# Project proposal bachelor thesis

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Bachelor thesis Mathematics and Computer Science

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## Context

The thesis will be done in the field of parallel computing. To be more specific, the thesis concerns the parallel execution of multiple independent tasks using a CPU. This greatly increases the throughput of a CPU compared to the sequential execution of tasks. However, the tasks in parallel can interfere with each other due to the limited bandwidth of the shared memory. This causes an increase in execution time for each task.

How much a certain task is slowed down when run in parallel is then determined by its own memory dependency and the memory dependencies of the other tasks. How exactly the execution time of a task in parallel execution compares to the execution time in isolation is not clear.

This relation can be determined by modelling the memory requests as entities travelling through the entire system. The memory requests start in the core and are sent to the memory. They return to the core once they have been served by the memory. They return to the memory after having spent some time in the core. Notice how the memory requests don't leave the system.

The model corresponding to this situation is called a closed migration process. The advantage of modelling a processor using such a process is that there is a lot of theory from mathematics available to use. The corresponding fields in mathematics are Markov chains and queueing theory. Markov chains is mostly about how one particle moves between states while queueing theory is mostly about how multiple particles move between queues. This means queueing theory can be used to model the large amount of memory requests moving through the computing system. The core and memory are then modelled as queues.

## Relevant literature

The relevant literature from queueing theory concerns the analysis of closed migration processes. The book [Kelly and Yudovina, 2014] discusses closed migration processes and their equilibrium distribution. Another paper discussing this is [Bruell et al., 1984].

The paper [Pathania and Henkel, 2018] discusses the HotSniper simulation software. This is the CPU simulation software that will be used to determine the execution time of tasks.

There seems to be a lack in the literature of theory about queueing network models used specifically for CPU's. This could mean that it is very difficult to define a queueing network that accurately models the CPU.

## Research question

The thesis will investigate the relation between the isolated execution of tasks and their execution time when run in parallel. The final goal is to determine the parallel execution time from the isolated execution times. It could be the case that the model is not a

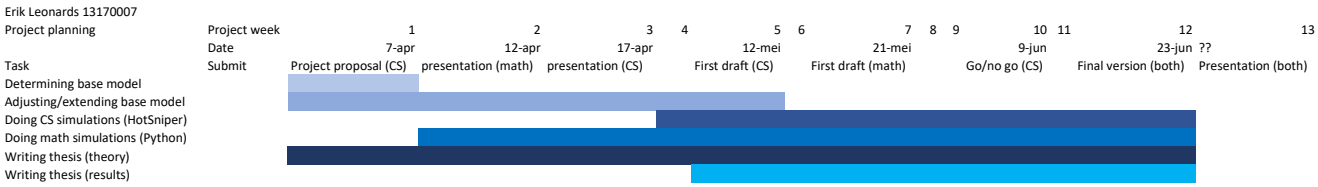
good representation of the CPU, which will result in inaccurate results. It would then be interesting to determine why exactly the model fails.

## Methods

The research question will be answered by defining a base model. The base model is equal to a closed migration process. The model will be extended and adjusted to hopefully better capture the dynamic in the CPU. The model will ultimately contain many abstract parameters. The values of these parameters can be determined by fitting the model to data from the HotSniper simulation program. Additional simulations using HotSniper can then be done in order to test the correctness of the model. The model can then be extended or adjusted. The testing and adjusting can be done until a satisfactory model has been found.

## The planning

The planning can be found below but is just a rough estimation.



# Bibliography

[Bruell et al., 1984] Bruell, S. C., Balbo, G., and Afshari, P. (1984). Mean value analysis of mixed, multiple class bcmp networks with load dependent service stations. *Performance Evaluation*, 4(4):241–260.

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[Pathania and Henkel, 2018] Pathania, A. and Henkel, J. (2018). Hotsniper: Sniper-based toolchain for many-core thermal simulations in open systems. *IEEE Embedded Systems Letters*, 11(2):54–57.