(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
$V =$
$\{1, 2, \ldots, v\}$
v
m
P
$\omega(P)$
$\hat{\omega}(P)$

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

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

$\alpha(V) \le$
$c(V, P)$
$[P_L(i, V), P_H(i, V)]$
V
i
$[0, P^*]$
P^*
$c(V, P) =$
$\min_{i\in M}\{\sum_{k\in V} C_k(i) +$
$P \cdot$
$i\}.$
$c_0(s, i)$
$i \in$
$\{1, 2, \ldots, v\}$
$s.$
$c_0(V, i)$
i
i
$c(V, P) =$
$c_0(V, m^*) +$
$P \cdot$
m^*
m^*
I_i
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
$c_0(V, i) =$
$\sum_{k=1}^{v} \lceil k/i \rceil t_k$
$\lceil \cdot \rceil$
$.$
$c_0(V, i) =$
$\sum_{k=1}^{v} \lceil k/i \rceil t_k$
$t_k, k \in$
V
$\sum_{k=1}^{v}(\lceil k/i \rceil -$
$\lceil k/(i+1) \rceil) t_k <$
$\sum_{k=1}^{v}(\lceil k/(i-1) \rceil -$
$\lceil k/i \rceil) t_k.$
$p_i(k)$
$\lceil k/i \rceil$
k
t_k
$p_{i-1}(i) -$
$p_i(i)$