From Logic and Computation Theory to Rigorous Methods for Software Engineering

Tribute to Egon Börger on the Occasion of His 75th Birthday

Alexander Raschke[1], Elvinia Riccobene[2], and Klaus-Dieter Schewe[3]

[1] Institute of Software Engineering and Compiler Construction, Ulm University, Ulm, Germanyalexander.raschke@uni-ulm.de
[2] Università degli Studi di Milano, Milan, Italy
elvinia.riccobene@unimi.it
[3] Zhejiang University, UIUC Institute, Haining, China
kdschewe@acm.org

Egon Börger started his scientific career in philosophy, and he came to computer science via studying in depth mathematical logic. He spent two decades in logic and three decades in computer science. As he phrased it himself, his youth was dedicated to mathematics and logic, his senior years to software engineering, and with beginning seniority he worked on business processes and other applied topics. What from a superficial view may look like a straight line from theory to practice fulfils in fact the principle of "negated negation" in the sense of the German philosopher Georg Wilheim Friedrich Hegel. By confronting theoretical insights with applied problems from which they were originally derived by abstraction, new enhanced challenges are discovered that require deep scientific and thus theoretical investigation on a higher quality level. Egon Börger is known not only as an excellent scientist but also as a virtuoso for playing with the dialectic antipodes of theory and practice, bringing theoretical results into applications and extracting challenging questions from applications in order to shift scientific knowledge to a higher level.

Egon Börger was born on May 13, 1946, in Westfalia in Germany. More than mathematics he loved music, so his ambition was to become a conductor, but his teachers advised against it. So he started to study philosophy at the Université de Paris I (Sorbonne) and the Institut Supérieur de Philosophie in Louvain. Professors Joseph Dopp and Jean Ladrière, followers of the tradition of Robert Feys, aroused his interest in mathematical logic and foundations of mathematics, which in 1966 brought Egon back to his home town, Münster. This was the last place he wanted to study, and even less he wanted to be a mathematician. However, the lively spirit of mathematical logic commemorated by Heinrich Scholz and his famous student and successor Hans Hermes was just too inspiring. Professors Scholz and Hermes were among the few scientists who realised the impact of Turing's solution of Hilbert's fundamental decision problem, which manifested itself in the tight relationship between abstract computing machines and descriptive logical languages.

From the very beginning Egon was part of the Münsteranian school of logic with a strong focus on the exploration of this relationship between logic and computing science, which coined his interest in this area. He became a student of Dieter Rödding

who continued the tradition started by Gisbert Hasenjäger, Hans Hermes, and Wilhelm Ackermann, and his Ph.D. thesis was dedicated to the complexity of decision problems.

One year after completing his Ph.D. he followed an invitation by Edoardo Caianello and joined the Università di Salerno as a lecturer to help develop a new institute for computer science. Between 1972 and 1976 he gave many lectures on various computer science topics, through which he gained a deep understanding of the discipline. He returned to Münster, where he completed his habilitation in 1976 with a thesis on complexity theory. Further years as a lecturer and Associate Professor at the Universities of Münster, Udine and Dortmund followed.

The relationship between logic and computing science determined Egon's first monograph on computation theory, logic, and complexity, which was published in German in —1985 (it was later translated into English), and also— his second monograph on the classical decision problem, which he published together with Erich Grädel and Yuri Gurevich in 1997. The first monograph focused on the concept of formal language as carrier of the precise expression of meaning, facts and problems, and formal operating procedures for the solution of precisely described questions and problems. At that time the text was at the forefront of a modern theory of these concepts, paving the way in which they developed first in mathematical logic and computability theory and later in automata theory, theory of formal languages, and complexity theory. In both monographs random access machines played an important role.

After the unexpected death of Dieter Rödding it was expected by many that Egon would become his successor, but official politics at the Universität Münster prevented this. This was to the detriment of the Universität Münster, where soon its excellent standing in logic and foundations of mathematics was devastated. Universität Münster is still one of the few universities in Germany without a decent computer science department and degree program. Fortunately, Egon could still choose between other offers, and he accepted the position of a chair in computer science at the Università di Pisa, which he held until his retirement in 2011, rejecting various offers from other prestigious universities.

