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Engineering in Dependability of Computer Systems and Networks

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Dependability of Computer Systems
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Brunów, Poland

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Contents

Water Quality Monitoring System Using WSN in Tanga Lake	1
Ali Al-Dahoud, Mohamed Fezari, and Hanene Mehamdia	
A Comparative Study of Statistical and Neural Network Models for PLC Network Traffic Anomaly Detection	10
Tomasz Andrysiak and Łukasz Saganowski	
Spreading Information in Distributed Systems Using Gossip Algorithm	21
Andrzej Barczak and Michał Barczak	
Structurization of the Common Criteria Vulnerability Assessment Process	33
Andrzej Białas	
Anomaly Detection in Network Traffic Security Assurance	46
Andrzej Białas, Marcin Michalak, and Barbara Flisiuk	
Development of the Multi-platform Human-Computer Interaction for Mobile and Wearable Devices	57
Agnieszka Bier and Zdzisław Sroczyński	
Tool for Assessment of Testing Effort	69
Ilona Bluemke and Agnieszka Malanowska	
Flow Shop Problem with Machine Time Couplings	80
Wojciech Bożejko, Radosław Idzikowski, and Mieczysław Wodecki	
Correspondent Sensitive Encryption Standard (CSES) Algorithm in Insecure Communication Channel	90
Rafał Chałupnik, Michał Kędziora, Piotr Józwiak, and Ireneusz Józwiak	
Numerical Analysis of the Building Materials Electrical Properties Influence on the Electric Field Intensity	99
Agnieszka Choroszucho and Adam Steckiewicz	






Framework to Verify Distributed IoT Solutions for Traffic Analysis in ATN Stations	110
Bogdan Czejdo and Wiktor B. Daszczuk	
The Picking Process Model in e-Commerce Industry	123
Alicja Dąbrowska, Robert Giel, and Marcin Plewa	
Evaluation of Design Pattern Utilization and Software Metrics in C# Programs	132
Anna Derezińska and Mateusz Byczkowski	
Scheduling Tasks in a System with a Higher Level of Dependability ...	143
Dariusz Dorota	
Comparison of Parallel and Non-parallel Approaches in Algorithms for CAD of Complex Systems with Higher Degree of Dependability ...	154
Mieczysław Drabowski	
Examples of Applications of CAD Methods in the Design of Fault Tolerant Systems	166
Mieczysław Drabowski	
The Concept of the ALMM Solver Knowledge Base Retrieval Using Protégé Environment	177
Ewa Dudek-Dyduch, Zbigniew Gomolka, Bogusław Twarog, and Ewa Zesławska	
Graph-Based Vehicle Traffic Modelling for More Efficient Road Lighting	186
Sebastian Ernst, Konrad Komnata, Marek Łabuz, and Kamila Środa	
A Fuzzy Approach for Evaluation of Reconfiguration Actions After Unwanted Events in the Railway System	195
Johannes Friedrich and Franciszek J. Restel	
On Some Computational and Security Aspects of the Blom Scheme ...	205
Alexander Frolov	
Registration and Analysis of a Pilot's Attention Using a Mobile Eyetracking System	215
Zbigniew Gomolka, Bogusław Twarog, Ewa Zesławska, and Damian Kordos	
Minimization Problem Subject to Constraint of Availability in Semi-Markov Reliability Models	225
Franciszek Grabski	
Method for Railway Timetable Evaluation in Terms of Random Infrastructure Load	235
Szymon Haładyn, Franciszek J. Restel, and Łukasz Wolniewicz	

