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Multi-Agent Systems

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1 Introduction

This paper will outline a *Delegate Multi-Agents System (DMAS)* solution that uses *Ant Colony Optimalisation (ACO)* techniques to solve the dynamic *Pickup and Delivery Problem (PDP)*. The performance of this solution will be compared with two other classic *Multi Agent Systems (MAS)*, *ContractNet* and *Gradient Field*.

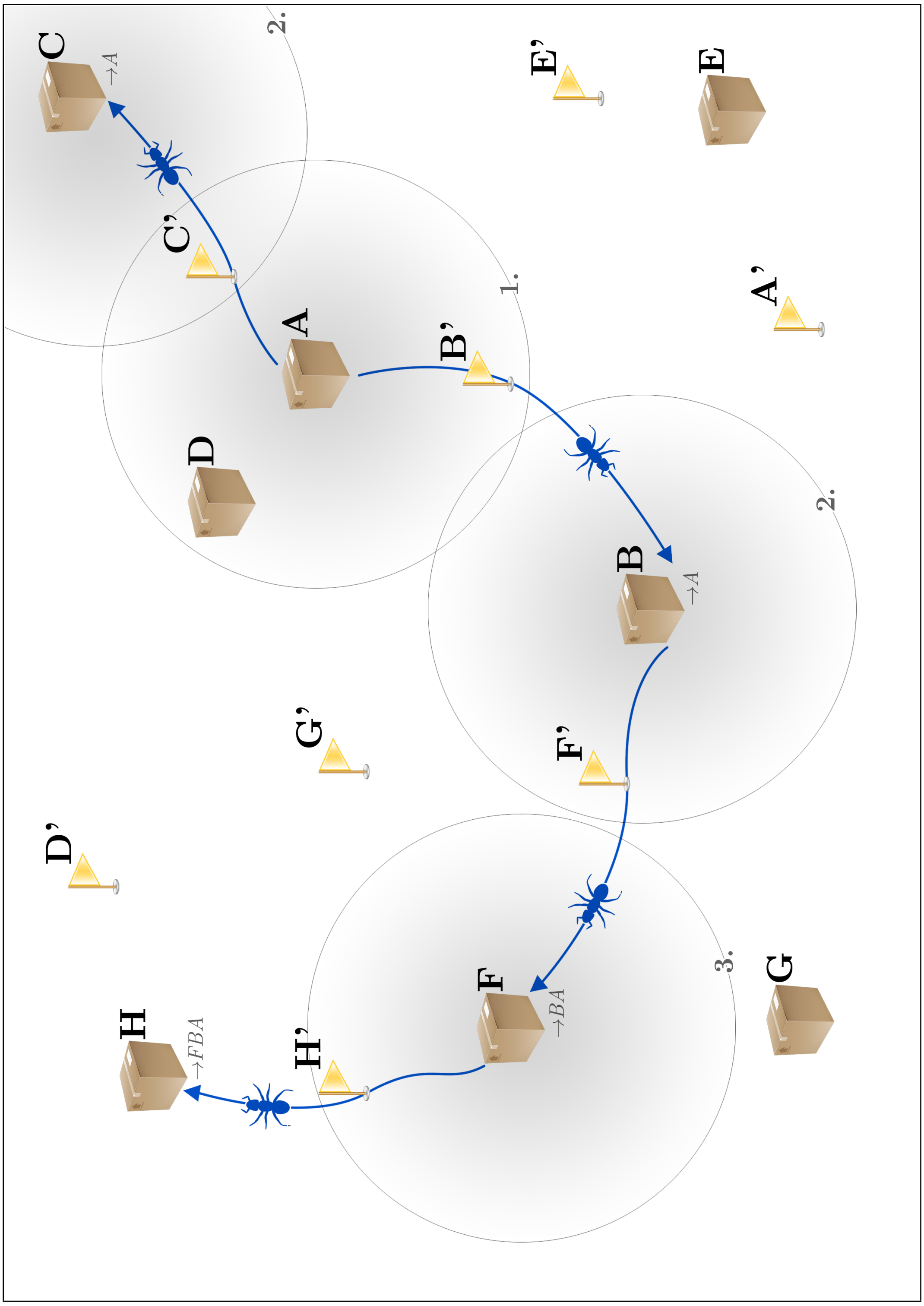
The considered PDP assumes that a truck can only transport one package at the time and that new packages can randomly be added to the system. The infrastructure will also remain the same and congestion on road segments will not occur.

