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1 Multi-agent task allocation

Multi-agent task allocation is a well known NP-hard problem, giving rise to many different approximate solutions. Two methods for task allocation have emerged as the main paradigms: threshold and auction based methods. In threshold methods, agents individually assess the constraints and their ability to complete each task. If an agent's abilities surpass a threshold on the constraints, then the agent assigns itself to the task. If not, the agent passes the information to other agents. An example is [8], which uses distributed constraint optimization (DCOP) as a basis for task allocation. A comparison between DCOP and swarm techniques is provided in [3]. On the other hand, market inspired auction methods typically require more communication and are more centralized. Zhang et al. [9] present an auction based approach to form executable coalitions, allowing multiple agents from different locations to reach a task and compete it efficiently. Recently, decentralized applications have been designed that add flexibility to the system (e.g., [5]). Our work strikes a balance between distribution and centralization, each agent is directed to an area by a central authority, but upon reaching the destination, agents act on their own logic.

Other approaches have been developed, such as modeling task allocation as a potential game [2]. Sandholm et al. [7] present a generalized coalition formation algorithm which produces solutions within a bound from the optimal via pruning. The work in [10] focuses on tasks that require multiple agents to complete, while simultaneously trying to efficiently use the agent's resources and time. Our approach also assumes multiple agents are required, but we allow the requirements of tasks to change over time.

Our work is most similar to Ramchurn et al. [6], except we reformulate the problem so task resources change over time. Instead of having deadlines for tasks that expire at specific times, we can consider each task having a minimum agent deadline which means a specific amount of agents must be assigned to the task by this time in order for the task to be doable. Urban search and rescue is a major focus of our work and we use the RoboCup Search and Rescue Simulator [4], which provides simulations on street and building maps of real cities. Emergency situations are very time critical and often lacking in information, as outlined in [1]. Most notably, when an emergency occurs agents are spatially spread out and must quickly coordinate with each other to accomplish tasks.

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