Representing Process Characteristics to Increase Confidence in Assurance Case Arguments	245
Aleksander Jarzębowicz and Szymon Markiewicz	
Dependability of Multichannel Communication System with Maintenance Operations for Air Traffic Management	256
Igor Kabashkin	
Modelling and Safety Assessment of Programmable Platform Based Information and Control Systems Considering Hidden Physical and Design Faults	264
Vyacheslav Kharchenko, Yuriy Ponochovnyi, Anton Andrashov, Eugene Brezhniev, and Eugene Bulba	
Dependability of Service of Substation Electrical Equipment: Estimation of the Technical Condition State with the Use of Software and Information Tools	274
Alexander Yu. Khrennikov, Nikolay M. Aleksandrov, and Pavel S. Radin	
Reliability Modeling of Technical Objects in the Airport Security Checkpoint	284
Tomasz Kisiel and Maria Pawlak	
Multi-clustering Used as Neighbourhood Identification Strategy in Recommender Systems	293
Urszula Kuźelewska	
Assessment of the Potential of the Waterway in the City Using a Fuzzy Inference Model	303
Michał Lower and Anna Lower	
The SCIP Interoperability Tests in Realistic Heterogeneous Environment	311
Piotr Lubkowski, Robert Sierzputowski, Rafał Polak, Dariusz Laskowski, and Grzegorz Rozanski	
Softcomputing Art Style Identification System	321
Jacek Mazurkiewicz and Aleksandra Cybulska	
Intelligent Agent for Weather Parameters Prediction	331
Jacek Mazurkiewicz, Tomasz Walkowiak, Jarosław Sugier, Przemysław Śliwiński, and Krzysztof Helt	
Mathematical Modeling of the Hot Steam-Water Mixture Flow in an Injection Well	341
Nail Musakaev, Stanislav Borodin, Sergey Rodionov, and Evgeniy Schesnyak	

Concept of Preventive Maintenance in the Operation of Mining Transportation Machines	349
Dinara Myrzabekova, Mikhail Dudkin, Marek Młyńczak, Alfiya Muzdybayeva, and Murat Muzdybayev	
Capabilities of ARCore and ARKit Platforms for AR/VR Applications	358
Paweł Nowacki and Marek Woda	
Log Based Analysis of Software Application Operation	371
Daniel Obrębski and Janusz Sosnowski	
The Impact of Strong Electromagnetic Pulses on the Operation Process of Electronic Equipment and Systems Used in Intelligent Buildings	383
Jacek Paś, Adam Rosiński, Jarosław Łukasiak, and Marek Szulim	
Modelling the Safety Levels of ICT Equipment Exposed to Strong Electromagnetic Pulses	393
Jacek Paś, Adam Rosiński, Marek Szulim, and Jarosław Łukasiak	
Prioritization of Tasks in the Strategy Evaluation Procedure	402
Henryk Piech and Grzegorz Grodzki	
Cost Analysis of Water Pipe Failure	411
Katarzyna Pietrucha-Urbanik and Barbara Tchórzewska-Cieślak	
Attack on Students' Passwords, Findings and Recommendations	425
Przemysław Rodwald	
Algorithm-Aware Makespan Minimisation for Software Testing Under Uncertainty	435
Jarosław Rudy	
Identifying Factors Affecting the Activities of Technology Parks	446
Elena V. Savenkova, Alexander Y. Bystryakov, Oksana A. Karpenko, and Tatiana K. Blokhina	
Security Analysis of Information Transmission in Intelligent Transport Telecommunications Network	456
Mirosław Siergiejczyk	
Semi-Markov Reliability Model of Internal Electrical Collection Grid of On-Shore Wind Farm	466
Robert Adam Sobolewski	
Cracking the DES Cipher with Cost-Optimized FPGA Devices	478
Jarosław Sugier	

Maintaining Railway Operational Requirements in the Context of the GSM-R User Interface Capacity	488
Marek Sumiła	
Benchmarking Comparison of Swish vs. Other Activation Functions on CIFAR-10 Imageset	498
Tomasz Szandala	
An Impact of Different Images Color Spaces on the Efficiency of Convolutional Neural Networks	506
Kamil Szyc	
Coordinated Resources Allocation for Dependable Scheduling in Distributed Computing	515
Victor Toporkov and Dmitry Yemelyanov	
Information Needs of Decision Makers for Risk Assessment in Road Transport	525
Agnieszka Tubis	
Low-Dimensional Classification of Text Documents	534
Tomasz Walkowiak, Szymon Datko, and Henryk Maciejewski	
Distance Measures for Clustering of Documents in a Topic Space	544
Tomasz Walkowiak and Mateusz Gniewkowski	
Author Index	553

Modelling and Safety Assessment of Programmable Platform Based Information and Control Systems Considering Hidden Physical and Design Faults

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Abstract. The information and control system (I&CS) of Nuclear Power Plant (NPP) is considered as a set of three independent hardware channels including on-line testing system. NPP I&C system's design on programmable platforms is rigidly tied to the V-model of the life cycle. Functional safety and availability during its life cycle are assessed using Markov models. Markov models are used to assess availability function and proof test period. The basic single-fragment model MICS01 contains an absorbing state in case of hidden faults and allows to evaluate risks of "hidden" unavailability. The MICS02 model simulates "migration" of states with undetected failures into states with detected faults. The results of Markov modeling (models MICS01 and MICS02) are compared to evaluate proof test period taking into account requirements for SIL3 level and limiting values of hidden fault probabilities.

