



Recycle Swarm Rulebook

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Glossary

SDK – kit that is given to the participants for implementing the Solutions for the Game.

Solution – code that adheres to the Specifications given in the SDK, and that, when executed within the proper context, plays according to the Rulebook

Framework – all the classes/libraries that are needed to develop and run a Solution for the Game.

Scenario – a set of values for the parameters of a particular Game that define a specific instance of the Game.

Game Instance – a running Scenario, including its internal state (e.g. to represent the progress of the Game).

Solution Instance – a running Solution, including its internal state.

Server – executable that creates a Game Instance, and to which Clients can connect.

Client – executable that creates a Solution Instance, connects to a Server, and constitutes the interface between the Game Instance (running on the Server) and this Solution Instance.



Game Concept

Introduction

The purpose of the game is to build a multi-agent system meant to clean a given area as efficiently as possible.

The various types of agents available in the system (scouts, harvesters, carriers), endowed with different sensing, acting and communicating abilities, must cooperate and coordinate in order to recycle as much garbage as possible in the given amount of time.

The proposed solution must take into account the characteristics of the map, the different types of garbage and the states in which it can be found on the map, and also cope with damages that might occur.

Goal of the game

A player's objective in the game is to earn a score as high as possible during the game time.

Since a player controls several vehicles, all vehicles have a contribution to the player's score. The goal is to have vehicles cooperating in order to maximize their collective score, as a team.

Game overview

Each participating team will start with several vehicles placed close to each other on the map; no other vehicles will be added later, and no vehicles will disappear during the game. All teams will be placed on the same map, with different initial positions. It will be ensured that no team gains an advantage over the others with respect to how vehicles are positioned on the map.

All teams will have an initial amount of money, in order to be able to perform the operations that require payment. The game uses continuous time, and there are no turns. The environment supports players by providing information about the position changes, the score or other important parameters. The game is given an amount of time to progress and it ends when the announced time has passed. The winning team is the one that has the highest score at the end of the game.

Game components

Recycle Swarm involves a series of concepts that are detailed below:

- Map
- Vehicles
 - Scouts
 - Harvesters
 - Carriers
- Types of garbage
 - Garbage piles
 - Packets
- Recycling Centers

Map

The map is a two-dimensional rectangular space, with continuous coordinates, made of cells with specified dimensions, expressed in distance units (they will be provided to the players at the beginning of the game).

The map is the space in which players may move their vehicles. It consists of several types of terrain. The following elements are located on the map: vehicles, garbage, Recycling Centers. Some have fixed positions; others may move or may be moved.

Map terrain types

The map may contain four types of terrain:

- Normal terrain
- Muddy terrain
- Rough terrain
- Obstacle

Any vehicle may drive over normal terrain, and no vehicle can drive over an obstacle. However, vehicles can see through obstacles. Depending on the vehicle type, some may drive over muddy and rough terrains, and some may not.

Vehicles

Each player controls several vehicles, of three different types:

- Scout vehicle
- Harvester vehicle
- Carrier vehicle

Vehicles are represented as points on the rectangular map. Even so, they cannot move straight through obstacles; the only way they can pass between two obstacles is on the diagonal.

Vehicles may move or take other actions, and may communicate with other vehicles of the same team, or of the opponent teams, by exchanging messages adhering to a given established protocol.

Depending on their type, vehicles may perform different actions, with different efficiency.

The game does not apply collision-detection to its elements, so vehicles can pass through other vehicles, or through garbage or Recycling Centers. However, no type of the vehicle can move through obstacles.

All vehicles:

- Have the complete map with the terrain types.
- Have a given visual range surrounding their position, within which they can see garbage piles, garbage packets, Recycling Centers and other vehicles of other teams. Once an object exits the area covered by the visual range of a vehicle, that vehicle has no access to any information concerning that object. The visual range is specific to each vehicle type and scenario dependent.
- Have access to their own parameters.

Depending on their type, vehicles have other specific abilities, described below:

Scouts

- Can move across normal, muddy and rough terrain.
- The speed to traverse the map is a vehicle parameter, expressed in distance units/second and is higher than the speed of a harvester or carrier.
- Cannot harvest garbage, nor carry garbage packets; this makes a scout most suited for discovering the elements on the map (vehicles, garbage, Recycling Centers).
- Can repair damaged vehicles.

Harvesters

- Can move across normal and muddy, but not rough terrain.
- The speed to traverse the map is a vehicle parameter, expressed in distance units/second, and is lower than the speed of a scout, and higher than the speed of a carrier.
- Can carry garbage packets. The capacity is a vehicle parameter, expressed in garbage units, and is lower than the capacity of a carrier. These attributes make a harvester most suited for turning garbage piles into packets, and, in some cases, for carrying packets across muddy terrain, over which carriers cannot drive.
- Are the only ones able to harvest garbage piles and process them into garbage packets. Note that this action cannot be delegated to another vehicle types.
- Cannot repair damaged vehicles.

