Agent-Based Software Development

Instructions for the Second Assignment —WoA

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Version 2.0
February 22, 2019

WoA

Contents

1. Motivation

Wizzard Entertainment Co., a game company specialized in real-time strategy games, is planning to release by the end of this year its new title, "World of Agents".

In *World of Agents*, players must create cities, collect resources and produce buildings and units in order to allow their tribes to grow in wealth, size and power. Players must explore and colonize an unknown territory in search for resources. They can interact with each other to interchange and negotiate with those resources. It is a peaceful version of the arise of the civilization.

Players in *World of Agents* can be human beings or autonomous artificial players. This allows single player games between a human player and several synthetic ones. It also allows to introduce artificial players in multiplayer games when not enough human players are available to complete the desired number of tribes on the board.

Wizzard Entertainment is concerned with the intelligence and believability of its artificial players, since it can be a major asset for players engagement. In that sense, it is encouraging designers to create efficient artificial players able to exhibit intelligent behaviors and, therefore, entailing a real challenge for human players.

With that purpose, Wizzard Entertainment is proposing interested companies to develop a software system called "WoA" in which they will be able to try and test their artificial players and their strategies. It will offer all the main functionalities of the game, including the communication and negotiation with other artificial players, and the best strategies will be included as artificial intelligent components in the future official release of the game.

The design and construction of that system is the main purpose of the work described in the present document.

2. Context

2.1. Player Registration

In order to be part of a WoA match, artificial players must register into the system. A player registered will take part in the next game and will be provided with initial resources and a starting location on the game board. The game will begin after the registration period and no further registration will be allowed afterwards.

Each player is identified in the system by a unique name consisting of a combination of the word "Tribe" and its team number. For instance, the identification in the system for the player of team "7" will be "Tribe7".

As a response to its registration request, the player will receive a notification from WoA indicating its acceptation in the system or the denial of registration, in case of arriving after the registration period.

2.2. Terrain

The scenario in which takes place the game does not present any geographical accident or obstacle affecting the movement of the different units. That means that units can move freely all over the board without limitations.

However, the terrain may content different elements with which the player's units may interact:

- buildings to store or produce goods;
- forests that can be chopped to obtain wood;
- ore that can be mined to obtain gold or stone;
- other player's units with which interchange goods;
- or just ground without any further interest.

Terrain is broken up into cells with a unique denomination, as shown in figure 1. Units passing by a piece of terrain analyze it automatically and are informed about its content. A cell may be empty (just ground), contain a building (only one per cell) or contain some resource to exploit (only one kind per cell). Additionally, any number of units of any tribe may also be present in the same cell.

2.3. Cities and Buildings

Once the registration period is over, each team is provided with 3 units in a random cell —from which the colonization adventure will start— and some initial resources to allow them to survive in their initial steps. One of the first things a unit can make is to search for a good place to found a new city by building a *Town Hall*. The conditions for a cell to contain a new Town Hall are:

- it must contain just plain ground;

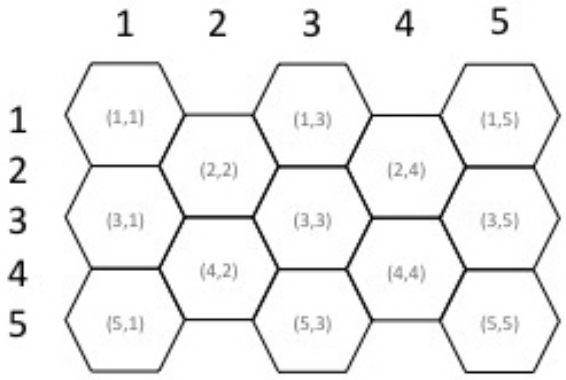

Figure 1: Fragment of a scenario terrain grid.

- there must not be any building already built (thus, belonging to another city) in any of its contiguous cells;
- the player must have enough resources to pay the price of building the Town Hall (see table 1 to check the price of each building).

The construction of any building takes a given time. When that time is up, the new city is born (a name must be provided) and any other building structure may be developed in any of its surrounding cells, extending that way its limits. The requirements for constructing a new building in a city are:

- the cell for the new building must contain just plain ground;
- it must be connected in any of the surrounding cells directly with a single Town Hall or indirectly through other buildings connected to a single Town Hall.
- the player must have enough resources to pay the price of building the new building (see table 1 to check the price of each building);

After the required time for developing the new building is over, it becomes available to be used by the tribe. There are three kinds of buildings in WoA:

Town Hall: only one per city. Produces new units.

Store: as many as needed per city. Stores a limited number of resources, *storage_capability*. There can be goods of different kinds mixed in

the same store. Once the storage limit is reached, overproduction of resources is lost if no new store is built.

