ANTWERPEN MANAGEMENT SCHOOL

On the convergence of Clean Architecture and the Normalized Systems.

A Design Science approach with C#.NET Restful API artifacts.

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Contents

1 Introduction

"*Pantha Rhei*" is, according to *Plato*, one of the famous philosophical statements first described by the Greek philosopher *Heraclitus*[1]. Translated as "everything flows" this statement is an unambiguous commitment to ubiquitous dynamics of everything that exists. "Life is flux", one of the constants in life is change.

In the realms of Software Engineering, the "laws of software evolution" (Lehman, 1980) refers to a series of laws described by Lehman. With these Laws, he describes the balance between the forces driving new developments on the one hand (a change) and the forces that slow down progress on the other hand. Based on *Heraclitus* philosophical statement, we know software engineering projects will frequently be subjected to change, probably due to changing functional requirements and technological progress. As these changes emerge, the complexity of these projects will gradually increase over time due to the increasing number of combinatorial effects. Eventually, this will render the system obsolete, according to Lehman (Lehman, 1980).

As the competitive environments of contemporary organizations are changing continuously, the speed at which changes emerge is also increasing. IT organizations are attempting to cope with this trend by adopting agility and maturing their agile practices (Kappelman et al., 2014). Therefore, agility has been defined as a measure for contemporary organizations to adapt to new environments and cope with rapid change (Neumann, 1994).

1.1 Introducing Software evolvability

the effort to apply change should stay constant over time, regardless of the type of change, whether it would be a functional, technical or architectural change.

«To-do: Link software evolvability to the first part of the introduction»
«To-do: Link combinatorial effects to a measure to determine software evolvability»

1.2 Introducing Normalized Systems Theorems

Normalized Systems theorems is a scientific approach to creating software systems based on the laws for software evolvability. These theorems have resulted in a documented track record of achieving software stability. Effectively, it reduces the number and impact of combinatorial effects in the source code. Combinatorial effects occur when the impact of a change is dependent on the size of the information systems. (Mannaert and Verelst, 2009).

[1] `https://plato.stanford.edu/entries/process-philosophy/`

Normalized Systems formulate their theorem as prescriptive structures (elements) that lead to a modular architecture with low coupling and high cohesion. The resulting software architecture will be designed to cope with future change (Mannaert and Verelst, 2009).

1.3 Introducing Clean Architecture

Clean Architecture is the accumulation of more than half a century of coding, designing, and architecting software systems by Martin, Robert C. He published experience in his book *Clean Architecture: A Craftsman's Guide to Software Structure and Design* in 2018. He states that it does not take much skill and knowledge to create a program like an information system. Designing software to be stable and evolvable so it can endure the tests of time.

The book's goal is to have a software architecture that minimizes the human resources required to build and maintain the information system. Just like Normalized Systems, it has a prescribed design of software classes that will lead to a modular architecture with low coupling and high cohesion (Martin, 2018).

1.4 Problem statement

Since the introduction of Normalized Systems Theorems, Java EE (Java Enterprise Edition) was used as a programming language in scientific research settings to describe the evolvability of software architectures based on the stability concepts of systems theory (Mannaert, Verelst, and Ven, 2012). Mannaert, Verelst, and Ven stated in the paper that the design theorems were formulated as modular structures that are independent of any software language or development paradigm.

Java EE is still a prevalent programming language for enterprise- and IT organizations. Many software solutions are created and maintained using this programming language.

1.5 Hypothesis

The hypothesis depicted in Figure 1.1: The hypothesis proposes that applying both Clean Architecture and Normalized Systems Theorems to a software architecture leads to a modular software architecture that mitigates combinatorial effects. Additionally, the hypothesis proposes improved stability and evolvability of the C# Software artifact, that is comparable with the result when using Java Software artifacts (Oorts et al., 2014; De Bruyn et al., 2018).

1.6 Conceptual framework

Figure 1.2 depicts the conceptual research framework. It describes the hypothesis that Normalized Systems Theorems positively impact the total amount of combinatorial effects on C# based information systems.

