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Master in Artificial Intelligence

Introduction to Multi-Agent Systems

Analysis of Cooperation Mechanisms

Deliverable 2

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1 Introduction

In this report we analyze the cooperation mechanisms of the multi agent system (MAS) described in the previous report with the task of recycling the garbage in a virtual city.

1.1 Goal Definition

All the agents in our MAS are contributing to the goal of recycling the garbage in the city in an efficient manner (except for the SystemAgent, which is solely taking care of the state of the virtual city and not further interacting with it). In order for several agents to contribute towards solving a distributed problem, they need to be coherent (working towards the same goal) and competent (knowledge how to work together). While we define the competence of the agents in the following sections, we start with defining the common goal of the MAS, that ensures coherent behavior.

According to the project description, the MAS ought to maximize the benefits (points received by recycling centers) while minimizing the time to recycle garbage. The agents' decisions will be based on evaluating different possible plans with with this goal and often there will be a trade off between achieving maximum points or minimal waiting time.

For all possible plans of actions $p \in \mathbb{P}$:

$$\max_{p \in \mathbb{P}} b(p)$$

with $b(p)$ being the sum of benefit points achieved with the plan p, and

$$\min_{p \in \mathbb{P}} t(p)$$

with $t(p)$ being an evaluation of the waiting time corresponding to p. Looking at the specific domain of garbage recycling, it makes sense to punish exceptionally long waiting times over-proportionately. Hence $t(p)$ will be the sum of squared waiting times of all garbages between showing up and being picked up by a HarvesterAgent.

Combining our two subgoals, we get

$$\max_{p \in \mathbb{P}} \theta_1 \cdot b(p) - \theta_2 \cdot t(p)$$

with θ_1 and θ_2 weighting the relative importance of benefits and weighting time.

1.2 Analysis of necessary cooperation

The MAS is cooperative-benevolent, i.e. all agents work towards the same goal.

- **Harvesting Coordination**
- **Scouting Coordination**
- **Vehicle Coordination**

2 Analysis of Cooperation Mechanisms

2.1 Overview

2.2 Contract Net

General Description

The Contract Net protocol was developed by R.G.Smith in 1980 [Smi80] and is based on the way in which companies put contracts out to tender. There are five phases the protocol runs through to resolve a certain task:

- **Recognition**: An agent (called the "manager") recognizes a task that has to be done and that it cannot solve or does not want to solve.
- **Announcement**: The manager announces the task to all agents (general broadcast), a group of agents (limited broadcast), or specific agents (point-to-point announcement). The specification of the task includes a description of the task, constraints, and meta-information.
- **Bidding**: When an agent receives a task evaluate the task with respect to their specific properties and, if they are able and willing to solve the task, they submit a tender to the manager, indicating the relevant capabilities of the agent to solve the task.
- **Awarding**: A manager may receive several tenders for a task. Based on the information provided in the tenders, it chooses the best fitting agent or agents to execute the task. Chosen agents are called contractors for this task.
- **Expediting**: The chosen contractor or contractors then execute the task. If there is more than one contractor, further cooperation mechanisms might be necessary.

The Contract Net is based on a mutual selection process: Managers can select the best fitting tender and contractors can decide, for which announced tasks they want to create a tender.

2.3 Auctions

2.4 Coalitions

2.5 PGP

2.6 Voting

3 Choice of Cooperation Mechanisms

auction vs. contractnet: harvesters don't have any incentive to get a task assigned with more resources (e.g. steps) than needed -¿ auction does not yield advantages but needs more computational effort and implementation complexity.

References

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