Aalto University
MS-E2177 - Seminar on Case Studies in Operations Research

Optimizing bus parking to enhance electric bus usage

Interim report

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1 Changes in the objectives and the scope of the project

The main objective of the project remains the same: creating a daily bus allocation plan for Koiviston Auto Jyväskylä depot so that the buses can be easily dispatched in the morning to their respective routes. We will also create a planning tool so that it is easy to create a new allocation plan when route plans for buses change every 4 months.

However, there have been important adjustments with regards to the more specific objectives of the project. The most significant of these are:

1. **Not taking into account situations in which there are buses that are broken or otherwise not in use.** We originally planned to create functionality in the planning tool to include these scenarios, but we concluded that this would be outside of the main contribution in this project. The most important problem for us to solve for Koiviston Auto is creating a parking plan that functions and assigns a bus to a specific place that will dispatch to a specific route in the morning. If there are broken buses, new ones are brought in to replace old ones and problem is more on the company's side to solve.

2. **Not taking into account in-day charging.** Generally each bus needs to be charged once during the day at the depot. During this charging, buses could technically switch routes with each other. This possibility was discussed with the company's representatives. However, implementing this in our model would require integrating our model with the company's data management systems. While possible, it could be difficult and require a lot of work, so we decided to leave considerations of in-day charging out of the project. From company's perspective, there should be sufficient room for in-day charging of buses with current configurations in the depot.

3. **Developing a dispatching algorithm.** Original plan was only to create a bus allocation plan for the depot with only bus *type* as a variable. However, when discussing with company representatives, their data systems require also information on which specific bus is parked to each specific spot. Thus, we still develop a bus allocation plan by type, but in addition to this, we will create a dispatching algorithm to guide how each specific bus is driven into and out of the depot. We will use Hamdouni et al. (2006) as the starting point.

Overall, these changes ensure that the project remains focused on delivering a practical and efficient parking and dispatching solution while staying within the project's feasible scope. By refining our objectives, we aim to provide Koiviston Auto with a robust tool that effectively addresses their operational needs.

2 Project status

2.1 Completed tasks

We have completed the literature review, focusing on optimization models related to depot allocation and stochastic arrival times. The review helped shape the structure of our model and guided our initial approach.

We have also begun developing the optimization tool in Julia. The first version of the model runs with preliminary data through a Python interface. The Python script reads in the bus types, as well as their scheduled departure and arrival times. Based on this input, the Julia code allocates buses by type according to arrival times. Instead of assigning individual buses the model currently performs allocation based on bus categories.

This version has produced raw, feasible solutions using arbitrage factors. However, the depot layout in the model does not yet fully match the real depot. Also some of the key constraints needed to assign specific parking spots are still missing.

In addition, we had a technical meeting with Koiviston Auto's IT department to discuss how the results should be delivered and in what format. Their feedback will help guide the next development phase and ensure the model is both usable and practical for their operations.

2.2 Ongoing tasks

Currently, the main focus is on identifying and implementing the remaining constraints that will allow the optimization model to accurately allocate parking positions to bus types. This includes making sure all bus types are considered and that the allocation allows for smooth exits without blocking.

The first algorithm allocates parking spots based on bus types, ensuring that the overall depot layout works efficiently. The second algorithm then assigns specific buses to the exact spots determined by the first algorithm. This step was added based on feedback from Koiviston Auto's IT department, as they require a detailed mapping of specific vehicles to their respective parking positions.

We have also decided to organize team programming days. These sessions allow us to work on the code together and ensures that everyone has an impact on the algorithm.

2.3 Future tasks

After having successfully managed to complete the first algorithm, we will focus on testing the model. Additionally, we work on the second algorithm and make sure it works together with the first one. It is important that overall system produces robust and realistic parking solutions that can be applied in practice.

Once both systems work together and produce feasible solutions, we conduct a sensitivity analysis to see how the model performs. This analysis shows us understand how reliable and robust our solution is.

We will create a simple interface to ensure the allocation can be easily imported into the clients system. Once we have a stable and satisfactory version of the model, we will begin writing the final report. We also plan to allocate enough time to ensure the final report and delivery are high quality.

