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NP-Hard

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(N)

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$$\begin{array}{ll}
 : & \\
 i = 1, 2, \dots, N & : N \\
 t = 1, 2, \dots, T & : T \\
 t & j & i & : X_{ijt} \\
 t & j & i & : I_{ijt} \\
 \left. \begin{array}{l} \text{اگر کالای } i \text{ در مرحله } j \text{ و پر یود } t \text{ تولید شود.} \\ \text{در غیر اینصورت } 0 \end{array} \right\} & Y_{ijt} \\
 j & i & : A_{ijt} \\
 & & t \\
 & t & i & : D_{it} \\
 & t & j & : C_{jt} \\
 & j & i & : a_{ij} \\
 j & i & : H_{ijt} \\
 & & t \\
 j & i & : S_{ij} \\
 j & i & : V_{ijt} \\
 & & t
 \end{array}$$

$$\text{Min } Z = \sum_{i=1}^N \sum_{j=1}^M \sum_{t=1}^T [A_{ijt} \cdot Y_{ijt} + V_{ijt} \cdot X_{ijt} + H_{ijt} \cdot I_{ijt}] \quad ()$$

$$I_{i,M,t+1} + X_{i,M,t} - I_{i,M,t} = D_{it} \quad i = 1, 2, \dots, N, t = 1, 2, \dots, T \quad ()$$

$$\begin{aligned}
& : & N & I_{i,j,t-1} + X_{i,j,t} = I_{i,j,t} + X_{i,j+1,t} & () \\
& : & j & i & : a_{ij} & i=1,2,\dots,N \quad j=1,2,\dots,M-1 \quad t=1,2,\dots,T & () \\
a_{ij} = \sum_{t=1}^N a_{ijt} & () & & & & \sum_{i=1}^N X_{ijt} \cdot a_{ijt} + S_{ijt} \leq Y_{ijt} C_{jt} & () \\
& : & j & & : \bar{a}_j & j=1,2,\dots,M \quad t=1,2,\dots,T & () \\
\bar{a}_j = \frac{1}{N} \sum_{i=1}^N a_{ij} & () & j=1,2,\dots,M & & & (X_{ijt}, I_{ijt}) \geq 0 & () \\
& : & j & & : C_j & Y_{ijt} \in \{0,1\} & () \\
C_j = \sum_{t=1}^N C_{jt} & () & & & & i=1,2,\dots,N \quad j=1,2,\dots,M \quad t=1,2,\dots,T & () \\
& & & & & & ()
\end{aligned}$$

$$q = \text{Min} \left\{ \frac{C_1}{\bar{a}_1}, \frac{C_2}{\bar{a}_2}, \dots, \frac{C_M}{\bar{a}_M} \right\} \quad ()$$

$$R_i = \frac{\bar{D}_i \cdot a_{ij}}{\sum_{j=1}^M \bar{D}_i \cdot a_{ij}} \quad j = \dots \quad ()$$

$$\bar{D}_i = \frac{1}{T} \sum_{t=1}^T D_{it} \quad i = 1, 2, \dots, T$$

() [] (EOQ) ()

() (λ_{jt})

() (j) (R_i) N []

$$C_{ij} = \begin{bmatrix} C_{11}R_1 & C_{21}R_1 & \dots & C_{M1}R_1 \\ C_{12}R_2 & C_{22}R_2 & \dots & C_{M2}R_2 \\ \vdots & \vdots & \vdots & \vdots \\ C_{1N}R_N & C_{2N}R_N & \dots & C_{MN}R_N \end{bmatrix}$$