Keywords: Functional safety modeling · Information and control system · Availability functions · Undetected failure

1 Introduction

Nuclear Power Plant (NPP) information and control systems (I&CSs) such as reactor trip systems are safety critical systems. Very stringent requirements have been developed to such systems characteristics and life cycle processes. During the development cycle, it is possible to change the architecture of the NPP I&CS project, correct the parameters of its elements, program code and other changes. This affects the final characteristics of the system (quality, reliability, availability, safety, etc.).

The software architecture is modified on functions changing or on the detected software faults elimination. This affects code characteristics and failures and recovery

flow parameters. In papers [1–3], the mathematical apparatus of Markov and semi-Markov processes was used to study systems with variable indicators. In [4], a systematic approach to the construction of multi-fragment models was considered, which allows to structure complex systems models development. NPP I&CS design on programmable platforms such as RadICS [5] is rigidly tied to the V-model of the life cycle. During the development, verification and validation phases of the project, the results are recorded at intermediate stages. During the execution of the stage, it is possible to change both the system architecture and its parameters. Therefore, the primary developed safety assessment models need to be adjusted for changes and linked to the stages of the V model.

I&CS design of one of the NPP emergency protection system subsystems, previously considered in [5, 6], is investigated in this paper. Block diagram of the I&CS is shown in Fig. 1. It's one-version I&CS which implements logic of voting "2 out of 3". It includes three independent channels basing on programmable (FPGA) modules of the platform, in particular digital and analog input and output modules, logic module. Each channel is checked by the on-line testing systems for the dangerous failures presence. The hardware channels use the similar software (VHDL). If VHDL design faults occur it is equivalent to a common cause failure (CCF). To minimize CCF risk diversity approach (hardware-software components and process version redundancy) is applied [7, 8].

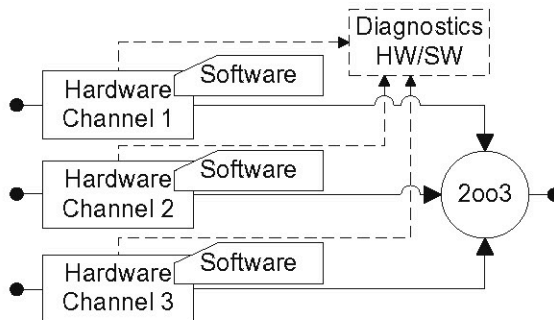


Fig. 1. I&CS reliability structural diagram [2].

Control system is characterized by the parameter of on-line test diagnostics coverage (DC). In the designed system, there are distinctions between the diagnostics of the hardware and software with the parameters DC_{HW} and DC_{SW} . Control is carried out continuously and the detected failures are eliminated immediately after detection.

The class of I&CS on programmable platforms RadICS [5, 8], which are used in NPP reactors emergency protection systems, is studied in this paper. Emergency protection systems belong to the group of complex objects, which are provided with regular proof tests. These tests are performed according to the regulations and should be treated as a separate process.

Author Index

A

Al-Dahoud, Ali, [1](#)
Aleksandrov, Nikolay M., [274](#)
Andrashov, Anton, [264](#)
Andrysiak, Tomasz, [10](#)

B

Barczak, Andrzej, [21](#)
Barczak, Michał, [21](#)
Bialas, Andrzej, [33](#), [46](#)
Bier, Agnieszka, [57](#)
Blokhina, Tatiana K., [446](#)
Bluemke, Ilona, [69](#)
Borodin, Stanislav, [341](#)
Bożejko, Wojciech, [80](#)
Brezhniev, Eugene, [264](#)
Bulba, Eugene, [264](#)
Byczkowski, Mateusz, [132](#)
Bystryakov, Alexander Y., [446](#)

C

Chałupnik, Rafał, [90](#)
Choroszuch, Agnieszka, [99](#)
Cybulska, Aleksandra, [321](#)
Czejdo, Bogdan, [110](#)

