Researchers Awarded Patent for Method to Innovate Mixed-signal Integrated Circuit Design

May 2015

by: UNT College of Engineering

Two University of North Texas (UNT) engineering researchers and an alumnus were awarded a U.S. patent for their work to advance the design of mixed-signal integrated circuits, which are used in cell phones and other portable technologies.

Dr. **Saraju Mohanty (http://www.cse.unt.edu/~smohanty/)** and Dr. **Elias Kougianos (https://engineering.unt.edu/technology/people/elias-kougianos)**, both with the UNT College of Engineering, as well as Dr. **Geng Zheng (https://www.linkedin.com/in/gengzheng)**, who received his Ph.D. in Computer Science and Engineering from UNT, are the co-inventors of an "**Intelligent metamodel integrated Verilog-AMS for fast and accurate analog block design exploration (http://www.google.com/patents/US20140282314)**."

Mixed-signal integrated circuits (mixed-signal ICs) are integrated circuits that have both analog circuits and digital circuits on a single semiconductor die. "Mixed-signal circuits and systems are heavily used in applications like smart mobile phones that we use every moment in our day-to-day life," Mohanty said.

As a specific usage example, they are often used for converting analog signals to digital signals.

Mixed-signal ICs are more difficult to design than analog-only or digital-only integrated circuits. The gap between abstraction levels in analog design is a major obstacle for advancing, implementing and verifying analog and mixed-signal integrated circuit design. “Based on my industrial experience I can say that full-blown simulation of a mixed-signal circuit at the physical design level is a matter of weeks and our invention reduces it to a matter of few hours,” Kougianos said.

In order to achieve high performance and high yield, mixed-signal system components or analog blocks must be optimized at both system and circuit levels. For a top-down design approach, which didn’t exist for analog or mixed-signal designs as of now, this process starts with designing and optimizing the system with block or component models at high levels of abstraction.

The specifications for each block that lead to the best system performance are then obtained. Each sub-block is then designed and optimized toward these specifications. Generating an accurate model requires a significant effort, but it is a one-time job. However, some important characteristics of the blocks are ignored at the existing high-level simulations, which makes the resulting sub-block specifications less reliable and less accurate, are accommodated through this invention.

Mohanty, Kougianos, and Zheng developed a method for modeling a circuit that includes storing a plurality of design variable ranges for a circuit component in a non-transient electronic data memory. Transistor-level simulations are then performed at a plurality of sample points for the circuit component to generate a plurality of design variable samples for the circuit component.

A neural network architecture is stored in the non-transient electronic data memory that models the plurality of design variable samples for the circuit component. A performance metric metamodel and a circuit parameter metamodel are also stored in the data memory. These metamodels are generated using Verilog-AMS (derivative of the Verilog hardware description language that includes analog and mixed-signal extensions). “We have named our invention iVAMS, i.e. intelligent Verilog-AMS,” Mohanty and Kougianos said.

In order to educate undergraduate and graduate students in this field of mixed-

signal design, Prof. Mohanty has recently authored a comprehensive textbook titled **Nanoelectronic Mixed-Signal System Design (http://www.mhprofessional.com/product.php?isbn=0071825711)** , published by McGraw-Hill under the ISBN: 978-0071825719 in 2015. This is a letter paper size 800-page text with 700 illustrations that comprehensively covers all aspects of Nanoelectronic mixed-signal VLSI Circuits and Systems. The book discusses mixed-signal circuit and system design based on both existing nanoscale CMOS and emerging nanoelectronic technologies and is adopted as a text in VLSI courses.

About the researchers

Mohanty is an Associate Professor in the UNT **Department of Computer Science and Engineering (http://www.cse.unt.edu/site/index.php)** and is the founder and director of the **NanoSystem Design Laboratory (http://nsdl.cse.unt.edu/)** (NSDL). He is the recipient of four patents with applications in Digital watermarking, Digital rights management (DRM), and Mixed-signal integrated circuit design.

Kougianos is an Associate Professor in the UNT **Department of Engineering Technology (https://engineering.unt.edu/technology/)** . He has over 25 years of industrial and research experience and is a co-founder of the **NanoSystem Design Laboratory (http://nsdl.cse.unt.edu/)** . He is a co-inventor of two patents with Mohanty.

Zheng is a Design Verification Engineer at Analog Devices where he performs design verification for various analog/mixed-signal circuits and systems. He was a recipient of the Outstanding Doctoral Student in Computer Science and Engineering at UNT. He did his Ph.D. research in **NanoSystem Design Laboratory (http://nsdl.cse.unt.edu/)** (NSDL) with Mohanty as a major and Kougianos as a co-major professor.

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