JOURNAL OF TRANSPORT

ISSUE 1, 2025 vol. 2
E-ISSN: 2181-2438
ISSN: 3060-5164

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RESEARCH, INNOVATION, RESULTS

TOSHKENT DAVLAT TRANSPORT UNIVERSITETI
Tashkent state transport university

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E-ISSN: 2181-2438
ISSN: 3060-5164
VOLUME 2, ISSUE 1
MARCH, 2025

jot.tstu.uz

TASHKENT STATE TRANSPORT UNIVERSITY

JOURNAL OF TRANSPORT

SCIENTIFIC-TECHNICAL AND SCIENTIFIC INNOVATION JOURNAL

VOLUME 2, ISSUE 1 MARCH, 2025

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The journal benefits from its official recognition under Certificate No. 1150 issued by the Information and Mass Communications Agency, functioning under the Administration of the President of the Republic of Uzbekistan. With its E-ISSN 2181-2438, ISSN 3060-5164 the publication upholds international standards of quality and accessibility.

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Application of the method of discrete allocation of vehicles to routes in the transportation of cotton raw materials

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Abstract: The article uses algorithms for solving the problem of distributing vehicles along routes when transporting cotton raw materials. Based on the proposed method, one of the solutions to the problem is determined, the number of vehicles sent to each route during the day, and the volume of transportation are shown. Depending on the type, number of vehicles and performance indicators of loading and unloading equipment and transportation costs, it will be possible to find other solutions that satisfy the conditions of the problem based on the discrete distribution method.

Keywords: vehicles, route, transportation, distribution, algorithm, cotton raw material, discrete, load level, collection, association

Avtomobil transport vositalarini marshrutlarga diskret taqsimlash usulini paxta xom-ashyosini tashishda qo‘llash

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Annotatsiya: Maqolada avtomobil transporti vositalarini marshrutlarga taqsimlash masalasining yechish algoritmlari paxta xom-ashyosini tashishda qo‘llanilgan. Taklif etilgan usul asosida masala yechimlaridan biri aniqlanib, kun davomida har bir marshrutga yo‘naltirilgan avtomobil transport vositalari soni va tashish hajmlari ko‘rsatilgan. Tashishga ajratilgan avtomobil transporti vositalarining turi, soni va ortish-tushirish vositalarining ish ko‘rsatkichlari hamda tashish xarajatlaridan kelib chiqib, diskret taqsimlash usuli asosida masala shartini qanoatlantiradigan boshqa yechimlarni ham topish mumkin bo‘ladi.

Kalit so‘zlar: avtomobil transporti vositalari, marshrut, tashish, taqsimlash, algoritm, paxta xom-ashyosi, diskret, yuklanganlik darajasi, yig‘ilma, birlashma

1. Kirish

Dunyoda global raqobatning kuchayishida transport tizimlaridan samarali foydalanish, ya’ni, ratsional transport vositalari va mexanizmlarini tanlashda jarayon ishtirokchilarining manfaatlarini inobatga olish hamda ularning ehtiёjlarini qondirish qobiliyati dolzarb vazifalardan bo‘lib qolmoqda. Mahsulot va xizmatlar tannarxini kamaytirish omili sifatida transport tizimining o‘rni muhim bo‘lib, mazkur tizimning rivojlanishi yaratilayotgan mahsulotlar tannarxida transport xarajatlarining kamayishi bilan birga milliy iqtisodiyot raqobatdoshligini ta’minlaydi[3].

Mavzuning dolzarbligi. Transport vositalarida tashish jarayonlarini boshqarish borasida olib borilgan ilmiy tadqiqotlar tafsiloti shuni ko‘rsatadiki, masalalarning mohiyatiga qarab chiziqli dasturlash, diskret dasturlash, dinamik dasturlash, stoxastik chiziqli dasturlashlar kabi modellashtirish usullari qo‘llaniladi.

