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TOSHKENT DAVLAT TRANSPORT UNIVERSITETI
Tashkent state transport university

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The Journal of Transport showcases groundbreaking scientific and applied research conducted by transport-oriented universities, higher educational institutions, research centers, and institutes both within the Republic of Uzbekistan and globally. Recognized for its academic rigor, the journal is included in the prestigious list of scientific publications endorsed by the decree of the Presidium of the Higher Attestation Commission No. 353/3 dated April 6, 2024. This inclusion signifies its role as a vital repository for publishing primary scientific findings from doctoral dissertations, including Doctor of Philosophy (PhD) and Doctor of Science (DSc) candidates in the technical and economic sciences.

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Selection of the sequence for railcar delivery and removal at loading and unloading fronts

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Abstract: Optimal organization of freight transportation processes is essential for the efficient use of railway infrastructure, reduction of railcar idle time, and minimization of logistics costs. This article addresses the issue of determining the sequence of servicing loading and unloading fronts at railway stations. Using a case study of a hypothetical railway station "A", various railcar delivery options were analyzed, and the optimal sequence was identified based on railcar-hour indicators. In real-world production conditions, when there is a need to dispatch railcars to multiple cargo facilities, it is recommended to automate the process of selecting the optimal service queue for the loading and unloading fronts. The study employed combinatorial methods, analytical calculations, and visual comparison techniques. The results contribute to increasing the efficiency of freight transportation processes. The article holds both scientific and practical value for railway transport professionals, logistics managers, and researchers.

Keywords: railway station, loading and unloading front, railcar-hours, combinatorial method, logistics, railcar turnover, transport efficiency

Vagonlarni yuk ortish-tushirish frontlariga olib kirib berish va olib chiqish ketma-ketligini tanlash

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Annotatsiya: Yuk tashish jarayonlarining optimal tashkil etilishi temir yo‘l infratuzilmasidan oqilona foydalanish, vagonlarni turib qolish vaqtini qisqartirish va logistika xarajatlarini kamaytirishda muhim ahamiyat kasb etadi. Ushbu maqolada temir yo‘l stansiyalarida yuk ortish-tushirish frontlariga xizmat ko‘rsatish ketma-ketligini belgilash muammosi ko‘rib chiqilgan. Shartli “A” temir yo‘l stansiyasi misolida olib borilgan tadqiqotda vagonlarni olib kirib berish variantlari tahlil qilinib, vagon-soat ko‘rsatkichlari asosida optimal ketma-ketlik aniqlangan. Ishlab chiqarish sharoitida bir nechta yuk obyektlariga vagonlarni uzatish masalasi paydo bo‘lganda ortish-tushirish frontlariga xizmat ko‘rsatishning optimal navbatini tanlash jarayonini avtomatlashtirish tavsiya etilgan. Tadqiqotda kombinatorika, analitik hisoblash va vizual taqqoslash usullaridan foydalanilgan. Natijalar yuk tashish jarayonlarida samaradorlikni oshirish imkonini beradi. Maqola temir yo‘l transporti sohasidagi mutaxassislar, logistika menejerlari va tadqiqotchilar uchun ilmiy va amaliy ahamiyatga molikdir.

Kalit so‘zlar: temir yo‘l stansiyasi, ortish-tushirish fronti, vagon-soat, kombinatorika usuli, logistika, vagon aylanishi, transport samaradorligi

1. Kirish

Temir yo‘l stansiyalariga bir nechta shoxobcha yo‘llari va turli korxonalar tutashgan bo‘lsa, ushbu infratuzilmaga xizmat ko‘rsatish tartibini to‘g‘ri rejalashtirish alohida ahamiyat kasb etadi. Ayniqsa, yuk frontlariga xizmat ko‘rsatish ketma-ketligini belgilash – temir yo‘l transporti ishlashining samaradorligi, logistika jarayonining uzluksizligi va korxonalarning ishlab chiqarish faoliyati uchun muhim hisoblanadi. Shuningdek vagon aylanmasini minimallashtirishga erishiladi [1-4].

