



$$x_{ijk} := \begin{cases} 1, & \text{if operation } j \text{ of job } i \text{ is allocated to service } k, \\ 0, & \text{otherwise.} \end{cases} \quad (1)$$

表 1: sky is sb

Sets	Descriptions
\mathcal{N}_i	set of operations of job i ; $j \in \mathcal{N}_i$
\mathcal{I}	set of jobs; $i \in \mathcal{I}$
\mathcal{K}	set of services; $k \in \mathcal{K}$
Parameters	Descriptions
λ_{ijk}	whether operation j of job i can be processed on service k
s_{ij}	start time of operation j of job i
c_{ij}	completion time of operation j of job i
p_{ij}	processing time of operation j of job i
M	a sufficiently large positive integer

$$y_{ijj'k} := \begin{cases} 1, & \text{if operation } j \text{ of job } i \text{ is processed before operation } j' \text{ of job } i \text{ on service } k, \\ 0, & \text{otherwise.} \end{cases} \quad (2)$$

$$z_{ijl} := \begin{cases} 1, & \text{if operation } l \text{ of job } i \text{ is processed after operation } j \text{ of job } i, \\ 0, & \text{otherwise.} \end{cases} \quad (3)$$

$$\text{minimize} \quad \max \sum_{i \in \mathcal{I}, k \in \mathcal{K}} c_{ijk}, \quad (4)$$

$$\text{subject to } \sum_{k \in \mathcal{K}} x_{ijk} = 1, \quad j \in \mathcal{N}_i, i \in \mathcal{I}, \quad (5)$$

$$x_{ijk} \leq \lambda_{ijk}, \quad j \in \mathcal{N}_i, i \in \mathcal{I}, k \in \mathcal{K}, \quad (6)$$

$$y_{iji'j'k} + y_{i'j'ijk} \leq x_{ijk}, \quad j \in \mathcal{N}_i, j' \in \mathcal{N}_{i'}, i, i' \in \mathcal{I}, (i, j) \neq (i', j'), k \in \mathcal{K}, \quad (7)$$

$$y_{iji'j'k} + y_{i'j'ijk} + 1 \geq x_{ijk} + x_{i'j'k}, \quad j \in \mathcal{N}_i, j' \in \mathcal{N}_{i'}, i, i' \in \mathcal{I}, (i, j) \neq (i', j'), k \in \mathcal{K}, \quad (8)$$

$$s_{ij} + p_{ij} - M(1 - y_{iji'j'k}) \leq s_{i'j'}, \quad j \in \mathcal{N}_i, j' \in \mathcal{N}_{i'}, i, i' \in \mathcal{I}, (i, j) \neq (i', j'), k \in \mathcal{K}, \quad (9)$$

$$s_{ij} + p_{ij} \leq z_{ijl}s_{il}, \quad j, l \in \mathcal{N}_i, i \in \mathcal{I}, j \neq l, \quad (10)$$

$$s_{ij} \geq 0, \quad j \in \mathcal{N}_i, i \in \mathcal{I}, \quad (11)$$

$$x_{ijk} \in \{0, 1\}, \quad j \in \mathcal{N}_i, i \in \mathcal{I}, k \in \mathcal{K}, \quad (12)$$

$$y_{iji'j'k} \in \{0, 1\}, \quad j \in \mathcal{N}_i, j' \in \mathcal{N}_{i'}, i, i' \in \mathcal{I}, (i, j) \neq (i', j'), k \in \mathcal{K}, \quad (13)$$

$$z_{ijl} \in \{0, 1\}, \quad j, l \in \mathcal{N}_i, i \in \mathcal{I}, j \neq l, \quad (14)$$