A Multi-Agent System for Truck Dispatching in Open-pit Mines

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Mining companies have operational objectives and various plans for achieving their goals. One of these plans is the production plan, which indicates, among other things, the quantity of the material that must be extracted and unloaded at different points of the mine. To achieve the objectives of the production plan, efficient material handling procedures must be developed. In this process, big shovels extract soil, rock, and ore from working benches and load huge trucks for transporting those materials. If the materials transported are soil and rocks, otherwise known as sterile materials, they must be unloaded in a waste dump. By contrast, if the material transported is ore, it must be unloaded at a crusher or at a stockpile. This process is an important logistic issue for an open-pit mine since it represents 50% of the operating costs.

Material handling is carried out in a dynamic environment, which can affect the performance or availability of the involved equipment, and therefore, it may affect the achievement of the objectives pursued. For example, changes in the state of the haulage routes, or equipment breakdowns are some reasons that may cause delays in material handling. Due to these influences, this is a complex process in open-pit mines.

In order to achieve an efficient material handling process, it is necessary to organize the operations of all equipment involved in the extraction and transport of material in an integrated way, particularly those dealing with the assignments at the destinations of the trucks. This is called truck dispatching. Nowadays, truck dispatching is done by people, who are otherwise known as dispatchers. The process is carried out with the support of computer systems (Truck Dispatching System - TDS). In other words, the dispatchers (or the TDS) indicate to truck operators where they have to go.

In order to give assignments to trucks, the system must take into account several aspects, such as mine status, information from the equipment (trucks, shovels, and crushers), production plans, and information about roads. Currently, most of these systems use a centralized approach based on the methods from operations research, simulation modelling, or heuristic procedures.

Research Problem and Solution Approach

The main problem with the systems that support truck dispatching in open-pit mines is that they do not provide a solution in a timely and efficient manner, causing missing production targets and/or increased operation cost. This is because these systems do not use the specific information for each entity involved in the process and provide only a delayed reaction to the dynamics of the environment.

In recent years, the Multi-Agent approach has been applied to trucks' dispatching processes although it has not been applied to open-pit mines. This approach uses intelligent agents, which are actually autonomous entities that observe the environment through sensors and act upon its changes. In this approach, agents can also interact with each other to achieve a common objective. Due to its decentralized features, the Multi-Agent approach is a valuable option for truck dispatching in open-pit mines.

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Since different entities are involved in the material handling process, each of which have their own objectives, specific knowledge, and behaviors, it is adequate to use an approach based on intelligent agents. This approach provides decentralized decision-making based on specific, timely, and realistic information. For instance, each truck can use proprietary information, information from the environment, and information from other agents to make its own decisions. However, in this approach, several issues are crucial, such as collaboration, coordination, competition, negotiation, and learning.

The complexity of the negotiations between agents varies depending on the environment. In a dynamic environment, agreements must be decided according to an environment state, but the environmental status may vary and thus may have not been considered during the negotiation process, resulting perhaps in a deal that is not useful in the new state of the environment. In this context, learning to make efficient decisions during the negotiation process is crucial, because a correct and timely decision avoids the problems mentioned above. In addition, if there are concurrent negotiations, the problem becomes even a more complex one.

Research Approach

This research will investigate how a Multi-Agent approach can improve a truck dispatching system in an open-pit mine, and how agents can improve their decision-making process in a dynamic environment. It will be focusing on the following three major questions:

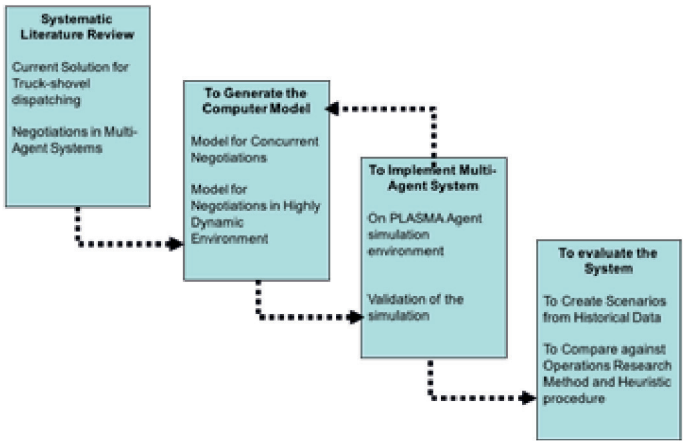
- How a truck dispatching system in an open-pit mine can deliver more efficient results
- How an agent can make more efficient decisions during concurrent negotiations in dynamic environments
- How an agent can learn from prior knowledge in order to support decision-making in negotiations within dynamic environments

Based on the points above, the working hypothesis is:

A Multi-Agent system with agents capable of making efficient decisions based on a negotiation process in a dynamic environment can provide better support to a truck dispatching in open-pit mines than the current approaches.

The aim of this research is therefore to enhance the truck dispatching process in open-pit mines using a Multi-Agent approach. To achieve this goal, the following objectives must be accomplished:

- A model for concurrent negotiations in Multi-Agent Systems must be created that takes the dynamics of the environment into account.
- A Multi-Agent System must be developed for truck dispatching in open-pit mines.
- An open-pit mine simulation must be developed to test and evaluate the Multi-Agent system.
- The developed system must be compared with Operations Research solutions and heuristic methods.



Research Approach

Expected Outcome

The expected outcome is divided into two aspects: The first one is related to truck dispatching in order to improve the performance of the process in terms of production efficiency and cost.

The second is related to the Multi-Agent approach that will contribute to a model for concurrent negotiations in dynamic environments, which can be used in different domains.