Vagonlarni ortish-tushirish frontlariga olib kirish tartibi noto‘g‘ri tanlansa, lokomotivning ortiqcha harakati, vaqt yo‘qotishlar, yo‘l infratuzilmasining samarasiz ishlatilishi va ortish-tushirish ishlaridagi kechikishlar yuzaga keladi. Aksincha, xizmat ko‘rsatishning to‘g‘ri ketma-ketligi bu kabi salbiy holatlarning oldini olib, yuk tashish jarayonini tez, aniq va uzluksiz bajarish imkonini beradi.

Vagonlarni olib kirish ketma-ketligini tanlashda yuklarning ustuvorlik darajasi (masalan, tez buziladigan mahsulotlar, xavfli yoki strategik ahamiyatga ega bo‘lgan yuklar), ortish-tushirish frontlarining bandligi yoki texnik holati ham hisobga olinishi lozim. Shu bois, har bir holatda ortish-tushirish frontlariga birinchi bo‘lib xizmat ko‘rsatish zarurati va ketma-ketlikni belgilash masalasi alohida e’tibor bilan ko‘rib chiqilishi zarur. Bu orqali nafaqat temir yo‘l infratuzilmasidan samarali foydalaniladi, balki barcha ishtirokchi tomonlar – temir yo‘l va unga tutashgan korxonalar manfaatlari ham muvozanatda saqlanadi [1-5, 8].

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2. Tadqiqot metodologiyasi

Tadqiqot obyekti sifatida shartli “A” temir yo‘l stansiyasi tanlandi. Ushbu stansiyada 4 ta yuk fronti mavjud bo‘lib, ular 2 ta asosiy bog‘lovchi yo‘l orqali stansiyaga ulangan (1-rasm). Barcha ortish va tushurish frontlari ulangan “A” temir yo‘l stansiyasining amaldagi sxemasi 1-rasmda keltirilgan, bundan “O‘zbekiston temir yo‘llari” AJ tasarrufidagi va MDH vagonlariga xizmat ko‘rsatuvchi ortish-tushirish frontlarini shartli ravishda 1, 2, 3 va 4-raqamlari bilan belgilandi.

Ortish-tushurish frontlariga vagonlarni ketma-ket olib kirishning variantlar soni kombinatorika usuli bo‘yicha quyidagi formula orqali aniqlanadi [6, 7]:

$$k = n! \quad (1)$$

bunda $n -$ xizmat ko‘rsatiladigan ortish-tushirish frontlari soni

Masalan 4 ta ortish-tushirish frontlari mavjud bo‘lganda,

$$k = 4! = 24$$

Ko‘rinib turibdiki, ortish-tushirish frontlariga vagonlarni ketma-ket olib kirib berishning 24 ta varianti mavjud. Biroq, tadqiq qilayotqan “A” stansiyasidagi xizmat ko‘rsatiluvchi 4 ta ortish-tushirish frontlari stansiyaga 2 ta bog‘lovchi yo‘l bilan ulanganligi tufayli variantlar soni quyidagicha aniqlanadi [6, 7]:

$$k = \frac{n!}{(n-1)} \quad (2)$$

yoki ketma-ket tanlov asosida:

$$k = \left(C_p^m\right)^{n-1} \quad (3)$$

bunda $p -$ tanlanishi mumkin bo‘lgan obyektlar soni;

$m -$ olib kirib berish amalga oshiriladigan obyektlar soni;

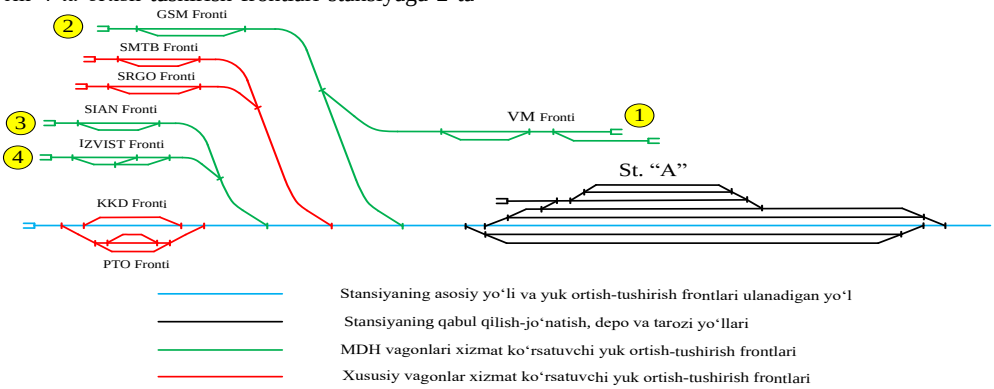
$n -$ xizmat ko‘rsatiladigan ortish-tushirish frontlari soni;