D

Dąbrowska, Alicja, [123](#)
Daszczuk, Wiktor B., [110](#)
Datko, Szymon, [534](#)
Derezińska, Anna, [132](#)
Dorota, Dariusz, [143](#)
Drabowski, Mieczysław, [154](#), [166](#)
Dudek-Dyduch, Ewa, [177](#)
Dudkin, Mikhail, [349](#)

E

Ernst, Sebastian, [186](#)

F

Fezari, Mohamed, [1](#)
Flisiuk, Barbara, [46](#)
Friedrich, Johannes, [195](#)
Frolov, Alexander, [205](#)

G

Giel, Robert, [123](#)
Gniewkowski, Mateusz, [544](#)
Gomolka, Zbigniew, [177](#), [215](#)
Grabski, Franciszek, [225](#)
Grodzki, Grzegorz, [402](#)

H

Haładyn, Szymon, [235](#)
Helt, Krzysztof, [331](#)

I

Idzikowski, Radosław, [80](#)

J

Jarzębowicz, Aleksander, [245](#)
Jóźwiak, Ireneusz, [90](#)
Jóźwiak, Piotr, [90](#)

K

Kabashkin, Igor, [256](#)
Karpenko, Oksana A., [446](#)
Kędziora, Michał, [90](#)
Kharchenko, Vyacheslav, [264](#)
Khrennikov, Alexander Yu., [274](#)
Kisiel, Tomasz, [284](#)

Komnata, Konrad, [186](#)
Kordos, Damian, [215](#)
Kuźelewska, Urszula, [293](#)

L

Łabuz, Marek, [186](#)
Laskowski, Dariusz, [311](#)
Lower, Anna, [303](#)
Lower, Michał, [303](#)
Lubkowski, Piotr, [311](#)
Łukasiak, Jarosław, [383](#), [393](#)

M

Maciejewski, Henryk, [534](#)
Malanowska, Agnieszka, [69](#)
Markiewicz, Szymon, [245](#)
Mazurkiewicz, Jacek, [321](#), [331](#)
Mehamdia, Hanene, [1](#)
Michalak, Marcin, [46](#)
Młynczak, Marek, [349](#)
Musakaev, Nail, [341](#)
Muzdybayev, Murat, [349](#)
Muzdybayeva, Alfiya, [349](#)
Myrzabekova, Dinara, [349](#)

N

Nowacki, Paweł, [358](#)

O

Obrębski, Daniel, [371](#)

P

Paś, Jacek, [383](#), [393](#)
Pawlak, Maria, [284](#)
Piech, Henryk, [402](#)
Pietrucha-Urbanik, Katarzyna, [411](#)
Plewa, Marcin, [123](#)
Polak, Rafał, [311](#)
Ponochovnyi, Yuriy, [264](#)

R

Radin, Pavel S., [274](#)
Restel, Franciszek J., [195](#), [235](#)
Rodionov, Sergey, [341](#)
Rodwald, Przemysław, [425](#)
Rosiński, Adam, [383](#), [393](#)
Rozanski, Grzegorz, [311](#)
Rudy, Jarosław, [435](#)

S

Saganowski, Łukasz, [10](#)
Savenkova, Elena V., [446](#)
Schesnyak, Evgeniy, [341](#)
Siergiejczyk, Mirosław, [456](#)
Sierzputowski, Robert, [311](#)
Śliwiński, Przemysław, [331](#)
Sobolewski, Robert Adam, [466](#)
Sosnowski, Janusz, [371](#)
Sroczyński, Zdzisław, [57](#)
Środa, Kamila, [186](#)
Steckiewicz, Adam, [99](#)
Sugier, Jarosław, [331](#), [478](#)
Sumiła, Marek, [488](#)
Szandała, Tomasz, [498](#)
Szulim, Marek, [383](#), [393](#)
Szyc, Kamil, [506](#)

T

Tchórzewska-Cieślak, Barbara, [411](#)
Toporkov, Victor, [515](#)
Tubis, Agnieszka, [525](#)
Twarog, Bogusław, [177](#), [215](#)

W

Wąlkowiak, Tomasz, [331](#), [534](#), [544](#)
Woda, Marek, [358](#)
Wodecki, Mieczysław, [80](#)
Wolniewicz, Łukasz, [235](#)

Y

Yemelyanov, Dmitry, [515](#)

Z

Zesławska, Ewa, [177](#), [215](#)