

Enabling Distributed Value Networks in Manufacturing as a Service Ecosystems through Cognitive Digital Twins

Konstantinos Kaparis and Andreas C. Georgiou

Quantitative Methods & Decisions Analytics Lab, Department of Business Administration,
University of Macedonia, Thessaloniki, Greece
k.kaparis@uom.edu.gr, acg@uom.edu.gr

Mourtos Ioannis, Zois Georgios and Lounis Stavros

Department of Management Science and Technology
Athens University of Economics and Business
ELTRUN the E-Business Research Center
mourtos@aueb.gr, georzoi@aueb.gr, oohay.liam@gmail.com

Patricia Casla

Senior researcher and Project Manager at Industrial Management and Innovation Unit
Ik4-Tekniker, Iñaki Goenaga 5, 20600 Eibar Spain
patricia.casla@tekniker.es

Abstract

This work presents the Tec4MaaSEs (T4M) project, which focuses on supporting Manufacturing as a Service (MaaS) ecosystems using advanced enabling technologies within the Industry 4.0 context. Central to the project is the development of a network of Digital Twins (DTs) that are both trustworthy and cognitive, enabling seamless collaboration within distributed value networks. The project examines three distinct value networks (VNs), each with specific needs and objectives: Value network 1 focuses on the production and distribution of electronic boards for white goods manufacturing. The aim is to optimize production and distribution processes by introducing an innovative ordering and production system that leverages the capabilities of multiple providers. Value network 2 involves stakeholders in the additive manufacturing sector, and focuses on mould production for plastic components. It seeks to promote the adoption of additive manufacturing by offering comprehensive services that include finishing processes like machining and coating. Additionally, the network addresses reducing idle periods in aggregate planning. Finally, Value network 3 is built around an EPC (Engineering, Procurement, and Construction) contractor responsible for constructing large-scale energy facilities. The focus is on streamlining and digitizing the negotiation process with suppliers at the strategic planning level. The project introduces standardized Information Models to improve communication and collaboration between the contractor and suppliers. The work concludes by emphasizing T4M's holistic approach to meeting diverse manufacturing challenges, serving as key facilitator in addressing these needs. This project was funded by the European Health and Digital Executive Agency, Project: 101138517, Tec4MaaSEs, HORIZON-CL4-2023-TWIN-TRANSITION-01

Keywords

Manufacturing as a Service (MaaS), Digital Twins, Industry 4.0, Value Networks.

Biographies

Konstantinos Kaparis obtained his PhD in Operational Research & Management Science from Lancaster University in 2008. He also holds an MSc in Operational Research and a BSc in Business Administration. His academic career includes roles as Senior Research Associate, Lecturer, and Assistant Professor at Lancaster University and currently, he serves as an Associate Professor in Quantitative Methods & Operational Research at the University of Macedonia, Greece. Dr. Kaparis specializes in operational research, particularly knapsack problems, cutting planes, and graph theory. His research has been published in renowned journals such as *Discrete Optimization* and the *European Journal of Operational Research*. He has presented at international conferences and contributed chapters to academic books. He has successfully secured research funding as Principal Investigator for projects like "Tec4MaaSEs" and has collaborated as a co-investigator on various projects related to sustainability and data analytics. He has extensive teaching experience at undergraduate and postgraduate levels, covering operational research, quantitative methods, and programming languages. His research contributions have earned him prestigious awards, including the O.R. Society annual Ph.D. Prize.

Andreas C. Georgiou is a Professor of Operational Research and Director of the Quantitative Methods and Decision Analysis Lab at the University of Macedonia's Department of Business Administration. He also directs the MBA program and previously led the Master's Program in Business Analytics and Data Science. His research focuses on Mathematical Methods in Business Analytics and Operations Research, with expertise in areas like Data Envelopment Analysis, stochastic systems discrete event simulation, and multiple criteria decision making. Prof. Georgiou has taught Quantitative Methods at various universities, and he is a member of numerous professional organizations, such as the OR Society, INFORMS, and the MCDM Society. He has contributed significantly to the field through research projects, PhD supervision, and over 80 publications in conferences and journals such as the *European Journal of Operational Research*, *Operations Research* and *Journal of the Operational Research Society*. Additionally, he has co-authored textbooks widely used in Greek universities and served on the organizing committees of numerous conferences.

Ioannis Mourtos is a Professor of Operations Research at the Department of Management Science & Technology, Athens University of Economics and Business. He studied Computer Engineering and Informatics at the corresponding department of the University of Patras and obtained both his MSc and PhD from the Operational Research Department, London School of Economics and Political Science. His research is focused in the areas of Combinatorial Optimisation and Integer Programming, examining also the integration of Integer Programming with Constraint Programming algorithms. He has published in Operations Research journals like *Mathematical Programming*, *Mathematics of Operations Research*, *INFORMS Journal on Computing*, *SIAM Journal on Discrete Mathematics* *Operations Research Letters*, *European Journal of Operational Research* and *Discrete Mathematics*, for several of which he has served as a reviewer. He has also participated in national and European research projects, in most of them as a Scientific Coordinator.

Georgios Zois is the Co-Head of the ADOPT research group of ELTRUN and Adjunct Professor at the Departments of Management Science and Technology and Informatics of AUEB. He holds a BSc. diploma in Computer Science from University of Ioannina, a MSc. in Logic, Algorithms and Computation from University of Athens and a PhD from Sorbonne University on algorithmic problems for energy and temperature-efficient computing. His research interests lie in the design and analysis of exact and near-optimal algorithms for real-life optimisation problems, including production scheduling and transportation. He has been awarded with various scholarships due to academic excellence (Heracleitus II, AUEB Action II, Google travel grant, etc.), while recently his algorithmic research in applications of Facility Location and Intermodal Transportation problems has been awarded with the "Thomas Makios" Supply Chain Award, by the Greek Cold Storage & Logistics Association. Dr. Zois has been working as technical coordinator on several EU-funded and private consulting projects, focusing on the design of optimisation services as part of Digital Twins in various industrial application areas, including process manufacturing, transport and logistics.

Stavros Lounis is a Senior Researcher at the ELTRUN E-Business Research Center of Athens University of Economics and Business (AUEB). He holds a PhD in Management Science and Technology from AUEB, a MSc in Information and Communication Technology (ICT) Systems from the School of Science and Technology of the International Hellenic University and a B.Sc. in Applied Informatics in Management and Finance from the Faculty of Management and Economics of the Technological Institute of Messolonghi. He has worked as a software engineer at the Institute for Language and Speech Processing (ILSP/ "Athena" R.C.), as well as in relevant positions

in the private and public sector. His research interests focus on Gamification of Electronic Services and Innovation and Entrepreneurship and his work has been presented in peer-reviewed academic journals and conferences.

Patricia Casla holds an MSc in Industrial Engineering (1992) and an Executive MBA (2006). She is a Senior Researcher and Project Manager at the Intelligent Information Systems Unit at Tekniker. Her research spans multiple fields, including: (1) production, quality, and industrial maintenance management; (2) optimising manufacturing processes through information technologies; (3) designing intelligent solutions within Industry 5.0 and personalised healthcare; and (4) applying semantic technologies in the industrial sector. She has contributed to over 24 collaborative research projects at national and international levels, primarily in manufacturing and healthcare. Nine of these were funded by European programmes, where she served as Principal Investigator for Tekniker's team in five (e.g., Tec4MaaSES, OntoCommons) and as Technical Coordinator for one (A4BLUE). She also represents Tekniker in the BDVA/DAIRO platform (Big Data Value Association in the Data, AI, and Robotics PPP) and the Knowledge Graph Association (KGA).