Masalalarda yuk tashishni rejalashtirish o‘z mohiyati bilan optimallik funksiyasi va cheklash tenglamalari talablariga doir yechimlarni aniqlash talab etilsa, hisob sxemalari va kompyuter algoritmlari keng tarqalgan chiziqli dasturlash usullari qo‘llaniladi [2,4,5,6].

Tadqiqot tahlillaridan kelib chiqib, shuni keltirish lozimki, har bir yo‘nalishga taqsimlanadigan avtomobil transporti vositalari soni o‘z mohiyatiga ko‘ra butun bo‘lishi kerak. Taqsimlash masalasini butun sonli chiziqli programalashtirish modellari ko‘rinishida ham yechish mumkin, lekin, avtomobil transport vositalarini marshrutlarga taqsimlash masalasini chiziqli programmalashtirish modellari ko‘rinishda yechishda quyidagi kamchilik va noqulayliklarga olib keladi:

- rejalashtirilgan yuk tashishni tashkil etish uchun har bir marshrutga taqsimlangan avtomobil transporti vositalariga xizmat ko‘rsatish uchun kerak bo‘ladigan ortish-tushirish mexanizmlarining optimal sonini aniqlash kerak bo‘ladi.
- avtomobil transporti vositalarini marshrutlarga taqsimlanish masalasini yechimida butun bo‘lmagan sonlarni butunlashtirib olish kerak va bu esa yechimni optimallik darajasini kamaytiradi.
- masalani yechimini aniqlashda har bir tashish marshrutida ishlayotgan ortish-tushirish mexanizmlarini kunlik ish vaqti davomida avtomobil transporti vositalari

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bilan to‘liq ta’minlash talabi hisobga olinmaydi. Tashish marshrutida ma’lum kunda ishlayotgan mexanizmlar soni hamisha butun bo‘lganligidan ularni kun mobaynida ish bilan to‘la ta’minlash uchun shu yo‘nalishga ma’lum sondagi avtomobillar ajratish lozim bo‘ladi.

Bunday talablarni yuqorida chiziqli programalashtirish modellarda hisobga olib bo‘lmaydi. Shuning uchun tufayli avtomobil transporti vositalarini marshrutlarga taqsimlash masalasining kombinatorli modellari va uni yechishni evristik algoritmlarini ishlab chiqish lozim bo‘ladi.

2. Tadqiqot metodikasi

Avtomobil transport vositalari (ATV)ning marshrutlarga taqsimlash masalasini diskret qo‘yilishida olinadigan yechim marshrutlarga taqsimlanadigan ATVlar soni har qanday qiymatlardan emas, balki mumkin bo‘lgan yechimlarni o‘z ichiga oladigan diskret to‘plamga tegishli qiymatlardan iborat bo‘ladi [7]. Diskret to‘plam elementlari har bir marshrut uchun ajratilishi mumkin bo‘lgan ATV sonlaridan iboratdir. Umumiy holda masalani yechish – bu, har bir marshrutga taqsimlanayotgan ATVlar sonini, ularni ma’lum diskret to‘plam elementlaridan iborat tarzda aniqlashdan iboratdir.

Diskret to‘plam elementlari har bir marshrut uchun ajratilishi mumkin bo‘lgan ATV sonlaridan iboratdir. Bunda, iste’molchi manzillarni har bir marshrutga taqsimlanishi mumkin bo‘lgan ATV soni jo‘natuvchi manzilda ATV lariga yuk ortuvchi va sh.k. boshqa xizmat ko‘rsatuvchi kanallarning sonlariga muvofiq ularni vaqt birligida yuk jo‘natish imkoniyatlaridan kelib chiqqan holda aniqlanadi. Umumiy holda masalani yechish – bu har bir marshrutga taqsimlanayotgan ATV lari sonlarini, ularni ma’lum diskret to‘plam elementlaridan iborat tarzda aniqlashdan iboratdir. ATVni marshrutlarga taqsimlash masalasini qo‘yilishini asoslashda quyidagi talablarni hisobga olish zarur bo‘ladi.