Demak, (2)-formulaga muvofiq “A” stansiyasida ortish-tushirish frontlariga xizmat ko‘rsatishning variantlar soni quyidagicha bo‘ladi:

$$k = \frac{n!}{(n-1)} = \frac{4!}{(4-1)} = \frac{24}{3} = 8$$

(3)- formulaga muvofiq “A” stansiyasida ortish-tushirish frontlariga ketma-ket tanlov asosida xizmat ko‘rsatishning variantlar soni quyidagicha bo‘ladi:

$$k = \left(C_p^m\right)^{n-1} = (C_2^1)^{4-1} = \left(\frac{2!}{(2-1)!}\right)^3 = 2^3 = 8$$



1-rasm. “A” temir yo‘l stansiyasining sxemasi

Shunday qilib, 4 ta ortish-tushirish frontlari stansiyaga 2 ta bog‘lovchi yo‘l bilan ulanganligi tufayli variantlar soni 8 tani tashkil etadi. Ushbu 8 ta variant kesimida vagonlarni ortish-tushirish frontlariga olib kirib berishning ketma-ketligini ko‘rib chiqamiz:

I variant: $st"A" \to 1 \to 2 \to st"A" \to 3 \to 4 \to st"A"$

II variant: $st"A" \to 1 \to 2 \to st"A" \to 4 \to 3 \to st"A"$

III variant: $st"A" \to 2 \to 1 \to st"A" \to 3 \to 4 \to st"A"$

IV variant: $st"A" \to 2 \to 1 \to st"A" \to 4 \to 3 \to st"A"$

V variant: $st"A" \to 3 \to 4 \to st"A" \to 1 \to 2 \to st"A"$

VI variant: $st"A" \to 3 \to 4 \to st"A" \to 2 \to 1 \to st"A"$

VII variant: $st"A" \to 4 \to 3 \to st"A" \to 1 \to 2 \to st"A"$

VIII variant: $st"A" \to 4 \to 3 \to st"A" \to 2 \to 1 \to st"A"$

VIII variant: $st"A" \to 4 \to 3 \to st"A" \to 2 \to 1 \to st"A"$

Yuqorida keltirilgan vagonlarni ketma-ket olib kirish variantlaridan kutib qolishlarning eng kam vagon-soat tashkil etishini aniqlashning maqsadli funksiyasini quyidagicha ifodalash mumkin:

$$B = \sum_{i=1}^{n} u_i \cdot t_i \to min \quad (4)$$

bunda $u -$ ortish-tushirish frontlariga olib kirib beriladigan vagonlar soni, vag.;

$t -$ ortish-tushirish frontlariga vagonlarni olib kirib berishdagi vaqt me’yori, soat.

Bunda quyidagi chegaralar mavjud bo‘ladi:

$$0 < u_i \le u_{\max}^{fr}; \qquad t_{\min}^{fr} \le t_i \le t_{\max}^{fr},$$

bunda u_{max}^{fr} bitta uzatishda ortish-tushirish frontlariga olib kirib berilishi mumkin bo‘lgan vagonlarning maksimal soni, vagon;

$t_{min}^{fr} -$ mos ravishda ortish tushirish frontlarida vagonlarolib kirib berishning minimal va maksimal vaqti, soat.

