Tracing Architectural Concerns in High Assurance Systems (NIER Track)

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ABSTRACT

Software architecture is shaped by a diverse set of interacting and competing quality concerns, each of which may have broad-reaching impacts across multiple architectural views. Without traceability support, it is easy for developers to inadvertently change critical architectural elements during ongoing system maintenance and evolution, leading to architectural erosion. Unfortunately, existing traceability practices, tend to result in the proliferation of traceability links, which can be difficult to create, maintain, and understand. We therefore present a decision-centric approach that focuses traceability links around the architectural decisions that have shaped the delivered system. Our approach, which is informed through an extensive investigation of architectural decisions made in real-world safety-critical and performance-critical applications, provides enhanced support for advanced software engineering tasks.

Categories and Subject Descriptors

D.2.11 [Software Architectures] Patterns

General Terms

Algorithms, Management, Measurement, Performance, Design

Keywords

Software Traceability, Architecturally Significant Requirements, Design Rationale, Architectural Preservation.

1. INTRODUCTION

Although a carefully designed and robust architecture is necessary for delivering a software system that satisfies its stakeholders' goals and quality concerns, it is not sufficient for guaranteeing that those quality concerns are satisfied over the lifetime of the software system. Unfortunately, ongoing maintenance activities resulting from new or modified requirements, general code re-factorings, performance tweaks, and bug fixes can erode the benefits derived from initial architectural decisions. Such

Architectural Erosion, occurs when large and small architectural decisions are intentionally or accidentally violated [1]. In a best case scenario, these violations decrease the maintainability of the system, making it difficult to understand and modify; while in more extreme cases architectural erosion may lead to catastrophic and systemic failure.

In practice, the architecture of a system and its qualities can be maintained using traceability methods that help developers fully understand the impact of design or implementation changes on architecturally significant requirements. Kruchten [2], Burge [3], and others have proposed a proactive approach to preventing design degradation through using design rationales to document architectural decisions. They argue that explicitly recording design decisions, justifications, alternatives, and conflicting perspectives, is necessary in order to preserve architectural qualities. Such approaches utilize traceability links to establish relationships between design decisions, rationales, and architectural views, but do not provide specific guidelines for how the traceability links should be established. Without careful consideration, the resulting traceability links can easily proliferate, creating a situation in which traceability is difficult and costly to maintain, and in which links degenerate into an inaccurate and non-useful state [4].

This situation is illustrated through a series of traceability meta-models that were produced from a study of high-end traceability practices in industry [5]. The Traceability Information Model (TIM) depicted in Figure 1, is derived from these meta-models and shows significant redundancy of traceability paths for establishing relationships between issues, conflicts, alternative options, arguments, rationales, assumptions, requirements, and design decisions. For example decisions can be traced directly to requirements, or can be traced indirectly through either rationales or through issues and conflicts. There is no guidance to inform architects as to the best way to establish traceability, and as a result, practitioners are ill-informed as to how best to accomplish this task. Furthermore, various studies have highlighted the need to simplify the creation and use of traceability as a major process improvement need [6].

The traceability problem is exacerbated when tracing quality constraints related to *architecturally significant requirements* (ASR), which describe concerns such as reliability, security, and maintainability. Such ASRs often have a broad reaching impact across the system and are realized through components and behaviors that are visible in a variety of architectural and implementation views at very different abstraction levels.

High Assurance Systems Engineering Proceedings

Villari, Massimo,Brandic, Ivona,Tusa, Francesco

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High Assurance Systems Engineering; Proceedings Bojan Cukic,Jing Dong,2008-01-01 **Proceedings, IEEE High-Assurance Systems Engineering Workshop, October 21-22, 1996, Niagara on the Lake, Ontario, Canada** ,1997 This text explores high assurance software design and development It includes specification and testing of high assurance systems quality and high assurance concurrency and high assurance high assurance execution environments security and reliability and high assurance **High-assurance Systems Engineering Symposium** IEEE Computer Society,1998 Partial Contents Formal Analytic Methods for Dependability Reliability Modeling Survivability Formal Methods Design for High Assurance Fault Analysis Testing High Assurance in Intelligent Systems **High Assurance Systems Engineering; Proceedings** Bojan Cukic,Jing Dong,2007 **Proceedings, Fifth IEEE International Symposium on High Assurance Systems Engineering (HASE 2000)** ,2000 The proceedings from this November 2000 conference in Albuquerque New Mexico feature 46 papers by computer scientists working with universities private companies and government agencies from around the world Topics include test based comprehension failure prediction models symposia benefits **Sixth IEEE International Symposium on High Assurance Systems Engineering** ,2001 This volume contains the conference proceedings of the 2001 6th IEEE International Symposium on High Assurance Systems Engineering *2015 IEEE 16th International Symposium on High-Assurance Systems Engineering (HASE 2015)* ,2015 *High-assurance Systems Engineering Symposium* IEEE Computer Society,1998 Partial Contents Formal Analytic Methods for Dependability Reliability Modeling Survivability Formal Methods Design for High Assurance Fault Analysis Testing High Assurance in Intelligent Systems *High-assurance Systems Engineering Symposium* ,1998 Netcentric System of Systems Engineering with DEVS Unified Process Saurabh Mittal,José L. Risco Martín,2013-02-22 In areas such as military security aerospace and disaster management the need for performance optimization and interoperability among heterogeneous systems is increasingly important Model driven engineering a paradigm in which the model becomes the actual software offers a promising approach toward systems of systems SoS engineering However model driven engineering has largely been unachieved in complex dynamical systems and netcentric SoS partly because modeling and simulation M S frameworks are stove piped and not designed for SoS composability Addressing this gap Netcentric System of Systems Engineering with DEVS Unified Process presents a methodology for realizing the model driven engineering vision and netcentric SoS using DEVS Unified Process DUNIP The authors draw on their experience with Discrete Event Systems Specification DEVS formalism System Entity Structure SES theory and applying model driven engineering in the context of a netcentric SoS They describe formal model driven engineering methods for netcentric M S using standards based approaches to develop and test complex dynamic models with DUNIP The book is organized into five sections Section I introduces undergraduate students and novices to the world of DEVS It covers systems and SoS M S as well as DEVS formalism

