Spiking Neural Network Architecture

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ARM microprocessors are found in nearly every consumer device, from smartphones to gameboxes to e-readers and digital televisions. But did you know that, combined, these same ARM microprocessor cores can simulate the human brain?

The Spiking Neural Network Architecture (SpiNNaker), a massively parallel neurocomputer architecture, aims to use more than one million ARM microprocessor cores to model—in real biological time—nearly one billion spiking neurons.[1] The model comes from the University of Manchester's Advanced Processor Technologies Team under the guidance of Steve Furber, an IEEE Fellow and 2013 IEEE Computer Pioneer Award recipient (www.youtube.com/watch?v=x_H_6xG1TEs). Furber's vision is to apply computer engineering techniques to multidisciplinary research on information processing in the brain.

In 2013, *IEEE Transactions on Computers* (TC) published Furber and his colleagues' article on the SpiNNaker system's architecture and physical design.[1] Furber also prepared a video illustrating the paper's contributions (www.youtube.com/watch?v=EhPpxsK2Ia0). As editor in chief of *TC*, I invite you to read not only the original paper but also its 2015 follow-up.[2] In the most recent paper, Furber and his colleagues describe the innovative SpiNNaker software:

> *It possesses an architecture that is completely scalable to a limit of over a million cores, and the fundamental design principles disregard three of the central axioms of conventional machine design: the core-core message passing is non-deterministic ...; there is no attempt to maintain state (memory) coherency across the system; and there is no attempt to synchronize timing over the system.*
>
> *Each of the million cores has ... only a small quotient of physical resource. ... The inter-core messages are small (≤72 bits) and the message passing itself is entirely hardware brokered, although the distributed routing system is controlled by specialized memory tables that are configured with software. The boundary between soft-, firm- and hardware is even more blurred than usual.*[2]

Each low-power ARM core has limited resources, so the SpiNNaker engine uses no more than 90 kilowatts of electrical power.

Furber and his team's research outlines a broader picture in which inexact computing—using less energy and power—could form the backbone of an emerging research and multidisciplinary application area. This topic is increasingly relevant in the context of sustainability and green computing. Their research also stimulates exploration of ways that the axioms of conventional machine design can be drastically changed to achieve different and very ambitious goals. Inspired by Furber and his colleagues, scientists might open themselves to new approaches in which creativity reshapes how computing systems are designed and implemented.

REFERENCES

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2. A.D. Brown et al., "SpiNNaker—Programming Model," *IEEE Trans. Computers*, vol. 64, no. 6, 2015, pp. 1769–1782.

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