$t_{max}^{fr} -$

3. Tadqiqot natijalari va muhokamasi

Tadqiq qilayotqan “A” stansiyasining ortish-tushirish frontlariga vagonlarni olib kirish va olib chiqish vaqt me’yorlarini analitik hisoblash usulidan foydalanilib 1-8-jadvallarda xizmat ko‘rsatish vagon-soatlarni hisoblashning matritsasi ishlab chiqildi. Shuningdek, barcha variantlar bo‘yicha (4)-formulaga tegishli qiymatlar qo‘yilib, har bir variant asosida ortish-tushirish frontlariga xizmat ko‘rsatish vagon-soatlari aniqlandi.

https://doi.org/10.56143/jot-journal.v2i2.272 Research, Innovation, Results

1-jadval

Ortish-tushirish frontlariga xizmat ko‘rsatishda vagon-soatlarni hisoblashning 1-variant matritsasi

u / t	1,6	1,2	1,5	1,5	Uzatish ketma-ketligi
2 ta vagon	+	-	-	-	1
2 ta vagon	+	+	-	-	2
3 ta vagon	+	+	+	-	3
1 ta vagon	+	+	+	+	4

$$B_I = 2 \cdot 1{,}6 + 2 \cdot (1{,}6 + 1{,}2) + 3 \cdot (1{,}6 + 1{,}2 + 1{,}5) + 1 \cdot (1{,}6 + 1{,}2 + 1{,}5 + 1{,}5) = 27{,}5 vag - soat,$$

2-jadval

Ortish-tushirish frontlariga xizmat ko‘rsatishda vagon-soatlarni hisoblashning 2-variant matritsasi

u / t	1,6	1,2	1,5	1,5	Uzatish ketma-ketligi
2 ta vagon	+	-	-	-	1
2 ta vagon	+	+	-	-	2
3 ta vagon	+	+	+	+	4
1 ta vagon	+	+	-	+	3

$$B_{II} = 2 \cdot 1{,}6 + 2 \cdot (1{,}6 + 1{,}2) + 3 \cdot (1{,}6 + 1{,}2 + 1{,}5 + 1{,}5) + 1 \cdot (1{,}6 + 1{,}2 + 1{,}5) = 30{,}5 vag - soat,$$

3-jadval

Ortish-tushirish frontlariga xizmat ko‘rsatishda vagon-soatlarni hisoblashning 3-variant matritsasi

u / t	1,6 soat	1,2 soat	1,5 soat	1,5 soat	Uzatish ketma-ketligi
2 ta vagon	+	+	-	-	2
2 ta vagon	-	+	-	-	1
3 ta vagon	+	+	+	-	3
1 ta vagon	+	+	+	+	4

$$B_{III} = 2 \cdot (1{,}6 + 1{,}2) + 2 \cdot 1{,}2 + 3 \cdot (1{,}6 + 1{,}2 + 1{,}5) + 1 \cdot (1{,}6 + 1{,}2 + 1{,}5 + 1{,}5) = 26{,}7 vag - soat,$$

4-jadval

Ortish-tushirish frontlariga xizmat ko‘rsatishda vagon-soatlarni hisoblashning 4-variant matritsasi

u / t	1,6 soat	1,2 soat	1,5 soat	1,5 soat	Uzatish ketma-ketligi
2 ta vagon	+	+	-	-	2
2 ta vagon	-	+	-	-	1
3 ta vagon	+	+	+	+	4
1 ta vagon	+	+	-	+	3

$$B_{IV} = 2 \cdot (1{,}6 + 1{,}2) + 2 \cdot 1{,}2 + 3 \cdot (1{,}6 + 1{,}2 + 1{,}5 + 1{,}5) + 1 \cdot (1{,}6 + 1.2 + 1{,}5) = 29{,}7 vag - soat,$$

5-jadval

Ortish-tushirish frontlariga xizmat ko‘rsatishda vagon-soatlarni hisoblashning 5-variant matritsasi

u / t	1,6 soat	1,2 soat	1,5 soat	1,5 soat	Uzatish ketma-ketligi
2 ta vagon	+	-	+	+	3
2 ta vagon	+	+	+	+	4
3 ta vagon	-	-	+	-	1
1 ta vagon	-	-	+	+	2

$$B_V = 2 \cdot (1{,}6 + 1{,}5 + 1{,}5) + 2 \cdot (1{,}6 + 1{,}2 + 1{,}5 + 1{,}5) + 3 \cdot 1{,}5 + 1 \cdot (1{,}5 + 1{,}5) = 28{,}3 vag - soat,$$

