Modular Formal Requirements-Driven Verification

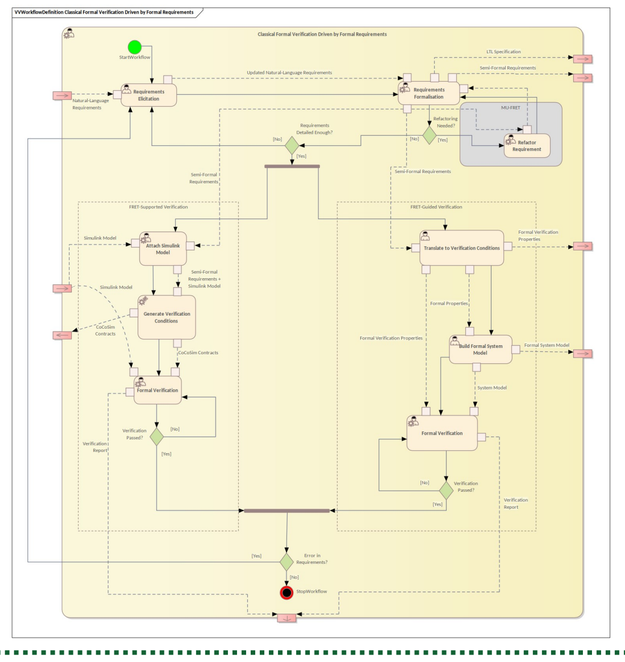
Improved Method

Base Method Description

Requirements are often expressed in natural language, and often at a level of detail that is not suitable for direct formalisation [SFM1]. A semi-formal language may be used as an intermediate between natural- and formal-languages, which avoids slowing down the requirements elicitation process, but still provides enough formalisation to both reduce ambiguities and make the requirements easier to (fully) formalise later on [SFM2].

Improved Method

Our improvement (MU-FRET) extends the existing requirements elicitation tool FRET, adapting software refactoring for FRET requirements and implementing a formal check that the requirement's meaning has not changed. The refactorings are based on existing requirements refactorings [MFRDV1]. This approach will make managing sets of requirements in FRET easier – especially during the elicitation process, where requirements are likely to change.



Layers of the multi-dimensional framework

Evaluation Environment Type	Evaluation Type	Type of Component	Evaluation Stage	Purpose of Component	Type of Requirement	Evaluation Performance Indicator

• **In-the-lab**
• Closed
• Open
	• Experimental – Testing
	• Experimental – Monitoring
	• Experimental – Simulation
	• **Analytical – Formal**
	• Analytical – Semi-Formal
		• **Model**
		• **Software**
		• Hardware
			• Concept
			• **Requirement Analysis**
			• **System Design**
			• **Architecture Design**
			• **Detail Design**
			• Implementation
			• Unit Testing
			• Integration Testing
			• System Testing
			• Acceptance Testing
			• Operation
			• Risk Analysis
			• Other
				• **Sensing**
				• **Thinking**
				• **Acting**
				• **Other**
					• **Non-functional – Safety**
					• Non-functional – Security
					• Non-functional – Privacy
					• Non-functional – Other
					• **Function**
						• V&V Process criteria
						  • Time of test execution
						  • Number of test cases
						  • Joint Management of SCP Requirements
						  • Effort needed for test
						  • Reduced cost and time for work on certification process and functional safety
						• SCP criteria
						  • Error coverage
						  • Number of safety/security requirement violations
						  • Number of malicious attacks and faults detected

Gaps & Limitations Addressed

- **Learning Curve [GAPM-FRV05]: The formalization of requirements is still a manual process and requires that the domain engineer, expert in the domain of the requirements, learns the formal language.**
- **Lack of Automation [GAPM-FRV06]: The formalization of natural language requirements remains largely a manual step.**

Connection to VALU3S Use Cases

- **UC5: Aircraft Engine Controller**

Foreseen Impacts

- **Enables users to rearrange requirements in response to mistakes, new information, or new requirements.**
- **Formally verifying that refactorings have not altered the meaning of the requirements.**
- **Lowers barrier to understanding, by using the terminology/functionality that users may be familiar with from software IDEs.**

Connection to V&V Tools

FRET (https://github.com/NASA-SW-VnV/fret)

MU-FRET (https://github.com/valu3s-mu/mu-fret)

References

- **[SFM1] Rozier, Kristin Yvonne, "Specification: The Biggest Bottleneck in Formal Methods and Autonomy" (2016). Verified Software. Theories, Tools, and Experiments (pp. 8-26). Springer. https://doi.org/10.1007/978-3-319-48869-1_2**
- **[SFM2] Giannakopoulou, D., Pressburger, T., Mavridou, A., & Schumann, J. (2020). Generation of formal requirements from structured natural language. In International Working Conference on Requirements Engineering: Foundation for Software Quality (pp. 19-35). Springer. https://doi.org/10.1007/978-3-030-44429-7_2**
- **[MFRDV1] Ramos, R., Piveta, E. K., Castro, J., Araujo, J., Moreira, A., Guerreiro, P., Pimenta, M. S., Price, R. T. Improving the Quality of Requirements with Refactoring. (2007) Simposio Brasileiro De Qualidade De Software (pp. 141-155). SBC. https://doi.org/10.5753/sbqs.2007.15573**

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