(V,c)

$$c(s,P)=\min\sum_{k\in V}\sum_{j\in O}c_{kj}x_{kj}+P\sum_{k\in s}x_{k1}s.t.\sum_{j\in O}x_{kj}-y_k^s=0,\forall k\in V,\sum_{k\in V}x_{kj}\le m_s,\forall j\in O,x_{kj}\in\{0,1\},\forall k\in V,\forall j\in O,y_k^s$$

P
m_s
s
m_s
m
$V=$
$\{1,2,\dots,v\}$
v
m
P
$t_i(i\in$
$V)$
$t_1<$
$t_2<$
$\cdots<$
t_v
$\omega(P)$
$\hat\omega(P)$

$$\omega(P)=\min_\alpha\{c(V,m(V,P))-\alpha(V):\alpha(s)\le c(s,m(s,P)),\forall s\in S,\alpha\in R^v\},$$

$$\hat\omega(P)=\min_\alpha\{c(V,m(V,P))-\alpha(V):\alpha(s)\le c(s,m(s,P)),\forall s\in S\backslash\{V\},\alpha\in R^v\}.$$

$\alpha(V)\le$
$c(V,m(V,P))$
$[P_L(i,s),P_H(i,s)]$
s
i
$[0,P^*]$
P^*
$c(V,m^*)=$
$\min_{i\in M}\{\sum_{k\in V}C_k(i)+$
$P\cdot$
$i\}.$
$c_0(s,i)$
$i\in$
$\{1,2,\dots,v\}$
$s.$
$c_0(V,i)$
i
i
$c(V,m^*)=$
$c_0(V,m^*)+$
$P\cdot$
m^*
m^*
i
P^i
I_i

$$c_0(V,i)+P^i i\le c_0(V,i-1)+P^i\cdot(i-1)c_0(V,i)+P^i i\le c_0(V,i+1)+P^i\cdot(i+1).$$

P^i
$c_0(V,i)-$
$c_0(V,i+$
$1)\le$
$P^i\le$
$c_0(V,i-$
$1)-$
$c_0(V,i)$
P^i
$[c_0(V,i)-$
$c_0(V,i+$
$1),c_0(V,i-$
$1)-$
$c_0(V,i)].$
I_i
$t_1<$
$t_2<$
$\cdots<$
t_v
$c_0(V,i)=$
$\sum_{j=1}^{\lceil v/i\rceil}\sum_{h=1}^{i}jt_{v-ij-h+i+1}$
$\lceil\cdot\rceil$
$.$
$c_0(V,i)$
i
$c_0(V,i)$

$$c_0(V,i)-c_0(V,i-1)<0,i\in\{2,3,\dots,v\}c_0(V,i)-c_0(V,i+1)<c_0(V,i-1)-c_0(V,i),i\in\{2,3,\dots,v-1\}.$$

$c_0(V,i)=$
$\sum_{j=1}^{\lceil v/i\rceil}\sum_{h=1}^{i}jt_{v-ij-h+i+1}$
$t_l,l\in$
V
$I_i=$