software modeling language and DUNIP It also assesses DUNIP with the requirements of the Department of Defense s DoD Open Unified Technical Framework OpenUTF for netcentric Test and Evaluation T E Section II delves into M S based systems engineering for graduate students advanced practitioners and industry professionals It provides methodologies to apply M S principles to SoS design and reviews the development of executable architectures based on a framework such as the Department of Defense Architecture Framework DoDAF It also describes an approach for building netcentric knowledge based contingency driven systems Section III guides graduate students advanced DEVS users and industry professionals who are interested in building DEVS virtual machines and netcentric SoS It discusses modeling standardization the deployment of models and simulators in a netcentric environment event driven architectures and more Section IV explores real world case studies that realize many of the concepts defined in the previous chapters Section V outlines the next steps and looks at how the modeling of netcentric complex adaptive systems can be attempted using DEVS concepts It touches on the boundaries of DEVS formalism and the future work needed to utilize advanced concepts like weak and strong emergence self organization scale free systems run time modularity and event interoperability This groundbreaking work details how DUNIP offers a well structured platform independent methodology for the modeling and simulation of netcentric system of systems **7th IEEE International Symposium on High-Assurance Systems Engineering (HASE 2002)** ,2002 HASE 2002 is an international forum for the discussion of systems engineering issues specifically related to high assurance and high consequence systems High assurance and high consequence systems are characterized by their stringent heterogeneous requirements either to ensure the safety of users or the economic survivability of systems Such requirements typically include a heterogeneous combination of high reliability permanent availability real time constraints security and fault tolerance **Reliability Engineering and Computational Intelligence** Coen van Gulijk,Elena Zaitseva,2021-08-06 Computational intelligence is rapidly becoming an essential part of reliability engineering This book offers a wide spectrum of viewpoints on the merger of technologies Leading scientists share their insights and progress on reliability engineering techniques suitable mathematical methods and practical applications Thought provoking ideas are embedded in a solid scientific basis that contribute to the development the emerging field This book is for anyone working on the most fundamental paradigm shift in resilience engineering in decades Scientists benefit from this book by gaining insight in the latest in the merger of reliability engineering and computational intelligence Businesses and IT suppliers can find inspiration for the future and reliability engineers can use the book to move closer to the cutting edge of technology Computer Systems and Software Engineering: Concepts, Methodologies, Tools, and Applications Management Association, Information Resources,2017-12-01 Professionals in the interdisciplinary field of computer science focus on the design operation and maintenance of computational systems and software Methodologies and tools of engineering are utilized alongside computer applications to develop efficient and precise information databases Computer Systems and Software Engineering Concepts Methodologies