ATVni tashish yo‘nalishlariga shunday taqsimlanadiki, natijada ular birlashadigan manzillarni yuk hajmiga bo‘lgan ehtiyoji qondiriladi. Klaster manzilga yetkazib berilayotgan yoki olib chiqilayotgan yuk hajmini uning ehtiyojiga muvofiq boshqarilishi turli masofalarga ega bo‘lgan marshrut yo‘nalishlariga taqsimlanayotgan ATV lari sonlarini o‘zgartirilishi (foydalanilayotgan ATV umumiy sonini o‘zgartirmagan holda) hisobiga erishiladi, ya’ni, klaster manzilni yuk olib kirish (yoki tarqatish)ga bo‘lgan ehtiyoji katta hajmda bo‘lsa ATV larini ko‘proq sonda kichikroq uzunlikdagi yo‘nalishlarga yoki aksincha, mazkur ehtiyoj kichikroq hajmda bo‘lsa ATV larini kattaroq uzunlikdagi marshrutlarga taqsimlanadi.

Turli yuk ko‘taruvchanlikka ega bo‘lgan avtomobil transport vositalarini marshrutlarga taqsimlash- bu har bir marshrutda yuk tashish uchun ajratilgan avtomobil transport vositalarini sonini ularni har bir turi bo‘yicha aniqlash va har bir ATV ni belgilangan marshrutda bajarilishi lozim bo‘lgan qatnovlar sonini belgilashdan iboratdir[1].

Avtotransport vositalarini tashish yo‘nalishlari bo‘yicha samarali taqsimlanishini paxta xom-ashyosini tashish misolida ko‘rib chiqamiz.

Yuk tashib kiritiluvchi klaster manzillaridagi paxta tozalash korxonasining tashish hajmiga bo‘lgan ehtiyoji Q_{min}=800 t va Q_{max}=1000 t. Paxta tozalash korxonasiga yuk tashib beruvchi marshrutlar to‘plami J={1,2,3,4}. Bunda $j(j\epsilon J)$ raqamlar marshrutlarga ularni tashish masofalarni oshib borish tartibida belgilangan. Berilgan marshrutlar j={1,2,3,4} uchun qatnov vaqti $t_j\,(j\epsilon J)$ = {1,1.5,2,2.5} soat, mos ravishda tashish yuk ko‘taruvchanligi bo‘yicha $i\epsilon${1,2} turdagi ATVlari bilan amalga oshiriladi: i=1-turdagi ATVni yuk ko‘taruvchanligi q_{n1}=6 t va uni soni $A_3^1 = 30$ dona; i=2-turdagi ATV uchun q_{n2}=12 t bo‘lib, bu turdagi avtomobillar $A_3^2 = 20$ donani tashkil etadi. Q_{ij}, S_{ij} parametrlarni qiymati 1 jadvalda, $i\epsilon${1,2} turdagi ATV uchun $//X^i_{j\sigma_j}//_{j\Sigma_j}$ matritsasi 2 va 3 jadvallarda berilgan.

Masalaning matematik ifodalanishi quyidagicha bo‘ladi:

$$W=\sum_{i\in I}\sum_{j\in J} X^{\,i}_{j\sigma_j} Q_{ij} \longrightarrow \text{extr};$$

$$\sum_{j\in J} X^{\,i}_{j\sigma_j} = A^i_3;\quad Q_{\min} \le \sum_{i\in I}\sum_{j\in J} X^{\,i}_{j\sigma_j}\cdot Q_{ij} \le Q_{\max};$$

$$X^i_{j\sigma_j} \in G_{j\sigma_j}; i \in I;$$

1- jadval

ATV larini turlari bo‘yicha marshrutlardagi ish unumdorligi Q_{ij} va S_{ij} tashish tannarxi qiymatlari

j ko‘rsatkich	Marshrutlar raqami			
	1	2	3	4
1. i=1- tur ATVni ish unumdorligi, Q1j (t)	36	24	12	6
2. i=2- tur ATVni ish unumdorligi, Q2j (t)	48	36	24	12
3. i=1- tur ATVni,tashish tannarxi S1j (so‘m/t)	15343	22356	24693	36391
4. i=2- tur ATVni,tashish tannarxi S2j (so‘m/t)	16869	24525	27106	39988

