Many efficient optimization algorithms are based on some kind of learning processes. For example, Ant Colony Optimization is based on deposition of pheromone in the graph, where virtual ants roam looking for a way. The ants monitor the amount of pheromones and use this information for support in choosing their next steps.

Modern research related to optimization algorithms (especially in the field of evolutionary algorithms) usually focuses on elitist approaches. In particular, the most popular variants of ACO learn only from the top generated feasible. The extracted simplified information becomes especially problematic in the case of multi-objective optimization, since usually there is no single best solution.

In this project, we plan to extend the Ant Colony Optimization algorithm to extract more knowledge from all the candidate solutions, transform it into a more comprehensive structure, and, hopefully, improve optimization results. Using such an approach the algorithm will be able to make better use of computational effort dedicated to preparing the solutions and gain more information also from negative examples.

Ant Colony Optimization algorithms are very natural methods of solving global optimization problems, in particular, difficult and important transport ones, as Traveling Salesman Problem (TSP) or various Vehicle Routing Problems (VRP). Due to intuitive modelling of transport and logistic problems, they have numerous industrial applications, which make them an important object of study. Transport problems become even harder, and more important, when multiple criteria are considered (e.g., one can minimize the travel time, expenses or the number of flight changes, and maximize the number of sights along the way).

Classic ACO (also in the multi-criteria optimization applications) leverages regular pheromone and requires existing of some kind of elitist solutions repository. An important information about the dominance (leading to inclusion of certain solutions into the repository) can be perceived only after construction of the full solutions by the ants.

In this project we propose to:

- Introduce two-dimensional pheromones into ACO, encoding more information about already constructed solutions (even the dominated ones), helping ants in perceiving the relation of dominance even during the construction of their solutions.

- Extend the feasible solutions repository (used for the pheromones updates) to keep more candidates than the classic ones, based on a single Pareto front and extract more information from these solutions to store them in the two-dimensional pheromone.

- Apply the idea of two-dimensional pheromone to various versions of ACO (e.g., AS, MMAS etc.).

- Verify the efficacy of such new ACO algorithms, comparing them to state of the art multi-criteria optimization algorithms (e.g., SPEA, NSGA, MACS, MOEA/D, MOPSO for TSP and VRP problems).

- Extend the applicability of the proposed algorithm by considering other important problems e.g., Bin Packing Problem or Virtual Machine Placement Problem.