Farm: as many as needed per city. Produces food.

Building	Gold	Stone	Wood	Units	Hours
Town Hall	250	150	200	1	240
Store	50	50	50	1	120
Farm	100	25	25	1	120

Table 1: Conditions for constructing buildings.

2.4. Resources

Tribes need certain resources to develop their civilization and to survive. Some resources can be obtained from the nature while others need to be produced by the tribe units. There are four kinds of resources in WoA:

Gold: mined from ore. Ore can be found in the nature, and may contain a variable percentage of gold (*gold_percentage*).

Stone: mined also from ore. The remaining percentage not being gold is used mainly as stone for building.

Wood: chopped from forests. Forests can be found in the nature. Used mainly as material for constructing buildings.

Food: harvested from farms. Needed to maintain alive the population.

To exploit any resource source (ore, forest or farm), a unit must be dedicated to the mining, cutting or harvesting of the resource. During the time of the resource exploitation, the unit must remain in the cell containing the ore, forest or farm. Otherwise, the operation will be aborted and no resource will be obtained. Times for obtaining resources are described in table 2.

The same resource may be simultaneously exploited by more than one unit, from the same tribe or from different ones. The exception is food, which only can be harvested from a farm by units of the same tribe that owns it. Resources exploited will be stored in any store of any city of the tribe with available room. If no room is available in any store, the surplus goods will be discarded.

Resource	Rate
Gold and stone	10 each 8 hours
Wood	10 each 6 hours
Food	5 each 24 hours

Table 2: Resources production rate.

At the beginning of the simulation, each ore location and forest starts with an initial, particular *resource_amount*. Each time the resource is exploited from one of these sources, the amount extracted is subtracted from the remaining amount of ore or wood, till the mine or the forest is depleted. When that happens, the ore location or the forest in question just "disappears", and the cell turns into plain ground. Farms, however, never get depleted.

2.5. Units

Once the registration period is over and all players have been randomly located in the map, a tribe only knows the cell in which its 3 initial units have been put. The rest of the map remains "foggy" to it and the only way to unveil other cells is exploring them by moving to them.

When a unit steps into a new cell, the information of the content of that cell is automatically transmitted to it and that knowledge is now available to the rest of the tribe units. However, that knowledge remains still hidden to other tribes, which must explore themselves that cell to gain it.

A unit has freedom to decide to which one of the six surrounding cells wants to move (see figure 2). Moving to a contiguous cell takes 6 hours.

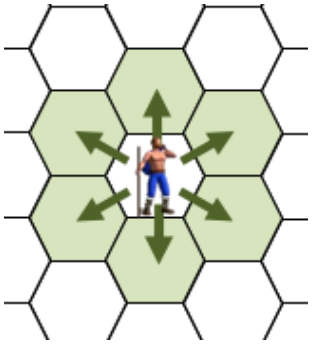

Figure 2: Possible movements for a unit.

Units are also responsible for developing new buildings. A unit may start the construction of a new building when the conditions described in section 2.3 are met. In that moment, the chosen cell gets blocked, avoiding any other construction on it, and the unit keep on building the new structure till the construction is over.

During the construction of a building, the unit cannot make any other activity. If the unit decides to change activity, the construction is aborted and the cell turns to be plain, empty and unblocked, allowing constructing new buildings on it.

Times for developing a new building are detailed in table 1. When that time is over, the building turns to be operative and the unit that built it is released.

Units also participate in the exploitation of resources. When a unit wants to obtain gold, stone, wood or food, it must go to the cell containing the correspondent ore, forest or farm and start working to get it. The unit must stay working during the full cycle indicated in table 2 to get the resources. Again, if the unit abandons the obtaining of the resource during the cycle, no resource will be obtained. In that case, no waste of ore or wood occurs in the correspondent mine or forest, in the case of gold, stone or wood production.

The only activity compatible with building or exploiting resources is interacting with units of other tribes. When two units of different tribes meet in the same cell, they can negotiate to decide the exchange of part of their resources. Units are not allowed to move to another cell during a negotiation with other units. If that happens, negotiation would be canceled.

Although each tribe starts the match with 3 units, new units may be created along it. New units are created in the Town Hall. To create a new unit, another existing unit of the tribe must go to the cell in which the Town Hall is and activate there the creation of a new unit. The existing unit does not need to stay in the Town Hall during the creation of the new unit, but the rest of the conditions for creating a new unit must be accomplished (see table 3).

	Gold	**Food**	**Hours**
New unit	150	50	150

Table 3: Conditions for creating new units.

Finally, units consume 1 food each 24 hours. If a unit remains without feeding for three days in a row, the unit will die.