6-jadval

Ortish-tushirish frontlariga xizmat ko‘rsatishda vagon-soatlarni hisoblashning 6-variant matritsasi

u / t	1,6 soat	1,2 soat	1,5 soat	1,5 soat	Uzatish ketma-ketligi
2 ta vagon	+	-	+	+	3
2 ta vagon	+	+	+	+	4
3 ta vagon	-	-	+	+	2
1 ta vagon	-	-	-	+	1

$$B_{VI} = 2 \cdot (1{,}6 + 1{,}5 + 1{,}5) + 2 \cdot (1{,}6 + 1{,}2 + 1{,}5 + 1{,}5) + 3 \cdot (1{,}5 + 1{,}5) + 1 \cdot 1{,}5 = 31{,}3 vag - soat,$$

7-jadval

Ortish-tushirish frontlariga xizmat ko‘rsatishda vagon-soatlarni hisoblashning 7-variant matritsasi

u / t	1,6 soat	1,2 soat	1,5 soat	1,5 soat	Uzatish ketma-ketligi
2 ta vagon	+	+	+	+	4
2 ta vagon	-	+	+	+	3
3 ta vagon	-	-	+	-	1
1 ta vagon	-	-	+	+	2

$$B_{VII} = 2 \cdot (1{,}6 + 1{,}2 + 1{,}5 + 1{,}5) + 2 \cdot (1{,}2 + 1{,}5 + 1{,}5) + 3 \cdot 1{,}5 + 1 \cdot (1{,}5 + 1{,}5) = 27{,}5 vag - soat,$$

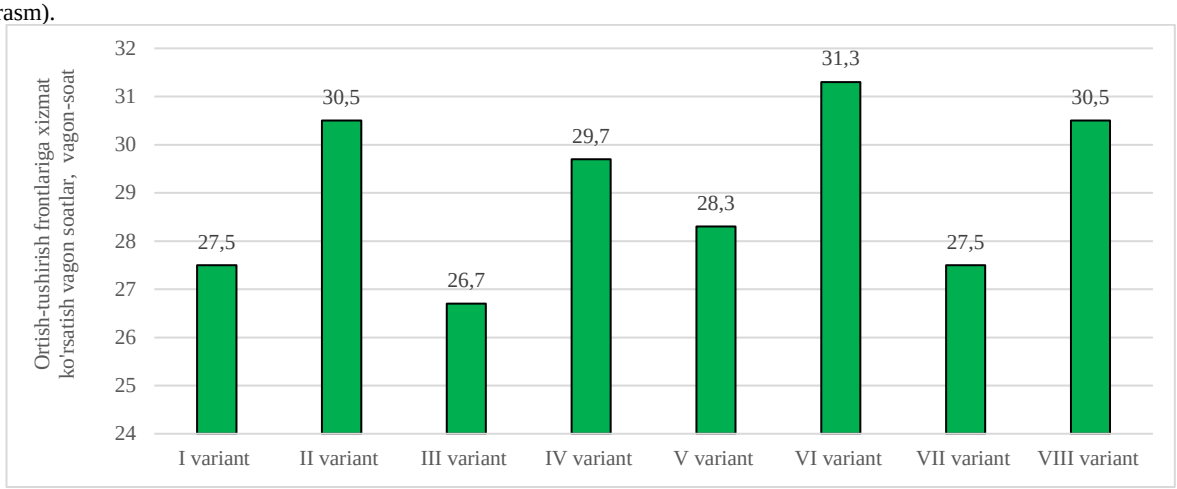
8-jadval

Ortish-tushirish frontlariga xizmat ko‘rsatishda vagon-soatlarni hisoblashning 8-variant matritsasi

u \ t	1,6 soat	1,2 soat	1,5 soat	1,5 soat	Uzatish ketma-ketligi
2 ta vagon	+	+	+	+	4
2 ta vagon	-	+	+	+	3
3 ta vagon	-	-	+	+	2
1 ta vagon	-	-	-	+	1

$$B_{VIII} = 2 \cdot (1{,}6 + 1{,}2 + 1{,}5 + 1{,}5) + 2 \cdot (1{,}2 + 1{,}5 + 1{,}5) + 3 \cdot (1{,}5 + 1{,}5) + 1 \cdot 1{,}5 = 30{,}5 vag - soat,$$

Shundan so‘ng 8 ta variant bo‘yicha ortish-tushirish frontlariga xizmat ko‘rsatish vagon-soatlarining gistogrammasi tuzildi (2-rasm).