Even though computing power is getting cheaper every day, not every (cross)road can be equipped with a device, capable of communicating with other agents. Therefore, it is assumed that all the agents are simulated in a virtual environment (e.g. a private cloud). Truck drivers only have a GPS device at their disposal. They receive the list of locations they have to visit from this virtual environment.

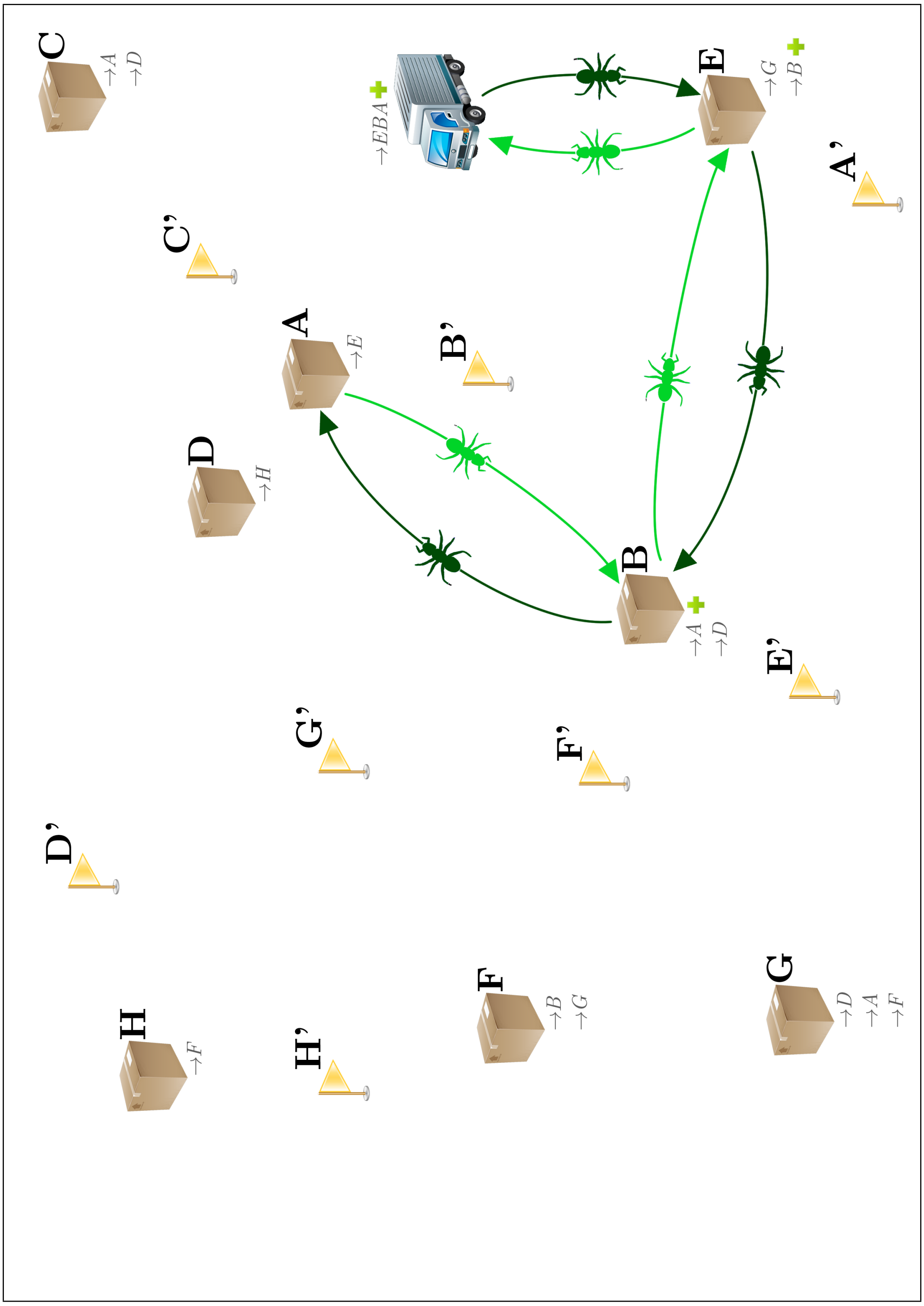
The reader is supposed to have a decent knowledge of *Multi-Agent Systems (MAS)* and the applications of *Ant Colony Optimalisation (ACO)* techniques in *Delegate Multi-Agent Systems (DMAS)*.

