

## RESEARCH OUTPUTS / RÉSULTATS DE RECHERCHE

### Welcome message

Mousavi, Mohammad; Schobbens, Pierre Yves

*Published in:*  
ACM International Conference Proceeding Series

*Publication date:*  
2021

*Document Version*  
Publisher's PDF, also known as Version of record

### [Link to publication](#)

*Citation for published version (HARVARD):*  
Mousavi, M & Schobbens, PY 2021, 'Welcome message', *ACM International Conference Proceeding Series*, vol. Part F171624-A, pp. x.

### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal ?

### Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.



**25th ACM International Systems and Software  
Product Line Conference  
September 6-11, 2021  
[www.splc2021.net](http://www.splc2021.net)**

**Proceedings - Volume A**

EDITED BY:

Mohammad Mousavi, Pierre-Yves Schobbens, Hugo Araujo, Ina Schaefer, Maurice H. ter Beek, Xavier Devroey, Jose Miguel Rojas, Monica Pinto, Leopoldo Teixeira, Thorsten Berger, Johannes Noppen, Iris Reinhartz-Berger, Paul Temple, Ferruccio Damiani and Justyna Petke







# 25th International Systems and Software Product Line Conference

Proceedings - Volume A

---

## Gold Sponsors



**BOSCH**

---

## Silver Sponsors



## Supporters



Association for  
Computing Machinery



**SIGSOFT**  
SPECIAL INTEREST GROUP ON SOFTWARE ENGINEERING



**The Association for Computing Machinery  
1601 Broadway, 10th Floor  
New York, New York 10019, USA**

**ACM COPYRIGHT NOTICE. Copyright © 2021 by the Association for Computing Machinery,**

**Inc. Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, to republish, to post on servers, or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from Publications Dept., ACM, Inc., fax +1 (212) 869-0481, or email [permissions@acm.org](mailto:permissions@acm.org).**

For other copying of articles that carry a code at the bottom of the first or last page, copying is permitted provided that the per-copy fee indicated in the code is paid through the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, +1-978-750-8400, +1-978-750-4470 (fax).

**ACM ISBN: 978-1-4503-8469-8**

# Table of Contents

<b>Welcome Message</b> . . . . .	<b>x</b>
<b>Organizing Committee</b> . . . . .	<b>xi</b>
<b>Program Committees</b> . . . . .	<b>xiii</b>
<b>Keynotes</b>	
Microservice-based Development: Something Old, Something New, Something Borrowed, and What We Can Do . . . . . <i>Julia Rubin</i>	xvi
Generating safety cases for large-scale industrial product lines . . . . . <i>Mattias Nyberg</i>	xvii
Where Are My Constraints and What Do They Constrain? . . . . . <i>Thomas Thüm</i>	xviii
<b>Variability Modeling and Analysis</b>	
[Research] Variability Modules for Java-like Languages . . . . . <i>Ferruccio Damiani, Reiner Hähnle, Eduard Kamburjan, Michael Lienhardt, and Luca Paolini</i>	1
[Research] From Pairwise to Family-based Generic Analysis of Delta-Oriented Model- Driven SPLs . . . . . <i>Christopher Pietsch, Udo Kelter and, Timo Kehrer</i>	13
[Industrial] Variability Realization in Model-based System Engineering using Software Product Lines Techniques: An Industrial Perspective . . . . . <i>Andreas Schaefer, Florian Rohlf, Martin Becker, Markus Andres and, Tim Kistenfeger</i>	25
<b>AI, Machine Learning and NLP</b>	
[Research] A Machine Learning Model to Classify the Feature Model Maintainability . . . . . <i>Publio Silva, Carla Bezerra and, Ivan Machado</i>	35
[Research] A Comparison of Performance Specialization Learning for Configurable Systems	46

*Hugo Martin, Mathieu Acher, Juliana Alves Pereira and, Jean-Marc Jézéquel*

[Research, Short Paper] Evaluating Recommender Systems in Feature Model Configuration 58  
*Mathias Uta, Alexander Felfernig, Viet-Man Le, Andrei Popescu, Thi Ngoc Trang Tran and, Denis Helic*

