Delft University of Technology

Artificial Intelligence Techniques
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# Assignment 2 - StarCraft MAS

*A Multi-Agent System for the StarCraft environment*

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# Introduction

This report describes the development of a team of GOAL agents to mimic a player in the game StarCraft. Every unit will be controlled by a different agent and there is no centralized managing agent among them. The agents are able to communicate and coordinate together in order to achieve their (common) goals. Earlier, a report has been handed in containing the strategy which will be implemented. This report contains the design specification of the MAS and an explanation of the implemented features. The objectives that were aimed for are used as guideline to specify agents and their goals. These objectives are also used as measurement of the performance.

Section 1 presents the basic information about the game and chosen race in order to understand the functionality, Section 2 describes the objectives that are aimed for, Section 3 explains the design of the MAS, and the performance is discussed in Section 4. Recommendations are presented in Section 5. Together with this report a zip file is submitted, containing all files needed to run the MAS.

# 1 Basic information

The aim of this first MAS is to set-up a basic colony. The goal is not necessarily to develop a MAS to fight enemies, but attacking functionalities are implemented. In this case the *Protoss* race is used. The working units are called *Probes*, they are used to mine resources and to start building constructions. The fighting units of Protoss that are trained by the MAS are *Zealots* and *Dragoons*. Every construction, except for the *Assimilator*, is to be built in proximity of a *pylon*, which creates a *Psionic matrix*. The game starts with a *Nexus*, this building can train *probes*. Other possible buildings are *Gateway*, which can warp protoss infantry units from their home territories, into the military colony. The *Assimilator* is built on *vespene geysers* to allow for harvesting *vespene gas*.

The basic material which have to be collected are *crystals*. This is done by the probes and are needed for every building, units and constructions. The second resource is *vespene gas*, used for advanced units and buildings. One other type of resource is the population cap (*psi*), determining how many units you can have. This cap can be expanded by building *pylons*.

# 2 Objectives

Creating a basic colony can be done in a variety of ways, but a few basic requirements are prescribed. The following achievements cover the basic requirements that were aimed for during the construction of the MAS:

- Start up and run MAS, connecting to StarCraft
- Collect minerals
- Two Gateways are constructed
- Assimilator is built on top of geyser, vespene gas is collected

- Pylons are built whenever the population cap is reached
- Zealots are trained by the Gateways

Besides the basic objectives, a few achievements are adopted additionally:

- A Cybernetics Core is constructed
- Dragoons and Zealots are both trained by the gateways
- Phase transitions in the behavior of agents for different phases of the game play
- Implemented attack strategy

The capability of the MAS to satisfy the totality of these objectives are used to measure the performance in Section 4.

# 3 MAS Design

Throughout the run time of the game, for each agent individually, a clear distinction is made between different phases of the game play. All independently working agents are able to retrieve common knowledge from the generic knowledge base. This knowledge base does not contain any managing capabilities and decisions are made by each agents themselves. In fact, this knowledge could be decentralized, but this knowledge base does not share information between agents and consists of factual aspects, such as available resources and amount of available units. Every independent agent has its own belief state that is updated with percepts. Based on these beliefs, goals are updated, actions are specified and phase transitions are made. Besides these functionalities, agents are capable of sending and receiving messages to or from other agents. Each type of agent is separately explained, along with their conditions for action specifications, in the subsections of this chapter. Interaction between the agents plays an important role in the functionality of the MAS. Conditional properties on goal updates of the agents are presented in Section 3.5, for the different phases of game play.

## 3.1 Nexus

Nexus exists from the beginning of the game and gets assigned a separate agent. The only task of the Nexus is building probes and communicating its position. Dependent on the game phase, the Nexus has as goal to keep the amount of probes at a certain level. It does so by adopting the train action specification whenever the goal to train them exists, the train queue is not too long and enough resources are available. The amount of available resources is stored in the belief base of the Nexus agent.

## 3.2 Probes

Probes have to perform several important functionalities, while the task of different probes can vary during the game. The implementation of the division of tasks is one of the challenges when no centralized managing agent is available. Once a probe is trained, its current *workerActivity* is '*idling*'. This believe of its own activity is continuously updated with its perceived activity. The main task of probes is to gather minerals, so this is the first thing a probe will adopt to its goal base when idling. During the initialization of a probe agent, the probe will ask the Nexus for its location and adds it to its belief state. In the strategy document submitted, it was mentioned that probes work according to a priority list. That is accomplished by keeping a list of buildings to build and only adopt it as a goal when the preceding building has already been constructed.

### 3.2.1 Constructing buildings

The question whether the MAS should start building a certain building, is evaluated by each probe individually. The actual build is only performed by one probe. In order to keep gathering resources and have no unnecessary movement of the remaining agents, only one probe should be assigned to perform the building task. This task assignment is decided by perception of all the probes individually. Each probe keeps track of the identities of all the available friendly units, represented by numbers. Once a probe notices that its own identity has the lowest number, it will add to its belief state that he is the builder. As soon as a build goal arises due to certain conditional properties and all pre-conditions of the action are full filled, the builder will immediately update its action specification. Once the building task is finished, the probe will continue its work as a gatherer.

