PROCEEDINGS

XXXI BRAZILIAN SYMPOSIUM ON SOFTWARE ENGINEERING
Foreword

The Brazilian Symposium on Software Engineering (SBES), annually promoted by the Brazilian Computer Society (SBC), is the premier Software Engineering event in Latin America. SBES is held in conjunction with CBSoft – Brazilian Conference on Software: Theory and Practice. The CBSoft program includes technical research and insightful ideas sessions, industry sessions, invited talks, courses, tutorials, panels, demonstration of software tools, a Ph.D. and M.Sc. dissertations/theses workshop, and several other satellite events. It traditionally puts together academics, practitioners and students.

In 2017, the three SBES tracks – Research, Insightful Ideas and Emerging Results, and Education – represent a milestone, since it is the first time the symposium includes three tracks, with a rich program with technical sessions, panels and evidence briefings. The program also includes three keynote speakers: (i) W. Eric Wong (University of Texas at Dallas, USA) with the talk entitled “Combinatorial Testing and Its Applications”; (ii) Dieter Rombach (Fraunhofer Institute for Experimental Software Engineering, Germany) with the talk entitled “New Software Engineering Challenges in the Era of Digital Transformation”; and (iii) Manoel Mendonça (Federal University of Bahia, Brazil) with the talk entitled “Visualizing Software”.

The SBES 2017 Research Track focuses on solid results with a strong contribution to the Software Engineering community. Papers on this track are reviewed based on its originality, relevance, technical soundness, and clarity of presentation, and can be analytical, experimental (primary study), literature review (secondary study), technological, or methodological.

The SBES 2017 - Insightful Ideas and Emerging Results Track focuses on new and inspiring ideas with promising future results, as well as on research work in progress with preliminary and interesting results. The track welcomes innovative new software engineering approaches – methods, techniques, tools – in early stages of research. It has been organized at SBES since 2015, so this is the third year of this track.

The SBES 2017 Education Track (former FEES - Forum of Education in Software Engineering) publishes high quality papers that address challenges, innovations, and best practices in Software Engineering education. The track focuses on curriculum development, empirical studies, best practices, personal or institutional experiences, and conceptual or theoretical work about Software Engineering Education. The Education Track aims to be a space in which, through publications, presentations and discussions of research and reports of experiences, we advance in the teaching-learning process in Software Engineering.

The technical program of the SBES 2017 – Research Track includes 24 research papers. The track had 71 submissions, with an acceptance rate of 34%. Most of the papers had four reviews. After the first round of reviews, a rebuttal phase took place. Based on the reviews and discussions, 24 papers have been selected. We thank the very active participation of the 84 program committee members and the 65 additional reviewers. The 24 accepted papers will be presented in technical sessions together with the accepted papers of the SBES 2017 Insightful Ideas and Emerging Results Track.

The technical program of the SBES 2017 – Insightful Ideas and Emerging Results Track is composed of 6 research papers selected from 22 submissions. The acceptance rate was about 27%. Each submitted paper was reviewed by three members of the program committee regarding its novelty, relevance, technical soundness, and clarity of presentation. Based on those reviews and discussions, a list of technical papers was selected. It is important to highlight the active participation of the 25 program
committee members and 7 additional reviewers, and their great dedication to provide detailed feedback for the authors of submitted papers. The accepted papers will be presented in technical sessions together with the accepted papers of the SBES 2017 Research Track.

Regarding the Education Track, the technical program of the track at SBES 2017 was composed of 12 papers selected from 41 submissions. The acceptance rate was about 29%. Each submitted paper was reviewed by three members of the program committee regarding its originality, relevance, technical soundness, and clarity of presentation. We are very grateful to all the 48 program committee members and 8 additional reviewers for their valuable and timely contribution to the reviewing process. The accepted papers will be presented in four technical sessions. In addition to the technical sessions, there will be a panel discussion about Software Engineering Education Challenges, moderated by Alessandro Garcia, with the participation of: Christina Chavez, Claudia Werner, Julio Leite, Marcelo Yamaguti, and Jair Leite.