## **Evolution**

[Research] Incremental Construction of Modal Implication Graphs for Evolving Feature Models . . . . . 64  
*Sebastian Krieter, Rahel Arens, Michael Nieke, Chico Sundermann, Tobias Heß, Thomas Thüm and, Christoph Seidl*

[Challenge Proposals] Managing Systems Evolving in Space and Time: Four Challenges for Maintenance, Evolution and Composition of Variants . . . . . 75  
*Gabriela Karoline Michelin, David Obermann, Wesley K. G. Assunção, Lukas Linsbauer, Paul Grünbacher and, Alexander Egyed*

[Journal First] Extended Abstract: ProDSPL: Proactive Self-Adaptation based on Dynamic Software ProductLines . . . . . 81  
*Inmaculada Ayala, Alessandro Vittorio Papadopoulos, Mercedes Amor and, Lidia Fuentes*

[Research, Short Paper] A Proposal for Organizing Source Code Variability in the Git Version Control System . . . . . 82  
*Junior Cupe Casquina and, Leonardo Montecchi*

## **Performance**

[Research] On Reducing the Energy Consumption of Software Product Lines . . . . . 89  
*Edouard Guegain, Clément Quinton and, Romain Rouvoy*

[Research] The Interplay of Compile-time and Run-time Options for Performance Prediction 100  
*Luc Lesoil, Mathieu Acher, Xhevahire Tërnavá, Arnaud Blouin and, Jean-Marc Jézéquel*

[Journal First] Automated Model-based Performance Analysis of Software Product Lines under Uncertainty – Extended Abstract . . . . . 112  
*Paolo Arcaini, Omar Inverso and, Catia Trubiani*

## **Case Studies and Benchmarks**

[Journal First] Empirical software product line engineering: A systematic literature review 113  
*Ana Eva Chacón-Luna, Antonio Manuel Gutierrez Fernandez, José A. Galindo and, David Benavides*

[Industrial] The architectural divergence problem in security and privacy of eHealth IoT product lines . . . . .	114
<i>Oleksandr Tomashchuk, Dimitri Van Landuyt and, Wouter Joosen</i>	
[Challenge Proposals] Variability Fault Localization: A Benchmark . . . . .	120
<i>Kien-Tuan Ngo, Thu-Trang Nguyen, Son Nguyen and, Hieu Vo Dinh</i>	
[Challenge Solutions] Spectrum-Based Feature Localization: A Case Study using ArgoUML	126
<i>Gabriela Karoline Michelin, Bruno Sotto-Mayor, Jabier Martinez, Aitor Arrieta, Rui Abreu and, Wesley Klewerton Guez Assunção</i>	
[Challenge Solutions] On the Scalability of Building Binary Decision Diagrams for Current Feature Models . . . . .	131
<i>Tobias Heß, Chico Sundermann and, Thomas Thüm</i>	

### **Community Efforts, Surveys, Reviews**

[Research] Yet Another Textual Variability Language? A Community Effort Towards a Unified Language . . . . .	136
<i>Chico Sundermann, Kevin Feichtinger, Dominik Engelhardt, Rick Rabiser and, Thomas Thüm</i>	
[Research] Safety, Security, and Configurable Software Systems: A Systematic Mapping Study . . . . .	148
<i>Andy Kenner, Richard May, Jacob Krüger, Gunter Saake and, Thomas Leich</i>	
[Research] Capturing the diversity of analyses on the Linux kernel variability . . . . .	160
<i>Johann Mortara and Philippe Collet</i>	
[Industrial] Over 20 years of Industrial Experience Sharing at SPLC: a Systematic Mapping Study . . . . .	172
<i>Maidier Azanza, Leticia Montalvillo Mendizabal and, Oscar Diaz</i>	
[Research, Short Paper] Bridging the Gap: Voices from Industry and Research on Industrial Relevance of SPLC . . . . .	184
<i>Klaus Schmid, Rick Rabiser, Martin Becker, Matthias Galster, Iris Groher and, Danny Weyns</i>	

### **Sampling, Variability Analysis and Visualization**

[Research] Monte Carlo Tree Search for Feature Model Analyses: a General Framework for Decision-Making . . . . .	190
<i>José Miguel Horcas Aguilera, José A. Galindo, Ruben Heradio, David Fernandez-Amoros and, David Benavides</i>	