2- jadval

$//X^1_{j\sigma_j}//_{j\Sigma_j}$matritsasi

j / σ_j	1	2	3	4
0	0	0	0	0
1	10	10	10	10
2	20	20	20	20
3	30	30	30	30

3- jadval

$//X^2_{j\sigma_j}//_{j\Sigma_j}$ matritsasi

j / σ_j	1	2	3	4
0	0	0	0	0
1	5	5	5	5
2	10	10	10	10
3	15	15	15	15

“Boshidan” tartibi bilan talabga doir yig‘ilmalarni shakllantiramiz.

AV turini belgilovchi i indeks qiymatini belgilaymiz i =1. “Boshidan” tartibida sinovchi yig‘ilma raqamini shakllantiramiz (2 operator): $\psi_1^1 \ldots \psi_e^1 \ldots \psi_c^1$ raqami 1-chi

indeksiga maksimal, qolganlariga minimal qiymat beramiz va yig‘ilma $H(X^i_{j\sigma_j})^{бош}_{сим}$ga quyidagi raqamini shakllantiramiz $-3^I0^I0^I0^I$ (4 operator).

Olingan $3^I0^I0^I0^I$ raqam uchun yig‘indi $\sum_{e=1}^{c}\psi_e^i$ qiymatini hisoblaymiz (6 operator):

$$\sum_{e=1}^{c}\psi_e^i = 3^I + 0^I + 0^I + 0^I = 3.$$

Yig‘indi qiymati (5 operator) $\sum_{e=1}^{c}\psi_e^i$ ni kasr $\frac{A_э^1}{\gamma_1} = \frac{30}{10} = 3$ qiymati bilan solishtiramiz (6 operator).

Bu qiymatlar tengligini $\sum_{e=1}^{c}\psi_e^i = \frac{A_э^1}{v_1} = 3$ aniqlaymiz (7 operator). Demak, $3^I0^I0^I0^I$ raqam boshidan shakllantirilgan talabga doir birinchi yig‘ilma raqamidir. Mazkur raqamga mos yig‘ilma $X^1_{13}X^1_{20}X^1_{30}X^1_{40}$ (9 operator). Yig‘ilmani talab doirasida ekanligini tekshiramiz:

$$\sum_{j\in J} X^1_{j\sigma_j} = X^1_{13} + X^1_{20} + X^1_{30} + X^1_{40} = 30 = A_э = 30.$$

i=2 turdagi AVlari uchun talabga doir yig‘ilmani shakllantiramiz. Bunda “boshidan” shakllantirilgan yig‘ilma raqami $3^20^20^20^2$ bo‘ladi (2 operator).

Hisoblaymiz (5 operator): $\sum_{e=1}^{c}\psi_e^i = 3^2 + 0^2 + 0^2 += 3$

Solishtiramiz (6,7 operator): $\sum_{e=1}^{c}\psi_e^1 = 3 < \frac{A_э^2}{v_2} = 4.$

Parametrlar $\Delta_k^i, \psi_{(1+\Delta_k^i)}$ qiymatlarini hisoblaymiz (8 b operator):

$$\Delta_k^2 = \left(\frac{A_э^2}{v_2 \cdot \sum_{e=1}^{c}\psi_e^2}\right)_{бут} = \left(\frac{20}{5\cdot 3}\right)_{бут} = 1,$$

$$\psi^2_{(1+\Delta_k^2)} = \psi_2^2 = \frac{A_э^2}{v_2} - \Delta_k^2 \cdot \sum_{e=1}^{c}\psi_c^2 = 4 - 1\cdot 3 = 1.$$

Talabga doir birinchi yig‘ilma raqami (9 operator): $\psi_1^{2\max}\psi_2^2\psi_3^{2\min}\psi_4^{2\min}$ - $3^2I^20^20^2$ bo‘ladi.

