

A New State-Model Based Approach for Refinement of Space Application Requirement

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Abstract

This work presents a new methodology for requirement refinement. It have been developed focusing on space systems case studies, including software analysis, satellite operations modes and missions requirements. This paper describes the technique called COFI-ref (CONformance and Fault Injection for Requirement Refinement) methodology with a small example of its application and presents some lessons learned of previously results.

1. Introduction

The state model-based approach presented in this paper is part of the Verification and Validation (V&V) activities of satellite/software operation requirements for space mission. This work takes place in the context of ITASAT Program established by the Brazilian Space Agency (Agência Espacial Brasileira – AEB) and developed in cooperation by the National Institute for Space Research (Instituto Nacional de Pesquisas Espaciais – INPE), the Technological Institute of Aeronautics (Instituto Tecnológico de Aeronáutica – ITA), other Brazilian universities, and with Technological University of Berlin (TU Berlin). The state model-based approach, COFI-ref, is based in a testing process including test and fault cases derivation called COFI (CONformance and Fault Tolerant) [1]. With this work we intend to demonstrate the effectiveness of focus the designer's attention to incomplete, ambiguous and incorrect requirements that occurs during requirement specification activities.

2. COFI-ref Description

The COFI-ref is based on the COFI methodology where the system to be tested is modeled in Mealy machines and the system behavior is partially represented in state models where transitions represent inputs and outputs of the interfaces.

The COFI-ref methodology comprehends 4 main steps, as illustrated in Figure 1:

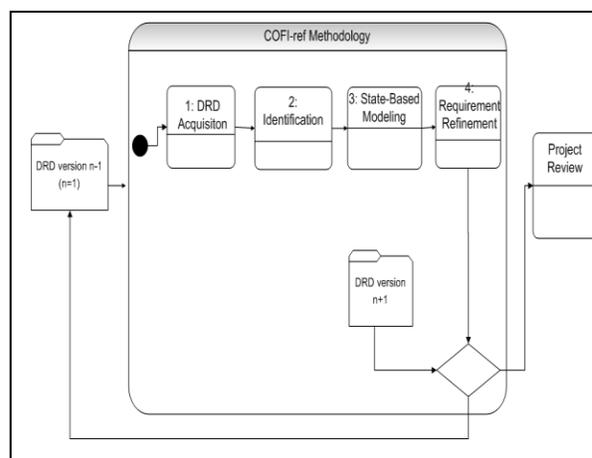


Figura 1 – COFI-ref main steps.

The DRD (Document Requirements Definition) is the input of the COFI-ref. The main steps are described below:

1. DRD Acquisition: through a formal review the System Engineering Team delivery the DRD to the V&V Team.
2. Identification: a heritage of COFI, the identification are for **services** that the user can recognizes, the **hardware faults** and the **events** (inputs) and **reactions** of the system.
3. State-Based Modeling: create partial models through Finite State Machine (FSM). For each service previously identified the following

FSM have to be created: (a) normal operation mode; (b) specified exception; (c) sneak path and fault tolerant.

4. Requirement Refinement: represents the refinement itself. This step is divided into some activities as shown in Figure 2. It represents the innovation on COFI standard methodology.

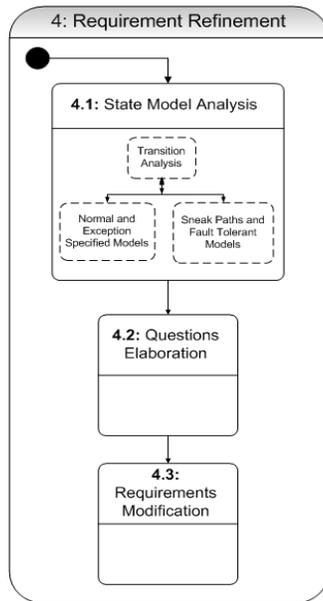


Figure 2 – Activities of the Requirement Refinement step of the COFI-ref methodology.

The activities included in the Requirement refinement step are:

- a) To analyze the partial models through a transition analysis.
- b) To elaborate questions.
- c) To modify the requirements.

4. Final Remarks

The idea of applying the testing methodology for satellite/software operation definition came from the good results obtained with COFI (Conformance and Fault Injection) methodology on previous work [2] [8] [9]. As part of the ISVV (Independent Software Verification and Validation) process, the results with the application of the COFI methodology has surprised the mission management as many errors were found [1]. However, the errors were found only in latter phases. Thus a variation of COFI (Conformance and Fault Injection), named COFI-ref has been applied [7] in early phases of the ITASAT Mission, as part of the mission requirement refinement.

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5. References

- [1] Ambrosio A. M.; Mattiello-Francisco, F. M.; Martins, E.. An Independent Software Verification and Validation Process for Space Applications. In: CONFERENCE ON SPACE OPERATIONS 9. (SPACEOPS 2008), 2008, Hidelberg. Proceedings... 2008. p. 9. CD-ROM. (INPE-15303-PRE/10112).
- [2] Ambrosio, A. M.; Martins, E.; Vijaykumar, N.L.; de Carvalho, S.V. "A Conformance Testing Process for Space Applications Software Services." JACIC - Aerospace Computing, Information, and Communication, Vol.3, N.4, pp.146-158. Publisher American Institute of Aeronautics and Astronautics - AIAA, April 2006, USA.
- [3] Duren, R. M. Validation (not just Verification) of Deep Space Missions. In: AEROSPACE CONFERENCE, 2006, Pasadena. Proceedings... Pasadena, CA: California Inst. of Technol., IEEE, 2006. 13p.
- [4] EUROPEAN COOPERATION FOR SPACE STANDARDIZATION. Space engineering: verification. ECSS-E-ST-10-02C, 5 March 2009.
- [5] ITASAT Mission Description Document (MDD), draft version 1.3, 19 de Fevereiro de 2010, U1000-DDD-01 rev. 0.
- [6] Larson, W.; Werts, J. (eds). Space mission analysis and design. 3. ed. [S.l.]: Space Technology Library, 1999.
- [7] Morais, M. H. E.; Ambrosio, A. M. New model-based approach for analysis and refinement of requirement specification to space operations. In: SpaceOps 2010 CONFERENCE, 2010, Huntsville. Proceedings... Hunstville, Alabama, USA: Von Braun Center, 2010.
- [8] Morais, M. H. E.; Ambrosio, A. M. Metodologia COFI (Conformance and Fault Injection) aplicada a um exemplo didático. São José dos Campos: INPE, 2009.
- [9] Pontes, R. P.; Morais, M. H. E.; Veras, P. C.; Ambrosio, A. M.; Villani E. "Model-based Refinement of requirement specification: A Comparison of two V&V Approaches." COBEM, International Congress of Mechanical Engineering, November 15-20, 2009, Gramado, RS, Brazil.