[Research, Short Paper] FeatureVista: Interactive Feature Visualization . . . . .	196
<i>Alexandre Bergel, Razan Ghzouli, Thorsten Berger and, Michel R. V. Chaudron</i>	

## Workshops

[VM4ModernTech 2021] International Workshop on Variability Management for Modern Technologies . . . . .	202
<i>Wesley K. G. Assunção, Inmaculada Ayala, Jacob Krüger and, Sébastien Mosser</i>	
[REVE 2021] 9th International Workshop on REverse Variability Engineering . . . . .	203
<i>Wesley K. G. Assunção, Roberto Erick Lopez-Herrejon, Tewfik Ziadi and, Jabier Martinez.</i>	
[VariVolution 2021] 4th International Workshop on Variability and Evolution of Software-intensive Systems . . . . .	204
<i>Lea Gerling, Sandra Greiner, Kristof Meixner and, Gabriela Karoline Michelon</i>	
[MODEVAR@SPLC 2021] 4th International Workshop on Languages for Modelling Variability . . . . .	205
<i>Thomas Thüm, Mathieu Acher, Philippe Collet and, David Benavides</i>	
[WEESR 2021] 4th Workshop on Experiences and Empirical Studies on Software Reuse . . . . .	206
<i>Jaime Chavarriaga and Julio Hurtado</i>	

## Tutorials

Describing Variability with Domain-Specific Languages and Models . . . . .	207
<i>Juha-Pekka Tolvanen and Steven Kelly</i>	
How I Met Your Implemented Variability: Identification in Object-Oriented Systems with symfinder . . . . .	208
<i>Johann Mortara and Philippe Collet</i>	
PRICES: Towards Web-Based Product Lines Generator . . . . .	209
<i>Maya R.A. Setyautami, Hafiyyan Sayyid Fadhlillah and, Ade Azurat</i>	
Requirements-driven Reuse Recommendation . . . . .	210
<i>Muhammad Abbas, Mehrdad Saadatmand and, Eduard Paul Enoiu</i>	
Reuse for Mass Personalisation Through Feature Models and Similarities . . . . .	211
<i>Mike Mannion and Hermann Kaindl</i>	
Variability Realization in UML/SysML Models . . . . .	212
<i>Martin Becker and Andreas Schaefer</i>	

Static Analysis and Family-based Model Checking with VMC . . . . . 214  
*Maurice H. ter Beek, Franco Mazzanti, Ferruccio Damiani, Luca Paolini, Giordano Scarso and,  
Michael Lienhardt*

# Welcome Message

Welcome to SPLC 2021, the 25th International Systems and Software Product Line Conference. Variability is at the core of most modern computer and cyber-physical systems. Product lines provide a structured method for dealing with variability. They represent one of the most exciting paradigm shifts in software and systems development, with new challenges and opportunities for both research and practice. For decades, SPLC has been the flagship venue for practitioners, researchers, and educators interested in systems and software product lines. SPLC is a great venue for learning about the state of the art as well as practice, trends, innovations, industry experiences, and challenges in the area of systems family engineering at large.

SPLC 2021 took place from September 6th to 11th. While originally meant to take place in Leicester, UK, the conference was made fully virtual. For participants, SPLC 2021 proposed a very exciting program of top notch research and industry papers as well as journal-first presentations, workshops, tutorials, challenges, solutions, tool demonstrations, doctoral proposals, artefacts, and great keynote presentations.

SPLC 2021 received 105 submissions: 45 research papers and 7 research artefacts, 7 industry papers, 3 journal-first papers, 6 workshop proposals, 2 challenge proposals and 3 solutions, 7 demo and tool papers, 5 doctoral proposals and 7 tutorial proposals. In the research track, based on at least three reviews and intensive discussions, the committees selected 12 full papers and 3 short papers, translating into a 33% acceptance rate. In the industry track, 3 full papers were accepted following the same rigorous process, translating into a 43% acceptance rate. We are especially grateful to all members of the program committees for helping us to seek submissions and provide valuable and constructive reviews.

