**Notation & Model**

|  |  |  |
| --- | --- | --- |
| **Variables** | | **Standard variable in python** |
|  | Route for courier |  |
|  | Route for drone |  |
|  | Courier wait time at j |  |
|  | Drone wait time at j |  |
| **Parameters** | |  |
|  | Sufficiently big number |  |
|  | Time windows of order i |  |
|  | Travel time for courier | Tt[j] |
|  | Travel time for drone | Td[j] |
| **Others** | |  |
|  | Time when courier arrives j |  |
|  | Time when drone arrives j |  |
|  | Customer location of order | fd[i] |
|  | Start point and end point for turck | ts, te |
|  | Start point and end point for drone | ds, de |
| **Sets** | |  |
|  | Order node (restaurant and customers) | N |
|  | 所有点的全集 | A |
|  | All resuppliable node set (drone reachable) | SU |
|  | +start node(0) and end node(e)  （\*在truck和drone的start/end node不同） | Nse |
|  | Customers’ nodes | Nc |
|  | Restaurant set | R |
|  | Restaurant set with drone deployed | Rd |
|  | Restaurant node set mapping to drone launch node i | Rmap[i] |
|  | Launch node set | L |
|  | + start node(0) and end node(e)  （\*在truck和drone的start/end node不同） | Lse |
|  | Drone launch node set mapping to restaurant node i | Lmap[i] |
|  | Feasible transfer launch node as drone launch from | Lt[i] |
|  | Order supply node set for drone bring restaurant order of node i | S[i] |
|  | Landing node set for drone supply restaurant order i to courier at node j. | LL[i][j] |
|  | 不成环约束 | al-x, al-u\_ |

Object:

The drone routing constraints

无人机在取订单，补货到处后，受限于航程，可行的降落点集合为

上面第一个约束非必要，因为一旦，一进一出约束 + 上面第二个一定保证至少有一个 。为啥不会出现2个？因为一进一出约束，第二个一定有某处进入，而上一个节点也必然有其先序节点。加上不成环约束，整个路径将只有s和e一个入口和出口，不可能出现第二条通路。

无人机从出发，只能去对应的，以及航程范围内的其他可行发射基地

无人机在处取订单后，受限于航程只能补货去

~~无人机从S只能去L~~

不成环的约束

起始点只出不进；终点只进不出:

Truck routing constraints

不成环的约束

起始点只出不进；终点只进不出:

Synchronization & Time Constraints

初始时间为0

计算truck到达j点的时间:

计算drone到达j点的时间:

Resupply时human courier必须比drone先到达，且需等待drone到达后才能离开去下一个节点

Pickup & delivery constraints

所有订单 仅可pickup/delivery一次

Truck在delivery之前必须先pick up

在必须备餐完毕才可取餐