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NP-Hard

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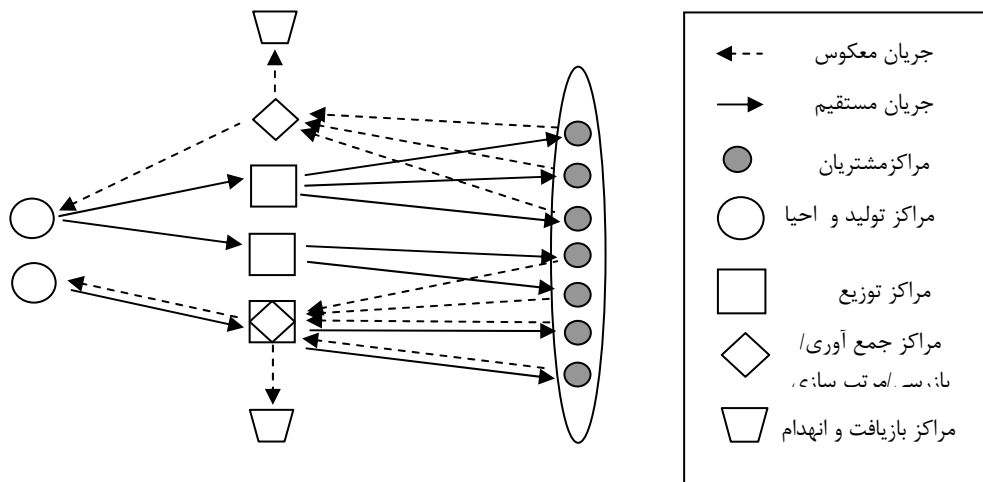
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نماد	تعریف
I	$.i \in I, M$
J	$.j \in J$
K	$.k \in K$
L	$.l \in L$
M	$.m \in M$
N	$.n, n' \in N$
E	$e \in E, E \subset J, E \subset L, L$
d_k	k
r_k	$() k$
s	$()$
f_i^n	$.n$
g_j^n	n
h_l^n	n
b_m^n	n
$f_e^{nn'}$	$.e$
cx_{ij}	j
cu_{jk}	k
cq_{kl}	$.l$
cp_{li}	$()$
ct_{lm}	$.m$
caw_i^n	$() .i$
cay_j^n	j
caz_l^n	$.l$
cav_m^n	$.m$
car_i^n	$() .i$
X_{ij}	مقدار جریان محصولات از مرکز تولید و احیاء (کارخانه) i به توزیع j .
U_{jk}	مقدار جریان محصولات از مرکز توزیع j به مرکز مشتری k .
Q_{kl}	$.l$
P_{li}	$.i$
T_{lm}	$.m$
W_i^n	$= \begin{cases} 1 \\ 0 \end{cases}$
Y_j^n	$= \begin{cases} 1 \\ 0 \end{cases}$
Z_l^n	$= \begin{cases} 1 \\ 0 \end{cases}$
V_m^n	$= \begin{cases} 1 \\ 0 \end{cases}$

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$$\begin{aligned}
 \text{Min } W &= \sum_{i \in I} \sum_{n \in N} f_i^n W_i^n + \sum_{j \in J} \sum_{n \in N} g_j^n Y_j^n + \\
 &\sum_{l \in L} \sum_{n \in N} h_l^n Z_l^n + \sum_{m \in M} \sum_{n \in N} b_m^n V_m^n - \\
 &\sum_{e \in E} \sum_{n' \in N} \sum_{n \in N} f_e^{nn'} Z_e^{n'} Y_e^n + \sum_{i \in I} \sum_{j \in J} c x_{ij} X_{ij} + \\
 &\sum_{j \in J} \sum_{k \in K} c u_{jk} U_{jk} + \sum_{k \in K} \sum_{l \in L} c q_{kl} Q_{kl} + \\
 &\sum_{l \in L} \sum_{m \in M} c t_{lm} T_{lm} + \sum_{l \in L} \sum_{i \in I} c p_{li} P_{li}
 \end{aligned}
 \tag{ }$$

$$\sum_{j \in J} U_{jk} = d_k \quad \forall k \in K
 \tag{ }$$

$$\sum_{l \in L} Q_{kl} = r_k d_k \quad \forall k \in K
 \tag{ }$$

$$\sum_{i \in I} X_{ij} = \sum_{k \in K} U_{jk} \quad \forall j \in J
 \tag{ }$$

$$\sum_{m \in M} T_{lm} = s \sum_{k \in K} Q_{kl} \quad \forall l \in L
 \tag{ }$$

$$\sum_{i \in I} P_{li} = (1-s) \sum_{k \in K} Q_{kl} \quad \forall l \in L
 \tag{ }$$

$$\sum_{i \in I} P_{li} = (1-s) \sum_{k \in K} Q_{kl} \quad \forall l \in L
 \tag{ }$$

$$\sum_{j \in J} X_{ij} \leq \sum_{n \in N} W_i^n c a w_i^n \quad \forall i \in I
 \tag{ }$$

$$\sum_{i \in I} X_{ij} \leq \sum_{n \in N} Y_j^n c a y_j^n \quad \forall j \in J
 \tag{ }$$

$$\sum_{k \in K} U_{jk} \leq \sum_{n \in N} Y_j^n c a y_j^n \quad \forall j \in J
 \tag{ }$$

$$\sum_{k \in K} Q_{kl} \leq \sum_{n \in N} Z_l^n c a z_l^n \quad \forall l \in L
 \tag{ }$$