We would like to thank our keynote speakers Mattias Nyberg, Julia Rubin, and Thomas Thüm, who graciously agreed to share their perspectives, experiences, and insights with the community. The program committee members and track chairs deserve a particular mention for their hard work in reviewing and discussing the papers. Our thanks also go to the Organisation Committee for taking on the arduous challenges involved in organising a virtual conference. We would like to thank our sponsors and institutional partners for their support and contributions. These include BT Plc. (Gold Sponsor), Robert Bosch GmbH (Gold Sponsor), Elsevier Science BV (Silver Sponsor), MetaCase (Silver Sponsor), the Association of Computing Machinery (ACM), and the ACM Special Interest Group on Software Engineering (SIGSOFT).

Sincerely,

Mohammad Reza Mousavi, Pierre-Yves Schobbens, Ina Schaefer, Maurice H. ter Beek, Xavier Devroey, José Miguel Rojas, Rick Rabiser, Mahsa Varshosaz, Monica Pinto, Leopoldo Teixeira, Thorsten Berger, Joost Noppen, Goetz Botterweck, Natsuko Noda, Iris Reinhartz-Berger, Paul Temple, Ferruccio Damiani, Justyna Petke, Tomoji Kishi, Jaejoon Lee, Hugo Araujo, Jan Oliver Ringert, Uraz Türker, and Carlos Diego Damasceno.

## **Organizing Committee**

### **General Chair**

Mohammad Mousavi, *King' College London, UK*  
Pierre-Yves Schobbens, *University of Namur, Belgium*

### **Research Track Chairs**

Ina Schaefer, *Technische Universität Braunschweig, Germany*  
Maurice H. ter Beek, *National Research Council, Italy*

### **Industrial Systems and Software Product Lines Chairs**

Thorsten Berger, *Ruhr-Universität Bochum, Germany*  
Johannes Noppen, *British Telecom, UK*

### **Challenge Track Chairs**

Iris Reinhartz-Berger, *University of Haifa, Israel*  
Paul Temple, *University of Namur, Belgium*

### **Demonstrations and Tools Chairs**

Tomoji Kishi, *Waseda University, Japan*  
Jaejoon Lee, *University of East Anglia, UK*

### **Workshops Chairs**

Xavier Devroey, *TU Delft, Netherlands*  
José Miguel Rojas, *University of Leicester, UK*

### **Journal First Chair**

Ferruccio Damiani, *Università degli Studi di Torino, Italy*  
Justyna Petke, *University College London, UK*

### **Tutorials Chairs**

Monica Pinto, *ITIS Software, University of Málaga, Spain*  
Leopoldo Teixeira, *Federal University of Pernambuco, Brazil*

### **Doctoral Symposium Chairs**

Rick Rabiser, *Johannes Kepler University Linz, Austria*  
Mahsa Varshosaz, *IT University of Copenhagen, Denmark*

### **Hall of Fame Chairs**

Natsuko Noda, *Shibaura Institute of Technology, Japan*  
Goetz Botterweck, *University of Limerick, Ireland*

### **Local Organizing Chair**

Mohammad Reza Mousavi, *King's College London, UK*  
Jan Oliver Ringert, *University of Leicester, UK*  
José Miguel Rojas, *University of Leicester, UK*  
Uraz Türker, *University of Leicester, UK*

### **Web and Publicity Media Chair**

Carlos Diego Nascimento Damasceno, *Radboud University Nijmegen, Netherlands*

### **Proceedings Chair**

Hugo Araujo, *University of Leicester, UK*

## Program Committees

### Research Track

Mathieu Acher	University of Rennes / INRIA, France
Eduardo Almeida	Federal University of Bahia, Brazil
Paolo Arcaini	National Institute of Informatics, Japan
Davide Basile	ISTI-CNR, Italy
David Benavides	University of Seville, Spain
Walter Cazzola	University of Milan, Italy
Jane Cleland-Huang	University of Notre Dame, USA
Loek Cleophas	TU Eindhoven, The Netherlands
Philippe Collet	Université Côte d'Azur, France
Maxime Cordy	University of Luxembourg, Luxembourg
Ferruccio Damiani	University of Turin, Italy
Alessandro Fantechi	University of Florence, Italy
Lidia Fuentes	University of Málaga, Spain
José A. Galindo	University of Seville, Spain
Øystein Haugen	Østfold University College Halden, Norway
Timo Kehrer	Humboldt-Universität zu Berlin, Germany
Axel Legay	UCLouvain, Belgium
Malte Lochau	University of Siegen, Germany
Roberto Lopez-Herrejon	ETS Montréal, Canada
Juliana Alves Pereira	Pontifical Catholic University of Rio de Janeiro, Brazil
Gilles Perrouin	University of Namur, Belgium
Justyna Petke	University College London, UK
Rick Rabiser	Johannes Kepler University Linz, Austria
Iris Reinhardt-Berger	University of Haifa, Israel
Klaus Schmid	University of Hildesheim, Germany
Sandro Schulze	Otto-von-Guericke-University of Magdeburg, Germany
Christa Schwanninger	Siemens Healthcare, Germany
Christoph Seidl	IT University of Copenhagen, Denmark
Daniel Strüber	Radboud University Nijmegen, The Netherlands
Leopoldo Teixeira	Federal University of Pernambuco, Brazil
Salvador Trujillo	IKERLAN Research Center, Spain
Ingrid Chieh Yu	University of Oslo, Norway