3. Game Considerations

3.1. Map

The map in which WoA takes place has very few restrictions. It is a flat map with no geographical barrier which allows the free movement of the units all over the world. It does not have borders either, which makes it to behave as a flattened sphere. The connection between cells, specially between those in the limits of the map is the one shown in figure 3.

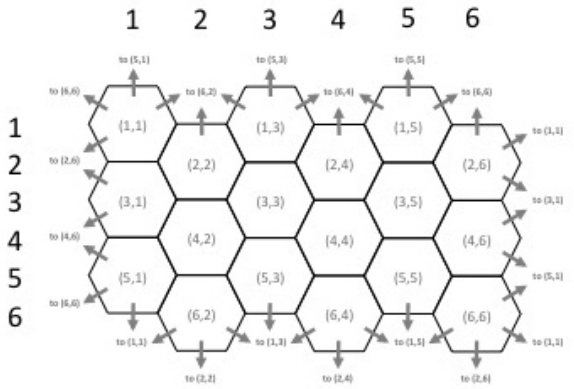

Figure 3: Interconnection of border cells in a 6×6 grid.

The dimensions of the map depend on each match, and are notified to all tribes at registration period.

3.2. Activity Visualization

Concurrent activity takes place during the development of a WoA match. However, each tribe is only aware of that one happening in its known territory. That comprises:

- **Units** (own or someone else's) **movement** along the known cells.
- **Resources** discovered, under exploitation or depleted in the known cells.
- **Buildings** constructed in the known cells.
- **Units** (own or someone else's) **dead** of starvation in the known cells.

Any other activity beyond the known limits of a tribe remain unaware for it.

3.3. Units Communication

It is compulsory to respect the environment communication limitations. No communication is allowed between units if they are not in the same cell or if they move while a communication has started. This is a strong restriction for the game development, and not respecting it will be considered cheating.

The communication protocol and the structure of the messages interchanged will be standard for all tribes.

3.4. Starting Distribution

Tribes will be distributed randomly all over the map. To give similar opportunities to all tribes, the system will communicate simultaneously each tribe its initial position, understanding this information as the beginning of the match phase.

The only restriction with the tribe starting position is that two tribes cannot appear initially on the same cell.

3.5. Game Development

Each game covers three differentiated, consecutive phases:

1. **Registration phase:** Tribes get registered in the system and receive all the information needed about the match. This phase lasts *duration_registration* hours.

2. **Match phase:** Tribes are located randomly in the map and start their autonomous evolution in the scenario. The duration of this phase is *duration_match* hours.

3. **Results phase:** The match is over and the results and scoring of the game are shown to the participants. After offering this information, the game is over.

The time units used in the game are “days” and “hours”, but they should not be considered as real days and hours, since the duration of a game would be excessive. One “WoA day” lasts 24 “WoA hours”, and one “WoA hour” lasts *hour_lenght* real seconds.

3.6. Results and Scoring

The performance of a tribe is determined by the conjunction of all its achievements during the match. The score of a tribe is obtaining from the weighted addition of the following results:

- *cells_explored*: Number of cells explored by the tribe.
- *cities_owned*: Number of cities owned by the tribe.
- *stores_owned*: Number of stores owned by the tribe.
- $farms\_owned$: Number of farm owned by the tribe.
- *units_owned*: Number of units owned by the tribe.
- *gold_owned*: Amount of gold owned by the tribe.
- *stone_owned*: Amount of stone owned by the tribe.
- *wood_owned*: Amount of wood owned by the tribe.
- $food\_owned$: Amount of food owned by the tribe.

From these results, the score for the tribe i is calculated with the formula shown in (1).

$$\begin{aligned} score_i = (&100 \times cells\_explored_i \\ &+500 \times cities\_owned_i \\ &+250 \times stores\_owned_i \\ &+300 \times farms\_owned_i \\ &+400 \times units\_owned_i \\ &+10 \times gold\_owned_i \\ &+2 \times stone\_owned_i \\ &+1 \times wood\_owned_i \\ &+5 \times food\_owned_i) \end{aligned} \tag{1}$$

Score must be calculated in real time to be able to follow the performance of every tribe. In the phase of results, the summary of each tribe final achievements and final score will be shown to the participants.

4. The Assignment

From the scenario proposed for this problem[1], every working group will adopt the role of a development team for the whole system, contending to build the best simulation environment and the best tribe performance.

In this same context, the professor of the subject will adopt the role of product owner and expert. To facilitate the interaction among the competing groups and the product owner, a weekly or biweekly meeting will be arranged, belonging to one of the two class sessions scheduled in the syllabus for this subject.

The aim of the assignment will be, thus, the development of an agent-based system using software engineering techniques, taking as basis the methodology recommendations reviewed in the classroom, and implementing the final design in the JADE platform.

