

OPPONENT'S EVALUATION OF THE MASTER'S THESIS

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Study program: Information Technologies
Specialization: Software Engineering
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Master's Thesis topic: Vehicle routing problem with soft time windows: Analysis of computational complexity and sensitivity

Evaluation of the thesis:

The submitted thesis deals with the Vehicle Routing Problem with Time Window Penalties (VRPTW), specifically the case where it is allowed to arrive outside the customer's time window, but such deviations are penalized. Both earliness and lateness are considered in the model.

The thesis is structured into three chapters. The first chapter provides the theoretical background: a basic literature review, a description of exact optimization algorithms for integer programming, and an overview of commonly used metaheuristic paradigms used in different VRP.

The second chapter presents the practical part. The author formulates an exact optimization model and discusses four different types of penalty terms for violations of time windows: linear, quadratic, exponential, and step-wise.

The third chapter contains a numerical study on a specific instance, applying the defined penalty structures.

The author's main contribution lies in the comparison of the penalty functions and a thorough discussion of each presented method—both from a computational perspective (e.g., maintaining convexity), and from a managerial perspective: how well each penalty type suits specific real-world requirements. These points are discussed in the Conclusion, and they demonstrate the author's thoughtful engagement with the topic and its practical relevance, which I view positively.

The thesis draws upon a rich selection of literature, indicating that the author has deeply immersed themselves in the subject. All sources are properly cited.

Unfortunately, there are several errors and shortcomings in the thesis, though they are not critical:

- The tables on pp. 25–35 summarizing metaheuristic algorithms and literature for VRPTW are not well designed, especially given the attempt to fit a full optimization model into a narrow column format.
- p. 39: Constraint (5) is bolded without a clear reason.
- p. 47: The stepwise penalty function is not displayed correctly; we observe steep linear segments instead of a clear vertical switch, likely due to discretization of the x-axis during plotting.
- p. 51: Reference error: "Error! Reference source not found"

- p. 70: Bookmark error: "Error! Bookmark not finished"

- In the numerical study, the author works with only one small instance, which is solved exactly. This makes it impossible to observe how the problem behaves as instance size increases—something important from a computational viewpoint.

- Some conclusions and observations in the comparative evaluation (p. 61) seem more influenced by the choice of specific parameters than by the form of the penalty function. Again, evaluating more instances would be necessary to generalize the findings.

Questions for the Defense

How would you model a situation where early arrival does not incur a penalty, but the vehicle must wait until the customer is available?

Is it possible to approximate quadratic or exponential penalty functions using linear constraints?

Overall evaluation of the thesis:

Most of the critical remarks concern formal aspects of the thesis and the numerical study, which would be more meaningful if more problem instances were included. Despite this, the thesis is intellectually rich and can serve as a solid foundation for further research in the area of VRPTW. Therefore, I recommend that the thesis be accepted and propose a grade of C.

I recommend **this thesis to be defended and suggest the following evaluation:**

C

Date: 8. 6. 2025

Thesis Opponent's Signature: