Flash Memories Researcher Wins Intel Ph.D. Fellowship

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Daniel Kane

Future USB drives, memory cards for cameras, and solid-state drives for smartphones, laptops and enterprise systems may all benefit from the research being performed by University of California, San Diego electrical engineering Ph.D. student Eitan Yaakobi. For his past research accomplishments and future research potential, Yaakobi earned a sought after 2010-2011 Intel Ph.D. Fellowship.

"This is a very prestigious award, and winning students are recognized as being tops in their areas of research," Intel reported in a statement. Flash memories are widely used in mobile, embedded, and mass-storage applications; and their use continues to grow. Smartphones and mp3 players, for example, rely on flash memories which - unlike hard drives - have no spinning disk or other moving mechanical parts that don't do well when dropped. Flash memories are relatively low power, and boast fast random access speed.

Flash technologies, however, still cost more per storage unit, and have shorter lifetimes, than the latest disk drives.

Yaakobi and his collaborators are working on improving the reliability, capacity and endurance of flash memories by improving the commands and instruction sets that tell flash memory devices how to work. This is the "coding" for flash memories.

"The number of times you can erase the memory is limited," said Yaakobi. "We are working on advanced coding schemes for flash to extend the lifetime and reliability of the memory so the next generation of flash will be more reliable and will have better endurance."

Yaakobi is advised by professors Paul Siegel, Alexander Vardy and Jack Wolf from the Department of Electrical and Computer Engineering (ECE) at the UC San Diego Jacobs School of Engineering.

"Eitan is one of the top two or three of the 60-plus Ph.D. students that I have advised in my 45 years of university teaching. He is extremely bright and very highly motivated. He grasps new concepts almost instantly and has demonstrated excellence in working in a number of different research areas," said Wolf in an article in the Winter 2010 Newsletter of the UCSD Center for Magnetic Recording Research (CMRR).

WOM Codes

With flash memories, once you write to memory, if you want to change a 1 to a 0, you need to erase an entire block of memory, which can be as large as 128 or 256 kilobytes.

Some of Yaakobi's work is focused on improving this situation. In particular, he and his collaborators are working on improving an instruction type that has been used to control flash and other so-called "write-once memories."

Initially, rewriting a single cell in write-once memories was not possible. But in 1982, Ronald Rivest and Adi Shamir developed codes that allow data to be written several times to write-once memories. These types of instruction are called Write Once Memory (WOM) Codes.

"We came up with better WOM codes that allow writing more information to the memory. These new schemes increase the amount of data you can write into the memory before you need to erase the memory," said Yaakobi. "Instead of writing once into the memory, one can write more than once into the memory - that means it is possible to write multiple times without erasing, so you can extend the lifetime of the flash by a factor of two or three or even more."

Yaakobi and his collaborators from the Center for Magnetic Recording Research (CMRR) are collaborating with computer science professor Steven Swanson and his Non-Volatile Systems Laboratory in the Department of Computer Science and Engineering (CSE) at UCSD in order to implement these theoretical advances in actual flash memory technologies.

"Eitan has played a critical role in the formation and growth of the research thrust on non-volatile memories at CMRR," says professor Siegel, who also serves as CMRR Director. "His research contributions - individual as well as in collaboration with researchers in industry and other universities - have brought tremendous visibility to this major new research program at the Center."

Yaakobi and collaborators recently presented related work at the 2010 IEEE Information Theory Workshop, and the 2010 Allerton Conference on Communication, Control and Computing. In December, he will give a presentation on error characterization and coding schemes for flash memories at the IEEE Globecom 2010 Workshop on Application of Communication Theory to Emerging Memory Technologies .

Media Contact: dbkane@ucsd.edu, or 858-534-3624