The development will be evaluated according to the continuous work of the working group, although there will be a final project presentation in the classroom by the end of the course, which will definitively influence the final grade[2].

In particular, this system is proposed to be developed following an incremental iterative development life-cycle, consisting in weekly or biweekly iterations with their corresponding integration among groups products. The functionality included in each iteration will be decided in the classroom by all the working groups according the priorities and risks perceived by the students.

The deadlines to be considered in this assignment are the following ones:

- **Sunday 26th May 2019 - 23:55 hours:** Deadline to deliver the complete system documentation (analysis, architectural design, detailed design), plus the system implementation.

  The documentation to be delivered, in pdf format, must begin by a single page cover containing the **assignment title, number of working team, and name and surname of the group components**.

  The rest of the document, must include, at least, the documentation generated as the result of the software engineering processes followed, the result of the SQA activities performed and, additionally, any kind

[1] NOTE: The professor is aware of the ambiguity and inaccuracy of the proposed problem, considering it an important factor for the simulation of the expected situation during this practical work.

[2] The professor of the subject might modify the evaluation criterion along the development of the assignment to benefit the students.

of documentation and techniques elaborated to complete those models (e.g. extensions and alternatives to the models reviewed in the classroom).

In addition, a description of the strategy for the designed and built tribe evolution software and some final conclusions shall be included.

The document must also include an iteration by iteration description of the process followed describing the work estimated, the work performed, burndown chart and sprint retrospective results.

Both that pdf documentation and the system code will be submitted in Moodle through a task that will be created for that purpose. In particular, every working group must submit the `.java` and `.class` elaborated files. More exactly, working groups must send a compressed file (`.zip`, `.rar` or `.jar`) containing the package structure created by the group with the corresponding files inside it, and also the pdf file with the work documentation. In addition, in the assignment document must be included an annex with the minimum necessary information to execute and manage the implemented system.

- **Monday 27th May 2019:** Presentation of the assignment in the classroom. The attendance to this presentation is mandatory.

4.1. Structure of the Product to Be Developed

With the aim of avoiding interference among the systems provided by every working group, they must be presented following several fundamental considerations. Following these instructions is compulsory to pass the assignment.

- Every group will provide two different agents as a result of its work:
  - one managing the tribe system called `AgTribeX` (being "X" the number of the work group);
  - and another one, called `AgPlatformX` (being "X" the number of the work group), responsible for activating the rest of the agents designed for the common simulation platform.

  That way, it will be possible to launch one random group platform with all the tribe systems developed by all the groups competing in it.
- The final product to be delivered **only** must show in the standard console some messages that will be agreed in the classroom weekly meetings. The following are just an example:

`TribeX: enters into the system`, when the tribe "X" enters into the system.

`Platform: activated`, when the platform enters into the system.

`Platform: TribeX registered`, when the tribe "X" gets registered for the match.

`Platform: ''Agentown'' founded in cell (A,B) by TribeX`, when the Tribe "X" builds a Town Hall for a new city called "Agenttown" in cell (A,B).

...

- The produced code must be contained into a package named "groupX", where "X" corresponds to the number of the working group. Inside that package must be, at least:
  - The `AgPlatformX.class` and `AgTribeX.class` files, that will be triggered in the code review, being "X" the number of the working group.
  - In this package will be also included any configuration file agreed by the students to make the platform to work. The description of the management of that file will be described as an annex in the documentation.
- All the packages "groupX" corresponding to the working groups will be situated, in addition, inside a common package called "WoA".
- Every package, folder and file path referenced inside the code must be relative.

4.2. Conditions to Pass

To consider passed the written documentation, it will have to include, at least, the documentation described in section 4, with the models enough to be able to understand and to reproduce the design in a future. They must be consistent among them and with the code delivered, and must satisfy all the requirements described in these instructions. It will be also valued the structure and style of the document.

To consider passed the implementation, it will have to work perfectly and **to be completely coherent with the analysis and design models presented in the paper documentation**, and comply the minimum requirements of legibility, order and style.

The code evaluation will be performed testing simultaneously all the groups tribes within the simulation platform of each working group (i.e. all tribes in group 1's platform, then all tribes in group 2's platform and so on).

It is indispensable to respect the common interfaces among all the groups agents. The specific way of structuring them and the rest of the system may be different from one working group to another, but always respecting that interface.

The maximum mark obtainable in this assignment is 10 points out of 10, including not only the documented and software results but also the process followed by the team.

After performing several tests among all the working groups systems together, an extra point will be added to the final mark of all the participant students if all the presented assignments work together in the right way.

In addition, the company obtaining the overall best results in the performed tests (the maximum accumulated score after all the matches played) will obtain an extra point in the final grade, the second best half of a point and the third one a quarter of a point.