We would like to thank all who contributed to this event. The quality of the technical program is a result of the dedication of the members of the program committee together with the additional reviewers. We also express our gratitude to the SBES steering committee for their great support and advice regarding the organization of the tracks. Finally, we also thank the great and hard work of Fernando Trinta, Rossana Andrade and Marum Filho – CBSoft 2017 General Chairs, and Marco Aurélio Graciotto Silva – SBES 2017 Proceedings Chair.

We hope you enjoy the technical program of the three SBES 2017 Tracks and the surroundings of Fortaleza.

José Carlos Maldonado (ICMC/USP) and Fabiano Cuttig Ferrari (UFSCar)  
Program Co-Chairs - SBES 2017 – Research Track

Uirá Kulesza, DIMAp/UFRN  
Program Chair - SBES 2017 – Insightful Ideas and Emerging Results Track

Tayana Uchôa Conte, UFAM  
Program Chair - SBES 2017 – Education Track
Research Track – Technical Committee

Program Chairs
José Carlos Maldonado (ICMC-USP)
Fabiano Cutigi Ferrari (UFSCar)

Program Committee
Adenilso Simão (ICMC/USP)
Aditya Mathur (Purdue University)
Alessandro Garcia (PUC-Rio)
Alexandre Correa (UNIRIO)
Ana Paiva (FEUP)
Antonia Bertolino (CNR)
Arilo Dias Neto (UFAM)
Arndt von Staa (PUC-Rio)
Auri Marcelo Rizzo Vincenzi (UFG)
Christiane Gresse von Wangenheim (UFSC)
Christina Chavez (UFBA)
Christoph Treude (University of Adelaide)
Claudio Werner (COPPE/UFRJ)
Claudio Sant’Anna (UFBA)
Daniel Berry (University of Waterloo)
Dieter Rombach (Fraunhofer Institute)
Edson A. Oliveira Jr (UEM)
Eduardo Almeida (UFBA)
Eduardo Figueiredo (UFMG)
Elisa Yumi Nakagawa (ICMC/USP)
Ellen Barbosa (ICMC/USP)
Fernanda Alencar (UFPE)
Fernando Castor (UFPE)
Fernando Marques Figueira Filho (UFRN)
Flavio Oquendo (UBS (France)
Glauco Carneiro (UNIFACS)
Guilherme Travassos (COPPE/UFRJ)
Gustavo Rossi (UNLP)
Henry Muccini (Università dell’Aquila)
Humberto Marques Neto (PUC Minas)
Igor Steinmacher (UTFPR)
Ingrid Oliveira de Nunes (UFRGS)
Itana Maria de Souza Gimenes (UEM)
Jaelson Castro (UFPE)
Jeff Offutt (George Mason University)
Jim Woodcock (University of York)
Júlio Leite (PUC-Rio)
Kiev Gama (UFPE)
Leonardo Murta (UFF)
Lincoln Rocha (UFC)
Luciano Baresi (Politecnico di Milano)
Marcelo de Almeida Maia (UFU)
Márcio Barros (UNIRIO)
Marcio Delamaro (ICMC/USP)
Marcio Ribeiro (UFAL)
Marco Aurélio Gerosa (IME/USP)
Marco Aurélio Graciotto Silva (UTFPR)
Marco Túlio Valente (UFMG)
Marcos Kalinowski (UFF)
Mehdi Bagherzadeh (Oakland University)
Miguel Goulão (UNL (Portugal))
Mike Papadakis (University of Luxembourg)
Nabor Mendonca (UNIFOR)
Nélio Cacho (UFRN)
Oscar Pastor (Universitat Politècnica de València)
Pedro Santos Neto (UFPI)
Rafael Prikладnicki (PUCRS)
Raphael Pereira de Oliveira (IFS)
Raul Wazlawick (UFSC)
Regina Braga (UFJF)
Ricardo Terra Nunes Bueno Villela (UFLA)
Rick Rabiser (Johannes Kepler University)
Roberta Coelho (UFRN)
Rodrigo Bonifacio de Almeida (UNB)
Rogerio de Lemos (University of Kent)
Rohit Gheyi (UFU)
Rosana Braga (ICMC/USP)
Rossana Andrade (UFC)
Sandra Fabbri (UFSCar)
Sérgio Soares (UFPE)
Silvia Abrahão (Universitat Politècnica de València)
Silvia Vergilio (UFPR)
Simone Souza (ICMC/USP)
Tao Xie (University of Illinois)
Tayana Conte (UFAM)
Thais Vasconcelos Batista (UFRN)
Tiago Massoni (UFCG)
Toacy Oliveira (COPPE/UFRJ)
Uirá Kulesza (UFRN)
Valter Camargo (UFSCar)
Vera Werneck (UE RJ)
Viviane Torres da Silva (UFF)
W. Eric Wong (The University of Texas at Dallas)
Yuanfang Cai (Drexel University)

