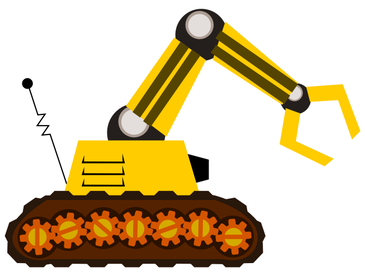
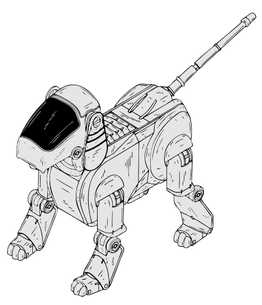
USC Viterbi
School of Engineering
Department of Computer Science

Dynamic Resource Allocation in Autonomous Multiagent systems

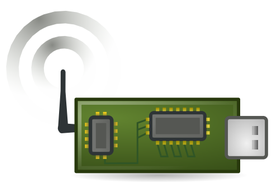
Nitin Kamra and Nora Ayanian

I. Long-duration autonomy in Robots

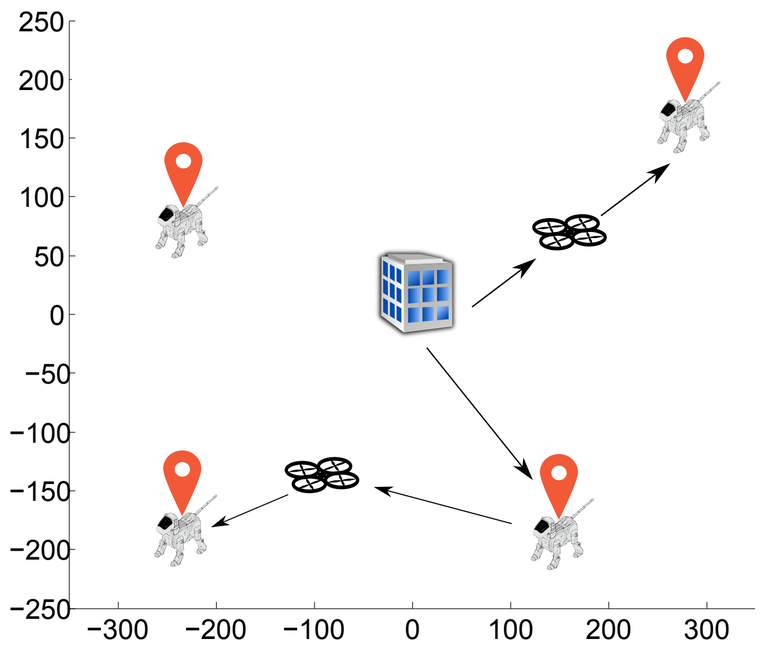




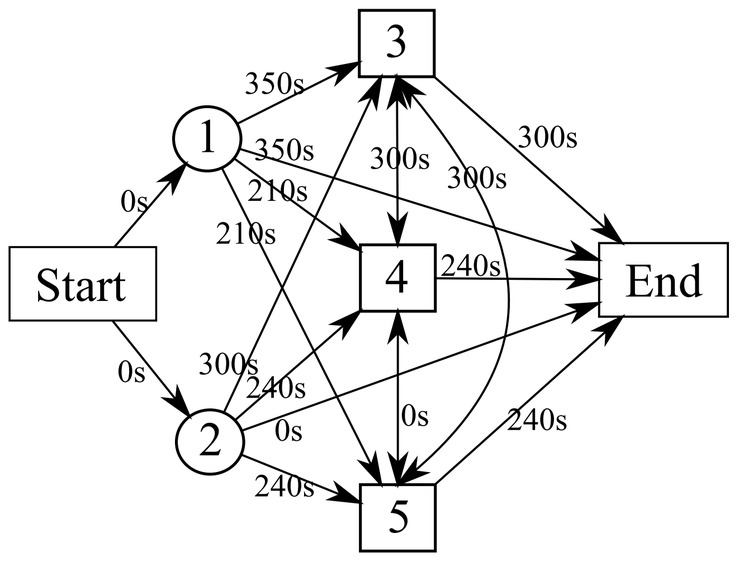
Robots need resources (batteries, sensors and cameras) for persistent autonomy.