$$\begin{aligned}
 & (j,t) \\
 & (i) \\
 & (C_1R_t, C_2R_t, \dots, C_M R_t) = (C'_1, C'_2, \dots, C'_M) \\
 & : \\
 & : \\
 & -(\text{H0}) \quad \begin{matrix} t & j \\ & j \\ & j \\ & j \\ & j \\ & j \\ & j \\ & j \\ & j \\ & j \end{matrix} \quad \begin{matrix} = A_{jt} \\ = X_{jt} \\ = V_{jt} \\ = h_{jt} \\ = I_{jt} \\ = C'_j \\ = D_t \end{matrix} \\
 & \text{H0} \\
 & : \\
 & (\text{P1}) \quad \left. \begin{matrix} 1 \\ 0 \end{matrix} \right\} = Y_{jt} \\
 & \text{اگر محصول در مرحله } j \text{ و پر یود } t \text{ تولید شود} \\
 & \text{در غیر اینصورت}
 \end{aligned}$$

$$\text{Min } Z = \sum_{j=1}^M \sum_{t=1}^T [A_{jt} \cdot Y_{jt} + V_{jt} \cdot X_{jt} + H_{jt} \cdot I_{jt}] \quad ()$$

$$\begin{aligned}
 & : \\
 & I_{M,t-1} + X_{M,t} - I_{M,t} = D_t \quad t=1,2,\dots,T \quad () \\
 & M \quad I_{j,t-1} + X_{j,t} - I_{j,t} - X_{j+1,t} = 0 \quad () \\
 & \quad j=1,2,\dots,M-1 \quad t=1,2,\dots,T \\
 & \sum_{j=1}^M (a_{jt} X_{jt} + S_j) \leq Y_{jt} C'_j \quad () \\
 & \quad j=1,2,\dots,M \quad t=1,2,\dots,T \\
 & X_{jt} \leq Y_{jt} C' \quad () \\
 & \quad j=1,2,\dots,M \quad t=1,2,\dots,T \\
 & (\text{P2}) \quad (X_{jt}, I_{jt}) \geq 0 \quad () \\
 & \quad j=1,2,\dots,M \quad t=1,2,\dots,T \\
 & Y_{jt} = \begin{cases} 1 & \text{if } X_{jt} \geq 0 \\ 0 & \text{در غیر اینصورت} \end{cases} \quad ()
 \end{aligned}$$

()



(P3)

$$\left(\begin{array}{c} \\ \\ \end{array} \right) \left[\begin{array}{c} \\ \\ \end{array} \right]$$

$$\left(\begin{array}{c} \\ \\ \end{array} \right) \begin{matrix} :T \\ :M \end{matrix}$$

(P4)

()

$$\left[\begin{array}{cccc|cccc} X_{11} & X_{12} & X_{13} & \dots & X_{1T} & I_{11} & I_{12} & I_{13} & \dots & I_{1T} \\ X_{21} & X_{22} & X_{23} & \dots & X_{2T} & I_{21} & I_{22} & I_{23} & \dots & I_{2T} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ X_{M1} & X_{M2} & X_{M3} & \dots & X_{MT} & I_{M1} & I_{M2} & I_{M3} & \dots & I_{MT} \end{array} \right]$$



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$$\begin{cases} X_{jt}^{offspring} = 0, & I_{jt}^{offspring} = -a_{jt} & \text{if } a_{jt} \leq 0 \\ X_{jt}^{offspring} = u[a_{jt}, X_{jt}^{parent1}] & I_{jt}^{offspring} = X_{jt}^{offspring} - a_{jt} & \text{if } a_{jt} > 0 \end{cases}$$

$j = 1, 2, \dots, M \quad t = 1, 2, \dots, T$

$$a_{jt} = D_{jt} - X_{jt}^{offspring} - I_{j,t-1}^{offspring} \quad ()$$

$j = 1, 2, \dots, M \quad t = 1, 2, \dots, T$

u(1,M)

$$a_{jt} = \begin{cases} (a_{jt} \leq 0) \\ (a_{jt} > 0) \end{cases}$$

$(t) \quad (j)$
 (a, b)
 (a, b)

P4

$$\begin{aligned} & (a_{jt}) \\ & (X_{jt}^{parent1}) \\ & (I_{jt}^{offspring}) \end{aligned} \quad () \quad (X_{jt}^{offspring})$$