Additional Reviewers
Ana Carolina Oran (UFAM)
Anderson Belgamo (IFSP)
Vanius Zapalowski (UFRGS)
Victor de Almeida (UFF)
Victor Ribeiro (UFRJ)
Vinicius Durelli (UFSJ)
Walter Takashi Nakamura (UFAM)
Xuelin Li (The University of Texas at Dallas)
Yihao Li (The University of Texas at Dallas)
Insightful Ideas and Emerging Results Track – Technical Committee

Program Chair
Uirá Kulesza (UFRN)

Program Committee
Adenilso Simao (ICMC-USP)
Arilo Dias Neto (UFAM)
Arndt von Staa (PUC-Rio)
Carlos Eduardo da Silva (UFRN)
Christina Chavez (UFBA)
Claudia Werner (COPPE-UFRJ)
Daniel Alencar da Costa (Queen’s University)
Daniela Brauner (UFRGS)
Eiji Adachi Barbosa (UFRN)
Fabiano Ferrari (UFSCar)
Fabio Kon (IME-USP)
Fernando Castor (UFPE)
Fernando Figueira Filho (UFRN)
Igor Steinmacher (UTFPR)
Ingrid Nunes (UFRGS)
José Maldonado (ICMC-USP)
Kiev Gama (UFPE)
Leonardo Murta (UFF)
Marco Aurelio Gerosa (Northern Arizona University)
Nabor Mendonca (UNIFOR)
Rafael Prikladnicki (PUCRS)
Rodrigo Bonifacio (UnB)
Rohit Gheyi (UFCG)
Sergio Soares (UFPE)
Valter Camargo (UFSCar)

Additional Reviewers
Anderson Barreto Rodrigues (UFAM)
Bruno Santos (UFSCar)
Daniel San Martin (UFSCar)
João Faccin (UFRGS)
Maria Ivanilse Calderon Ribeiro (UFAM)
Silvia Meireles (UFAM)
Silvio Costa Sampaio (UFRN)
Education Track – Technical Committee

Program Chair

Tayana Conte (UFAM)

Program Committee

Ana Paula Bacelo (PUCRS)
Ana Regina Rocha (COPPE/UFRJ)
Andreia Malucelli (PUCPR)
Bruno Gadelha (Universidade Federal do Amazonas)
Carla Silva (Universidade Federal de Pernambuco)
Cesar França (Federal Rural University of Pernambuco)
Christiane Gresse von Wangenheim (UFSC - Universidade Federal de Santa Catarina)
Christina Chavez (Universidade Federal da Bahia)
Claudia Werner (COPPE/UFRJ)
Daltro Nunes (UFRGS)
Davi Viana (Universidade Federal do Maranhão)
Edmundo Spoto (UFG - Universidade Federal de Goias)
Edson OliveiraJr (Universidade Estadual de Maringá)
Eduardo Figueiredo (UFMG - Federal University of Minas Gerais)
Elder Rodrigues (UNIPAMPA - Universidade Federal do Pampa - Alegrete)
Fabio Rocha (UNIT)
Fernando Castor (Federal University of Pernambuco)
Francisco Dantas (State University of Rio Grande do Norte)
Gleison Santos (Unirio)
Heitor Costa (Federal University of Lavras)
Igor Steinmacher (UTFPR - Universidade Tecnológica Federal do Paraná)
Igor Wiese (UTFPR - Universidade Tecnológica Federal do Parana)
Ingrid Nunes (UFRGS)
Jair Leite (Universidade Federal do Rio Grande do Norte)
Juliano Lopes de Oliveira (Universidade Federal de Goiás)
Leila Ribeiro (Universidade Federal do Rio Grande do Sul)
Luciana Zaina (UFSCAR)
Marcelo Yamaguti (PUCRS)
Marco Wehrmeister (UTFPR)
Marco Aurélio Gricioto Silva (Universidade Tecnológica Federal do Paraná)
Maria Augusta Vieira Nelson (Pontificia Universidade Católica de Minas Gerais)
Mauricio Aniche (IME/USP)
Milene Serrano (UnB/FGA - Universidade de Brasilia)
Monalessa Perini Barcellos (Universidade Federal do Espirito Santo)
Natasha Valentim (Universidade Federal do Amazonas)
Paulo Meirelles (Universidade de Brasília)
Pedro Santos Neto (Universidade Federal do Piauí)
Rafael Prikladnicki (PUCRS)
Roberta Coelho (Universidade Federal do Rio Grande do Norte)
Rodolfo Resende (DCC/UFMG)
Rodrigo Santos (UNIRIO)
Rossana Andrade (UFC - Universidade Federal do Ceará)
Sabrina Marczak (PUCRS)
Sheila Reinehr (Pontificia Universidade Católica do Paraná)
Simone Souza (ICMC-USP)
Uirá Kulesza (UFRN - Universidade Federal do Rio Grande do Norte)
Valter Camargo (Universidade Federal de São Carlos)