3 Changes in project plan

The updated schedule for the project is presented in Figure 1 where the current time is shown by a red line. The completed, ongoing and future tasks were described in the previous part, and these are also updated in the project plan schedule, which allows us to follow the project and see that we stay on track. Most of the schedule has stayed the same and we have been following the schedule quite well, but there have been some small changes because of the updated in project scope and objectives.

We added a whole new task to problem formulation and developing optimization model part to build specific bus allocation optimization based on block patterns from the first optimization. Reasons for this were discussed before. This created a need for some adjustments in our schedule. We plan to finish the original model already next week, so a bit earlier than originally expected. This is because we need to have enough time to build the second part of the solution and we plan to finish it at the end of April.

We also decided to organize team programming days in the middle of April to fully concentrate on the coding and hopefully crunch the last missing parts of the needed code together as efficiently as possible within those days to the stage where we have fully working model as desired by the client. After this we can continue with robust investigation and validating results.

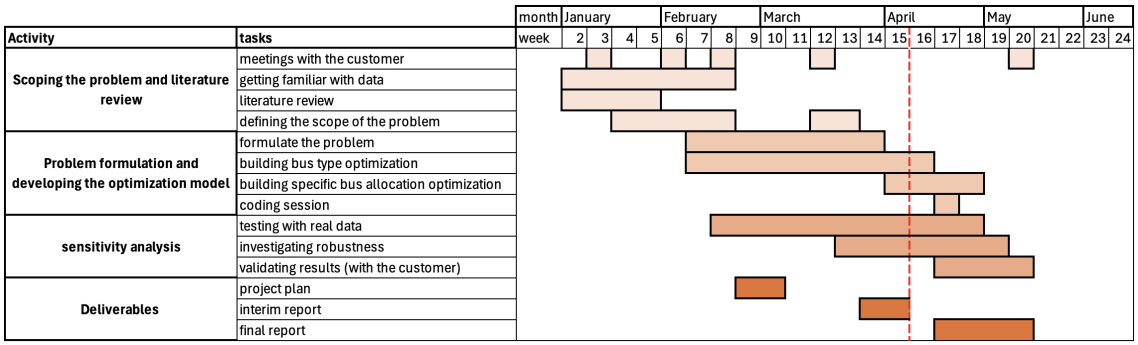

Figure 1: The updated schedule for the project.

4 Updated risk management plan

The project risks and mitigation actions are presented in Table 1. We kept them mostly the same as they have not yet realized, but there is still a possibility for that. The first risk is already realized in the way that we need to build two different models where the second one takes as input the results from the first one. They are closely related to each other which does not create a big issue so the impact was low.

Our objectives for the project are now reduced from the original ones. Thus we think the likelihood of having too many objectives causing high complexity is not that high during rest of the project. We lowered its likelihood from medium to low for this risk.

Table 1: Identified project risks and mitigation actions.

Risk	**Effect**	**Likelihood**	**Impact**	**Mitigation**
Problem is too complex or multi-objective to solve with one model	Project may not deliver a usable solution for the client	Low	High	Define core problems at the start; expand scope only if time allows
Implementation is not completed properly for the client	Client cannot use the model effectively	Low	High	Communicate implementation requirements and expectations clearly throughout
Communication problems with the client	Final solution may not meet client needs	Low	High	Maintain proactive communication; clarify requirements early
Unrealistic assumptions	Model may not deliver on promised outcomes, leading to disappointment	Low	Medium	Set clear, realistic expectations and communicate limitations throughout
Lack of time	Model may be incomplete or unreliable	Low	High	Stick to the schedule and adapt quickly to any delays
Unsuitable data	Model may not reflect real-world use cases	Low	High	Request additional data promptly when gaps are identified
Communication issues within the team	Work may become misaligned or inefficient	Medium	Medium	Project manager ensures clear and consistent internal communication

References

Hamdouni, M., Soumis, F., Desaulniers, G., Odile, M., and van Putten, M. (2006). Dispatching buses in a depot using block patterns. *Transportation Science*, 40(3):259–391.