(P1)

M

u(0,1)

() () ()

$$X'_{jt} = X_{jt} + 0/1(C'_j - X_{jt}) \quad \text{if } X_{jt} \leq C'_j \quad ()$$

$$X'_{jt} = X_{jt} - 0/1(X_{jt} - a_{jt}) \quad \text{if } X_{jt} > C'_j \quad ()$$

$$I'_{jt} = X_{jt} - a_{jt} \quad j=1,2,\dots,M \quad t=1,2,\dots,T \quad ()$$

[] (0-T)

()

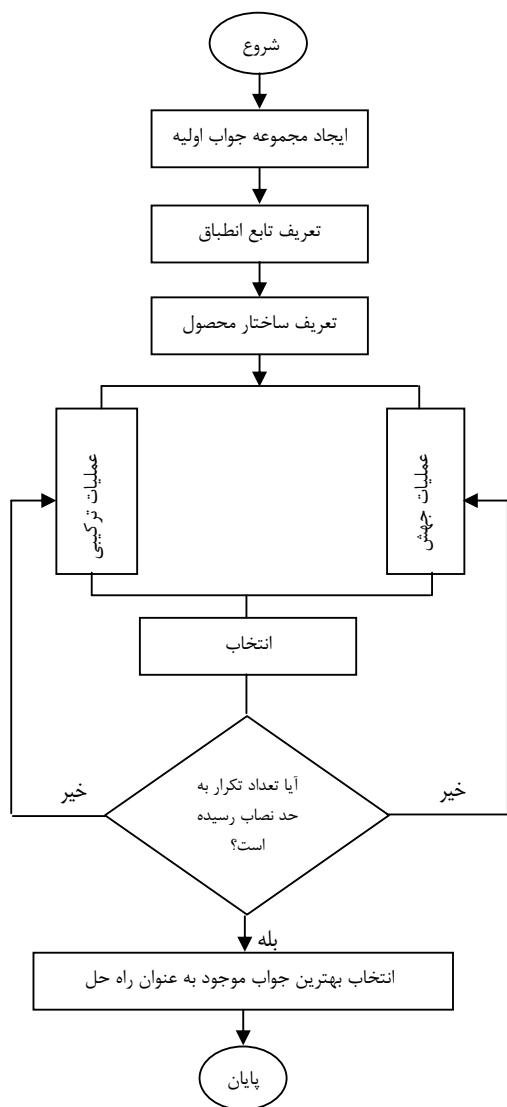
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$$\begin{cases} S_{jt} \times 100 & \text{if } X_{jt}^{parent1} = 0, \text{ and } X_{jt}^{parent2} = 0 & (r2) \\ S_{jt} \times 100 & \text{if } X_{jt}^{parent1} > 0, \text{ and } X_{jt}^{parent2} > 0 & (r3) \end{cases}$$

()
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در جدول . HGA, H0
(۴) مشاهده می‌شود که جواب روش HGA نسبت به روش‌های H0 و MA هزینه کمتری دارد.



. HGA :

H0

HGA

() HGA

Visual Basic

()

Parameter	Interval
C_j	u(1.5,3)
A_{ij} for low setup cost	u(15,90)
A_{ij} for high setup cost	u(50,950)
H_j	u(0.2,0.5)
d_{ij} for find items	u(0,200)
d_{ij} for no find items	U(0,20)

.H0 MA HGA :

تعداد مراحل	H0	MA	HGA
	/	/	/
	/	/	/
	/	/	/
	/	/	/
	/	/	/

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$$RC_i = (C'_j - \sum_{j=1}^M \overline{D}_i \cdot a_{ij})$$

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RCT=)

$$\left(\sum_{j=1}^M RC_j\right)$$

(N.M.T) = (3×3×5)

(N.M.T) = (5×8×15)

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$$CA_i = RCT \cdot \frac{\overline{D}_i \cdot a_{ij}}{\sum_{i=0}^N C'_j a_{ij}} \quad ()$$