Additional Reviewers
Adriano Santos (Universidade Federal de Minas Gerais)
Claudia Susie Rodrigues (COPPE/UFRJ)
Fischer Ferreira (Universidade Federal do Rio Grande do Sul)
Italo Araújo (Universidade Federal do Ceará)
Mauricio Souza (Universidade Federal de Minas Gerais)
Robson Locatelli (Universidade Estadual do Rio Grande do Norte)
Rute Castro (Universidade Federal do Ceará)
Ticianne Darin (Universidade Federal do Ceará)
Table of Contents

Keynotes

New Software Engineering challenges in the era of Digital Transformation
Dieter Rombach .......................................................... 1

Combinatorial Testing and Its Applications
W. Eric Wong .......................................................... 2

Visualizing Software
Manoel Mendonça ....................................................... 3

Research Track

Ecosystems and Systems-of-Systems

Hearing the Voice of Developers in Mobile Software Ecosystems
Awdren Fontão, Fabricio Lima, Bruno Ábia, Rodrigo Pereira dos Santos, Arilo Claudio Dias-Neto .... 4

How Has the Health of Software Ecosystems Been Evaluated? A Systematic Review
Simone da Silva Amorim, Félix Simas S. Neto, John D. McGregor, Eduardo Santana de Almeida,
Christina von Flach G. Chavez ........................................ 14

Verification and Validation

Incremental Strategy for Applying Mutation Operators Emphasizing Faults Difficult to be Detected by Automated Static Analyser
Vinicius Barcelos Silva, Cláudio Antonio Araujo, Edmundo Sérgio Spoto, Auri Marcelo Rizzo Vincenzi .... 24

Test Case Prioritization: A Systematic Review and Mapping of the Literature
Heleno de Souza Campos Junior, Marco Antônio Pereira Araújo, José Maria N. David, Regina Braga,
Fernanda Campos, Victor Ströele ........................................ 34

Experimental Software Engineering

An Analysis of the Empirical Software Engineering over the last 10 Editions of Brazilian Software Engineering Symposium
Davi Monteiro Barbosa, Rômulo Gadelha de Moura Lima, Thayse Maia Alencar, Francisco Bruno
Neves, Italo Yeltsin Medeiros Bruno, Francisco Thiago Gomes Vieira, Mariela Inês Cortés .......................... 44

