

Advances in Intelligent Systems and Computing 470

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Jarosław Sugier
Tomasz Walkowiak
Janusz Kacprzyk *Editors*

Dependability Engineering and Complex Systems

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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 multi-disciplinary 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 Biały, 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

Multiclass SVM/HMM Vowels Recognition System Towards Improving Human Computer Interaction	1
Ali Al-Dahoud, Mohamed Fezari, Abadi Wassila and Tahmer Al-Rawashdeh	
Numerical Simulation of the Passenger Side Airbag Deployment in Out-of-Position	13
Driss Bendjaballah, Ali Bouchoucha and Mohamed Lakhdar Sahli	
Critical Infrastructure Protection—How to Assess the Protection Efficiency	25
Andrzej Bialas	
Selection of Metrics for the Defect Prediction	39
Ilona Bluemke and Anna Stepień	
Hybrid Generalized Additive Wavelet-Neuro-Fuzzy-System and Its Adaptive Learning	51
Yevgeniy Bodyanskiy, Olena Vynokurova, Iryna Pliss, Dmytro Peleshko and Yuriy Rashkevych	
Data Mining Algorithms in the Analysis of Security Logs from a Honeypot System	63
Michał Buda and Ilona Bluemke	
About Synergy of Flows on Flower	75
Alexander P. Buslaev, Alexander G. Tatashev and Marina V. Yashina	
Estimation of Travel Time in the City Based on Intelligent Transportation System Traffic Data with the Use of Neural Networks	85
Piotr Ciskowski, Adrianna Janik, Marek Bazan, Krzysztof Halawa, Tomasz Janiczek and Andrzej Rusiecki	

Evaluation of Deletion Mutation Operators in Mutation Testing of C# Programs	97
Anna Derezińska	
Tracing Life Cycle of Software Bugs	109
Bartosz Dobrzyński and Janusz Sosnowski	
Modification of Neural Network Tsang-Wang in Algorithm for CAD of Complex Systems with Higher Degree of Dependability	121
Mieczyslaw Drabowski	
Simulation and Experimental Analysis of Quality Control of Vehicle Brake Systems Using Flat Plate Tester	135
A.I. Fedotov and M. Młyńczak	
Analytical Identification of Parameters Influencing Measurement Quality Using Flat Brake Tester	147
A.I. Fedotov and M. Młyńczak	
Arithmetic in Finite Fields Supporting Type-2 or Type-3 Optimal Normal Bases	157
Sergey Gashkov, Alexander Frolov and Igor Sergeev	
Stochastic Runge–Kutta Software Package for Stochastic Differential Equations	169
M.N. Gevorkyan, T.R. Velieva, A.V. Korolkova, D.S. Kulyabov and L.A. Sevastyanov	
The Assessment Method of the Organization of Municipal Waste Collection Zones	181
Robert Giel and Marcin Plewa	
NuSMV Model Verification of an Airport Traffic Control System with Deontic Rules	195
Paweł Głuchowski	
Semi-Markov Model of Damage Process	207
Franciszek Grabski	
The Problem of Tyre Footprint Width Estimation by Fibre Optic WIM Sensors in Condition of Geometric Complexity	219
Alexander Grakovski and Alexey Pilipovets	
Study of Dependencies Between Concrete Deterioration Parameters of Fly Ash-Based Specimens	229
Vlasta Ondrejka Harbuľáková, Adriana Eštoková and Alena Luptáková	

Influence of Data Uncertainty on the Optimum Inspection Period in a Multi-unit System Maintained According to the Block Inspection Policy 239
 Anna Jodejko-Pietruczuk and Sylwia Werbińska-Wojciechowska

Effectiveness of Redundancy in Communication Network of Air Traffic Management System 257
 Igor Kabashkin

Resilience Assurance for Software-Based Space Systems with Online Patching: Two Cases 267
 Vyacheslav Kharchenko, Yuriy Ponochovnyi, Artem Boyarchuk and Eugene Brezhnev

A Mathematical Model to Regulate Roads Traffic in Order to Decongest the Urban Areas of Constantine City 279
 Mouloud Khelf, Salim Boukebbab and Mohamed Salah Boulahlib

The Use of a Simulation Model of the Passenger Boarding Process to Estimate the Time of Its Implementation Using Various Strategies 291
 Artur Kierzkowski

