Editorial: Diversity Galore & A Call for Resilient, Sustainable and Secure System Design

This online-only issue of Volume 13 of *ACM Transactions on Embedded Computing Systems* has an unusual diversity in its coverage of topic areas in the domain of embedded systems. It combines four special issues—some of which have been in preparation for a while, and some have had a faster turnaround time. The special issue on Real Time and Embedded Technology and Applications is based on some of the selected contributions from the 2012 edition of the RTAS conference. The special issue on Domain-Specific Multicore Computing is based on a workshop with the same title from 2012 as well. The special issue on Cross-Layer Dependable Computing also started accepting papers in 2012. On the other hand, Applications of Concurrency in System Design themed special issue is based on the 2013 edition of the ACSD conference.

This special issue indeed shows the vast range of research areas and topics that are being tackled in making embedded computing more efficient, dependable, optimized, and able to exploit concurrency in applications and available architectures. This also points out the immense number of challenges the engineers face in delivering the next generation embedded systems—the next smart phone, the next automotive or aeroplane, or next generation critical infrastructures. On one end of the system stack, nanoscale manufacturing is ushering in uncertainty in computing in terms of variations of parameters that were deterministic in the past, or in terms of dependability. On the other end, growing demand on functionalities, crowded and noisy communication media, reducing time-to-market windows, and ever increasing customer expectation are challenging the traditional methodology, abstraction-based separation of concern, and design process.

As one can garner by browsing through the articles in this issue, while the challenge is mouting, so are the efforts and innovations by researchers. New approaches, ranging from defining domain-specific languages, compilers, and tools to the breaking down of abstraction barriers for cross-layer design optimization, ensure that no stone is left unturned to achieve dependability in the face of uncertainty, optimization when clear separation of abstraction layers start to melt away, and validation in the face of paramount complexity.

Having witnessed the evolution in design automation over the last decade and a half, I still find that, in spite of all these highly innovative research efforts, engineering productivity, system dependability, and exploitability of available concurrency provided by today's architecture remains a huge challenge. But what bothers me the most is that even further challenges are emerging all the time. To give a few examples, let me mention cybersecurity, resilience in the face of cyber attacks as well as other catastrophic unforeseen events, and sustainable system design.

In the beginning, cybersecurity was more about confidentiality and privacy of data and less about integrity and availability of computing and services. Today, while confidentiality and privacy of data remain as vulnerable as ever, we are faced with the issue of malicious manipulation of the computation process, denial of service or computation, especially in the domain of critical infrastructures, automotive, and aviation. While no one has claimed that the MH370 flight was lost due to cyber attacks, is it not possible to make that happen through cyber attacks launched on the distributed embedded flight control by an onboard attacker using wireless communication? It has been shown by

multiple researchers that many of today's automotive controls can be easily manipulated remotely. What about the power grid, nuclear plants, or chemical manufacturing plants? They all are distributed embedded systems, and they have vulnerabilities that can be exploited like what was done in Iran by the Stuxnet worm.

The notion of resilience is discussed a lot these days, including in social sciences. A resilient system has the ability to fight through an attack—malicious or naturally occurring events including system bugs. Resilient systems can gracefully degrade to minimal functionality that can keep the system safe until it is recovered or shut down. Do we have methodologies, metrics, tools, trade-offs for resilient embedded computing system design? If not, we must, in my view. A compromised avionics control must be able to detect that it has been compromised, and it must switch to a safe yet minimal control to land an aircraft to safety. A compromised nuclear plant must not lose complete control in a disaster like in Fukushima, and it must do a graceful shutdown irrespective of how unforeseen the events might be.

While the third issue, sustainability, is not exactly associated with the two design qualities just mentioned, it is nonetheless very urgent and important. Although green computing in the data centers and high-performance computing arena has made some headway, in the embedded computing arena, it is still not a primary focus. The smart phone we use still needs charging at the end of the day and generates a lot of heat to do routine activities, leading to various issues including health concerns. Energy/heat are not the only issues though, the lifecycle management of these devices is also a concern in polluting nature and requires a thorough look.

While to some readers it might seem irrelevant to this compendium of special issues and their topics, I am using my editorial column to raise these concerns and invite researchers to take these issues seriously, and I am sure many of my esteemed colleagues have been doing so. I would encourage submission of articles on these topics to the TECS journal; I believe that it will be enriched by the publication of articles that address these concerns. To be clear, I am not suggesting that articles on traditional topics of embedded computing arena will get any less consideration. The traditional topics are extremely challenging areas of research, and we need more articles on those as well. Nevertheless, we need some articles on the topics of secure, resilient, and sustainable embedded system design. I will also encourage special issue proposals on these topics, and we also have two associate editor positions unfilled in these areas. So I urge all readers to look at our journal website and contact me if any of you are willing to take on these topics as your editorial responsibility, especially resiliency and sustainability in embedded system design.

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