Carriers

- Can only move across normal terrain.
- The speed to traverse the map is a vehicle parameter, expressed in distance units/second, and is lower than the speed of the other types of vehicles.
- Can carry garbage packets. The capacity is a vehicle parameter, expressed in garbage units, and is generally higher than the capacity of a harvester.
- Cannot harvest garbage.
- Cannot repair damaged vehicles.

Types of garbage

There are three types of garbage:

- Plastic
- Metal
- Glass

Garbage piles

A garbage pile is the raw form of garbage situated on the map. It has a quantity and a type. It cannot be moved, but it can be harvested, and turned into garbage packets.



Packets

A garbage packet is the processed form of garbage. A vehicle may produce a packet out of the entire pile, in which case the pile disappears entirely from the map, or out of part of the pile, in which case the rest of the pile remains on the map.

A garbage packet may be either situated on the map (belonging to a team), or in the possession of a vehicle. It can be moved, and it has the same quantity and type as the pile (or part of the pile) it was harvested from.

A garbage pile or packet contains garbage of a single type.

Recycling centers

Recycling Centers are fixed points on the map, where vehicles may dispose of the garbage packets, in return for points and money. Earned points are the same regardless of the center where garbage was recycled. Some offer higher payment, while others could offer no payment at all for some garbage types.

Payment varies:

- For different types, even at the same center
- At different centers, even for the same type of garbage

The capacity of a center is unlimited; therefore, a center will not refuse any packet.

Delegated recycled garbage gives the points to the initiator of the contract, while any monetary payment goes to the team of the vehicle that actually delivered the garbage to the Recycling Center.

Game Rules

Types of actions:

- Vehicle actions
- Damage and repairing
- Moving
- Harvesting
- Loading and unloading
- Recycling
- Delegating

Vehicle Actions

Vehicles may perform several actions. These are either immediate actions (the time to complete depends only on the environment's time of response) or delayed actions (the time to complete may vary).

The available actions for vehicles are:

- Request information on any vehicle on the map, as long as the unique identifier of the vehicle is known (e.g. the vehicle is in the same team, was once in the visual range, or was learned from a delegated action)
 - Immediate action
 - The environment responds with the requested information
- Move across the map, by plotting a course of one or several way-points
 - Delayed action; duration is affected by the speed attribute of the vehicle
 - The environment responds with the chosen route, and gives updates on the position when reaching each of the initial waypoints
- Harvest garbage in the form of garbage piles, processing it into garbage packets
 - Delayed action; duration is affected by the harvesting rate attribute of the vehicle
 - The environment responds with the newly produced packet(s) when it's done
- Load and unload garbage packets
 - Immediate action
 - The environment responds with <done> or <fail>
- Stop from moving, harvesting, or repairing

- Immediate action
- The environment acknowledges the termination of the current action, if any
- Recycle garbage packets, at one of the Recycling Centers on the map
 - Immediate action
 - The environment responds with <done> or <fail>
- Repair a damaged vehicle, of the same team or of an opponent one
 - Delayed action
 - The environment responds with <done> or <fail>
- Enable and disable a visual SOS of limited range, when the damage suffered does not allow them to alert all vehicles on the map
 - Immediate action
 - The environment responds with <done> or <fail>
- Delegate a different vehicle to transport or recycle garbage packets in their stead, or repair a damaged vehicle
 - Delayed action
 - Involves an exchange of several messages
 - Contracts are formal and are enforced by the system

Damage and Repairing

A vehicle may suffer one of these two types of damage:

- Mechanical – the vehicle may no longer move, but may communicate, and request aid from the team or from all the vehicles
- Mechanical and communication – the vehicle cannot move nor work, nor communicate anymore, and can only ask for help by enabling a visual SOS, limited to its visual range

Some types of vehicles (Scouts) are able to repair other vehicles of the same team, or of a different one.

Moving

Vehicles move across the map by communicating to the environment their desired course, through one point or a list of way-points. The environment periodically communicates the way-points reached, and in the end, the fact that the destination is reached, as well as the new position.

While moving across the map, the vehicle receives information about the elements in its visual range.

The vehicle may request to stop at any time. As all actions take place in real time, there may be a lag between the moment of the request and the actual moment of the stop; therefore, the vehicle should ask for its new position.

The game does not apply collision-detection to its elements, so vehicles can pass through other vehicles, or through garbage or Recycling Centers. However, no type of vehicle can move through obstacles; the only way they can pass between two obstacles is on the diagonal. Even if a vehicle cannot move through obstacles, it can see through them.