2 Approach

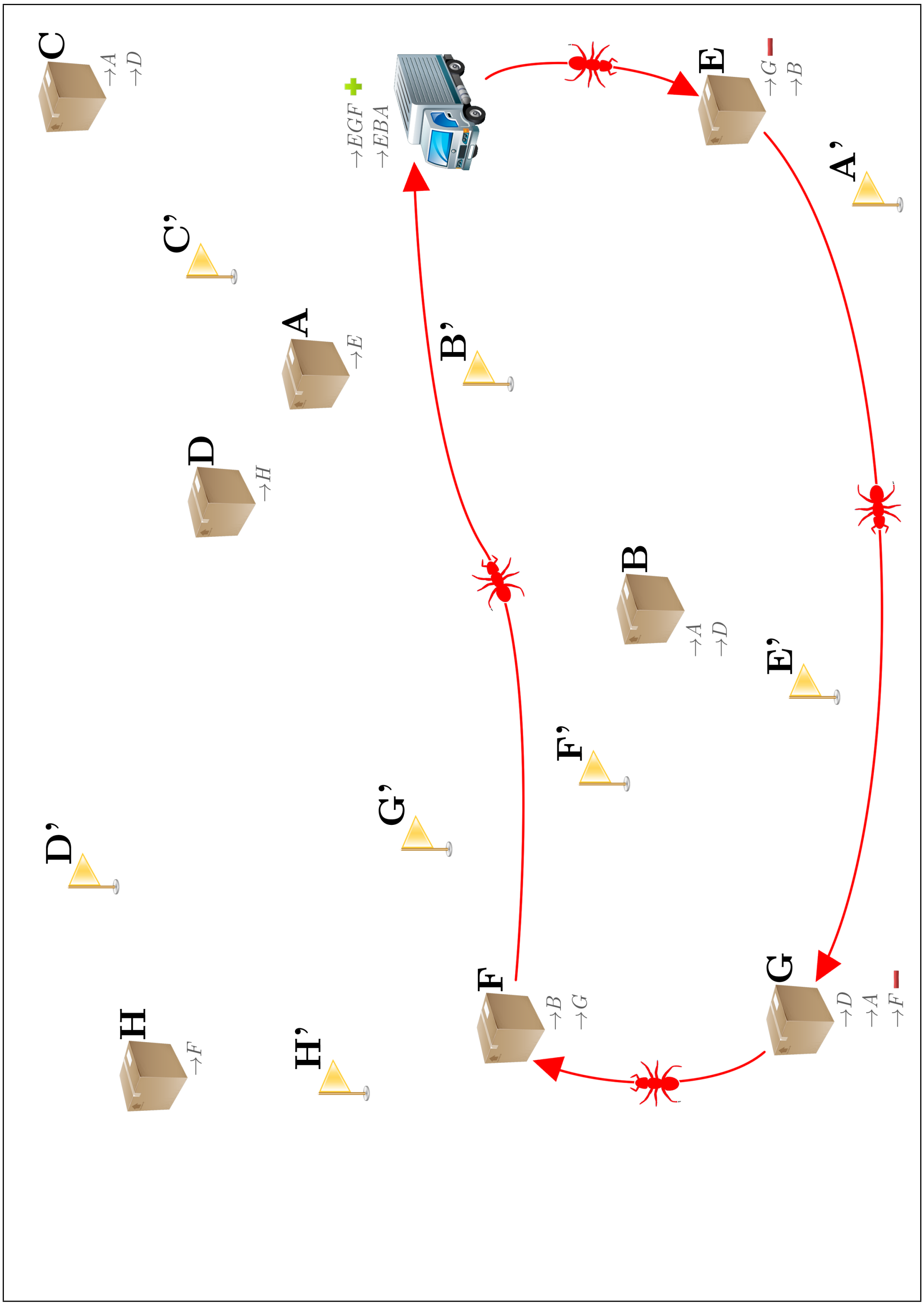
There are many possible ways of using a *Delegate Ant MAS (DMAS)* to solve the *General Pickup and Dellivery Problem (PDP)*. This section will outline a solution that defines two agents:
These
In real life situations will