## Artifacts Evaluation

Xavier Devroey	Delft University of Technology, The Netherlands
Clemens Dubsclaff	TU Dresden, Germany
Jessie Galasso	University of Montréal, Canada
Jacob Krüger	University of Magdeburg, Germany
Michael Lienhardt	ONERA, France
Jacopo Mauro	University of Southern Denmark, Denmark
Kristof Meixner	TU Wien, Austria
Leticia Montalvillo	Ikerlan Research Center, Spain
Lina Ochoa Venegas	Eindhoven University of Technology, The Netherlands
Luca Paolini	University of Turin, Italy
Clément Quinton	University of Lille, France
Luisa Rincón	Pontificia Universidad Javeriana, Colombia
Ștefan Stănculescu	Hitachi ABB Power Grids Research, Switzerland
Andrea Vandin	Sant'Anna School of Advanced Studies, Italy

## Industrial Systems and Software Product Lines Track

Martin Becker	Fraunhofer IESE Kaiserslautern, Germany
Lodewijk Bergmans	Software Improvement Group, The Netherlands
Paul Clements	BigLever Software, USA
Lidia Fuentes	University of Málaga, Spain
Sebastien Gerard	CEA, France
Paul Grünbacher	Johannes Kepler University Linz, Austria
Sten Grüner	ABB Corporate Research Germany, Germany
Iris Groher Johannes	Kepler University Linz, Austria
Jean-Marc Jézéquel	University of Rennes, France
Luisa Rincon	Universidad Nacional de Colombia, Colombia
Mehrdad Saadatmand	RISE SICS Västerås, Spain
Bran Selic	Malina Software Corp., Canada
Juha-Pekka Tolvanen	MetaCase, Finland
Hironori Washizaki	Waseda University, Japan

## Challenges Track

Angel Jesus Varela Vaca	University of Seville, Spain
Clement Quinton	University of Lille, France
Danny Weyns	KU Leuven, Belgium
Edson OliveiraJr	State University of Maringá, Brazil
Goetz Botterweck	Lero and Trinity College Dublin, Ireland

Jabier Martinez  
Jessie Galasso-Carbonnel  
Jose Galindo  
Lea Gerling  
Lukas Linsbauer  
Matthias Galster  
Sandra Greiner  
Sofia Ananieva  
Stefan Fischer  
Tewfik Ziadi  
Wesley Assuncao

Tecnalia, Spain  
Université de Montréal, Canada  
University of Seville, Spain  
University of Hildesheim, Germany  
Technical University of Braunschweig, Germany  
University of Canterbury, New Zealand  
University of Bayreuth, Germany  
FZI Research Center for Information Technology, Germany  
Software Competence Center Hagenberg, Austria  
Sorbonne University, France  
Federal University of Technology - Paraná, Brazil

## Journal-First Track

Sofia Ananieva  
Wesley K. G. Assunção  
Mikaela Cashman  
Walter Cazzola  
Laurence Duchien  
Lea Gerling  
Stefania Gnesi  
Eduard Kamburjan  
Christoph Seidl  
Leandro Souza

FZI Research Center for Information Technology, Germany  
Pontifical Catholic University of Rio de Janeiro (PUC-Rio), Brazil  
Iowa State University, USA  
Università degli Studi di Milano, Italy  
University of Lille, France  
University of Hildesheim, Germany  
ISTI-CNR, Italy  
University of Oslo, Norway  
Technische Universität Braunschweig, Germany  
Federal University of Pernambuco, Brazil



