Preface

This volume contains the proceedings of the International Workshop on Measurement and Metrics for Green and Sustainable Software Systems (MeGSuS'18) held on

October 9th, 2018 in conjunction with the Empirical Software Engineering International Week (ESEIW) in Oulu, Finland.

With the recent proliferation of wearable devices and mobile applications, Information and Communication Technology (ICT) is increasing its impact on the environment due to its resource and power consumption. However, ICTs can also make a significant contribution to saving energy, by autonomous optimization efforts and by inducing changes of user behaviour attitudes and values.

A variety of research work on Green and Sustainability ICT has focused on measuring the level of greenness of hardware components from an environmental perspective. In the last years, there has been an increasing interest in having clear metrics for measuring the carbon footprint of software, the amount of resources used by software, and how it affects the environmental impact of ICT. However, measuring software sustainability is a challenging task, due to the complexity of its direct and indirect effects on the environment and dependencies among sustainability aspects. More empirical evidence on the performance, reliability and usefulness of the proposed metrics is required.

The workshop MeGSuS'18 aimed to provide a forum for researchers and practitioners

i) to discuss their current work on measurement practices for greening and making more sustainable software systems

ii) to present empirical studies on metrics used to design sustainable software systems from different domains (e.g. smart transportation, healthcare, education) and assess/predict the greenness in the ICT industry (e.g. data centers, embedded system software)

iii) to identify the main challenges and define a research agenda on the topic of Measurement and Metrics for Green and Sustainable Software.

The main discussion topics have been:

- Reusing existing measures to extract software "greenness" information
- Measurement to support green decision making
- Tools for automatic collection/analysis of measures for green and sustainability of software systems
- Design of empirical studies on the effectiveness and usefulness of sustainability metrics
- Measurement practices in Green and Sustainability IT

The following 5 papers were reviewed by three reviewers and accepted to be presented at the *MeGSuS workshop:*

Shola Oyedeji, Ahmed Seffah and Birgit Penzenstadler. **Classifying the Measures of Software Sustainability According to the current Perceptions**

Energy efficiency is one of the very few measures widely used for evaluating green and sustainable software systems. This paper proposes to investigate the current measures of software sustainability from four different perceptions: Sustainability in Software Development, Green Software Systems, and Software for Sustainability, and Sustainability of the Software Eco System. While exploring the literature on green and sustainable software, this paper identifies and compiles the measures of green software and software sustainability. The paper classifies the existing measures according to these four sustainability perceptions.

Thibault Béziers La Fosse, Jean-Marie Mottu, Massimo Tisi, Jérôme Rocheteau and Gerson

Sunyé. **Characterizing a Source Code Model with Energy Measurements**

Energy consumption is a critical point when developing applications.

Either for battery-saving purposes, for lowering the cost of data-centers, or simply for the sake of having an eco-friendly program, reducing the energy needed to run a software becomes mandatory. Model-Driven Engineering has shown great results when it comes to program understanding and refactoring. Modeling the source code along with its energy consumption could be a powerful asset to programmers in order to develop greener code.

For that purpose, this paper presents an approach for modeling energy consumption inside a source code model. Energy metrics are gathered at runtime, modeled using the standard Structured Metrics Meta-model, and associated to the source code model, enabling model-driven techniques for energy analysis and optimizations.

Franci Suni Lopez, Nelly Condori-Fernandez and Denisse Muñante   **End-user perceptions on social sustainability in context-aware applications: An experiment design**

The paper proposes the design of an empirical study to investigate how users understand and perceive the social sustainability of context-aware software applications, that are built based on the HAPPYNESS framework, by using videos embedded in an on-line questionnaire.

Authors conducted a and report outcomes of the pilot study that aims to evaluate the feasibility of the empirical study and test the instruments used for a set of social sustainability-quality requirements (security and satisfaction) from an end-user perspective.

Alessandra Bagnato and Rocheteau Jerome. **Towards Green Metrics Integration in the MEASURE Platform**

Their aim is to reuse green metrics across software development projects that are drawn out from open source project unit test suites. They identify three use cases for their tool suite:

(1) monitoring energy consumption and/or power peaks at run-time during software production phase,

(2) comparing energy consumption of similar software components when evaluating their energy efficiency, and

(3) building a knowledge base about software energy consumption in order to help developers at earlier phases, as a support to build static analysis methods.

Currently, further metrics are being solicited for other dimensions of sustainability beyond energy efficiency.

Anouer Rouissi and Jérôme Rocheteau. **A Model-Driven Approach for Measuring the Energy Cost of JAVA Data Structures**

This paper aims at presenting a model-driven approach in order (1) to represent data types and data structures thanks to a domain-specific language and (2) to generate tests that make it possible to measure their energy cost. The latter corresponds to an abstraction of the energy consumption of software components, precise and suitable enough to be embedded into static analysis.

The paper is not included in the workshop proceedings since the authors decided to not submit a revised version of the paper to the post-proceedings.

Moreover, we conducted a focus group study with all participants of the workshop. The objective of this study was to discuss on the usefulness of existing metrics from the MEASURE platform for measuring software sustainability.

The following members served in the international program committee:

- Achim Guldner, *Environmental Campus Birkenfeld, Trier University of Applied Sciences, Germany*

- Alain Abran, *Ecole de Technologie Supérieure ETS - Université du Québec, Canada*

- Andreas Fritsch, *Karlsruhe Institute of Technology, Germany*

- Colin Venters, *University of Huddersfield, UK*

- Coral Calero, *Universidad de Castilla-La Mancha*

- Giuseppe Procaccianti, *Vandebron B.V., The Netherlands*

- Isabel Brito, *Polytechnic Institute of Beja, Portugal*

- Ivano Malavolta, *Vrije Universiteit Amsterdam, The Netherlands*

- Jérôme Rocheteau, *ICAM, France*

- Luigi Buglione, *Engineering.IT / ETS*

- Manuel F. Bertoa, *University of Malaga, Spain*

- Ma Ángeles Moraga, *Universidad de Castilla-La Mancha, Spain*

- Nour Ali, *Brunel University London*

- Patricia Lago, *Vrije Universiteit Amsterdam, The Netherlands*

- Rami Bahsoon, *School of Computer Sc, University of Birmingham*

- Sandro Morasca, *Università degli Studi dell'Insubria, Italy*

- Sedef Akinli Kocak, *Ryerson University, Canada*

- Stefan Naumann, *Environmental Campus Birkenfeld, Trier University of Applied Sciences, Germany.*

- Xavier Franch, *Technical University of Catalunya, Spain*

We would like to take this opportunity to thank the people who have contributed to the MeGSuS 2018 workshop. We wish to thank all authors and reviewers for their valuable contributions, and we wish them a successful continuation of their work in this area. We wish to thank our invited speakers Dr. Birgit Penzenstadler for her keynote: "Conceptual modeling of goals and metrics to visualize the measurement of sustainability" and Harri Oinas-Kukkonen, PhD, for his keynote: "Persuasive systems design for sustainability".

We thank the organization of the ESEIW 2018 conference in which this workshop has been embedded and hope to see you all again at ESEIW 2019 in Brazil next year.

December, 2018   The Organizational Committee
                                                   Alessandra Bagnato, Softeam R&D
                                                          Department, France
                                                   Nelly Condori-Fernandez UDC/
                                                         VUA, Spain/Netherlands
                                                   Eva Kern, Leuphana University,
                                                                Germany