### 3.2.2 Gathering vespene gas

Gathering vespene gas is again a task that is not common for all probes. The aim of the MAS is that only one probe gathers vespene gas. The assignment of this task is similar to the assignment of the builder identity. For a probe to satisfy the percept that he is the vespene gas gatherer, it should, opposite to the builder, have the highest identity amongst all probes. Also, a finished assimilator is to be present. Note that these identity based role distributions may vary as new probes are trained.

## 3.3 Gateway

A constructed gateway implies that a gateway agent should be launched. The functionality of a gateway agent is equal for all of them. The gateway agent is able to perceive its own queue size, the available resources and the phase of the game play the MAS is currently in. The goal of the gateway agents solely depends on the current phase, while the action specification is made when the precepts fulfill the conditions of a queue size smaller then 2, sufficient amount of psi left and the presence of enough crystals and gas. Actual goals for different phases are specified in Section 3.4. One key element for victory, is that gateways always (no matter what) produce a Zealot when they have plenty of minerals (¿200) and the train queue is empty.

## 3.4 Phase transitions

Phase transitions happen when certain conditions are met. These transition rules are equal for all agents. Once the conditions for a phase transition are met, all agents that perceive those conditions will update their own phase in their belief state. At startup, every agent will start in the **first phase** of the game play. The transition rule for going to the **second phase**, is the presence of at least eight Zealots in the game (can be in the training queue). The rule for going to the **third phase** is the presence of at least three Dragoons and at least twelve probes. Of course, the presence of these infantry units represents the achievement of intermediate steps in order to make it possible to train them. In the following subsections, the objectives of each phase are illustrated. Note that newly launched agents start at phase 1 and only continue to the next phase while transition rules still hold! Since a backwards phase transition does not exist, separate agents can be in different phases of game play.

## 3.5 Goals

Goals are updated during the game, dependent on certain variables and the phase of the game. Some goals remain the same throughout the game, and thus independent of the phase, such as certain goals for the *probe agents*:

- Gather minerals when idling
- When builder → build pylons when psi is needed, build one assimilator when at least 6 probes exist and no assimilator exists yet, build gateways as long as no 2 gateways exist.
- When gas gatherer → start gathering gas when assimilator is available in belief state.

Some goals of the agents are phase dependent and are presented per phase in Table 1

| | Probes | Nexus | Gateway |
|---|---|---|---|
| Phase 1 | | Train up to 8 probes | Train up to 12 Zealots |
| Phase 2 | When builder → build up to one Cybernetics core when resources allow | Train up to 12 probes | Train up to 50 Zealots and 50 Dragoons |
| Phase 3 | When builder → build up to 4 gateways | Train up to 12 probes | Train up to 50 Zealots and 50 Dragoons |

Table 1: Goals of agents that are phase dependent

## 3.6 Infantry units

Infantry units that are trained in the gateway all get the same agent assigned. This agent is capable of performing a collaborative attacking strategy. As soon as a infantry unit is trained, it adopts a goal that it wants to move closer to the enemy base. All units gather at a certain group location, close to the enemy base. Choke points and the opponents base location are added to the belief base of the unit at initialization. Therefore, a choke point close to the enemies base is chosen as assembly point.

As soon as units start to arrive at the group location, communication between them arises to come up with an attack strategy. Every unit keeps a list of the present infantry units by communicating their identities to the other agents of the units. Since the exact names of the infantry units is not known beforehand, a request message is sent to all agents with `all.send`?(), to ask if there exists other infantry units that are ready to attack. Units that are close to the group location respond with `'ready'` and send their ID. The replies are stored in the believe state. When more than 6 units are ready, they attack. The cluster of units starts to attack the opponents base, by adopting this as a goal. Since units only make a list of ready units at the group location when they are present at the group location themselves, the attacking of the enemy occurs in waves of clustered infantry units. The cluster size can be set to a desirable level in order to optimize for victory.

# 4 Performance of the MAS

The MAS performs as expected. Only one probe constructs buildings. Also, just one probe collects gas at the Assimilator. Just as expected, when a new probe is trained, having a higher ID than the current gas collector, the old collector goes mining minerals and the new probe is the new gas collector. The attack waves of the offensive units also perform as expected.

In the end, all the MAS performance criteria are met: Over 4 buildings are being constructed, gas is collected, Protoss is on offense. Due to the resistance of the opponent, the AI is not always able to win the game.

# 5 Recommendations

Initially, the desired procedure for the probes to determine which one is the builder or the gas collector was by having the probe send messages. This method failed due to the asynchronous behaviour of the messaging system. Some probes did not respond yet while an other probe already made a decision based on incomplete information. This resulted in multiple probes trying to construct a building or gather gas. Therefore, because of the robustness of logic based on percepts, this is favoured instead of decision making based on intercommunication, whenever possible.

The intelligence of the MAS in this project is static. Goals are defined beforehand according to a desired sequence of events. The project team recommends an alternative dynamic approach, for example one that uses cost functions that can be optimized to determine the strategy, superior to the approach used in this report. Another example of a more intelligent approach is to train infantry units according to a goal that adapts to the race of the opponent. Certain units may be stronger against common types of specific races, which can lead to an easier victory.

Furthermore, a very large variety of percepts is made available by the environment that can be used in favor of the MAS. A good agent uses percepts about the current state of the game to modify the strategy and goals of the agents. The current agent functions good, as long as there are no unanticipated events, such as an enemy attacking and buildings, probes being destroyed. A good agent, should be able to cope with a changing game environment.