Latex Sample File

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1 Problem description

Our problem is the assignment of heterogeneous agents to tasks which have a cost that grows over time. To fully represent this we need to incorporate: (1) the tasks growing naturally over time and (2) agents who can reduce this cost. This type of problem has an inherit positive-feedback loop. If a task is growing faster than the agents are reducing it, then it will grow in the next time step. Now that the task is bigger, it will grow even faster than in the previous time step and overcome the agent reduction by a larger amount. This causes the size of tasks to rapidly increase if not enough reduction is applied by the agents The opposite is true for when agents reduce tasks more than they grow. In the next time step the task will be smaller and grow less, which means the same agents will reduce the cost more in the next time step than this one.

We assume both agents and tasks have a locations to remain general for domains with robots that need to travel to reach tasks. We make no other assumptions on the spatial locations of agents or tasks other than an agent must be at a task's location in order to work on that task. Our methods are still applicable if there is no concept of distance or location when we look at the case when agents can instantly travel to different tasks. In addition we also look at the case when agents can only be assigned once and then have to remain at that task. For our problem to address both of these simultaneously, we assume agents can have any desirable initial assignments and locations. After this point, it takes agents a known travel time to reach another task.

2 Related work

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.

References

[1] Álvaro Monares, S. F. Ochoa, J. A. Pino, V. Herskovic, J. Rodriguez-Covili, and A. Neyem. Mobile computing in urban emergency situations: Improving the support to firefighters in the field. *Expert Systems with Applications*, 38(2):1255 – 1267, 2011.

[2] A. Chapman, R. A. Micillo, R. Kota, and N. Jennings. Decentralised dynamic task allocation using overlapping potential games. *The Computer Journal*, 2010.

[3] P. R. Ferreira, Jr., F. dos Santos, A. L. C. Bazzan, D. Epstein, and S. J. Waskow. RoboCup Rescue as multiagent task allocation among teams: experiments with task interdependencies. *Journal of Autonomous Agents and Multi-Agent Systems*, 20(3):421–443, 2010.

[4] H. Kitano and S. Tadokoro. RoboCup Rescue: A grand challenge for multiagent and intelligent systems. *AI Magazine*, 22(1):39–52, 2001.

[5] M. Nanjanath, A. Erlandson, S. Andrist, A. Ragipindi, A. Mohammed, A. Sharma, and M. Gini. Decision and coordination strategies for RoboCup Rescue agents. In *Proc. SIMPAR*, pages 473–484, 2010.

[6] S. Ramchurn, A. Farinelli, K. Macarthur, M. Polukarov, and N. Jennings. Decentralised coordination in RoboCup Rescue. *The Computer Journal*, 53(9):1–15, 2010.

[7] T. Sandholm, K. Larson, M. Andersson, O. Shehory, and F. Tohmé. Coalition structure generation with worst case guarantees. *Artificial Intelligence*, 111(1–2):209–238, 1999.

[8] P. Scerri, A. Farinelli, S. Okamoto, and M. Tambe. Allocating tasks in extreme teams. In *Int'l Conf. on Autonomous Agents and Multi-Agent Systems*, pages 727–734, 2005.

[9] Y. Zhang and L. E. Parker. Task allocation with executable coalitions in multirobot tasks. In *Proc. IEEE Int'l Conf. on Robotics and Automation*, pages 3307–3314, 2012.

[10] X. Zheng and S. Koenig. Reaction functions for task allocation to cooperative agents. In *Int'l Conf. on Autonomous Agents and Multi-Agent Systems*, pages 559–566, 2008.