Tekshiramiz: $\sum_{j\in J} X^2_{j\sigma_j} = X^2_{13} + X^2_{21} + X^2_{30} + X^2_{40} = 15 + 5 + 0 + 0 = 20 = A_э^2 = 20.$

Shunday qilib yig‘ilmalar birlashmasi raqamlari $\{3^I0^I0^I0^I$ va $3^20^20^20^2\}$ bo‘ladi.

Birlashma uchun yig‘indi $A_{сим}^{бош}$ qiymatini hisoblaymiz (10 v operator):

$$A_{сим}^{бош} = \left(\sum_{i\in J}\sum_{j\in J} X^i_{j\sigma_j}\cdot Q_{ij}\right)^{бош}_{сим} = X^1_{13}Q_{11} + X^1_{20}Q_{12} + X^1_{30}Q_{13} + X^1_{40}Q_{14} +$$
$$+ X^2_{13}Q_{21} + X^2_{21}Q_{22} + X^2_{32}Q_{23} + X^2_{40}Q_{24} = 30\cdot 36 + 0\cdot 24 + 0\cdot 12 + 0\cdot 6 +$$
$$+ 15\cdot 48 + 5\cdot 36 + 0\cdot 24 + 0\cdot 12 = 1080 + 900 = 1980\,t.$$

Ma’lum bo‘ldiki $A^{бош}_{син} = 1980 > Q^{max} = 1000\,t.$ t ekan (12 a operator).

Bu holda, masalani yechimini talabga doir birinchi yig‘ilmada “o‘ngga” yo‘nalishdagi ko‘chirishlar orqali aniqlash mumkin (13 b operator):

Ehtiyojni qondiruvchi ko‘chirish qiymatini hisoblaymiz (14 operator):

$$З^{ўнг}_{ЭК\min} = A^{бош}_{сим} - Q_{max} = 1980 - 1000 = 980\,t;$$

$$З^{ўнг}_{ЭК\max} = A^{бош}_{сим} - Q_{\min} = 1980 - 800 = 1180\,t.$$

Ehtiyojni qondiruvchi ko‘chirish qiymatini $(З^{ўнг}_{ЭК\min} - З^{ўнг}_{ЭК\max})$ ta’minlaydigan ko‘chirish variantlarini aniqlaymiz. Variantlar tahlilini eng katta i dan boshlaymiz, ya’ni i=2. $H(X^2_{j\sigma_j})^{бош}_{1mg}$ yig‘ilma uchun $З^{2(1mg)}_{max(ўнг)}$ qiymatini hisoblaymiz (16 operator):

$$З^{2(1mg)}_{max(ўнг)} = \left(\sum_{j\in J} X^2_{j\sigma_j}\cdot Q_{2j}\right)^{бош}_{1mg} - \left(\sum_{j\in J} X^2_{j\sigma_j}\cdot Q_{2j}\right)^{бош}_{1mg} =$$
$$= (15\cdot 48 + 5\cdot 36 + 0\cdot 24 + 0\cdot 12) - (0\cdot 48 + 0\cdot 36 + 5\cdot 24 + 15\cdot 12) =$$
$$= 900 - 300 = 600t.$$

Yig‘indi qiymati $\sum_{i=2} З^{2(mg)}_{max(ўнг)} = 600t$ ni $З^{ўнг}_{ЭКmin}$bilan solishtirib, quyidagi holatni aniqlaymiz (8 operator):

$$\sum_{i=2} З^{2(1mg)}_{\max(ўнг)} = 600t < З^{ўнг}_{ЭК\min} \quad 980t.$$

AV turini keyingi i indeksiga o‘tamiz: i =2-1=1 .