Tools and Applications is a comprehensive reference source for the latest scholarly material on trends techniques and uses of various technology applications and examines the benefits and challenges of these computational developments Highlighting a range of pertinent topics such as utility computing computer security and information systems applications this multi volume book is ideally designed for academicians researchers students web designers software developers and practitioners interested in computer systems and software engineering   Big Data Analytics for Cyber-Physical Systems Shiyan Hu,Bei Yu,2020-06-25 This book highlights research and survey articles dedicated to big data techniques for cyber physical system CPS which addresses the close interactions and feedback controls between cyber components and physical components The book first discusses some fundamental big data problems and solutions in large scale distributed CPSs The book then addresses the design and control challenges in multiple CPS domains such as vehicular system smart city smart building and digital microfluidic biochips This book also presents the recent advances and trends in the maritime simulation system and the flood defence system   **Information Retrieval and Management: Concepts, Methodologies, Tools, and Applications** Management Association, Information Resources,2018-01-05 With the increased use of technology in modern society high volumes of multimedia information exists It is important for businesses organizations and individuals to understand how to optimize this data and new methods are emerging for more efficient information management and retrieval Information Retrieval and Management Concepts Methodologies Tools and Applications is an innovative reference source for the latest academic material in the field of information and communication technologies and explores how complex information systems interact with and affect one another Highlighting a range of topics such as knowledge discovery semantic web and information resources management this multi volume book is ideally designed for researchers developers managers strategic planners and advanced level students   **Achieving Federated and Self-Manageable Cloud Infrastructures: Theory and Practice** Villari, Massimo,Brandic, Ivona,Tusa, Francesco,2012-05-31 Cloud computing presents a promising approach for implementing scalable information and communications technology systems for private and public individual community and business use Achieving Federated and Self Manageable Cloud Infrastructures Theory and Practice overviews current developments in cloud computing concepts architectures infrastructures and methods focusing on the needs of small to medium enterprises The topic of cloud computing is addressed on two levels the fundamentals of cloud computing and its impact on the IT world and an analysis of the main issues regarding the cloud federation autonomic resource management and efficient market mechanisms while supplying an overview of the existing solutions able to solve them This publication is aimed at both enterprise business managers and research and academic audiences alike   *Model-Based Testing of Reactive Systems* Manfred Broy,Bengt Jonsson,Joost-Pieter Katoen,Martin Leucker,Alexander Pretschner,2005-06-27 Testing is the primary hardware and software verification technique used by industry today Usually it is ad hoc error prone and very expensive In recent years however many attempts have been made to

develop more sophisticated formal testing methods This coherent book provides an in depth assessment of this emerging field focusing on formal testing of reactive systems This book is based on a seminar held in Dagstuhl Castle Germany in January 2004 It presents 19 carefully reviewed and revised lectures given at the seminar in a well balanced way ensuring competent complementary coverage of all relevant aspects An appendix provides a glossary for model based testing and basics on finite state machines and on labelled transition systems The lectures are presented in topical sections on testing of finite state machines testing of labelled transition systems model based test case generation tools and case studies standardized test notation and execution architectures and beyond testing   Security of Cyber-Physical Systems Hadis Karimipour,Pirathayini Srikantha,Hany Farag,Jin Wei-Kocsis,2020-07-23 This book presents a comprehensive overview of security issues in Cyber Physical Systems CPSs by analyzing the issues and vulnerabilities in CPSs and examining state of the art security measures Furthermore this book proposes various defense strategies including intelligent attack and anomaly detection algorithms Today s technology is continually evolving towards interconnectivity among devices This interconnectivity phenomenon is often referred to as Internet of Things IoT IoT technology is used to enhance the performance of systems in many applications This integration of physical and cyber components within a system is associated with many benefits these systems are often referred to as Cyber Physical Systems CPSs The CPSs and IoT technologies are used in many industries critical to our daily lives CPSs have the potential to reduce costs enhance mobility and independence of patients and reach the body using minimally invasive techniques Although this interconnectivity of devices can pave the road for immense advancement in technology and automation the integration of network components into any system increases its vulnerability to cyber threats Using internet networks to connect devices together creates access points for adversaries Considering the critical applications of some of these devices adversaries have the potential of exploiting sensitive data and interrupting the functionality of critical infrastructure Practitioners working in system security cyber security security and privacy will find this book valuable as a reference Researchers and scientists concentrating on computer systems large scale complex systems and artificial intelligence will also find this book useful as a reference

  Real-Time Database Systems Kam-Yiu Lam,Tei-Wei Kuo,2006-04-18 In recent years tremendous research has been devoted to the design of database systems for real time applications called real time database systems RTDBS where transactions are associated with deadlines on their completion times and some of the data objects in the database are associated with temporal constraints on their validity Examples of important applications of RTDBS include stock trading systems navigation systems and computer integrated manufacturing Different transaction scheduling algorithms and concurrency control protocols have been proposed to satisfy transaction timing data temporal constraints Other design issues important to the performance of a RTDBS are buffer management index accesses and I O scheduling Real Time Database Systems Architecture and Techniques summarizes important research results in this area and serves as an

excellent reference for practitioners researchers and educators of real time systems and database systems

    <u>Software-Implemented Hardware Fault Tolerance</u> Olga Goloubeva,Maurizio Rebaudengo,Matteo Sonza Reorda,Massimo Violante,2006-09-19 Software Implemented Hardware Fault Tolerance addresses the innovative topic of software implemented hardware fault tolerance SIHFT i e how to deal with faults affecting the hardware by only or mainly acting on the software The first SIHFT techniques were proposed and adopted several decades ago but they have been the object of new interest in the past few years mainly due to the need for developing low cost safety critical computer based applications in fields such as automotive biomedics and telecommunications Therefore several new approaches to detect and when possible correct transient and permanent faults in the hardware have been recently proposed These approaches are innovative with respect to those proposed in the past since they are of higher applicability often starting from the source level code of an application and generality being capable of coping with many different fault types The book presents the theory behind software implemented hardware fault tolerance as well as the practical aspects related to put it at work on real examples By evaluating accurately the advantages and disadvantages of the already available approaches the book provides a guide to developers willing to adopt software implemented hardware fault tolerance in their applications Moreover the book identifies open issues for researchers willing to improve the already available techniques

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