WLAN System with Iterative Decoding of OFDM Multi-symbols 303
 Robert Kotrys, Maciej Krasicki, Piotr Remlein, Andrzej Stelter and Paweł Szulakiewicz

Context Information in a Collaborative Recommender System Deployed in Real Environment 313
 Urszula Kuźelewska

The Concept of the Effective Multi-channel CSMA/CA Detector 323
 Dariusz Laskowski, Marcin Pólkowski and Piotr Lubkowski

Clustering Context Items into User Trust Levels 333
 Paweł Lubomski and Henryk Krawczyk

Dependability Metrics for Network Systems—Analytical and Experimental Analysis 343
 Jacek Mazurkiewicz

Assessing the Costs of Losses Incurred as a Result of Failure 355
 Katarzyna Pietrucha-Urbanik

Impulse Transmission Model of Macroeconomic Cycle Within the Framework of the Theory of Shocks: Aspect of Economic Security 363
 Z.A. Pilipenko, E.V. Savenkova, A.I. Pilipenko, E.A. Morosova and O.I. Pilipenko

Multi-agent Systems for Intelligent Retrieval and Processing of Information 373
 Aneta Poniszewska-Maranda and Łukasz Gebel

Architecture for Internet of Things Analytical Ecosystem 385
 Andrzej Ratkowski

Optimal Path Evolution in a Dynamic Distributed MEMS-Based Conveyor 395
 Haithem Skima, Eugen Dedu, Julien Bourgeois, Christophe Varnier and Kamal Medjaher

The Issue of Analyzing Measurement Data of Driving Speed in Large Urban Areas. 409
 Emilia Skupień and Agnieszka Tubis

Implication of Availability of an Electrical System of a Wind Farm for the Farm’s Output Power Estimation 419
 Robert Adam Sobolewski

CPU Utilization Analysis of Selected Genetic Algorithms in Multi-core Systems for a Certain Class of Problems 431
 Jakub Sobuś and Marek Woda

Monitoring Reliability of Embedded Systems 445
 Janusz Sosnowski and Karol Zakrzewski

Implementation Efficiency of BLAKE and Other Contemporary Hash Algorithms in Popular FPGA Devices. 457
 Jarosław Sugier

Risk Analysis of Interference Railway GSM-R System in Polish Conditions 469
 Marek Sumiła

Water Producers Risk Analysis Connected with Collective Water Supply System Functioning. 479
 Dawid Szpak and Barbara Tchórzewska-Cieślak

Analysis of Reshuffling Cost at a Container Terminal. 491
 Justyna Świeboda and Mateusz Zajac

Scheduling in Grid Based on VO Stakeholders Preferences and Criteria 505
 Victor Toporkov, Dmitry Yemelyanov, Alexander Bobchenkov and Alexey Tselishchev

Vulnerability of Passenger Transportation System—The Main Information Provided by Key Stakeholders. Case Study 517
 Agnieszka Tubis and Sylwia Werbińska-Wojciechowska

Asynchronous System for Clustering and Classifications of Texts in Polish 529
Tomasz Walkowiak

Simulation-Based Dependability Analysis of Systems in Multiple Time-Horizons 539
Tomasz Walkowiak and Dariusz Caban

Compression Codec Change Mechanisms During a VoIP Call. 551
Radosław Wielemborek, Tomasz Sobieraj and Dariusz Laskowski

Dependability Model of an Area Monitoring System with Mobile Sensors. 561
Wojciech Zamojski

Supr: Adaptive Byzantine Fault-Tolerant Replication 571
Maciej Zbierski

Flood Risk Assessment from Flash Floods in Bodva River Basin, Slovakia 583
Martina Zeleňáková, Lenka Gaňová, Pavol Purcz, Ladislav Satrapa, Martin Horský and Vlasta Ondrejka Harbul'áková

Invariant-Based Performance Analysis of Timed Petri Net Models 595
W.M. Zuberek

Author Index 605

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).