Right at the time of his relocation to Pisa he joined forces with Michael M. Richter and Hans Kleine Büning to establish an annual conference on "Computer Science Logic" (CSL), which soon led to the foundation of the European Association for Computer Science Logic (EACSL) with Egon as its first chairman. He held this position until 1997. Together with the North American conference series "Logic in Computer Science" (LiCS), CSL still counts as one of the most prestigious conferences in theoretical computer science focusing on the connections between logic and computing.

From 1985 on, the field of computer science started to stretch out into many new application areas. Distributed computing over networks became possible, database systems facilitated concurrent computation, artificial intelligence ventured from a niche area to a useful technology enabling inferential problem solving in diagnosis, controlling machines through software became possible, etc. Together with his long-standing collaborator Yuri Gurevich he realised that the rapid developments in computing would require radically new methods in computer science logic. It was Yuri who first formulated a "new thesis" moving computations on Tarski structures to the centre, while Egon realised that the idea of "evolving algebras"—now known as

Abstract State Machines (ASMs)—does not only create a new paradigm for the foundations of computing, subsuming the classical theory, but at the same time can be exploited for rigorous systems engineering in practice thereby fulfilling the criteria of a "software engineering" discipline that deserves this name.

One of the first achievements was the definition of an operational semantics of the Warren Abstract Machine for Prolog programs, and this work by Egon led to the formal foundation of a comprehensive abstract semantics of Prolog used by the ISO Prolog standardisation committee. Since then he has systematically and tirelessly pushed experiments to apply ASMs to real-life software systems, in particular industrial software-based systems. Unlike many other renowned researchers in the field of logic and computation, Egon never liked hiding in a snail shell away from the problems that arise in computing applications. He actively sought the challenges arising in practice. Four of his five sabbaticals during his active time in Pisa were spent with companies (IBM, Siemens, Microsoft, and SAP). He organised several Dagstuhl Seminars, acted as co-chair of several summer schools, gave numerous invited talks, and visited international institutions and academies.

He triggered and led the effort of international groups of researchers who developed the ASM method for high-level system design and analysis. At the beginning of 2000 he wrote another monograph, known as the ASM book, establishing the theoretical foundations of the formal method for building and verifying complex software-based systems in an effectively controllable manner, namely by stepwise refinement of abstract ground models to executable code. To provide a forum for ASMs, he started, in 1994, the annual workshop on Abstract State Machines, which later, in 2008, was turned into the international ABZ conference series to promote fruitful integration of state-based formal methods.

Many extensions of the ASM method are due to Egon, who has always been able to identify and capture new potential of the method, referring to new characteristics of modern complex systems. With the intention of exploiting the ASM method to tackle new challenging computational aspects, Egon has worked in many different computer science areas: from programming languages to hardware architectures, software architectures, control systems, workflow and interaction patterns, business processes, web applications, and concurrent systems.

During his long and still very active research carrier, Egon has made significant contributions to the field of logic and computer science. Since 2005 he has been an Emeritus member of the International Federation for Information Processing. In 2007, in recognition of his pioneering work in logic and its applications in computer science, he received the prestigious Humboldt Research Award, and since 2010, he has been a member of Academia Europea. He is the author of more than 30 books and over 200 scientific publications. Among the published books, three underline applications of the ASM method: (1) the book on Java and the Java Virtual Machine (JVM), which provides a high-level description of Java and the JVM together with a mathematical and an experimental analysis, and shows the correctness of a standard compiler of Java programs to JVM code and the security critical bytecode verifier component of the JVM; (2) the book on Subjective Business Process Management, which presents a novel BPM methodology focusing on process actors and their interactions; and (3) the

modelling companion with many detailed application examples of the ASM method, in particular in connection with concurrent systems.

Besides his scientific contributions as a logician and computer scientist, we would like to emphasise two prominent characteristics of Egon as a researcher, namely his deep intuition for addressing real, open and challenging problems, and his passionate approach toward solving research problems by looking deeply into problems, understanding them thoroughly, discussing them broadly with other researchers, and consistently working very hard.

Many international computer science communities owe a lot to Egon, be it for his scientific contributions and wide dissemination of his scholarly work, for his open mind, his still active service activity or his tenacious intellectual honesty.

With this Festschrift we want to express special thanks to Egon, a real master who inspired all of us.

April 2021

Alexander Raschke
Elvinia Riccobene
Klaus-Dieter Schewe