Harvesting

Harvesting represents picking up garbage piles, turning them into garbage packets, and marking them as owned by the team. A garbage packet is measured in garbage units. Harvesting is not an instant action (like loading or unloading), it is an action which happens at a given rate, expressed in garbage units/second.

Since piles cannot be moved, harvesting is necessary for gathering the garbage. Once a pile, or part of a pile, is turned into a packet, it cannot be turned back into a pile, and it cannot be picked up by a vehicle of a different team.

A packet may contain only part of the pile, but once the garbage is turned into a packet, it cannot be split any more. The rest of the pile remains available for further harvesting, by the same team or by a different one.

After harvesting, the packet is positioned back on the map, and it needs to be subsequently picked up, in order to be moved and recycled.

Note that only a certain type of vehicle can harvest (Harvesters).

Loading, Unloading and Carrying

Packets must be loaded by a vehicle that can carry them, in order to be moved across the map. To successfully load packets, the vehicle must be in the immediate vicinity of the packet.

Loaded packets may be subsequently unloaded, when:

- the vehicle reaches the Recycling Center
- the vehicle needs to clear up space
- the vehicle moved the packets to a different position so that another vehicle may pick them up

To successfully unload packets for recycling, the vehicle must be in the immediate vicinity of the Recycling Center.

Loading and unloading are immediate actions, with the environment informing the vehicle of the success of the action. Loading may fail if the quantity to be loaded exceeds the difference between the maximum capacity and the capacity of the other packets carried at that moment.

Carrying is requested in a similar fashion to the moving action, and it may also be stopped at any time. Just like in the case of a move action, the vehicle is informed of its position. The difference between the two actions is that carrying involves moving around with packets.

Loading and unloading are actions that happen instantaneously.

Note that not all types of vehicles can load or unload packet. Harvesters and Carriers are the types of vehicles that can carry packets.

Recycling

Recycling of the garbage can be done when the vehicle is positioned in the near vicinity of a Recycling Center.

The vehicle must submit a request, in order to get the garbage recycled. Recycling is an action that happens instantaneously.

Recycling will never fail, because the capacity of a center is unlimited. As mentioned above, a team's score rises as an effect of a recycling action.

Delegating

At the beginning of the game, all vehicles can subscribe to be announced about different types of actions they are interested in. When an action they are interested in appears, all subscribing vehicles to that type of action will be announced.

A delegation can only occur between vehicles from different teams.

A vehicle may request a different vehicle from another team to perform an action, in exchange for money.

The actions that may be delegated are:

- Carrying garbage packets - the vehicle informs of:
 - The packet list
 - The destination position
 - The collateral it expects for ensuring the packets are carried to the destination
- Recycling garbage packets - the vehicle informs of:
 - The packet list
 - No destination is needed, as the Recycling Center to which the packets are to be carried is for the delegated vehicle to decide
 - The collateral it expects for ensuring the packets are recycled
- Repairing a damaged vehicle - the vehicle informs of:
 - The damaged vehicle that requested assistance – note that this includes information concerning the position
 - The collateral it expects for ensuring the vehicle is repaired

To any of these 3 actions, a vehicle willing to accept the request responds with an offer that includes information about the price expected for performing the action, and the estimated time of completion.

Note: The estimated time cannot be longer than the remainder of the game, at that moment.

The collateral consists of a sum of money. It is returned to the delegated vehicle only after the task is successfully completed, in the established time. Otherwise, it is kept by the vehicle that delegated it.



After a delegated action is successfully finished in the established amount of time, both vehicles interacting will receive social bonuses; the vehicle that accepted the action will gain a greater social bonus than the one delegating it.

During the game, packets do not change owner through delegation:

- The delegate vehicle is rewarded the money they asked for (after completing the task in the established time), and the social bonus for the cooperation
- The vehicle that delegated the task is rewarded points and money for recycling, and a small social bonus for the successful interaction.

In the case of a repair request:

- The delegate vehicle is rewarded the money they asked for (after completing the task in the decided time), and the social bonus for the cooperation.
- The vehicle which delegated the task is rewarded a small social bonus for the successful interaction.



Game progress

Initial vehicle parameters

The exact coordinates, as well as other map parameters, will be available for all vehicles at the beginning of the game. It will be ensured that no team will gain an advantage over the others with respect to vehicle positioning on the map.

At the beginning, each vehicle has the position of all the vehicles in its team; after the game starts and vehicles exit the visual range of the current vehicle, the current vehicle will not automatically know the position of the others, even if belonging to the same team.

All vehicles belonging to a team start the game in a position close to each other. No vehicles are added afterwards.

Initial team credit

Teams will start the game with a given amount of money, in order to be able to perform the operations that require payment. When a team runs out of money, such operations will simply fail (there are no additional penalties for running out of money).

The teams will start with no points available.

