Advances in Intelligent Systems and Computing 470

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Dependability Engineering and Complex Systems

Proceedings of the Eleventh International Conference on Dependability and Complex Systems DepCoS-RELCOMEX. June 27–July 1, 2016, Brunów, Poland

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Preface

In this volume of "Advances in Intelligent Systems and Computing," we are pleased to present proceedings of the Eleventh International Conference on Dependability and Complex Systems *DepCoS-RELCOMEX* which took place in a picturesque Brunów Palace in Poland from June 27 to July 1, 2016. It was an event in a series organized annually by Department of Computer Engineering of Wrocław University of Science and Technology since 2006 although its heritage is much older. It dates nearly 40 years back and begun with two cycles of events: RELCOMEX (1977–89) and Microcomputer Schools (1985–95) which were then organized by the Institute of Engineering Cybernetics (predecessor of the Department) under the leadership of Prof. Wojciech Zamojski, still the DepCoS chairman. In contrast to those previous events focused on classical reliability analysis, the DepCoS mission is to promote a more comprehensive approach which in the new century has earned the name *dependability*. Products of the conferences were initially published by the IEEE Computer Society (2006–09), then also by Wrocław University of Technology Publishing House (2010–12) and presently by Springer in "Advances in Intelligent Systems and Computing" Volume nos. 97 (2011), 170 (2012), 224 (2013), 286 (2014), and 365 (2015).

Design, implementation, and maintenance of contemporary complex systems have brought many new challenges to "classic" reliability theory. The complex systems are understood by us as integrated unities of technical, information, organization, software, and human (users, administrators, and management) assets, and their complexity comes not only from involved technical and organizational internal structure built upon diverse hardware and software resources but also from complexity of information processes (data processing, monitoring, management, etc.) which must be executed in their specific environment. In operation of such wide-ranging (and often also geographically distributed) systems, their resources are dynamically allocated to ongoing tasks and the rhythm of system events (incoming and/or ongoing tasks, decisions of a management subsystem, system faults, defensive system reactions and adaptations, etc.) may be considered as deterministic and/or probabilistic stream of events. Security and confidentiality issues

enforced by social context of information processing introduce further complications into the modelling and evaluation methods. Diversity of the processes being realized, their concurrency and their reliance on in-system intelligence often make construction of strict mathematical models impossible and lead to application of intelligent and soft computing methods.

Dependability is the contemporary answer to new challenges in reliability evaluation of such systems. Dependability approach in theory and engineering of complex systems (not only computer systems and networks) is based on multidisciplinary approach to system theory, technology, and maintenance of the systems working in real (and very often unfriendly) environment. Dependability concentrates on efficient realization of tasks, services, and jobs by a system considered as a unity of all technical, information, and human assets, in contrast to "classical" reliability which is more restrained to analysis of technical resources (components and structures built from them). This difference has shaped natural evolution in topical range of subsequent DepCoS conferences which can be seen over the recent years.

The program committee of the 11th International DepCoS-RELCOMEX Conference, its organizers, and the editors of these proceedings would like to gratefully acknowledge participation of all reviewers who helped to refine contents of this volume and evaluated conference submissions. Our thanks go to, in alphabetic order, Andrzej Białas, Frank Coolen, Manuel Gil Perez, Zbigniew Huzar, Vyacheslav Kharchenko, Jan Magott, Jacek Mazurkiewicz, Marek Młyńczak, Tomasz Nowakowski, Yiannis Papadopoulos, Oksana Pomorova, Krzysztof Sacha, Janusz Sosnowski, Jarosław Sugier, Victor Toporkov, Tomasz Walkowiak, Marina Yashina, Irina Yatskiv, Wojciech Zamojski, and Włodzimierz Zuberek.

Thanking all the authors who have chosen DepCoS as the publication platform for their research, we would like to express our hope that their papers will help in further developments in design and analysis of complex systems, being a valuable source material for scientists, researchers, practitioners, and students who work in these areas.

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Contents

Resilience Assurance for Software-Based Space Systems with Online Patching: Two Cases

Vyacheslav Kharchenko, Yuriy Ponochovnyi, Artem Boyarchuk and Eugene Brezhnev

Abstract The paper discusses the problems of resilient software engineering for unmanned software-based space systems. Resilience is achieved by online patching of software upon emergence of defects providing a stable link to the ground control center. Based on the specifics of satellite orbits it offers two case models: a multifragment one—for systems with a continuous link from geostationary orbits; a multiphase one—for recurrent link from elliptic orbits. The results of the modeling offer the possibility to plan the values of the software initial failure rate and the period of preventive tests that would ensure required reliability and availability.

Keywords Reliability and availability of software-based space systems · Online patching · Markov's multifragment and multiphase models

1 Introduction

The rocket and space industry is one of the most important sectors of the world economy. The opportunities offered by rocket and space technology, its reliability and safety depend heavily on the characteristics of Software-Based Space Systems (SBSpS), their hardware and software quality. This paper considers unmanned space crafts (SC), which do not provide for the restoration of the SBSpS hardware.

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In contrast to hardware, software of unmanned SC's can be restored and modified provided stable link to the ground control center [1]. This ensures software resilience, that is its resistance to changes in the requirements and conditions of the external environment as well as to occurrence of unspecified defects [2].

Development of software is an expensive process, with the major costs coming not from creation of the code, but from its qualification testing. According to standards accepted in the space industry the term "qualification testing" [3] is used to denote "the whole set of actions for verification and validation of critical software". The high cost of testing is due to the need to simulate outer space environment conditions in terrestrial conditions. The use of resilient upgradable software in SC's provides for a more flexible distribution of verification stages and elimination of detected defects during SC operation. The choice of software architecture must first be validated using mathematical models, which should take into account software modifications and re-engineering in the process of operation a space complex.

Existing models of systems with variable parameters use simulation methods [4], Bayesian analysis [5] and the most preferred method of Markov's and semi-Markov's processes [6]. In [7], a system approach is developed to the construction of multifragment models, but it does not provide modeling of procedures related to software online patching.

This research is aimed at the development and analysis of SBSpS availability models, which architecture allows for periodic or online patching of the code of software functions. The paper is structured as follows: the second section is devoted to the availability assessment of onboard software-based space systems and researched space computer system (Sect. 2.1); description of initial model SBSpS, which includes two duplicated hardware channels (Sect. 2.2). The third section offers an approach to developing availability model of geostationary software-based space systems with online patching and continuous link. The fourth chapter contains the detailed model presentation and research of software-based space systems with elliptical orbit, online patching and recurrent link. In the last chapter the conclusions are made, directions for future works are outlined.

2 Availability Assessment of Onboard Software-Based Space Systems

2.1 Researched Space Computer System

The need for software verification and updates of SBSpS requires a hardware architecture as in Fig. 1 [8].

The ground system sends the initiation commands to start verification procedures, which are processed by a special input data processing and decision unit (cancel module).

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