How Do Software Developers Identify Design Problems? A Qualitative Analysis
Leonardo da Silva Sousa, Roberto Oliveira, Alessandro García, Jaejoon Lee, Tayana Conte, Willian
Nalepa Ozumi, Rafael Maiani de Mello, Adriana Lopes, Natasha Malveira Costa Valentim, Edson César Cunha de Oliveira, Carlos José Pereira de Lucena ........................................ 54
<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding Technical Debt at the Code Level from the Perspective of Software Developers</td>
<td>64</td>
</tr>
<tr>
<td>How Does Refactoring Affects Internal Quality Attributes? A Multi-Project Study</td>
<td>74</td>
</tr>
<tr>
<td>Investigating the Effectiveness of Peer Code Review in Distributed Software Development</td>
<td>84</td>
</tr>
<tr>
<td>Tweaking Association Rules to Optimize Software Change Recommendations</td>
<td>94</td>
</tr>
<tr>
<td>What Are Software Engineers Asking About Android Testing on Stack Overflow?</td>
<td>104</td>
</tr>
<tr>
<td>Automatic Generation of Search-Based Algorithms Applied to the Feature Testing of Software Product Lines</td>
<td>114</td>
</tr>
<tr>
<td>Comprehensibility of Heterogeneous Configuration Knowledge: An User Study</td>
<td>124</td>
</tr>
<tr>
<td>Comparing Configuration Approaches for Dynamic Software Product Lines</td>
<td>134</td>
</tr>
<tr>
<td>The Clash Between Requirements Volatility and Software Contracts</td>
<td>144</td>
</tr>
<tr>
<td>Specifying Safety Requirements with GORE Languages</td>
<td>154</td>
</tr>
<tr>
<td>Late Decomposition of Applications into Services through Model-Driven Engineering</td>
<td>164</td>
</tr>
<tr>
<td>Improving the Structure of KDM Instances via Refactorings: An Experimental Study Using KDM-RE</td>
<td>174</td>
</tr>
<tr>
<td>Reuse of Model-Based Tests in Mobile Apps</td>
<td>184</td>
</tr>
<tr>
<td>Adding Human Interaction Aspects in the Writing of User Stories: A Perspective of Software Developers</td>
<td>194</td>
</tr>
<tr>
<td>Is There a Demand for Software Transparency?</td>
<td>204</td>
</tr>
</tbody>
</table>
Analysing Requirements Communication Using Use Case Specification and User Stories
Ana Carolina Oran, Elizamary Nascimento, Gleison Santos, Tayana Conte .......................... 214

Social Aspects and Industrial Applications of Software Engineering

Students’ Engagement in Open Source Projects : An Analysis of Google Summer of Code
Jefferson O. Silva, Igor Scaliantne Wiese, Igor Steinmacher, Marco Aurélio Gerosa ................ 224
Software Knowledge Registration Practices at Software Innovation Startups - Results of an Exploratory Study
Luciana Maria Azevedo Nascimento, Guilherme Horta Travassos ................................. 234

Insightful Ideas and Emerging Results Track

Challenges to the Development of Smart City Systems: A System-of-Systems View
Everton Cavalcante, Nêlio Cacho, Frederico Lopes, Thais Batista .................................. 244
Testing context-aware software systems: Unchain the context, set it free!
Santiago Matalonga, Guilherme Horta Travassos ......................................................... 250
Programming Language Adoption as an Epidemiological Phenomenon
Emanoel Barreiros, Jones Albuquerque, João F. L. de Oliveira, Helaine Lins, Sergio Soares ... 255
Modeling of Video Games Using Workflow Nets and State Graphs
Franciny M. Barreto, Stéphane Julia ................................................................. 261
Paper Prototyping in a Model-Driven Process for Android Application Simulation Support
Abner Augusto Lima de Oliveira, Cidcley Teixeira de Souza ........................................ 267
Task Scheduling Optimization on Enterprise Application Integration Platforms Based on the Meta-heuristic Particle Swarm Optimization
Daniela F. Sellaro, Rafael Z. Frantz, Inma Hernández, Fabricia Roos-Frantz, Sandro Sawicki 273

Education Track

Gamification in Software Engineering Education

‘ZTScrum’: A Board Game to Teach Scrum
Andreza de Souza Brito, Jeferson Kenedy M. Vieira .................................................. 279
Testing Game: An Educational Game to Support Software Testing Education
Pedro Henrique Dias Valle, Rafaela Vilela Rocha, José Carlos Maldonado ...................... 289
Gamification applied for Software Engineering teaching-learning process
Fabricio de Sousa Pinto, Paulo Caetano da Silva ....................................................... 299

Project Based Learning and Document Analysis

PBL Integration into a Software Engineering Undergraduate Degree Program Curriculum: An Analysis of the Students Perceptions
Gilleanes Thorwald Araujo Guedes, Andréa Sabedra Bordin, Aline Vieira de Mello, Amanda Meincke Melo ......................................................... 308

