

February 22, 2024

# **Research Proposal**

Master's Thesis in Technology (DTEK1002)

**Florian Dejonckheere**

fwdejo@utu.fi

## **ABSTRACT**

**Working title:** *Identification of Module Boundaries in a Modular Monolith Architecture using Automated technologies*

The modular monolith architecture emerged in recent years as the harmonization of the monolithic and microservices architectures. The paradigm offers a compromise between modularity, flexibility, and scalability. Many monolithic applications are being migrated to modular monoliths or microservices entirely, to satisfy increasingly complex and volatile business requirements. This process is labour-intensive, slow, and may take months to years for larger codebases. Modularization of a codebase typically requires the developer to have an intimate knowledge of both the application code and domain.

In this thesis, we investigate the modular monolith software architecture, and how modules are typically determined as part of the modularization efforts. We propose an automated solution based on dependency analysis and machine learning algorithms to aid in the identification of module boundaries, and evaluate its effectiveness using a case study. We discuss the results and draw conclusions about the proposed solution.

## Aims and goals

The thesis can be divided into two parts: a literary part and a more practical part. For the literary part, I first analyze the origins and characteristics of the modular monolith software architecture, and compare it to similar software architectures. Then, I investigate how the identification of module boundaries is typically done, and how it could be improved through using automated technologies.

For the practical part, I design a solution in the form of a tool for developers that automatically identifies optimal module boundaries in a monolithic codebase. Then, I apply the proposed solution to a real-world use case, and evaluate how effective it is.

The use case I intend to use for the proof-of-concept is called NephroFlow Link, part of the NephroFlow Product Suite. NephroFlow Link is a middleware application written in Ruby that acts as a data broker between connected dialysis machines and the NephroFlow cloud platform. It is currently designed as a monolithic application, and is deployed as a single process on a single server. However, the application is becoming increasingly complex which slows down the development velocity and increases the maintenance burden on the developers. Furthermore, the requirements in regard to scalability and extensibility are increasing rapidly, which leads me to believe the application would benefit from a modular monolith architecture. I intend to develop the proposed solution using NephroFlow Link as a case study.

## Research questions

**Research Question 1:** What is the modular monolith architecture, and what sets it apart from monolithic and microservices architectures?

**Motivation:** Explore why the modular monolith architecture is becoming increasingly popular, and why it is considered a viable alternative to monolithic and microservices architectures.

**Research Question 2:** Which challenges and opportunities arise when considering adoption of the modular monolith architecture for an existing codebase?

**Motivation:** Investigate how restructuring an existing codebase as a modular monolith would impact the development process and resulting product.

**Research Question 3 (optional):** Which automated technologies exist to help modularize a monolithic architecture?

**Motivation:** Investigate technologies based on dependency analysis and semantic clustering to automatically determine optimal module boundaries in a modular monolith architecture. Choose one technology to focus on, and justify the choice.

**Research Question 4:** How can (*automated technology*) effectively identify optimal module boundaries in a modular monolith architecture?

**Motivation:** Implement (*automated technology*) for the given use case and compare to manual modularization efforts in terms of accuracy, efficiency, development velocity.

## Methodology

To find an answer for the first three research questions, a thorough literature study is done, and relevant work is mentioned and summarized. The fourth research question is answered using an empirical study on the use case.

Based on the principles of the modular monolith architecture, module boundaries are manually identified within the application. This is done by experienced developers that have an intimate knowledge of both the codebase and the application domain. Next, using the proposed solution, module boundaries are automatically identified within the application.

To evaluate the effectiveness of the proposed solution, key criteria are identified. Certain key criteria are selected and the selection is justified.

1. **Accuracy:** how close do the module boundaries of the automated technologies align with the manually identified ones? The degree of alignment is measured using metrics such as Jaccard similarity.
2. **Modularity:** how modular are the boundaries identified by the automated technologies? The degree of modularity is measured using metrics such as the modularity  $Q$ , the clustering coefficient, and the Fenton and Melton metric.
3. **Efficiency:** how much effort is required to implement the automatically identified module boundaries compared to manual modularization? Feedback from experienced developers is gathered using surveys and interviews.
4. **Adaptability:** how well do the modules react to changes in the codebase and evolving requirements? The impact is measured empirically by introducing changes in the environment or requirements, and observing how well the boundaries adapt to the change using metrics such as code churn and defect density.

By measuring these key criteria quantitatively and qualitatively for the module boundaries of the automated and the manual modularization, I can assess the effectiveness of the automated technologies in a thorough and objective manner.