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CA_i

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Visual Basic (VB)

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Lingo

HGA-LR

MA

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(ε)

(ΔTC)

(ε

Problem Size (N.M.T)	Number of Problems Solved	()		
		MA	Lingo	HGA-LR
3*3*5	5	48	45	45
3*3*10	8	85	83	72
3*3*15	10	97	92	93
3*4*5	5	85	74	85
3*4*10	8	99	83	96
3*4*15	10	135	132	131
3*5*5	5	335	221	219
3*5*10	8	317	245	232
3*5*15	10	328	282	215
3*6*5	5	299	245	225
3*6*10	8	318	314	278
3*6*15	10	339	-	305
4*3*5	5	341	322	321
4*3*10	8	482	425	428
4*3*15	10	518	-	482
4*4*5	5	485	325.25	352
4*4*10	8	496	-	485
4*4*15	10	-	-	491
4*5*5	5	568	-	542
4*5*10	8	593	-	594
4*5*15	10	-	-	632
4*6*5	5	625	-	615
4*6*10	8	-	-	594
4*6*15	10	-	-	624
5*7*5	5	-	-	722
5*7*10	8	-	-	748
5*7*15	10	-	-	827
5*8*5	5	-	-	752
5*8*10	8	-	-	832
5*8*15	10	-	-	925

RCT

HGA-LR

HGA-LR

Lingo

MA

HGA-LR

/ /

N

Lingo , HGA-LR :

MA

(+)

/ HGA-LR
(Lingo , MA)

Problem Size (N.M.T)	Number of Problems Solved	()		
		MA	Lingo	HGA-LR
3*3*5	5	0.451	0.321	0.232
3*3*10	8	0.691	0.592	0.691
3*3*15	10	1.582	1.221	0.895
3*4*5	5	2.221	2.251	1.851
3*4*10	8	3.820	3.341	2.952
3*4*15	10	5.892	8.252	7.211
3*5*5	5	14.595	20.281	11.127
3*5*10	8	17.621	36.328	15.351
3*5*15	10	19.422	40.271	15.854
3*6*5	5	127.323	245.292	112.217
3*6*10	8	215.252	385.291	175.241
3*6*15	10	218.251	-	215.361
4*3*5	5	315.261	485.121	225.845
4*3*10	8	319.427	495.285	252.481
4*3*15	10	325.428	-	251.253
4*4*5	5	428.426	411.516	322.271
4*4*10	8	432.251	-	324.265
4*4*15	10	-	-	392.276
4*5*5	5	545.812	-	412.291
4*5*10	8	592.581	-	431.297
4*5*15	10	-	-	480.353
4*6*5	5	661.357	-	482.521
4*6*10	8	-	-	511.267
4*6*15	10	-	-	520.827
5*7*5	5	-	-	525.924
5*7*10	8	-	-	548.238
5*7*15	10	-	-	565.278
5*8*5	5	-	-	522.299
5*8*10	8	-	-	582.258
5*8*15	10	-	-	592.257

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واژه های انگلیسی به ترتیب استفاده در متن

- 1- Material Resource Planning (MRP)
 - 2- Material Resource Planning II (MRPII)
 - 3- Enterprise Resource planning (ERP)
 - 4- Master Production Schedule (MPS)
 - 5- Bill of Material (BOM)
 - 6- Wagner-Within Algorithm (WW)
 - 7- Lagrangean Relaxation (LR)
 - 8- Genetic Algorithm (GA)
 - 9- Simulated Annealing (SA)
 - 10- Memetic Algorithm (MA)
 - 11- Ant-Colony Algorithm (ACA)
 - 12- Neighborhood Search (NS)
 - 13- Hybrid Genetic Algorithm (HGA)
 - 14- Combinatorial Optimization
 - 15- Diversification
 - 16- Intensification
 - 17- Remaining Capacity Total (RCT)
-