Author Index

A

Al-Dahoud, Ali, [1](#)
Al-Rawashdeh, Tahmer, [1](#)

B

Bazan, Marek, [85](#)
Bendjaballah, Driss, [13](#)
Bialas, Andrzej, [25](#)
Bluemke, Ilona, [39](#), [63](#)
Bobchenkov, Alexander, [505](#)
Bodyanskiy, Yevgeniy, [51](#)
Bouchoucha, Ali, [13](#)
Boukebbab, Salim, [279](#)
Boulahlib, Mohamed Salah, [279](#)
Bourgeois, Julien, [395](#)
Boyarchuk, Artem, [267](#)
Brezhnev, Eugene, [267](#)
Buda, Michał, [63](#)
Buslaev, Alexander P., [75](#)

C

Caban, Dariusz, [539](#)
Ciskowski, Piotr, [85](#)

D

Dedu, Eugen, [395](#)
Derezińska, Anna, [97](#)
Dobrzyński, Bartosz, [109](#)
Drabowski, Mieczyslaw, [121](#)

E

Eštoková, Adriana, [229](#)

F

Fedotov, A.I., [135](#), [147](#)
Fezari, Mohamed, [1](#)
Frolov, Alexander, [157](#)

G

Gaňová, Lenka, [583](#)
Gashkov, Sergey, [157](#)
Gebel, Łukasz, [373](#)
Gevorkyan, M.N., [169](#)
Giel, Robert, [181](#)
Głuchowski, Paweł, [195](#)
Grabski, Franciszek, [207](#)
Grakovski, Alexander, [219](#)

H

Halawa, Krzysztof, [85](#)
Harbul'áková, Vlasta Ondrejka, [229](#), [583](#)
Horský, Martin, [583](#)

J

Janiczek, Tomasz, [85](#)
Janik, Adrianna, [85](#)
Jodejko-Pietruczuk, Anna, [239](#)

K

Kabashkin, Igor, [257](#)
Kharchenko, Vyacheslav, [267](#)
Khelf, Mouloud, [279](#)
Kierzkowski, Artur, [291](#)
Korolkova, A.V., [169](#)
Kotrys, Robert, [303](#)
Krasicki, Maciej, [303](#)
Krawczyk, Henryk, [333](#)
Kulyabov, D.S., [169](#)
Kuźelewska, Urszula, [313](#)

L

Laskowski, Dariusz, [323](#), [551](#)
Lubkowski, Piotr, [323](#)
Lubomski, Paweł, [333](#)
Luptáková, Alena, [229](#)

M

Mazurkiewicz, Jacek, 343
Medjaher, Kamal, 395
Młyńczak, M., 135, 147
Morosova, E.A., 363

P

Peleshko, Dmytro, 51
Pietrucha-Urbanik, Katarzyna, 355
Pilipenko, A.I., 363
Pilipenko, O.I., 363
Pilipenko, Z.A., 363
Pilipovecs, Alexey, 219
Plewa, Marcin, 181
Pliss, Iryna, 51
Pólkowski, Marcin, 323
Poniszewska-Maranda, Aneta, 373
Ponochovnyi, Yuriy, 267
Purcz, Pavol, 583

R

Rashkevych, Yuriy, 51
Ratkowski, Andrzej, 385
Remlein, Piotr, 303
Rusiecki, Andrzej, 85

S

Sahli, Mohamed Lakhdar, 13
Satrapa, Ladislav, 583
Savenkova, E.V., 363
Sergeev, Igor, 157
Sevastyanov, L.A., 169
Skima, Haithem, 395
Skupień, Emilia, 409
Sobieraj, Tomasz, 551
Sobolewski, Robert Adam, 419
Sobuś, Jakub, 431
Sosnowski, Janusz, 109, 445
Stelter, Andrzej, 303

Stepień, Anna, 39
Sugier, Jarosław, 457
Sumiła, Marek, 469
Świeboda, Justyna, 491
Szpak, Dawid, 479
Szulakiewicz, Paweł, 303

T

Tatashev, Alexander G., 75
Tchórzewska-Cieślak, Barbara, 479
Toporkov, Victor, 505
Tselishchev, Alexey, 505
Tubis, Agnieszka, 409, 517

V

Varnier, Christophe, 395
Velieva, T.R., 169
Vynokurova, Olena, 51

W

Walkowiak, Tomasz, 529, 539
Wassila, Abadi, 1
Werbińska-Wojciechowska, Sylwia, 239, 517
Wielemborek, Radosław, 551
Woda, Marek, 431

Y

Yashina, Marina V., 75
Yemelyanov, Dmitry, 505

Z

Zajac, Mateusz, 491
Zakrzewski, Karol, 445
Zamojski, Wojciech, 561
Zbiernski, Maciej, 571
Zełeňáková, Martina, 583
Zuberek, W.M., 595