2-rasm. Ortish-tushirish frontlariga xizmat ko‘rsatish vagon-soatlariniyu barcha variantlar bo’yicha miqdorlari

2-rasmdan ko‘rish mumkinki, vagonlarni ortish-tushirish frontlariga olib kirib berishdagi vagon-soatlarning eng minimal qiymati $B_{III} = 26{,}7$vagon-soatga teng, ya’ni III varianga to‘g‘ri keladi. Bu esa, yuk frontlariga xizmat ko‘rsatishda samaradorlikni oshirish, vagonlarning stansiyada kamroq vaqt turishini ta’minlash va resurslardan oqilona foydalanish imkonini beradi.

Qo‘lda hisoblash usuli (masalan, kombinatorik usullar bilan ketma-ketliklarni aniqlash) kam ortish-tushirish frontlari sonida nisbatan samarali bo‘lishi mumkin. Biroq, ortish-tushirish frontlari soni oshgan sari hisoblashning murakkabligi geometrik ravishda ortadi.

Masalan, o‘zaro bog‘lanmagan n ta yuk frontining xizmat ko‘rsatish ketma-ketligini aniqlash uchun $n!$ sonidagi kombinatsiyalarni ko‘rib chiqish kerak bo‘ladi. Qo‘lda hisoblash amaliy jihatdan 6 tagacha yuk frontigacha samarali bajarilishi mumkin. 7 tadan ortiq bo‘lganda esa hisoblash hajmi keskin oshadi va inson tomonidan bajarilishi juda ko‘p vaqt va kuch talab qiladi. Shu sababli ushbu masalani hal qilish uchun algoritmi asosida dasturiy ta’minotini ishlab chiqish maqsadga muvofiq bo‘ladi. Chunki raqamli dasturlar katta hajmdagi ma’lumotlarni tezkor va xatolarsiz qayta ishlashga imkon beradi. Bu yuk frontlari soni oshgan sari ayniqsa muhim bo‘ladi.

Avtomatlashtirilgan dasturlar va matematik modellar asosida eng kam vagon-soatli variantlarni aniqlab, yuk frontlari bo‘yicha olib kirib berishning optimal ketma-ketlikni taklif qilinadi.

4. Xulosa

Bir nechta shoxobcha yo‘llari tutashgan temir yo‘l stansiyasida yuk frontlariga xizmat ko‘rsatish ketma-ketligini aniqlash masalasi kutub qolishlarning eng kam vagon-soatlari usuli asosida kompleks tarzda tadqiq etildi. Tadqiqot davomida yuk operatsiyalarining texnologik tavsifi, stansiya infratuzilmasining tashkiliy-texnik imkoniyatlari va vagon oqimlarining intensivligi ortish-tushirish fronlariga xizmat ko‘rsatish ketma-ketligini belgilashning muhim omillari ekanligi qayd etildi. Amalga oshirilgan hisob-kitoblar natijasida yuk frontlarining o‘zaro joylashuvi va xizmat ko‘rsatish muddatidan kelib chiqqan holda yuklash-tushirish ishlarining optimal ketma-ketligini belgilash mumkin. Tanlangan ketma-ketlik asosida vagonlarning stansiyada ortiqcha turib qolish ehtimoli sezilarli darajada kamaytiriladi, bu esa butun transport jarayonining samarali tashkil etilishini ta’minlaydi.

Taklif etilayotgan usulning qo‘llanilishi yuk tashish jarayonlarida vagon-soat yo‘qotishlarini minimallashtirish, ishchi kuchi va texnik vositalardan maksimal foydalanish hamda transport tizimining umumiy xizmat ko‘rsatish darajasini optimallashtirishda muhim ahamiyat kasb etadi. Tadqiqot natijalari shuni ko‘rsatdiki, optimal xizmat ko‘rsatish ketma-ketligi stansiya faoliyatining uzluksizligini ta’minlaydi, yuk oqimlarining oqilona boshqarilishini tashkil etadi hamda kesishuvchi marshrutlar paydo bo‘lishining oldini olishga xizmat qiladi.

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