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$$\sum_{l \in L} T_{lm} \leq \sum_{n \in N} V_m^n cav_m^n \quad \forall m \in M \quad ()$$

$$\sum_{l \in L} P_{li} \leq \sum_{n \in N} W_i^n car_i^n \quad \forall i \in I \quad ()$$

$$\sum_{m \in M} T_{lm} + \sum_{i \in I} P_{li} \leq \sum_{n \in N} Z_l^n caz_l^n \quad \forall l \in L \quad ()$$

$$\sum_{l \in L} P_{li} \leq B \sum_{j \in J} X_{ij} \quad \forall i \in I \quad ()$$

$$\sum_{n \in N} W_i^n \leq 1 \quad \forall i \in I \quad ()$$

$$\sum_{n \in N} Y_j^n \leq 1 \quad \forall j \in J \quad ()$$

$$\text{Min } W = \sum_{i \in I} \sum_{n \in N} f_i^n W_i^n + \sum_{j \in J} \sum_{n \in N} g_j^n Y_j^n +$$

$$\sum_{l \in L} \sum_{n \in N} h_l^n Z_l^n + \sum_{m \in M} \sum_{n \in N} b_m^n V_m^n -$$

$$\sum_{e \in E} \sum_{n \in N} \sum_{n' \in N} f_e^{nn'} Q_e^{nn'} + \sum_{i \in I} \sum_{j \in J} cx_{ij} X_{ij} + \quad ()$$

$$\sum_{j \in J} \sum_{k \in K} cu_{jk} U_{jk} + \sum_{k \in K} \sum_{l \in L} cq_{kl} Q_{kl} +$$

$$\sum_{l \in L} \sum_{m \in M} ct_{lm} T_{lm} + \sum_{l \in L} \sum_{i \in I} cp_{li} P_{li}$$

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W1

$$\sum_{n \in N} Z_l^n \leq 1 \quad \forall l \in L \quad ()$$

$$\sum_{n \in N} V_m^n \leq 1 \quad \forall m \in M \quad ()$$

$$W_i^n, Y_j^n, Z_l^n, V_m^n \in \{0,1\} \quad ()$$

$$\forall i \in I, \forall j \in J, \forall l \in L, \forall m \in M, \forall n \in N$$

$$X_{ij}, U_{jk}, Q_{kl}, T_{lm}, P_{li} \geq 0$$

$$\forall i \in I, j \in J, k \in K, l \in L, m \in M$$

$$Q_e^{nn'} = Z_e^n * Y_e^{n'} \quad ()$$

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$Q_e^{nn'}$

$Q_e^{nn'}$

$Y_e^n, Z_e^{n'}$

$Q_e^{nn'}$

$Y_e^n, Z_e^{n'}$

() ()

$$2Q_e^{nn'} \leq Z_e^{n'} + Y_e^n \quad \forall e \in E, \forall n \in N, \forall n' \in N \quad ()$$

$$(IJ+JK+KL+LM+LI) \quad ()$$

$$N(I+J+L+M+EN) \quad ()$$

$$() \quad ()$$

$$2(2I+2J+K+M)+5L+EN^2 \quad ()$$

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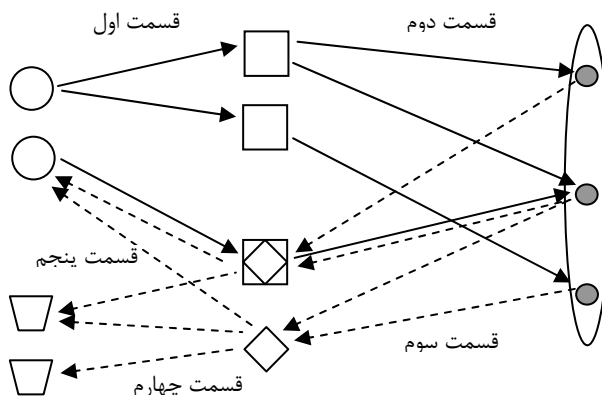
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	قسمت اول					قسمت دوم					قسمت سوم					قسمت چهارم				قسمت پنجم				
	I-J					J-K					L-K					M-L				I-L				
گره	1	2	1	2	3	1	2	3	1	2	3	1	2	1	2	3	1	2	1	2	1	2	1	2
اولویت v(I)	2	4	1	5	3	6	3	1	2	4	5	1	4	3	2	5	2	4	1	3	3	1	2	4
سطوح ظرفیت	1	2	1	3	3	1	1	2	3	2	1	1	2	2	2	1	3	2	1	3	2	1	2	3