Figuur 1: Feasibility Ants (example scenario 1)

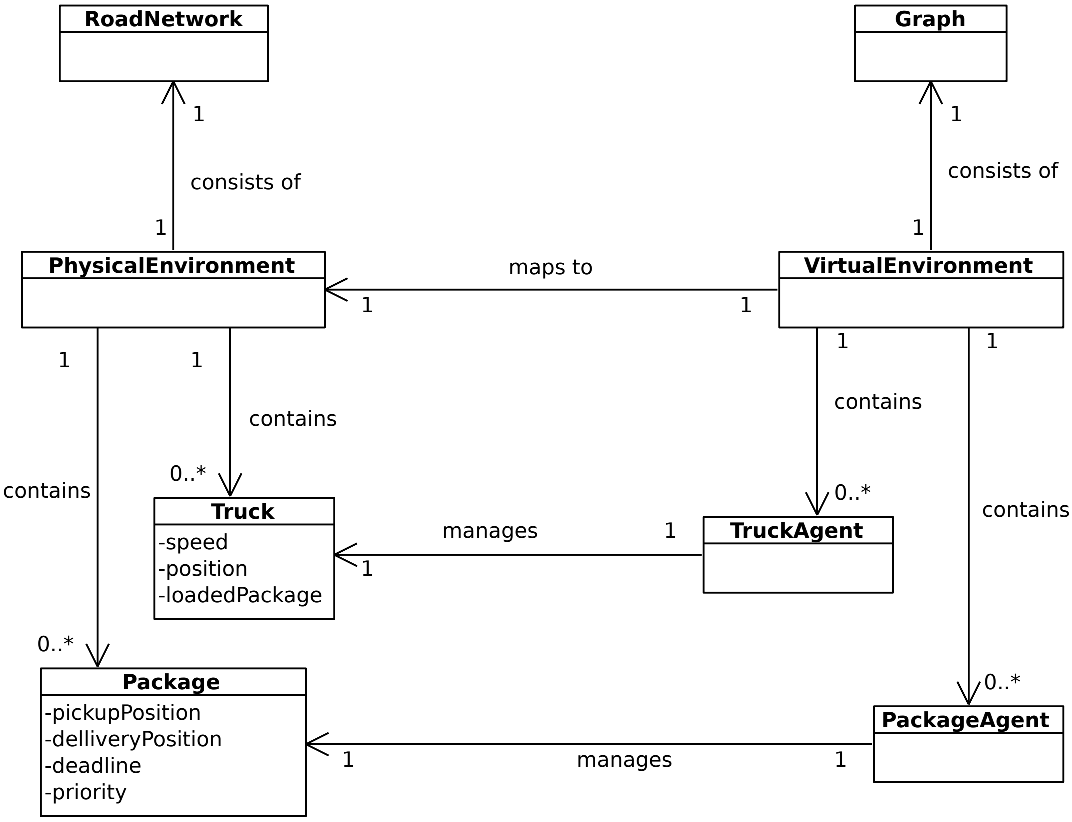


Figuur 2: Exploration Ants (example scenario 2)