# Microservice-based Development: Something Old, Something New, Something Borrowed, and What We Can Do

**Julia Rubin** - *The University of British Columbia, Canada*

**Abstract.** Whenever you watch Netflix or order from Amazon, you use microservice-based applications. Such applications follow a SOA-inspired architectural principle of building complex systems as a composition of small, loosely coupled components that communicate with each other using language-agnostic APIs. Microservices have recently become popular in industry due to their advantages, such as greater software development agility and improved scalability of deployed applications. Yet, proper adoption of microservices induces numerous technical and organizational changes. This talk will discuss several of these challenges, based on empirical data we gathered from more than 50 industrial practitioners. We will then focus on two of the challenges in more detail: managing variants in microservice-based systems and decomposing monolithic applications into microservices. We will discuss some existing solutions for addressing these challenges and possible future research directions for the SPLC community.

**About Julia Rubin.** Julia Rubin is an Assistant Professor at the Department of Electrical and Computer Engineering at the University of British Columbia. She holds a Canada Research Chair (Tier II) in Trustworthy Software. Julia received her PhD in Computer Science from the University of Toronto, Canada and worked as a postdoctoral researcher at MIT, USA. She also spent almost 10 years in industry, working for IBM Research, where she was a research staff member and a research group manager. Julia's research interests are in software engineering, program analysis, software security, and reliability in complex software systems. Her work in these areas won five Distinguished/Best Paper Awards at major conferences, such as ICST'21, ISSTA'18, ASE'15, and SPLC'13, and was runner-up for Facebook's Internet Defense Prize at the USENIX Security Symposium'14. Julia serves on program committees of several flagship conferences in software engineering, such as ICSE, FSE, and ASE. She co-chaired the program committees of SPLC'14, ECMFA'14, FASE'17, CASCON'20, and will co-chair the program committee of ASE in 2022.

## Generating safety cases for large-scale industrial product lines

**Mattias Nyberg - Scania and Royal Institute of Technology, Sweden**

**Abstract.** The heavy-vehicle manufacturer Scania has a complex product line consisting of billions of possible product configurations. Faced with the challenge of arguing that each of the configurations is safe, Scania has, in collaboration with KTH, developed a general methodology to build a so called “safety case” for a complex product line. The goal has been to generate it as automatically as possible from existing engineering data. The presentation will explain the methodology and share experiences from the huge effort of trying to implement it in the industrial context of Scania.

**About Mattias Nyberg.** Mattias Nyberg is an adjunct (part-time) professor at Royal Institute of Technology (KTH) in the department of Mechatronics. His main affiliation is Scania CV AB, a leading global heavy-truck manufacturer. He received a PhD in Electrical Engineering from Linköping University in 1999 specializing in vehicular systems. After dissertation he has worked mainly in industry; first for Daimler in Stuttgart, Germany, and then at Scania with a current focus on functional safety and product line engineering. In parallel with his industrial career, he is very active in academic research. He has supervised six PhD students. He is also an author of more than 100 scientific publications, and has received the SAE Vincent Bendix award.

## Where Are My Constraints and What Do They Constrain?

**Thomas Thüm** - *University of Ulm, Germany*

**Abstract.** The adoption of product lines in industrial practice is challenged by feature interactions. In theory, adding a single feature to a product line can double the number of products. In practice, constraints between the features drastically limit the number of useful products. Where do we find those constraints? What do we do with those constraints? And where on earth are all the smart technologies that help our overwhelmed engineers? Since 2007, I am involved in the development of FeatureIDE. In this keynote, I would like to share experiences made with product-line research and its application to industrial practice.

**About Thomas Thüm.** Thomas Thüm is a professor for the Construction and Analysis of Secure Software Systems at the University of Ulm since January 2020. His research interests range from Software Engineering and Formal Methods to Artificial Intelligence and Security. In particular, his research focuses on variability and evolution of software systems. From 2015 to 2019, he was a postdoctoral researcher at the TU Braunschweig in Ina Schaefer's institute. He received his Ph.D. in 2015 from the University of Magdeburg under the supervision of Gunter Saake. His Ph.D. thesis received the Dissertation Award 2015 of the University of Magdeburg and his master's thesis the Software Engineering Award 2011 of the Ernst Denert Foundation. He coauthored more than 100 peer-reviewed publications and is known for his contributions to the famous open-source project FeatureIDE. Since 2020, he is an associate editor for ACM Transactions on Software Engineering and Methodology (TOSEM).

