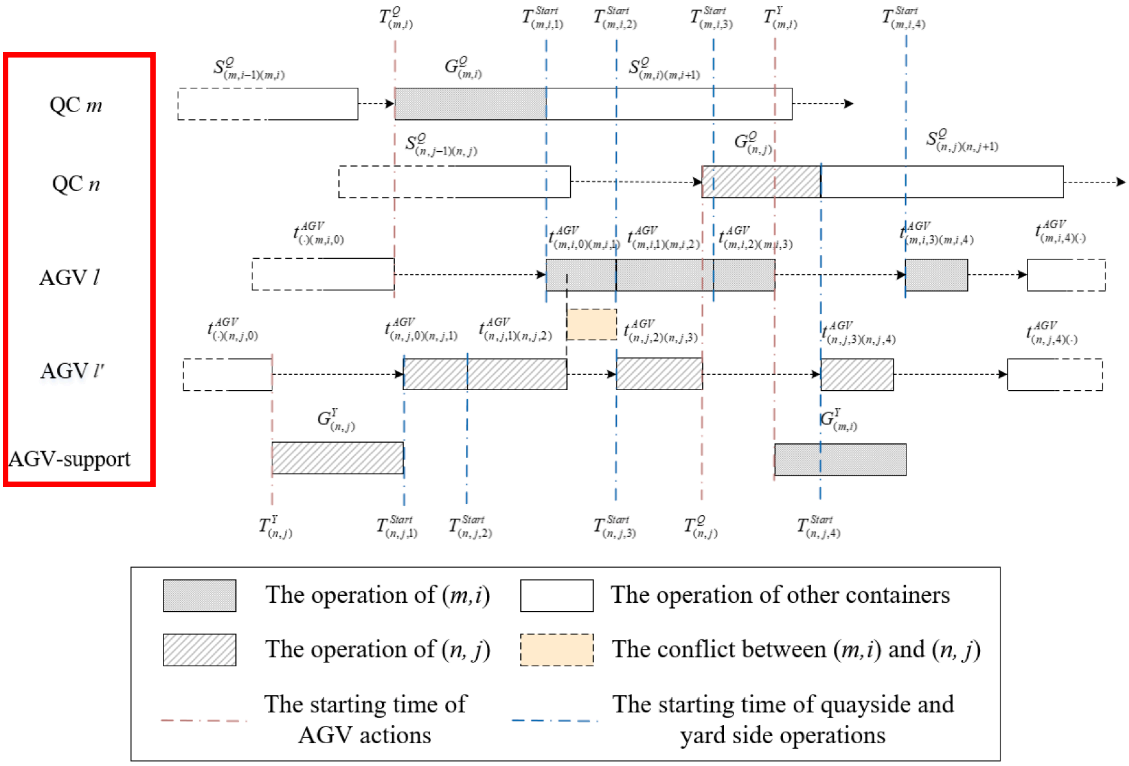
3 essential transporters
Of this problem



Gantt
Chart

Fig. 7. An illustrative example of the sequence and the timing of two exemplary containers.

$$U^{AGV}_{(m,i,\alpha_1)(n,j,\alpha_2)} + U^{AGV}_{(n,j,\alpha_2)(m,i,\alpha_1)} + 3 - P^Y_{(m,i,\alpha_1),y} - P^Y_{(n,j,\alpha_2),y} + \sum_{x=1}^{x'} \left(P^X_{(m,i,\alpha_1-1),x} + P^X_{(n,j,\alpha_2),x} - P^X_{(m,i,\alpha_1),x} - P^X_{(n,j,\alpha_2-1),x}\right) \geq 0, \quad \forall (m,i,\alpha_1),(n,j,\alpha_2) \in W^H, \forall y \in Y^R, \forall x' \in X^R \tag{23}$$

$$T^Q_{(m,i)} + G^Q_{(m,i)} + M\left(1 - U^{QC}_{(m,i)(n,j,\alpha)}\right) \geq T^{Start}_{(n,j,\alpha)}, \forall (m,i) \in C, \forall (n,j,\alpha) \in W^H \tag{24}$$

$$T^{Start}_{(n,j,\alpha)} + t^{AGV}_{(n,j,\alpha-1)(n,j,\alpha)} + M\left(1 - U^{QC}_{(m,i)(n,j,\alpha)}\right) \geq T^Q_{(m,i)}, \forall (m,i) \in C, \forall (n,j,\alpha) \in W^H \tag{25}$$

$$U^{AGV}_{(m,i,\alpha_1)(n,j,\alpha_2)} + U^{AGV}_{(n,j,\alpha_2)(m,i,\alpha_1)} \geq P^X_{(m,i,\alpha_1),x} + P^X_{(n,j,\alpha_2),x} - 1, \forall (m,i,\alpha_1),(n,j,\alpha_2) \in W^V, \forall x \in X^R \tag{27}$$

$$U^{AGV}_{(m,i,\alpha-1)(m,i,\alpha)} = 1, \forall (m,i) \in C, \forall \alpha \in \{2,3,4\} \tag{28}$$

$$\left(3 - U^{QC}_{(m,i)(n,j,\alpha_2)} - P^Y_{(m,i,\alpha_1),y} - P^Y_{(n,j,\alpha_2),y} + \left| \sum_{x=1}^{O_{(m,i)}} P^X_{(n,j,\alpha_2),x} - \sum_{x=O_{(m,i)}+1}^{x_R} P^X_{(n,j,\alpha_2-1),x} \right| \right) M + T^{Start}_{(n,j,\alpha_2)} + t^{AGV}_{(n,j,\alpha_2-1)(m,i,\alpha_1)} \geq T^Q_{(m,i)} + G^Q_{(m,i)}, \quad \forall (n,j,\alpha_2) \in W^H, \forall y \in Y^S, \forall (m,i) \in D \forall \alpha_1 \in \{0\} \, or \forall (m,i) \in L \forall \alpha_1 \in \{3\} \tag{26}$$