

Ensemble-Based Software Engineering for Modern Computing Platforms

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ABSTRACT

Software systems have evolved from being ‘stand-alone systems’ to ‘systems of systems’ to meet the challenging needs of societies. Contemporary software systems such as socio-technical systems are composed of distributed and heterogeneous agents, the embedded environment, and software components. Addressing the disruptions caused by run-time changes in the environment while designing software systems remains a challenging task in practice. *Ensembles* enable systems with collective adaptability to be built as emergent aggregations of autonomous and self-adaptive agents. The phenomenal aspect of this type of systems allows agents (i.e. services, people and things) affected by an issue to adapt collaboratively with minimal impact on their own preferences through a collective resolution process. In this paper we report the outcomes of the 2nd ACM SIGSOFT International Workshop on Ensemble-Based Software Engineering for Modern Computing Platforms (EnSEmble 2019), which was held as part of the 27th ACM Joint European Software Engineering Conference and Symposium on the Foundations of Software Engineering (ESEC/FSE 2019) in Tallinn, Estonia, on August 26th, 2019.

Introduction

Ensemble-based Systems consist of diverse heterogeneous agents composing a socio-technical system [Par16, ZFB⁺11, Buc19]. Individual agents opportunistically enter a system and self-adapt in order to leverage the ensemble’s resources and capabilities to perform their task more efficiently or effectively. The collaborative nature of the system makes their engineering and the management of run-time adaptations much trickier [WA13]. Changes in the behavior of one agent may break the consistency of the whole collaboration, or have negative repercussions on other participants. Adaptation must, therefore, be collective. Agents must be able to self-adapt simultaneously and, at the same time, preserve the collaboration and benefits of the system (or sub-system) they are within. In this context we consider software systems that are composed of large-scale *ensembles* of widely distributed, largely autonomous and heterogeneous entities situated in both the physical world and in back-end computer systems. These entities (Services, Things and People) are interconnected, online, and to some extent programmable. For these reasons we need modern computing platforms such as serverless computing, containers, fog computing,

cloud computing, or the Internet of Things. Creating software that leverages the possibilities of such platforms and accounts for their limitations entails several challenges, affecting many software engineering activities.

Goal. In this workshop series, we seek to bring together researchers and practitioners in the field of software engineering to present and discuss latest ongoing research as well as radical new research directions in engineering modern and future software applications involving several and heterogeneous domains. This second edition of the workshop aimed to analyze and propose new paradigms for distributed software platforms, including sharing and reuse of everything: applications, objects, and services, but also sharing the economy aspect of these entities.

1. WORKSHOP CHAIRS

The 2019 edition of the EnSEmble workshop has been organized by:

- Antonio Brogi, University of Pisa, Pisa, Italy
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- Rafael Capilla, Universidad Rey Juan Carlos, Madrid, Spain
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- Zoltán Ádám Mann, University of Duisburg-Essen, Essen, Germany
- Marina Mongiello, Polytechnic University of Bari, Bari, Italy
- Francesco Nocera (Main Contact), Polytechnic University of Bari, Bari Italy

2. TOPICS

Topics of interest for the EnSEmble workshops series include the following:

- Engineering web of things and web of everything
- Software architectural styles and patterns for connecting objects, devices and services
- Engineering new paradigm for software architecture
- Modern computing platforms: serverless computing, containers, edge and fog computing, cloud computing, Internet of Things, service mesh, AI/ML systems
- Effect on software engineering activities: requirements management, software design, analysis and verification, programming, quality assurance, deployment, maintenance, configuration management, DevOps
- Liquid software
- Challenges for distributed applications
- Architectures and frameworks for smart devices connection
- Microservices and distributed software models
- Architecture for adaptive systems
- Optimization and decision-making approaches
- Scalability and Performance analysis
- Languages, platforms, APIs and other tools for Ensembles
- Quality assurance for Ensembles
- Internet of events (Internet of Content (IoC), Internet of People (IoP), Internet of Things (IoT), Internet of Locations (IoL))
- General concepts: virtualization, software-defined everything, everything as a service, loose coupling
- Cross-cutting concerns: security, performance, dependability, quality of service, quality of experience, energy efficiency
- Sustainable software engineering
- Emerging paradigms of software platform: crowdfunding, crowdsourcing
- Sharing economy: sharing and reusing
- Gamification and Engagification mechanisms for people
- Cooperation and competition algorithms in multi-agent systems
- Empirical software engineering for Ensembles
- Scenarios, case studies, and experience reports of Ensembles in different contexts (e.g., Smart Mobility, Smart Energy/Smart Grid, Smart Buildings, Emergency, etc..).
- Applications and tools behaving in shared economy environment and domains: Crowdfunding, car sharing, house-sharing, coworking.

3. ACCEPTED PAPERS

In the 2nd edition of the workshop (EnSEmble 2019 [NBM⁺19]) each submitted paper was reviewed by three members of the Program Committee and the selection of the accepted papers was decided based on the quality (novelty, relevance, clarity of presentation, correctness) and contribution to the workshop. The summary of the three selected papers is as follows.

EnergyAware: A Non-intrusive Load Monitoring System to Improve the Domestic Energy Consumption Awareness. In this paper by Buono and his colleagues [BBCP19], the authors present the use of a cheap and easy-to-apply Non-Intrusive Load Monitoring (NILM) system that notifies people about their domestic energy consumption, also with alerts if energy plant overload occurs, through a mobile app specifically developed for this purpose. The mobile app also records the consumption and shows both real-time and historical data.

Assessing the Greenability of Ensembles. In this paper by Patón-Romero and his colleagues [PRBRP19], the authors discuss the role of ensembles in keeping large computing infrastructures and architectures running. Although these critical elements are key for the correct functioning of an entire system, energy consumption and the environmental impact of the ensembles are not usually considered. The authors suggest to study the use of the “Governance and Management Framework for Green IT”, a framework to assess the greenability of ensembles. The authors identify the goals and metrics that should be considered, as well as the practices and activities that must be assessed to ensure that the ensembles work in an eco-sustainable manner, to achieve an entire green system.

Semi-automatic Generation of Cybersecurity Exercises: A Preliminary Proposal. In this paper by Ribaud and Valenza [RV19], the authors propose the use of flow-based programming – and specifically the Node-RED tool – to semi-automatically generate resources for cybersecurity competitions and training. They define a library of modules which can be easily combined to build a pool of fresh exercises for educational purposes in cybersecurity.

4. REMARKS AND FUTURE WORK

Despite the broad and extensive research in the field of software engineering for large-scale distributed systems, especially conducted in recent years, many questions are still open. In particular, distributed systems are becoming increasingly heterogeneous, dynamic and of large dimensions. Even if technology is making great progress proposing high-performance platforms and paradigms, the software engineering of such systems must be yet improved with the introduction of new programming languages, intelligent algorithms and supporting tools. Our goal is to continue in proposing new editions of this workshop trying to attract more contributions both from academia and industry, pushing further on emerging contributions from young researchers, developers and experts alike to inspire new ideas for the future.

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