# Empirical software product line engineering: A systematic literature review. An IST journal publication

Ana Eva Chacón-Luna  
achaconl1@unemi.edu.ec  
Universidad Estatal de Milagro  
Milagro, Ecuador

José A. Galindo  
jagalindo@us.es  
ETSI Informática  
Universidad de Sevilla  
Sevilla, Spain

Antonio Manuel Gutiérrez Fernández  
antonio.gutierrez@jku.at  
CDL VaSiCS, LIT CPS Lab  
Johannes Kepler University  
Linz, Austria

David Benavides  
benavides@us.es  
ETSI Informática  
Universidad de Sevilla  
Sevilla, Spain

## ABSTRACT

The adoption of Software Product Line Engineering (SPLE) is usually only based on its theoretical benefits instead of empirical evidences. In fact, there is no work that synthesizes the empirical studies on SPLE. This makes it difficult for researchers to base their contributions on previous works validated with an empirical strategy. The objective of this work is to discover and summarize the studies that have used empirical evidences in SPLE limited to those ones with the intervention of humans. This will allow evaluating the quality and knowing the scope of these studies over time. Doing so, research opportunities can arise. Analyzing the authors and institutions that investigate SPLE supported by empirical studies will also help to know which institutions have knowledge of the subject, leading to detect and encourage collaboration among researchers. A systematic literature review was conducted with the focus on those studies in which there is human intervention and were published between 2000 and 2018 (the systematic literature review was developed in 2019). We considered peer-reviewed papers from journals and top software engineering conferences. Out of a total of 1880 studies in the initial set, a total of 62 primary studies were selected after applying a series of inclusion and exclusion criteria. We found that, approximately 56% of the studies used the empirical case study strategy while the rest used experimental strategies. Around 86% of the case studies were performed in an industrial environment showing the penetration of SPLE in industry while 81% of the experiments were conducted in an academic environment. Around 95.16% of the studies address aspects related to domain engineering while application engineering received less attention. Most of the experiments and case study evaluated showed an acceptable level of quality. The first study found dates from 2005 and since 2008, the interest in the empirical SPLE has increased.

## CCS CONCEPTS

• **Software and its engineering** → **Software product lines**; • **General and reference** → **Empirical studies**.

## KEYWORDS

Software product lines, Empirical strategies, Case study, Experiment, Systematic literature review

### ACM Reference Format:

Ana Eva Chacón-Luna, Antonio Manuel Gutiérrez Fernández, José A. Galindo, and David Benavides. 2021. Empirical software product line engineering: A systematic literature review. An IST journal publication. In *25th ACM International Systems and Software Product Line Conference - Volume A (SPLC '21)*, September 6–11, 2021, Leicester, United Kingdom. ACM, New York, NY, USA, 1 page. <https://doi.org/10.1145/3461001.3473062>

## 1 INFORMATION ABOUT THE PUBLICATION

This publication appeared in the December 2020 issue of the journal *Information and Software Technology* (IST). IST is in ISI-JCR (2019) in Q2 in the area of software engineering at position 28 out of 108 which puts it on the edge of Q1 which is the quartile it has been in since 2015.

The publication is available through: <https://doi.org/10.1016/j.infsof.2020.106389>

## ACKNOWLEDGMENTS

This work was partially funded by the EU FEDER program, the MINECO project OPHELIA (RTI2018-101204-B-C22); the Juan de la Cierva postdoctoral program; the TASOVA network (MCIU-AEI TIN2017-90644-REDT), and; the Universidad Estatal de Milagro, and the Junta de Andalucía METAMORFOSIS project.

---

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the owner/author(s).

*SPLC '21, September 6–11, 2021, Leicester, United Kingdom*

© 2021 Copyright held by the owner/author(s).

ACM ISBN 978-1-4503-8469-8/21/09.

<https://doi.org/10.1145/3461001.3473062>