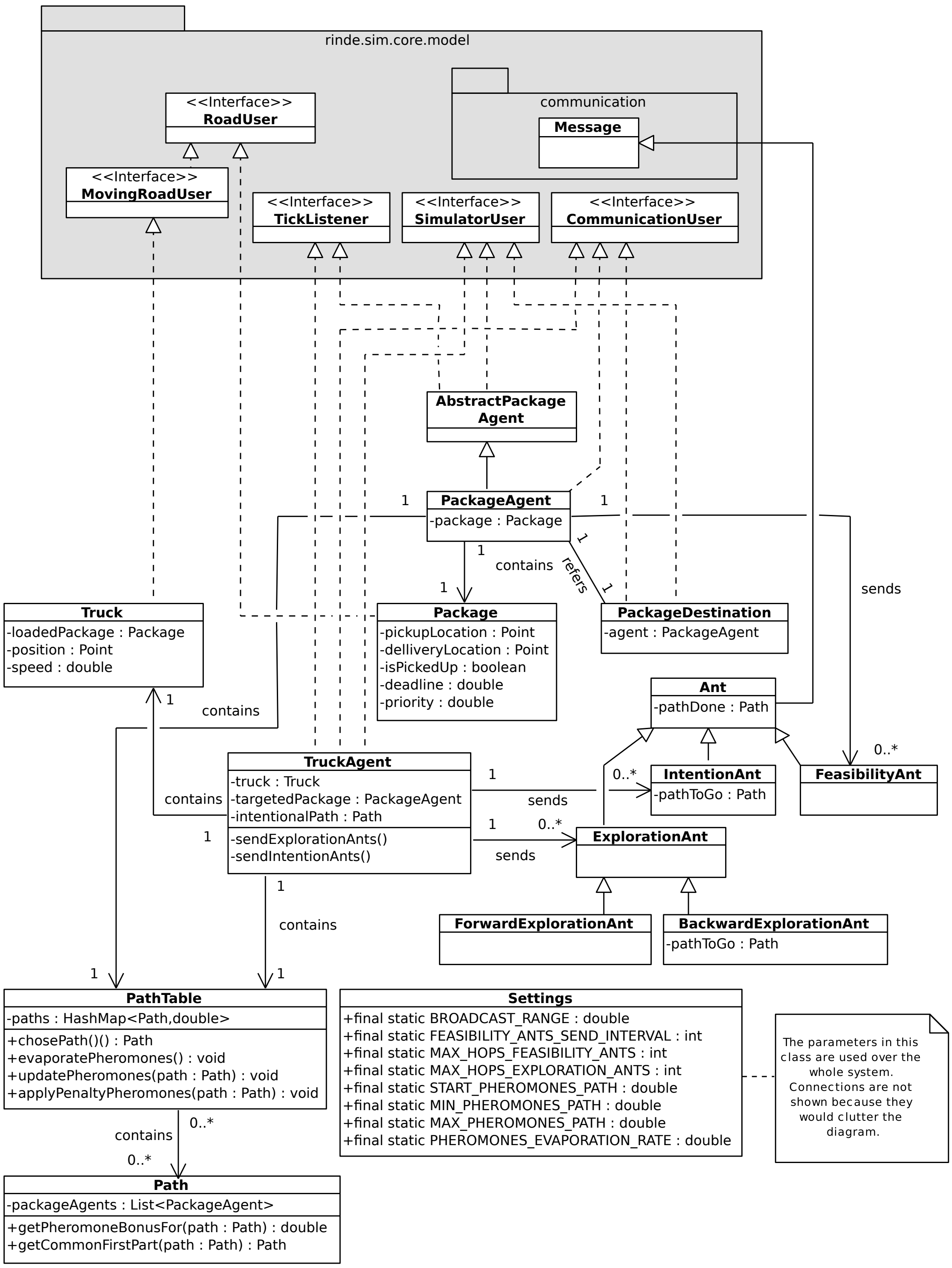


Figuur 3: Intention Ants (example scenario 3)