j : K :
 k : J :
 j : b_j :
 k : Ca_{kn} :
 j : c_{kj} :
 $v(2^*(k+j))$:
 g_{kj} :
 n : Y_{kn} :
 $\sum_j b_j \geq 0$
 $g_{kj} = 0 \quad \forall j \in J, k \in K$

$$l = \arg \max \{v(1, t), t \in K \mid + |J|\} \quad \forall j \in J, k \in K$$

$$k^* = l \quad l \in K$$

$$n^* = v(2, k^*) \quad j^* = \arg \min \{c_{kj} \mid v(1, j) \neq 0, k \in K\}$$

$$j^* = l$$

$$n^* = v(2, k^*) \quad k^* = \arg \min \{c_{kj} \mid v(1, j) \neq 0, k \in K\}$$

$$g_{k^*j^*} = \min(Ca_{kn^*}, b_{j^*})$$

$$Ca_{kn^*} = Ca_{kn^*} - g_{k^*j^*}, b_{j^*} = b_{j^*} - g_{k^*j^*}$$

$$v(1, j^*) = 0 \quad b_{j^*} = 0 \quad v(1, k^*) = 0 \quad Ca_{kn^*} = 0$$

$$Y_{kn^*} = 1 \quad n = v(2, k) \quad \sum_{j \in J} g_{kj} \geq 0 \quad k$$

$$() \quad 2.(I+J+J+K+L+K+L+M+L+I+L) \quad ()$$

جواب منتخب اول	قسمت اول					قسمت دوم					قسمت سوم					قسمت چهارم				قسمت پنجم				
	I-J					J-K					L-K					M-L				I-L				
گره	1	2	1	2	3	1	2	3	1	2	3	1	2	1	2	3	1	2	1	2	1	2	1	2
اولویت v(I)	2	4	1	5	3	6	3	1	2	4	5	1	4	3	2	5	2	4	1	3	3	1	2	4
سطوح ظرفیت	1	2	1	3	3	1	1	2	3	2	1	1	2	2	2	1	3	2	1	3	1	2	2	3

جواب منتخب دوم	قسمت اول					قسمت دوم					قسمت سوم					قسمت چهارم				قسمت پنجم				
	I-J					J-K					L-K					M-L				I-L				
گره	1	2	1	2	3	1	2	3	1	2	3	1	2	1	2	3	1	2	1	2	1	2	1	2
اولویت v(I)	1	4	2	5	3	2	5	1	6	4	3	1	2	3	4	5	2	4	1	3	3	1	2	4
سطوح ظرفیت	1	3	1	2	2	1	1	2	3	2	1	1	1	1	2	1	3	3	1	3	1	3	2	2

بردار تصادفی	1	0	0	1	1 (مشابه قسمت)
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جواب تولید شده	قسمت اول					قسمت دوم					قسمت سوم					قسمت چهارم				قسمت پنجم				
	I-J					J-K					L-K					M-L				I-L				
گره	1	2	1	2	3	1	2	3	1	2	3	1	2	1	2	3	1	2	1	2	1	2	1	2
اولویت v(I)	1	4	2	5	3	6	3	1	2	4	5	1	4	3	2	5	2	4	1	3	3	1	2	4
سطوح ظرفیت	1	3	1	2	2	1	1	2	3	2	1	1	2	2	2	1	3	3	1	3	1	2	2	3

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جواب منتخب	قسمت اول					قسمت دوم					قسمت سوم					قسمت چهارم				قسمت پنجم				
	I-J					J-K					L-K					M-L				I-L				
گره	1	2	1	2	3	1	2	3	1	2	3	1	2	1	2	3	1	2	1	2	1	2	1	2
اولویت v(I)	2	4	1	5	3	6	3	1	2	4	5	1	4	3	2	5	2	4	1	3	3	1	2	4
سطوح ظرفیت	1	2	1	3	3	1	1	2	3	2	1	1	2	2	2	1	3	2	1	3	1	2	2	3

بردار تصادفی	1	0	1	0	1
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جواب تولید شده	قسمت اول					قسمت دوم					قسمت سوم					قسمت چهارم				قسمت پنجم				
	I-J					J-K					L-K					M-L				I-L				
گره	1	2	1	2	3	1	2	3	1	2	3	1	2	1	2	3	1	2	1	2	1	2	1	2
اولویت v(I)	2	5	1	4	3	6	3	1	2	4	5	1	4	5	2	3	2	4	1	3	4	1	2	3
سطوح ظرفیت	1	2	1	3	3	1	1	2	3	2	1	1	2	2	2	1	3	2	1	3	1	2	2	3

