Mathematical Model of Fixed Destinations Case

For modeling the fixed destinations case, a new set $V_i$ for vehicles of depot $i \in D$ with $|V_i| = v_i$, and decision variables $x_{dvij}, d \in D,\ v \in V_d,\ (i,j) \in A$ are introduced based on Section IV. $x_{dvij}$ is 1 if arc $(i,j) \in A$ is traversed by tractor $v \in V_d$ of depot $d \in D$, or 0 otherwise. As the vehicles must return to their original depots, parameters $c_i,\ i \in D$ are no longer needed. The mathematical model of fixed destinations case is as follows:

$$\min \sum_{j\in D}\sum_{v\in V_j}\sum_{i\in N\backslash D} x_{jvij}(s_i + t_{ij}) - \sum_{j\in D}\sum_{v\in V_j}\sum_{i\in N\backslash D} x_{jvji}(s_i - t_{ji}) \tag{26}$$

$$\text{s.t.} \quad \sum_{d\in D}\sum_{v\in V_d}\sum_{i\in \vec{A}_j} x_{dvij} = 1, \forall j \in N\backslash D \tag{27}$$

$$\sum_{i\in \vec{A}_j} x_{dvij} - \sum_{i\in \overleftarrow{A}_j} x_{dvji} = 0, \forall d \in D, \forall v \in V_d, \forall j \in N\backslash D \tag{28}$$

$$\sum_{i\in \overleftarrow{A}_d} x_{dvdi} - \sum_{i\in \vec{A}_d} x_{dvid} = 0, \forall d \in D, \forall v \in V_d \tag{29}$$

$$\sum_{i\in \overleftarrow{A}_d} x_{dvdi} \le 1, \forall d \in D, \forall v \in V_d \tag{30}$$

$$\sum_{d\in D}\sum_{v\in V_d}\sum_{k\in D\backslash\{d\}}\left(\sum_{i\in N\backslash\{k\}} x_{dvki} + \sum_{i\in N\backslash\{k\}} x_{dvik}\right) = 0 \tag{31}$$

$$s_i + t_{ij} \le M\left(1 - \sum_{d\in D}\sum_{v\in V_d} x_{dvij}\right) + s_j, \forall (i,j) \in A, \forall i \notin D, \forall j \notin D \tag{32}$$

$$t_{di}\sum_{v\in V_d} x_{dvdi} \le s_i \le H - t_{id}\sum_{v\in V_d} x_{dvid}, \forall i \in N\backslash D, \forall d \in D \tag{33}$$

$$y_{ij}^{IFT} + y_{ij}^{EFT} + y_{ij}^{ET} \le K\sum_{d\in D}\sum_{v\in V_d} x_{dvij}, \forall (i,j) \in A \tag{34}$$

$$\sum_{v\in V_d}\sum_{i\in N\backslash D} x_{dvdi} \le v_d,\ \ \forall d \in D \tag{35}$$

$$x_{dvij} \in \{0,1\}, \forall d \in D,\ \forall v \in V_d,\ \forall (i,j) \in A \tag{36}$$

$$(8), (11)\text{-}(18), (22), \text{and } (23) \tag{37}$$

Except for Constraints (29)-(31), all other constraints have the same meaning as Model MILP-MD counterparts, except that the form of expression has changed. Constraints (29) ensure that vehicles eventually return to their original depot. Constraints (30) enforce that each depot vehicle is dispatched no more than once. Notably, vehicles are exclusively deployed for customer services and, given the absence of transportation demands within the depots, no inter-depot shuttling is needed. So $\sum_{d\in D}\sum_{v\in V_d}\sum_{k\in D\backslash\{d\}}\sum_{i\in D\backslash\{k\}} x_{dvki} = 0$ holds. Moreover, due to the fixed-destination assumption, each vehicle departs from and returns to a dedicated depot, precluding departures from or returns to any other depots. This makes $\sum_{d\in D}\sum_{v\in V_d}\sum_{k\in D\backslash\{d\}}\sum_{i\in N\backslash D\backslash\{k\}} x_{dvki} = 0$ established. Combining these two points gives Constraints (31).