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Smart and Sustainable Collaborative Networks 4.0

22nd IFIP WG 5.5 Working Conference on Virtual Enterprises, PRO-VE 2021
Saint-Étienne, France, November 22–24, 2021
Proceedings

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Preface

Widespread digital transformation in industry and services is strongly enabled by the results achieved through more than two decades of research and development in the inter-disciplinary Collaborative Networks (CNs) paradigm. The PRO-VE series of conferences, now in its 22nd edition, has been a successful vessel for presenting innovative concepts and tools as well as providing a proper sand box to investigate and intersect new models and approaches that address the challenges raised. As such, this annual conference gives a bird's-eye view of the CN area and its achieved milestones, identifies forthcoming open challenges, and proposes research directions that require developing novel and/or disruptive solutions.

In the very last edition of the PRO-VE conference series, in 2020, the highlights of the past achievements in Collaborative Networks were structured as CN 1.0, CN 2.0, and CN 3.0. It further addressed the new emerging challenges in this area, e.g., the exponential increase in the availability of both data and intelligence, the vast progress in digitalization, and the proper positioning of humans in highly collaborative, dynamic, and resilient networks. The academic world was then invited to focus on addressing its newly introduced notion of Collaborative Networks 4.0, as the next generation of collaborative networks, in the era of applied artificial intelligence and digital transformation. By then, the following items were identified as the main challenges on which to focus: hybridization in CN structure, where network entities constitute organizations, people, intelligent systems, and machines; formation of distributed cognitive systems; collaborative decision making among humans and intelligent autonomous systems; managing big data; mass collaboration and collaborative creativity; and modeling and formalizing rights and liabilities, monetization, accountability, ethics, trust, and risk/disruption management. With this, the conference directed the community to focus on understanding and creating new collaboration culture and business models, with the purpose of addressing sustainable collaborative value creation.

Meanwhile, since last year, the world has encountered major health and economic crises caused by the COVID-19 pandemic, which emphasized that disruptive situations, at different scales, tend to be increasingly frequent and have strong impacts on society. As predicted by PRO-VE, smart and digital technologies supporting agility, scalability, resilience, and adaptability, which characterize CN 4.0, have nowadays become the critical features for most sectors of our modern societies, including the manufacturing industry and services sectors. Many properties of CN 4.0 can contribute to building a more resilient and sustainable world, providing that the socio-economic actors can implement efficient learning mechanisms, applying the lessons learned from recent crises. The crucial importance of Collaborative Networks in the current situation has led us to highlight the theme of the 2021 conference, targeting "Smart and Sustainable Collaborative Networks 4.0". Agile and sustainable systems and business models, based on open collaborative processes, are not only the answer to the increasing need

for customization but also provide higher resilience, i.e., through joint reconfiguration of market-offers, production processes, and consumption patterns, among others. Digitalization of both products and services enable a transition towards a larger vision of value creation. Furthermore, digitalization strengthens research trends on societal impacts, and makes it possible to focus progressively on the more ecological value chains, based on circular and collaborative economy.

Combined with the current boom of applied artificial intelligence including machine learning, the Collaborative Networks facilitate high potentials to boost Industry 4.0. The PRO-VE Working Conference sheds light on many applications within the industrial economy, at different levels of organization, spanning from human/robot collaboration at the detail process level to the high-level management of a manufacturing system's lifecycle, design and management of supply/value networks, and running the business ecosystems. However, the digital transition similarly affects all sectors of the economy, as strongly as each industry itself. Many other activity sectors are also concerned, where agility, resilience, and sustainability are the key challenges, e.g., Health 4.0, Agriculture 4.0, Cities 4.0, Transportation 4.0, Logistics 4.0, Education 4.0, and even Tourism 4.0. With an eye on these diverse application fields, PRO-VE 2021 provided a forum for sharing experiences, discussing trends, and identifying new opportunities, thus introducing innovative solutions for the new generation of Smart and Sustainable Collaborative Networks 4.0. Today more than ever, everyone realizes the need to network and boost collaboration at all levels of our modern societies, and to interlink different types of organizations, including private companies, public institutions, business, and non-profit organizations, down to the level of their industrial- and service-oriented processes. Therefore, the resilience and efficiency of our modern societies as a whole appear to be based on collaborative networking.