(2-opt)

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(3-opt)

(2-opt)

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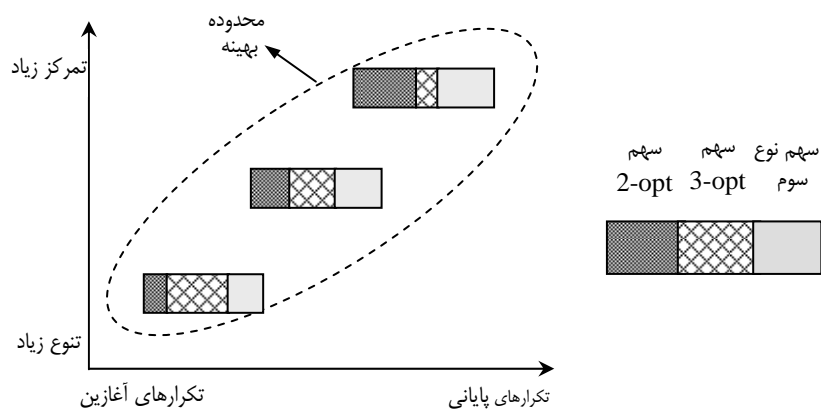
استراتژی استفاده از جستجوهای همسایگی پویا

(3-opt)

(2-opt)

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$$(I+K+L+J+M+I)*2.5$$

$$i=1 \text{ to } k$$

$$i < \text{tun}-k/5$$

شماره مسئله	<i>I</i>	<i>J</i>	<i>K</i>	<i>L</i>	<i>M</i>	<i>N</i>
1	2	3	5	3	1	2
2	5	10	10	5	4	2
3	5	10	15	10	4	3
4	10	15	20	15	5	2
5	20	40	50	40	10	2
6	20	40	70	40	10	3
7	30	50	100	50	10	3

نتایج محاسباتی

$$\% \text{ error} = \frac{(\text{ans.PA} - \text{ans.LINGO})}{\text{ans.LINGO}} \times 100 \quad ()$$

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MATLAB

LINGO 8.0

Dual core 1.6

GB Ram

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				()			LINGO	LINGO	(%)
	max	min	ave	max	min	ave	()		
1-1	1956848	1927073	1933130	4.95	4.56	4.64	1927017	2	0.31
1-2	1899400	1898900	1899100	5.57	5.09	5.19	1898838	1	0.01
1-3	1889000	1869400	1877300	4.92	4.43	4.55	1869302	1	0.42
2-1	3710000	3520700	3570500	72.46	73.19	72.90	3520067	11	1.43
2-2	3791200	3671700	3734600	73.53	71.10	72.27	3660542	10	2.02
2-3	3580600	3510900	3544300	73.51	73.18	73.36	3500314	42	1.25
3-1	3219500	3049200	3104000	245.1	240.4	242.8	3037564	284	2.18
3-2	3163100	3039400	3098400	242.8	238.0	240.4	2996245	463	3.40
3-3	3163700	3055300	3111800	246.7	241.4	243.2	3014262	340	3.23
4-1	10729000	10529000	10600100	334.5	331	332	10028350	580	5.7
4-2	10891000	10590000	10621000	336.1	336.1	335.7	9914315	671	7.5
4-3	9865000	9648000	9785000	320.4	316.4	318.7	9108376	463	7.4
5-1	2002400	1866200	1929466	425.2	423.3	424			
5-2	1965400	1882100	1920200	424.2	403.0	417.9	-	>7200	-
5-3	1983100	1903500	1950200	420.3	412.8	417.7			
6-1	17985000	17663000	17824000	653.1	649.7	651.7			
6-2	21183000	20253000	20629000	661.8	649.1	655	-	-	-
6-3	18904000	18387000	18730000	646.2	644.6	644.7			
7-1	31851000	30610000	31153000	971.2	959.7	965.6			
7-2	30883000	30468000	30556000	982.7	975.7	978.6	-	-	-
7-3	30691000	30570000	30629000	989.5	974.4	981.3			

LINGO 8.0

LINGO 8.0 ()

LINGO 8.0

LINGO 8.0

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- 1 - Sub-optimality
 - 2 - Cross dock
 - 3 - Disposal
 - 4 - Memetic algorithm
 - 5 - Physical programming
 - 6 - Priority-based
 - 7 - Hybrid scatter search
 - 8 - Recoverable products
 - 9 - Scrapped
 - 10 - Remanufacturing
 - 11 - Demanufacturing
 - 12 - Recycling
 - 13 - Roulette wheel
 - 14 - Cross over
 - 15 - Diversification
 - 16 - Intesification
-