As a teacher, I want to know what to teach in requirements engineering so that professionals can be better prepared.
Fabiane Barreto Vavassori Benitti ................................................................. 318
Problem-Based Learning to Align Theory and Practice in Software Testing Teaching
Jean Felipe P. Cheiran, Elder de Macedo Rodrigues, Ewerson Luiz de Souza Carvalho, João Pablo Silva da Silva ................................................................................................................................. 328

Experience Reports
Teaching Software Development for the Cloud: An Experience Report
Fernando Antonio Mota Trinta, Emanuele Santos .................................................................................................................. 338
Coding Dojo as a transforming practice in collaborative learning of programming: an experience report
Peterson Luiz da Rosa Rodrigues, Luiz Paulo Franz, Jean Felipe P. Cheiran, João Pablo Silva da Silva, Andréa Sabedra Bordin .................................................................................................................. 348
Retrospective for the Last 10 years of Teaching Software Engineering in UFC’s Computer Department
Rossana Maria de Castro Andrade, Ismayle Sousa Santos, Italo Linhares de Araújo, Bruno Sabóia, Fernanda Siewerdt .................................................................................................................. 358
AGES - an interdisciplinary space based on projects for Software Engineering learning
Marcelo H. Yamaguti, Flávio M. de Oliveira, Cásio A. W. Trindade, Alessandra C. S. Dutra .................................................................................................................. 368

Reference Models and Systematic Reviews
A Reference Model for Teaching Collaborative Mobile Systems
Bruno Gadelha, Alberto Castro .................................................................................................................. 374
A Systematic Review to Assist in Identifying Teaching Approaches to Guide the Application of an Interdisciplinary Software Factory in IT Undergraduation
Marcela da Conceição Oliveira de Souza, Sandro Ronaldo Bezerra Oliveira, Silvio Romero Lemos Meira 384

Author Index 392
New Software Engineering challenges in the era of Digital Transformation

Dieter Rombach
Fraunhofer Institute for Experimental Software Engineering

Keynote

Abstract

Digital transformation is one major megatrend for the years to come. As digital transformation we define the occurrence of new intelligent products (e.g., trucks that can diagnose themselves) or services (e.g., streaming services) as well as completely new business models (e.g., Uber) by means of interconnecting all things (physical products, digital items, and people) as well as using data intelligently. The resulting smart ecosystems appear in all sectors of Industry, public life as well as private life. These software systems are extremely complex, open, adaptive, and of high quality of service demands. Consequently, we have to adapt our software and system engineering approaches. This presentation lays out the challenges, and offers solutions. In the end, hints towards a new agenda for software engineering research & technology are given. The entire presentation is supported by real-life examples.
Combinatorial Testing and Its Applications

W. Eric Wong
University of Texas at Dallas

Keynote

Abstract

Studies have shown that combinatorial testing can help programs detect hard-to-find software bugs that may not be revealed by test cases generated using other testing techniques. The first part of this talk focuses on traditional black-box requirements-based combinatorial testing. In particular, I will discuss results and lessons learned from two real-life industry applications: a control panel of a rail-road system and a Linux system. The second part extends the concept of combinatorial testing to a white-box structure-based setting. I will present an advanced coverage criterion, Combinatorial Decision Coverage, in conjunction with symbolic execution to achieve high coverage cost-effectively without suffering from potential space exploration. Finally, I will explain how combinatorial testing can be applied to a graph-based methodology for testing IoT (Internet of Things).
We see not with our eyes, but with our brain. Envisioning software is the process of building mental models of software structures, characteristics and functionalities from a visual representation of it. This talk will discuss how this broad concept has being a topic of interest for computer scientists since the early days of computing, and how it has evolved into a software visualization discipline. Using examples draw from our research, the talk will focus on three topics of this evolution. First, we discuss the role of visualization metaphors in building meaningful representations of software, in the small and in the large. Secondly, we discuss how to combine different visual metaphors and interaction mechanisms to facilitate software comprehension, emphasizing the role of experimentation in this process. Lastly, we present how this approach can integrate diverse and heterogeneous data sources to tackle complex software engineering tasks, using technical debt management as our example.