To better tackle the multidimensional complexity of Collaborative Networks, PRO-VE 2021 aimed to put forth a multidisciplinary forum, with conference contributions coming from both the engineering/computer science and the managerial/socio-human communities, including industrial and electrical engineering, computer science, manufacturing, organization science, logistics, managerial, and social sciences. These multiple points of view fuel both the interdisciplinary nature of the research and development on Collaborative Networks, as well as the multidisciplinary networking spirit of the PRO-VE Working Conferences.

PRO-VE 2021 was the 22nd event in a series of successful conferences, which included PRO-VE 1999 (Porto, Portugal), PRO-VE 2000 (Florianopolis, Brazil), PRO-VE 2002 (Sesimbra, Portugal), PRO-VE 2003 (Lugano, Switzerland), PRO-VE 2004 (Toulouse, France), PRO-VE 2005 (Valencia, Spain), PRO-VE 2006 (Helsinki, Finland), PRO-VE 2007 (Guimaräes, Portugal), PRO-VE 2008 (Poznan, Poland), PRO-VE 2009 (Thessaloniki, Greece), PRO-VE 2010 (St. Etienne, France), PRO-VE 2011 (São Paulo, Brazil), PRO-VE 2012 (Bournemouth, UK), PRO-VE 2013 (Dresden, Germany) , PROVE 2014 (Amsterdam, The Netherlands), PRO-VE 2015 (Albi, France), PRO-VE 2016 (Porto, Portugal), PRO-VE 2017 (Vicenza, Italy), PRO-VE 2018 (Cardiff, UK), PRO-VE 2019 (Torino, Italy), and PRO-VE 2020 (Valencia, Spain).

This proceedings includes selected papers from the PRO-VE 2021 conference submissions. It provides a comprehensive overview of major challenges that are being currently addressed related to sustainability and resilience and, specifically, recent advances in various domains related to Collaborative Networks and their applications. In this direction, the following five key areas are highlighted in these proceedings:

- Resilience and sustainability of Collaborative Networks and their ecosystems
- Collaboration management, spanning from operational life-cycle management to value creation boosting
- Digitalization of Collaborative Networks, embracing the definition of digital strategies and the multiple applications of ontologies, IoT, and CPS
- Multiple dimensions of the Factory of the Future
- Advanced collaborative learning environments, contributing to the deployment of an eco-systemic culture on CN 4.0

At a more detailed level, the 2021 conference papers are organized around the following subject headings:

– Sustainable Collaborative Networks
– Sustainability via Digitalization
– Analysis and Assessment of Business Ecosystems
– Human Factors in Collaboration 4.0
– Maintenance and Life-Cycle Management
– Policies and New Digital Services
– Safety and Collaboration Management
– Simulation and Optimization
– Complex Collaborative Systems and Ontologies
– Value Co-creation in Digitally Enabled Ecosystems
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– Knowledge Transfer and Accelerated Innovation in Factories of the Future
– Interoperability of IoT and CPS for Industrial CNs
– Sentient Immersive Response Network
– Digital Tools and Applications for Collaborative Healthcare
– Collaborative Networks and Open Innovation in Education 4.0
– Collaborative Learning Networks with Industry and Academia
– Industrial Workshop

We would like to express our thanks to all the authors from academia, research, and industry for their contributions. Continuing with the tradition of the PRO-VE conferences, we hope this collection of papers represents both a valuable tool for those interested in research advances and emerging applications in Collaborative Networks, and in identifying future open challenges for research and development in this area. We also very much appreciate the dedicated time and effort spent by the members of the PRO-VE International Program Committee, who supported us with the selection of

articles for the conference and provided valuable and constructive comments to help authors with improving the quality of their papers.

November 2021

Luis M. Camarinha-Matos
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