$H(X^1_{j\sigma_j})^{бош}_{1mg}$ yig‘ilma uchun $З^{1(1mg)}_{max(ўнг)}$qiymatini hisoblaymiz (16 operator):

$$З^{1(1mg)}_{max(ўнг)} = (30\cdot 36 + 0\cdot 24 + 0\cdot 12 + 0\cdot 6) - (0\cdot 36 + 0\cdot 24 + 0\cdot 12 + 30\cdot 6) =$$
$$= 1080 - 180 = 900t.$$

Yig‘indi $\sum_{i=2}^{1} З^{1(1mg)}_{max(ўнг)}$ qiymatini hisoblaymiz (17 operator):

$$\sum_{i=2}^{1} З^{1(1mg)}_{max(ўнг)} = 600 + 900 = 1500t.$$

Solishtiramiz (18, 19b operator):

$$\sum_{i=2}^{1} З^{1(mg)}_{max(ўнг)} = 600 + 900 = 1500t > З^{унга}_{ЭКmax}$$

Bu holda asoslangan algoritmni blok-sxemasiga binoan $H(X^1_{j\sigma_j})^{бош}_{1mg}$ yig‘ilmada “o‘ngga” ko‘chirish o‘tkazish lozim (20b operator). Ehtiyojni qondiruvchi ko‘chirishni qoldiq $H(X^1_{j\sigma_j})^{бош}_{1mg}$ qiymatini hisoblaymiz (21b operator).

$$0З^{ўнг}_{\min} = З^{ўнг}_{\min} - \sum_{i=I}^{i-1} З^{i(1mg)}_{\max(ўнг)} = 980 - 600 = 380\,t;$$

$$0З^{ўнг}_{\max} = З^{ўнг}_{\min} - \sum_{i=I}^{i-1} З^{i(1mg)}_{\max(ўнг)} = 1180 - 600 = 580\,t;$$

$H(X^1_{j\sigma_j})^{бош}_{1ЭК}$ yig‘ilma raqami $3^10^10^10^1$ ni (22 operator) va ko‘chirish varianti m (m=1) ni aniqlaymiz: bunda m=1 bo‘lganligi uchun $\kappa^m = 0$ va $d^m = 1$ bo‘ladi (24 operator).

Ko‘chirishni qabul qiluvchi bo‘lishi mumkin bo‘lgan indeksni tartib raqamini $(c - \kappa^m)$ =(4-0)=4 ni aniqlaymiz. Demak, $\psi_{(c-\kappa^m)} = \psi_4$ qabul qiluvchi $d^m = 1$ va $\psi_{d^m} = \psi_1$ esa m=1 varianti uchun jo‘natuvchi indeks hisoblanadi . Endi ψ_4 indeksi qabul qiluvchi indeks bo‘lganligini aniqlaymiz, ya’ni $\psi_4 = 0$ ni ψ_4^{max} bilan solishtiramiz va aniqlaymiz (25,26 operator).

Indeksni qabul qilish imkoniyatini aniqlaymiz: $\psi_4^{KI} = \psi_4^{\max} - \psi_4 = 3 - 0 = 3.$ Endi ψ_1 indeksini jo‘natish imkoniyatini aniqlaymiz: $\psi_1 = 3$ ni ψ_1^{min} bilan solishtiramiz (27, 28, 29, 30 operatorlar).

$\psi_1 > \psi_{1min}$; ψ_1 indeksini jo‘natish bo‘yicha imkoniyati $\psi_1^{ЖИ} = \psi_1 = 3$ ekan.

m=1 variantidagi ko‘chirishni mumkin bo‘lgan qiymatini $\psi_1^{ЖИ\rightleftarrows} = 3\psi_4^{KI} = 3$ va $\psi_4^{KI} = 3$ hisobga olgan holda aniqlaymiz (31 operator):

$$З_{\psi_1\psi_4} = (Q_{11} - Q_{14})\cdot v\cdot \psi_1^{ЖИ} = (36 - 6)\cdot 10\cdot 3 = 900t.$$

Ko‘chirishni faqat m=1 varianti bo‘lganligi uchun (32 operator)

$$\sum_{m=1} З_{\psi_1\psi_4} = 900t.$$

Solishtiramiz (35 operator):

$$\sum_{m=1} З_{\psi_1\psi_4} = 900t > О З^{(унг)}_{ЭКmax} \text{ ва } \psi_4^{(унг)} = 3 > 1.$$