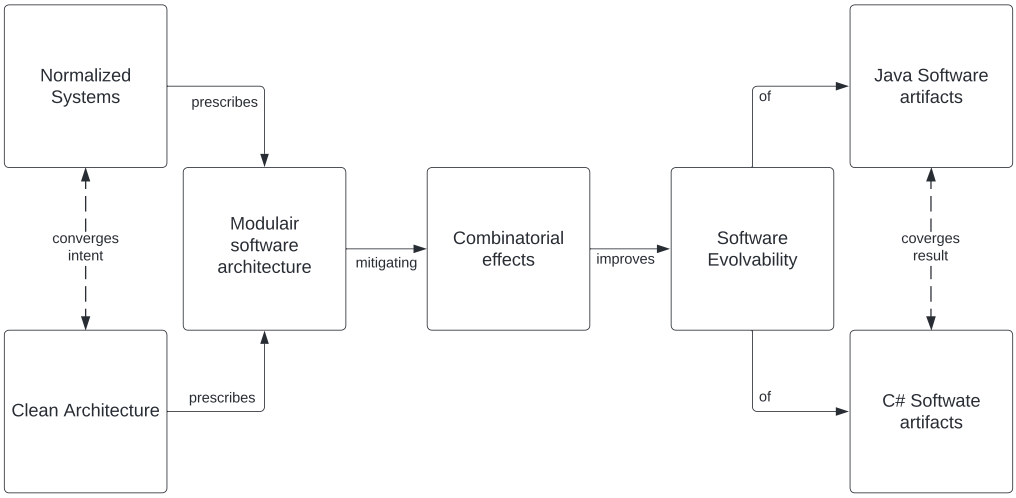

FIGURE 1.1: The hypothesis

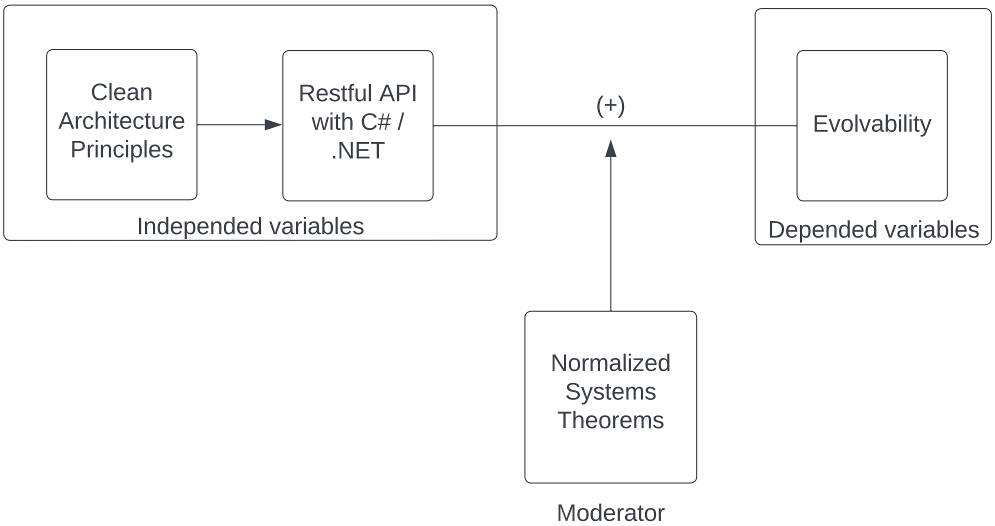

FIGURE 1.2: Overall conceptual framework.

1.7 Research questions

Considering the hypothesis described in 1.6 the following research is determined:

'What is the applicability of Normalized Systems Theorems on restful APIs designed based on the Clean Architecture principles and build with C#/.NET'

The following sub-questions can be formulated that support the research on the main research question:

- What is the literature stating about evolvable software systems.
- What is the literature stating about combinatorial effects on software changes in software systems.

- What is the literature stating on how one can measure combinatorial effects of a change on a software system.
- Which principles of Clean Architecture contribute to a reduction of combinatorial effects, in a way that they complement the theorems of normalized systems.

2 Theoretical background

2.1 Main Section 1

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3 Research and design approach

This chapter describes the overall research design approach and contains the conceptual framework that is applicable for research assignment at hand.