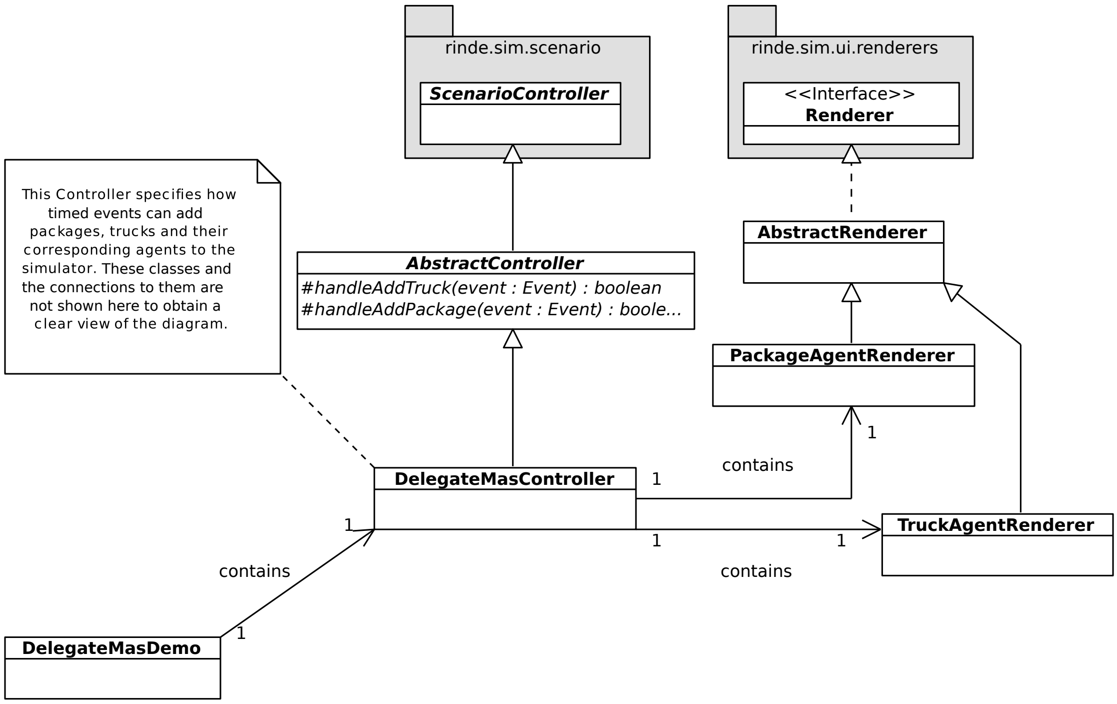
3 Development



Figuur 4: Class Diagram (part I)



Figuur 5: Class Diagram (part I)



Figuur 6: Class Diagram (part II)

4 Evaluation

In order to evaluate the DMAS solution, it is compared to two reference solutions: Gradient Field and Contract Net. We will describe them in a nutshell.

Gradient Fields are based on electrical fields: packages and trucks have opposite charges and will thus attract each other. However, trucks will repel other trucks because they are able to move and have equal charges. This will make sure that the work is divided among all trucks.

In a Contract Net, package agents will broadcast the position of their packages. (Some) Truck agents will receive the broadcasted message and repond with an offer to pick up the package. The package agent will then evaluate all the offers it received and inform the senders whether they won the offer or not. When a truck receives an accepted proposal, it can still decide that there is a better alternative. In this case, the package agent is informed of a failure. The contract is now broken and the package will again broadcast the position of its package.

4.1 Experiments

As explained in **??**, the DMAS solution will try to plan an optimal route. As a consequence, we are particularly interested in the performance of this system. We test this in a number of ways.

First, the overall performance is measured by counting the number of delivered packages in a fixed time window.

Second, we track the time that passes between the creation of a package and the pickup. This can serve as an indication for the responsiveness to dynamism.

Third, all packages should be delivered within a given time window. Therefore, the lateness for every delivery is logged.

Finally, to evaluate the efficiency of the chosen routes, the total distance travelled by trucks is also measured.

All this information is gathered during a fixed-time scenario in which a number of trucks start with an initial amount of packages. Every time a package is delivered, a new one is added. This will prevent the trucks from running out of packages and will not flood the system with too much packages either.

Because of the optimal path planning, we expect to see a high thoughput (delivered packages) and a low value for total distance travelled.

4.2 Comparison

4.3 Critical Reflection

First of all, the system manages to get the task done. A huge advantage to this system is that it can plan ahead, whereas the Contract Net and the Gradient Field solution in particular do not/cannot plan ahead. Using heuristics, the delegate MAS solution can find an optimal path throughout the system.

One of the disadvantages about this system is that it will not always find packages at a given moment. Sometimes, it is required to navigate randomly until packages nearbycan "hear" the truck agent. One way to solve this problem would be to periodically increase the broadcast radius of truck agents (up to a maximal range) when no packages are found in a certain time window.

Another way to solve this problem could be to combine multiple solutions into one hybrid solution. When no packages are found, a Gradient Field could be used to spread the agents accross the physical environment. This will increase the coverage of the map and hence the chance for packages to be heard by trucks.

5 Conclusion