Parametrlar $\Delta З^{ўнг(m)}_{ЭКmin}$ va $\Delta З^{ўнг(m)}_{ЭКmax}$ qiymatlarini hisoblaymiz (38 operator):

$$\Delta З^{ўнг(m)}_{ЭК\min} = О З^{ўнг}_{ЭК\min} = 380\,t, \quad \Delta З^{ўнг(m)}_{ЭК\max} = О З^{ўнг}_{ЭК\max} = 580\ t$$

https://doi.org/10.56143/2181-2438-2025-1-167-171 Research, Innovation, Results

Lozim bo‘lgan to‘la ko‘chirishlar sonini aniqlaymiz (38 operator):

$$n_{\min}^{\text{ўнг}(1)} = \frac{\Delta З_{ЭК\min}^{\text{ўнг}(1)}}{З_{\psi_1\psi_4}^{бут}} = \frac{380}{(36-6)\cdot 10} = \frac{380}{300} = 1.26;$$

$$n_{\max}^{\text{ўнг}(1)} = \frac{\Delta З_{ЭК\max}^{\text{ўнг}(1)}}{З_{\psi_1\psi_4}^{бут}} = \frac{580}{(36-6)\cdot 10} = \frac{580}{300} = 1.93.$$

Ma’lum bo‘ldiki $n_{\min}^{\text{ўнг}(1)} - n_{\max}^{\text{ўнг}(1)}$ oraliqda butun son mavjud emas (39 operator).

$n_{min}^{\text{ўнг}(1)}$qiymatdan kichik bo‘lgan eng katta butun sonni aniqlaymiz (41 operator):

Bunday son $n_{min(б)}^{\text{ўнг}(1)} = 1$.

$d^m - 1$ chi indeksdan ko‘chirishni minimal kerakli va mumkin bo‘lgan maksimal qiymatini hisoblaymiz (42 operator):

$$З_{\min 1}^{\text{ўнг}} = \Delta З_{\min}^{\text{ўнг}(1)} - n_{\min(б)}^{\text{унг}(1)} З_{\psi_{d^m}\psi_{(c-\kappa^m)}}^{бир} = 380 - 1\cdot 300 = 80\ t;$$

$$З_{\max 1}^{\text{ўнг}} = \Delta З_{\max}^{\text{ўнг}(1)} - n_{\min(б)}^{\text{ўнг}(1)} З_{\psi_{d^m}\psi_{(c-\kappa^m)}}^{бир} = 580 - 1\cdot 300 = 280\ t.$$

Parametr $Q_{i(c-\kappa^m)}^{min}$ ва $Q_{i(c-\kappa^m)}^{max}$ qiymatlarini hisoblaymiz (44operator):

$$Q_{i(c-\kappa^m)}^{\max} = Q_{11} - \frac{З_{\min 1}^{\text{ўнг}}}{v_1} = 36 - \frac{80}{10} = 28;$$

$$Q_{i(c-\kappa^m)}^{\min} = Q_{11} - \frac{З_{\max 1}^{\text{ўнг}}}{v_1} = 36 - \frac{280}{10} = 8.$$

Yig‘ilma (H($X_{j\sigma_j}^1$) raqamidagi har “e” tartib raqamiga mos $Q_{ij(e)}$ qiymatlarini belgilaymiz (45 operator): $e = \{1234\}$

$$Q_{ij} = \{36; 24; 12; 6\} \text{ ya’ni,}$$

$$Q_{11} = 36t, Q_{12} = 24t,\ Q_{13} = 12t, Q_{14} = 6t.$$

Tahlil etilayotgan indeksni e raqamini aniqlaymiz (45 operator): $e = (c - \kappa^m) = 4 - 0 = 4$. Bunga mos Q_{ij} qiymati $Q_{14} = 6t$. solishtiramiz (46 operator): $Q_{14} = 6t < Q_{1(c-\kappa^m)}^{min}$. κ^m indeksni 1 ga oshiramiz (47 operator) $e = 4 - 1 = 3$. Bunga mos Q_{ij}: $Q_{13} = 12t$. Bu holda quyidagi munosabat mavjudligini aniqlaymiz: $Q_{i(c-\kappa^m)}^{\min} = 8 < Q_{13} = 12 > Q_{1(c-\kappa^m)}^{\max} = 28$ (46, 48 operatorlar).