# Contents

1. **Abstract**
2. **Introduction:** general introduction to the topic, and identification of challenges and obstacles related to the topic. Explanation about why and for whom the topic is relevant, and what the expected outcome of the research is. Scope of the research thesis.
3. **Background:** historical background of the topic, and theoretical background needed to understand the thesis.
4. **Related work:** relevant work and research related to the topic.
  1. **Monolithic architecture:** definition and explanation of monolithic architecture.
  2. **Microservices architecture:** definition and explanation of monolithic architecture.
5. **Methodology:** explanation of the research methodology used.
6. **Modular monolith:** definition and explanation of modular monolith architecture.
  1. **Architecture:** definition and explanation of modular monolith architecture. Answer to Research Question 1. Justification for choice of modular monolith in this thesis.
  2. **Challenges and opportunities:** answer to Research Question 2.
  3. **Modularization:** problem statement regarding identification of optimal module boundaries.
7. **Proposed solution:** investigation and design of a proposed solution for identification of optimal boundary identification. Answer to Research Questions 3 and 4.
8. **Case study:** application of the proposed solution to a real-world use case.
  1. **Background:** background information about the use case.
  2. **Analysis:** analysis and proposed solution to the problem, design and implementation choices.
  3. **Evaluation:** evaluation of the proposed solution in the context of the use case.
  4. **Results:** results of the evaluation.
  5. **Discussion:** analysis and discussion of the results. Ability of the proposal solution to generalize. Justify the reason for existence of the modular monolith paradigm.
9. **Conclusion and future work:** summary of the thesis, and possible future work related to the topic
10. **Bibliography**

## References

- Abgaz, Y., Mccarren, A., Elger, P., Solan, D., Lapuz, N., Bivol, M., Jackson, G., Yilmaz, M., Buckley Jim, & Clarke, P. *Decomposition of Monolith Applications Into Microservices Architectures: A Systematic Review: Vol. PP.*
- Almeida, J., & Silva, A. R. *Monolith Migration Complexity Tuning Through the Application of Microservices Patterns.*
- Alshuqayran, N., Ali, N., & Evans, R. *A Systematic Mapping Study in Microservice Architecture.*
- Anand, V., Garg, D., Kaufmann, A., & Mace, J. *Blueprint: A Toolchain for Highly-Reconfigurable Microservice Applications.* Association for Computing Machinery.
- Andrade, B., Santos, S., & Silva, A. R. *From Monolith to Microservices: Static and Dynamic Analysis Comparison.*
- Baboi, M., Iftene, A., & Gifu, D. *Dynamic Microservices to Create Scalable and Fault Tolerance Architecture* (Vol. 159).
- Bacchiani, L., Bravetti, M., Giallorenzo, S., Mauro Jacopo, Talevi, I., & Zavattaro, G. *Microservice Dynamic Architecture-Level Deployment Orchestration* (Vol. LNCS-12717). Springer International Publishing.
- Barde, K. *Modular Monoliths: Revolutionizing Software Architecture for Efficient Payment Systems in Fintech* (Vol. 71).
- Brito, M., Cunha, J., & Saraiva, J. *Identification of microservices from monolithic applications through topic modelling.* Association for Computing Machinery.
- Fan, C.-Y., & Ma, S.-P. *Migrating Monolithic Mobile Application to Microservice Architecture: An Experiment Report.*
- Ghemawat, S., Grandl, R., Petrovic, S., Whittaker, M., Patel, P., Posva, I., & Vahdat, A. *Towards Modern Development of Cloud Applications.* Association for Computing Machinery.
- Gonçalves, N., Faustino, D., Silva, A. R., & Portela Manuel. *Monolith Modularization Towards Microservices: Refactoring and Performance Trade-offs.*
- Jin, W., Liu, T., Cai, Y., Kazman, R., Mo, R., & Zheng, Q. *Service Candidate Identification from Monolithic Systems Based on Execution Traces* (Vol. 47).
- Kendall, S. C., Waldo, J., Wollrath, A., & Wyant, G. *A Note on Distributed Computing.* Sun Microsystems, Inc.
- Ruoyu Su, & Xiaozhou Li. *Modular Monolith: Is This the Trend in Software Architecture?.*
- Villamizar, M., Garcés, O., Castro, H., Verano, M., Salamanca, L., Casallas, R., & Gil, S. *Evaluating the monolithic and the microservice architecture pattern to deploy web applications in the cloud.*

Wolfart, D., Assunção, W. K. G., Silva, I. F. da, Domingos, D. C. P., Schmeing, E., Villaca, G. L. D., & Paza, D. d. N. *Modernizing Legacy Systems with Microservices: A Roadmap*. Association for Computing Machinery.