising network, since they operate in a way that is very similar to the network prsented in this paper. Moreover, in a franchising network it is possible to implement and control coordination between deliveries.

Basing on results obtained in the computational experiments it may be stated that utilization of synchronization priority makes the problem more flexible and adjusted to the real conditions. In real conditions can be found shops or warehouses where simultaneous unloading of several suppliers is either impossible or unwelcome.

In this paper results obtained for a small network were presented. Continuation of research in this field is recommended, since there are many other aspects of cyclic deliveries that were not taken into consideration in this problem. Amongst them are to be listed: deliveries to warehouses or logistics center where many deliveries can be received in the same time, costs of travel and waiting time or vehicle assignment problem.

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HARMONOGRAMOWANIE CYKLICZNYCH DOSTAW TOWARÓW DO ODBIORCÓW O RÓŻNYCH PRIORYTETACH SYNCHRONIZACJI DOSTAW

STRESZCZENIE. **Wstęp:** W pracy przedstawiono problem harmonogramowania cyklicznych dostaw towarów do odbiorców o różnych priorytetach synchronizacji dostaw. Punkty handlowe, o których mowa w tym artykule, nierzadko są ulokowane przy ulicach, newralgicznych dla prawidłowego ruchu kołowego w mieście. W takich miejscach koordynacja dostaw do sklepów ma kluczowa znaczenie, gdyż zapobiega równoczesnym przyjazdom dostawców, a co za tym idzie tworzeniu utrudnień w ruchu.

Metody: Problem harmonogramowania cyklicznych dostaw towarów do odbiorców o różnych priorytetach synchronizacji dostaw został sformułowany jako zadanie teoretyczne, dla którego zbudowano model programowania całkowitoliczbowego mieszanego. Specyficzne ujęcie problemu harmonogramowania dostaw cyklicznych było inspirowane problemem układania rozkładów jazdy miejskiej komunikacji publicznej.

Wyniki: Eksperyment obliczeniowy polegał na rozwiązaniu i porównaniu uzyskanych wyników dla czterech zbudowanych zadań programowania całkowitoliczbowego mieszanego dla problemu cyklicznych dostaw do odbiorców o różnych priorytetach. Wraz ze wzrostem priorytetu dla jednego odbiorcy ogólna liczba synchronizacji dla całej sieci cyklicznych dostaw zmniejszyła się. W celu porównania jakości rozwiązań wyznaczono wskaźnik synchronizacji, rozumiany jako stosunek liczby synchronizacji dla danego odbiorcy do całkowitej ich liczby w rozwiązaniu dla danego zadania. Zastosowanie priorytetu synchronizacji dla odbiorcy spowodowało poprawę jego wskaźnika synchronizacji dostaw.

Wnioski: Przedstawiony model programowania liniowego mieszanego dla zadania harmonogramowania cyklicznych dostaw z priorytetami dla odbiorców może być wykorzystywany do tworzenia harmonogramów dla dostawców produktów do odbiorców, u których występują ograniczenia związane z jednoczesnym obsługiwaniem kilku dostawców równocześnie.

Słowa kluczowe: harmonogramowanie dostaw cyklicznych, programowanie całkowitoliczbowe mieszane, optymalizacja, okna czasowe.

DER ZEITPLAN DER REGELMÄSSIG WIEDERKEHRENDEN PRODUKTLIEFERUNG MIT RÜCKSICHT AUF SYNCHRONISATIONSPRIORITÄTEN DER LIEFERUNG VERSCHIEDENER EMPFÄNGER

ZUSAMMENFASSUNG. Einleitung: In der Arbeit wurde das Modell der linearen vollnumerischen gemischten Programmierung für die Aufgabe des Zeitplans der regelmäßig wiederkehrenden Lieferung mit Fensterfunktionen für die Empfänger verschiedener Synchronisationsprioritäten dargestellt. Die Handelspunkte, von denen in diesem Artikel gehandelt wurde, sind nicht selten bei den Straßen untergebracht, die für den Fahrzeugverkehr neuralgisch sind. In diesen Plätzen hat die Koordination der Lieferung die Schlüsselbedeutung, weil sie den gleichzeitigen Ankünften der Lieferanten und demzufolge der Entstehung von Verkehrsbehinderungen vorbeugt.
Methode: Das Problem des Zeitplans von regelmäßig wiederkehrender Produktlieferung für die Empfänger verschiedener Synchronisationsprioritäten wurde als theoretische Aufgabe formuliert, für den das Modell der vollnumerischen gemischten Programmierung gebildet wurde. Die spezifische Darstellung des Problems wurde von dem Problem der Fahrplanzusammenstellung für den öffentlichen Verkehr inspiriert.
Ergebnisse: Das Rechenexperiment bestand darin, die erreichten (für vier gebaute Aufgaben der vollnumerischen gemischten Programmierung für das Problem der zyklischen Produktlieferung für die Empfänger verschiedener Synchronisationsprioritäten) Ergebnisse zu lösen und zu vergleichen. Mit der Prioritätssteigerung für einen Lieferanten hat sich die allgemeine Zahl der Synchronisierung für die ganze Netz der regelmäßig wiederkehrenden Lieferungen verringert. Zwecks des Qualitätsvergleiches von Lösungen wurde Synchronisierungsanzeiger festgelegt, der als Verhältnis der Synchronisationszahl für den gegebenen Lieferanten zu allen ihren Zahlen in der Aufgabelösung verstanden wird. Die Verwendung von der Synchronisierungspriorität für den Empfänger hat die Verbesserung seines Anzeigers der Lieferung-Synchronisierung verursacht.
Fazit: Das dargestellte Modell der gemischten Linienprogrammierung für die Aufgabe des Zeitplans von zyklischen Lieferungen mit Prioritäten für die Empfänger kann zur Zeitplanbildung für Produktlieferanten zu Empfänger verwendet werden, bei denen die Beeinträchtigung der gleichzeitigen Bedienung von einigen Lieferanten vorkommt.

Codewörter: Zeitplan der regelmäßig wiederkehrenden Lieferung, vollnumerische gemischte Programmierung, Optimierung, Fensterfunktion

Katarzyna Zofia Gdowska, Roger Książek
AGH University of Science and Technology
Faculty of Management
30 Mickiewicza Av., 30-059 Krakow, Poland
e-mail: kgdowska@zarz.agh.edu.pl
e-mail: rksiazek@zarz.agh.edu.pl