

## **TransForm: Theoretical Foundations of Transactional Memory**

The research project [TransForm](#), where [FORTH ICS](#) acted as the coordinator, has recently been completed. TransForm was a project funded by the [European Commission](#) in the context of the [Marie Curie Initial Training Network](#) action. The project contributed significantly to building the theoretical underpinning for the design and analysis of Transactional Memory (TM) systems.

The widespread adoption of multi-core processors has led to a new software revolution, the concurrency revolution. Despite the fact that concurrency is almost as old as computing and a big number of concurrent programming models and languages have been proposed in past, harnessing the difficulty of parallel programming is still a necessity. So, what the revolution is about is way more than concurrency alone: it is about concurrency for the masses.

Transactional Memory is a new programming paradigm which is considered very promising by many researchers and which has led to a plethora of publications in the past ten years. Deep understanding of the capabilities and the properties of TM systems was highly desirable in order to better understand such systems, as well as to thoroughly evaluate them and greatly improve them.

Project TransForm significantly contributed in this direction. It explored the semantics of TM systems and formulated a common framework for the design of TM algorithms and the comparison of their performance. As a result of the research efforts of the project, correctness and progress criteria for such systems were proposed and suitable complexity metrics were introduced. Moreover, efficient implementations of TM systems were designed and tested, and fundamental software structures such as shared data structures were efficiently implemented on top of them. Finally, some of the inherent limitations of such systems were discovered; such limitations have to be taken into account when designing TM systems.

TransForm offered high-quality education to twelve Early Stage Researchers (ESR) who were employed for the needs of the project. Those researchers were at an early stage of their research career, being only in possession of a Masters (MSc) degree and not of a Doctoral (PhD) title. Through their participation in the network, they were offered appropriately structured training in the research area of the project, namely concurrent computing. They were also exposed to additional training activities which armed them with the required complementary skills for a successful career. Last but not least, the project brought the ESR in contact with other professional environments such as the industry. Most of the ESR participated in the graduate studies programmes of the organizations they worked for (or the Universities co-located with these organizations), for the purpose of obtaining a PhD, and have been adequately trained through the work in the project for this purpose.

Project TransForm conducted research that can contribute to the following areas in the future. The research results conducted in TransForm are already seen as a point of reference for the design and analysis of concurrent algorithms, be they TM-oriented or not. Moreover, the research efforts of the project shed light on fundamental issues of the design and analysis of TM systems and contributed to the accurate comprehension of their actual properties. This can facilitate the widespread adaptation

of those systems and consequently the easier production of concurrent software. Finally, TransForm has led to the creation of a powerful network of collaboration between academic and research organizations and the industry which aims at efficiently using parallelism in order to fully exploit the available computational power that multi-core processors have or will have to offer in the future.

TransForm lasted for three years. Five organizations participated with Greece being the project coordinator through the [Foundation of Research and Technology Hellas \(FORTH\)](#), and more specifically through its [Institute of Computer Science \(ICS\)](#). The other organizations were the Swiss Federal Institute of Technology in Lausanne (École Polytechnique Fédérale de Lausanne – EPFL) in Switzerland, the Berlin University of Technology (Technische Universität Berlin – TUB) in Germany, the Technion – Israel Institute of Technology, and the University of Rennes 1 (Université de Rennes 1) in France. The project was further supported and co-supervised by a board of industrial partners: Deutsche Telekom (Germany), Microsoft Research (Cambridge, United Kingdom), Oracle Labs (Massachusetts, USA), IBM (T.J. Watson Research Center, USA).

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