II. Objective



III. Convert to graph



IV. Mathematical Formulation: Vehicle Routing Problem with Time Windows

$$\min_{x,a,d} \{f_{untimed}(d) + \lambda f_{travel}(x,a,d)\} \tag{1}$$

where

$$f_{untimed}(d) = \sum_{i \in (V-K)} p_i (d_i - \tau_i + T_{A,i})^2$$

$$f_{travel}(x,a,d) = \sum_{k \in K} \sum_{(i,j) \in E} x_{ij}^k (a_j - d_i)$$

subject to the constraints:

$$\sum_{k \in K} \sum_{j \in V \cup \{\omega\}} x_{ij}^k \leq 1, \qquad \forall i \in V \tag{2}$$

$$x_{\alpha k}^k = 1, \qquad \forall k \in K \tag{3}$$

$$\sum_{i \in V} x_{i\omega}^k = 1, \qquad \forall k \in K \tag{4}$$

$$\sum_{i \in \{\alpha\} \cup V} x_{ih}^k = \sum_{j \in (V-K) \cup \{\omega\}} x_{hj}^k, \qquad \forall h \in V, k \in K \tag{5}$$

$$a_i - d_i + T_S \leq 0, \qquad \forall i \in (V-K) \tag{6}$$

$$d_i - a_j + t_{ij} \leq Z \left(1 - \sum_{k \in K} x_{ij}^k\right), \qquad \forall (i,j) \in E \tag{7}$$

$$T_{start} \leq a_i \leq T_{start} + t_{bound}, \qquad \forall i \in (V-K) \cup \{\omega\} \tag{8}$$

$$T_{start} \leq d_i \leq T_{start} + t_{bound}, \qquad \forall i \in V \tag{9}$$

$$T_{start} + t_{bound} \left(1 - \sum_{k \in K} \sum_{j \in V \cup \{\omega\}} x_{ij}^k\right) \leq d_i, \qquad \forall i \in V \tag{10}$$

$$d_k - Z(1 - x_{k\omega}^k) \leq T_{start}, \qquad \forall k \in K \tag{11}$$

$$\sum_{(i,j) \in E} x_{ij}^k - 1 \leq C^k - c^k, \qquad \forall k \in K \tag{12}$$

$$\sum_{(i,j) \in E} x_{ij}^k B_r^k (t_{ij} v) \leq B^k, \qquad \forall k \in K \tag{13}$$

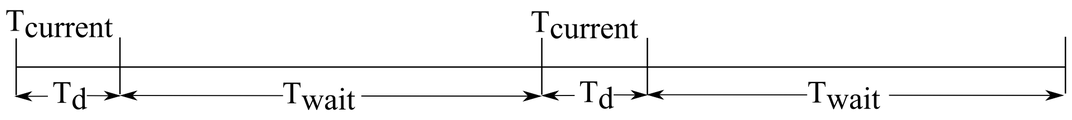
V. Solve the MIQP

$$\min_x \frac{1}{2} x^T H x + f^T x$$

s.t.

$$Ax \leq b$$
$$A_{eq} x = b_{eq}$$
$$lb \leq x \leq ub$$

VI. Shift Time Window



VII. Contributions

- Synthesizes delivery schedule for time-bound delivery requests;
- Imposes relative priorities while scheduling for resources;
- Enables built-in modes of human input to allow modification of delivery times and priorities;
- Allows a relaxed delivery schedule (by missing a few deliveries) if all the incoming requests cannot be met; and
- Allow dynamic re-routing of delivery robots even after they have been dispatched;

VIII. Results