3.1 Research model

The research approach is based on the Design Science method. The following section describes the research model based on the Design Science research framework (Recker, 2013, (P. 107)). According to Recker Design Science has been formulated as followed:

> *'A research paradigm in which a designer answers questions relevant to human problems via the creation of innovative artifacts, thereby contributing new knowledge to the body of scientific evidence. The designed artifacts are both useful and fundamental in understanding that problem.'*

Figure 3.1 depicts a graphical view of the research approach based on the Design Science Research framework. The fundamental components of this research are two separate artifacts.

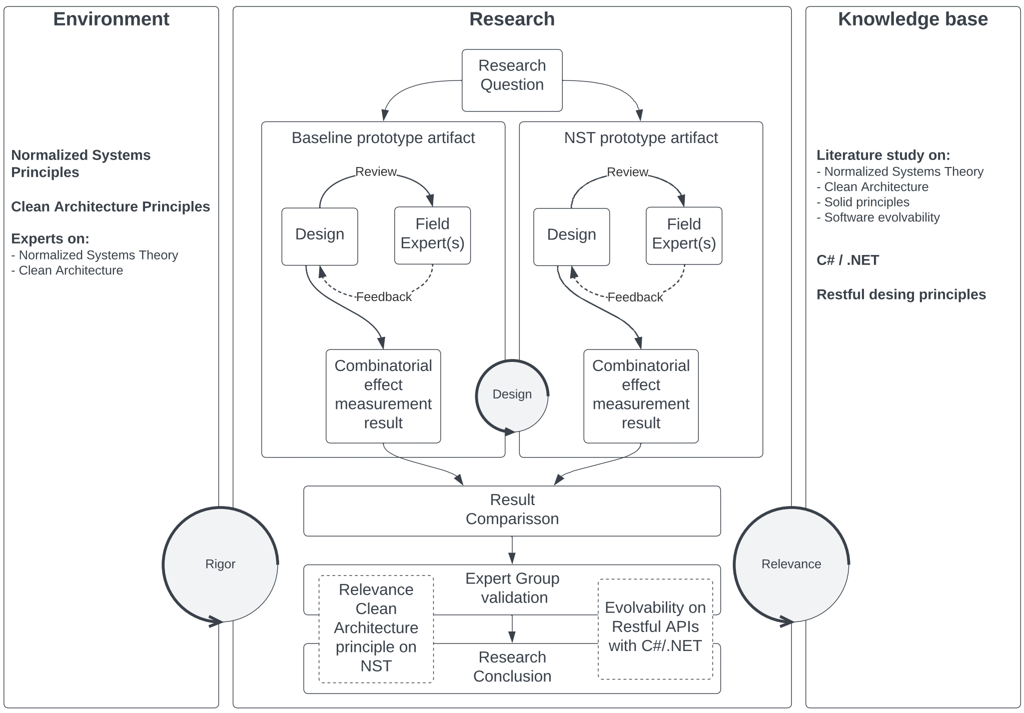

FIGURE 3.1: Research approach.

The first artifact is intended to be a working prototype of a Restful API, designed following to the Clean Architecture principles (Martin, 2018) using C#/.NET programming language. The second artifact follows the results of the baseline artifact. It is enhanced with the design based on the Normalized Systems Theorems. The artifact uses the Software Generation concepts like expanding, rejuvenation and harvesting as proposed in the paper "On the Realization of Meta-Circular Code Generation and Two-Sided Collaborative Metaprogramming" (Mannaert, Cock, and Uhnak, 2020)

Each artifact will endure a review cycle done by field experts of on each of the given design principles. The review cycle is used to ensure that the design and implementation are according to those design principles.

Besides the review of the field experts, the artifacts will also be validated by using an automated instrument (script) that measures the number of combinatorial effects on both of the artifacts. The combinatorial effects are measured in a spectrum of changes in different area's of the artifacts. For example:

- A change in a data entity
- A change in a use case
- A change in an action
- A change in a validation
- etc...

The outcome of the measurements on combinatorial effects on both artifacts are the basis for the comparison results. These results will be discussed and validated by a control group determining the effect on the evolvability when using the Normalized Systems Theorems in a C#/.NET restful API.

4 Artifact design

4.1 Main Section 1

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5 Evaluation results

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6 Discussion

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7 Conclusies

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