Game Progress and Time

The game uses continuous time. All vehicles may take action at any given moment in time, and will be responded to in an asynchronous fashion. There are no turns. The game is played with more than one team on the same map. The duration of a game is limited to a value that will be available to all vehicles at the beginning of the game, but may vary from game to game.

During the progress of the game, no other vehicles will be added and no vehicles will disappear. The layout of the map, as well as the time limit, will not change.

Information provided by the environment

When the case, the environment informs a vehicle of the following:

- **VehicleInitialized** – at the beginning of the game, the vehicle is informed that it can now perform actions on the map
- **PositionUpdated** – periodically, when the vehicle's position changes
- **BalanceUpdated** – when the vehicle's team balance (amount of money) changes
- **ObjectsDetected** – when one or several static objects (i.e.: a garbage pile, garbage packet, or Recycling Center) enter the vehicle's visual range
 - Note that this may happen only when the vehicle does the moving, as the objects are positioned on the map
 - This is also sent when an object's properties are modified (eg. quantity for garbage piles), or when the object disappears from the map (is picked up by another team)
- **VehiclesInRange** – when one or several vehicles enter the vehicle's visual range
 - Note that this may happen either when the vehicle does the moving, or when a different vehicle moves in its vicinity
 - This is also sent when a vehicle exits the visual range
- **SosDetected** – when a vehicle in its vicinity activates the SOS
 - This is also sent when a vehicle deactivated the SOS
- **VehicleBroken** – when the vehicle suffers damage
- **VehicleRepaired** – when the vehicle has been repaired by some other vehicle
- **Offer** – when the vehicle is made an offer to perform an action as a request from a different vehicle
- **ContractCompleted** – sent to both parties when a contract is successfully completed
- **ContractExpired** – sent to both parties when a contract expires

Game end

The game ends when the initially given time has passed. The winning team is the one that has the highest score at the end. The score represents the amount of points (points earned, money and social bonuses) available at the end of the game.



Game Score

During the game, one may earn points by:

- Earning money, from:
 - Garbage recycling – the amount of money is different depending on the Recycling Center
 - Successfully finishing delegated actions from other teams – having one vehicle perform a delegated action, requested by a vehicle of a different team
 - The collateral from a mission that has not been successfully completed in the decided amount of time, by one vehicle of the other teams
- Earning points, as payback for:
 - Garbage recycling – a player is rewarded a certain amount of points for packets collected in Recycling Centers; this amount is the same for all Recycling Centers, regardless of what money they offer; garbage that is recycled as a result of a delegated action awards points to the initiator of the contract
 - Gathering garbage packets – a player is rewarded for garbage that is gathered and harvested from piles into packets
 - Performing delegated actions for other teams – having one of its vehicles perform a delegated action requested by a vehicle of a different team
- Earning social bonuses, for initiating cooperation with vehicles of a different team:
 - Performing a task requested by a vehicle of a different team or by requesting and successfully delegating another vehicle to perform a task
 - Repairing a damaged vehicle of a different team
- Completing specific missions (e.g.: recycling a minimum amount of a certain type of garbage, successfully completing a certain number of social interactions, etc.)

Also, one may lose/spend points by:

- Losing/spending money:
 - Losing the collateral from a delegated action that it has accepted, but has not successfully completed in the specified amount of time
 - Spending money on delegated actions to other teams, after the delegated action was successfully completed in the specified amount of time



- Losing social bonuses:
 - When a vehicle accepts a delegated action from another vehicle, but does not successfully complete it in the decided amount of time

At the end of the game, the money, and the social bonuses earned during the game by all vehicles from the same teams will be converted into points.

The actual conversion rates from money and social bonuses points will be detailed in the next release of the SDK.

The winning team is the one that has the highest score.



Technical Specifications

Running a solution

The command for running a solution:

- In Windows

```
java jade.Boot -gui -agents  
scenario:org.aimas.wo.recycleswarm.scenario.ScenarioAgent(test1.xml,class1,class2)
```

- In Linux

```
java jade.Boot -gui -agents  
'scenario:org.aimas.wo.recycleswarm.scenario.ScenarioAgent(test1.xml,class1,class2)'
```

test1.xml is the file that specifies the parameters of the scenario, and class1 and class2 are the fully qualified class names that are loaded for the agents of team 1, and team2 respectively. The classes must extend the `jade.core.Agent` class, and are standard Jade agents, but they must comply with the specifications when communicating with the environment, or agents from other teams.

When running the platform, `recycleswarm.jar`, `jade.jar` and several other libraries, which are mentioned in the release notes, must be included in the `CLASSPATH` variable. See `start.bat` and `start.sh` for concrete examples on how to run the agents.

Note: The current release is a beta version of the game platform. Certain features are not yet implemented or not fully functional. Specifically, contracts are not yet supported. The next release will include more detailed feedback to players about their solutions. Please, refer to the documentation in the SDK for more detailed technical specifications.