Shunday qilib $1^1 0^1 2^1 0^1$ raqami $3^1 0^1 0^1 0^1$ raqamidan ψ_1^1 indeksdan ψ_3^1 indeksiga $n_{min(б)}^{\text{ўнг}} = 1$ta, ya’ni, 1-chi indeksdan 3-chiga to‘liqmas ko‘chirish asosida bajarildi. Olingan raqamni $0^2 0^2 1^2 3^2$ raqami bilan birlashmasi masalani yechimi hisoblanadi.

Buni tekshirib ko‘ramiz (10v operator):

$$\sum_{i\in J}\sum_{j\in J} X_{j\sigma_j}^{i} \cdot Q_{ij} = X_{11}^1 Q_{11} + X_{32}^1 Q_{13} + X_{31}^2 Q_{23} + X_{43}^2 Q_{24} =$$

$$10\cdot 36 + 20\cdot 12 + 5\cdot 24 + 15\cdot 12 = 360 + 240 + 120 + 180 = 900t.$$

Ma’lum bo‘ldiki, yig‘ilmalar birlashmasi masalani shartini bajaradi, ya’ni (12v operator)

$$Q_{\min} = 800 < \sum_{i\in J}\sum_{j\in J} X_{j\sigma_j}^{i} Q_{ij} < Q_{\max} = 1000$$

Shunday qilib qo‘yilgan talabga javob beruvchi yig‘ilmalar raqamlarini birlashmasi$1^1 0^1 2^1 0^1$ va $0^2 0^2 1^2 3^2$. Mazkur birlashma tashish hajmini (800-1000 t.) oraliqdagi qiymatlarini hamda tashish xarajatlari eng kam bo‘lishligini ta’minlaydi. Avtomobil transport vositalari turi va tashish marshrutlari bo‘yicha taqsimlanganganda tashish xarajatlari 21900360 so‘mni tashkil etdi:

$$X_{11}^1 \cdot Q_{11} \cdot S_{11} + X_{32}^1 \cdot Q_{13} \cdot S_{13} + X_{31}^2 \cdot Q_{23} \cdot S_{23} + X_{43}^2 \cdot Q_{24} \cdot S_{24} = 360 \cdot 15343 + 240 \cdot 24693 + 120 \cdot 27106 + 180 \cdot 39988 = 21900360.$$

3. Xulosa

Ko‘rinib turibdiki, erishilgan yuklanganlik darajasi 900 tonna bo‘lib, u talab etilayotgan 800÷1000 soat oralig‘iga tushdi. Demak, masala yechimi $X_{11}^1 Q_{11} X_{32}^1 X_{31}^2 Q_{23} X_{43}^2 Q_{24}$ ko‘rinishda bo‘lib, kun davomida 1-tur avtomobil transporti vositasidan 10 donasi 1-marshrutga taqsimlanib, 360 tonna, 20 donasi 3-marshrutga yo‘naltirilib, 240 tonna, 2-tur avtomobil transporti vositasidan 5 donasi 3-marshrutga taqsimlanib, 120 tonna va 15 donasi 4-marshrutga taqsimlanganishi aniqlandi. Bunda, kun davomida rejalashtirilgan 900 tonna yuk iste’molchilarga tashib berildi va ajratilgan avtomobil transporti vositalari eng kam xarajatni ta’minlaydigan variantda yo‘nalishlarga taqsimlandi.

Yuqorida keltirilgan usul asosida masala shartini qanoatlantiradigan boshqa yechimlarni ham topish mumkin. Natijada avtomobil transporti vositalarini xafta, oy va yil davomida samarali taqsimlash imkoniyati tug‘iladi. Avtomobil transporti vositalari bajarayotgan avtoqatnovlarni marshrutlarga taqsimlashni diskret usuli algoritmi ishlab chiqilgan.

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