New Method Evaluates Boolean Formulas Using Sneak Paths

In crossbar computing, sneak paths are transformed from computational challenges into first-class design elements.

Crossbar computing and, particularly, the evaluation of Boolean formulas, has been an active and ongoing research topic. Boolean-formula computation that uses memristor circuits has also been recently examined. Previous memristive Boolean-formula evaluation strategies have encountered two major problems. The first involves the use of a few memristors that interact with other non-memristive circuit elements. This heterogeneous mixture of circuit elements is difficult to place on the same hybrid chip. The second problem is the requirement of a global clock due to the reliance on correctly timed, sequenced inputs. Such synchronous extreme-scale circuits are quite difficult to design. As a well-known issue, sneak paths have posed a particular challenge in the design of pervasive general-purpose crossbar computing paradigms. This significant amount of current can flow through unknown paths in parallel to the relevant memristor and can prevent the correct detection of current resistance or flow through the device.

Advantages
UCF researchers have created an efficient, low-energy method that repurposes sneak paths in nano-crossbar computing to create a Boolean-formula evaluation strategy. This novel method is an effective approach for synthesizing high-performance customized to arithmetic and logic circuits. Additionally, this groundbreaking paradigm eliminates the need for the traditional Von Neumann architectural separation of memory and computation units. This design can be useful in several fields including computational data science, cybersecurity, and extreme-scale simulation of complex systems.

Technical Details
This invention encodes a Boolean formula using a memristor-based crossbar lattice, consisting of nanowires arranged in rows and columns, with at least one sneak path that exists between the input and the output nanowires when the Boolean formula evaluates to TRUE. Each memristor is connected to a unique pair of nanowires from an associated row and an associated column and is assigned a flow state and a no-flow state, per the encoded Boolean formula. A memristor is configured to allow current flow through the memristors between the linked row and column nanowires when in a flow state, and to prevent current flow when in a no-flow state.

UCF Inventors
Sumit Jha, Ph.D.; Alvaro Velasquez

Related Publication

Benefits
• Efficient
• Low in energy
• Eliminates the barrier between memory and microprocessor

Applications
• High-performance computing
• Computational data science
• Cybersecurity
• Extreme-scale simulation of complex systems
  – Agent-based models
  – Biochemical reactions
  – Fluid dynamics computations

Tech Field
Software

Keywords
Boolean formula, memristor, nano-crossbar computing, crossbar computing, sneak paths, simulation, data science, agent-based models, nanowires, fluid dynamics

Patent Pending