Tiny chip mimics brain, delivers supercomputer speed

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IBM's new neurosynaptic processor intergrates 1 million neurons and 256 million (414) synapses on a single chip. Credit: IBM

Researchers Thursday unveiled a powerful new postage-stamp size chip delivering supercomputer performance using a process that mimics the human brain.

The so-called "neurosynaptic" chip is a breakthrough that opens a wide new range of computing possibilities from self-driving cars to artificial intelligence systems that can installed on a smartphone, the scientists say.

The researchers from IBM, Cornell Tech and collaborators from around the world said they took an entirely new approach in design compared with previous computer architecture, moving toward a system called "cognitive computing."

"We have taken inspiration from the cerebral cortex to design this chip," said IBM chief scientist for brain-inspired computing, Dharmendra Modha, referring to the command center of the brain.

He said existing computers trace their lineage back to machines from the 1940s which are essentially "sequential number-crunching calculators" that perform mathematical or "left brain" tasks but little else.

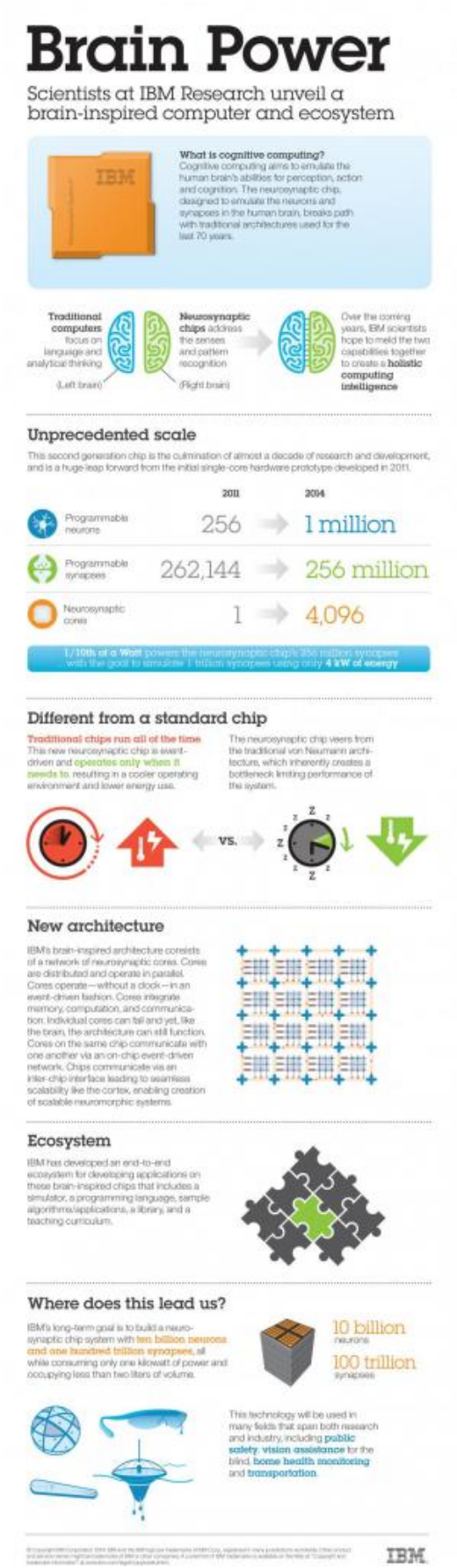
The new chip dubbed "TrueNorth" works to mimic the "right brain" functions of sensory processing—responding to sights, smells and information from the environment to "learn" to respond in different situations, Modha said.

It accomplishes this task by using a huge network of "neurons" and "synapses," similar to how the human brain functions by using information gathered from the body's sensory organs.

The researchers designed TrueNorth with one million programmable neurons and 256 million programmable synapses, on a chip with 4,096 cores and 5.4 billion transistors.

A key to the performance is the extremely low energy use on the new chip, which runs on the equivalent energy of a hearing-aid battery.

Sensor becomes the computer


Brain Power
Scientists at IBM Research unveil a brain-inspired computer and ecosystem
What is cognitive computing?
Cognitive computing aims to emulate the human brain's abilities for perception, action and cognition. The neurosynaptic chip, designed to emulate the neurons and synapses in the human brain, breaks path with traditional architectures used for the last 70 years.
Traditional computers focus on language and analytical thinking
(Left brain)
Neurosynaptic chips address the senses and pattern recognition
(Right brain)
Over the coming years, IBM scientists hope to meld the two capabilities together to create a holistic computing intelligence
Unprecedented scale
This second generation chip is the culmination of almost a decade of research and development, and is a huge leap forward from the initial single-core hardware prototype developed in 2011.
2011
2014
Programmable neurons
256
1 million
Programmable synapses
262,144
256 million
Neurosynaptic cores
1
4,096
1/10th of a Watt powers the neurosynaptic chip's 256 million synapses with the goal to simulate 1 trillion synapses using only 4 kW of energy
Different from a standard chip
Traditional chips run all of the time
This new neurosynaptic chip is event-driven and operates only when it needs to, resulting in a cooler operating environment and lower energy use.
The neurosynaptic chip veers from the traditional von Neumann architecture, which inherently creates a bottleneck limiting performance of the system.
vs.
New architecture
IBM's brain-inspired architecture consists of a network of neurosynaptic cores. Cores are distributed and operate in parallel. Cores operate—without a clock—in an event-driven fashion. Cores integrate memory, computation, and communication. Individual cores can fail and yet, like the brain, the architecture can still function. Cores on the same chip communicate with one another via an on-chip event-driven network. Chips communicate via an inter-chip interface leading to seamless scalability like the cortex, enabling creation of scalable neuromorphic systems.
Ecosystem
IBM has developed an end-to-end ecosystem for developing applications on these brain-inspired chips that includes a simulator, a programming language, sample algorithms/applications, a library, and a teaching curriculum.
Where does this lead us?
IBM's long-term goal is to build a neurosynaptic chip system with ten billion neurons and one hundred trillion synapses, all while consuming only one kilowatt of power and occupying less than two liters of volume.
10 billion
neurons
100 trillion
synapses
This technology will be used in many fields that span both research and industry, including public safety, vision assistance for the blind, home health monitoring and transportation.
IBM

Infographic: A brain-inspired chip to transform mobility and Internet of Things through sensory perception. Credit: IBM

This can allow a chip installed in a car or smartphone to perform supercomputer calculations in real time without connecting to the cloud or other network.

"The sensor becomes the computer," Modha told AFP in a phone interview.

"You could have better sensory processors without the connection to Wi-Fi or the cloud.

This would allow a self-driving vehicle, for example, to detect problems and deal with them even if its data connection is broken.

"It can see an accident about to happen," Modha said.

Similarly, a mobile phone can take smells or visual information and interpret them in real time, without the need for a network connection.

"After years of collaboration with IBM, we are now a step closer to building a computer similar to our brain," said Rajit Manohar, a researcher at Cornell Tech, a graduate school of Cornell University.

The project funded by the US Defense Advanced Research Projects Agency (DARPA) published its research in a cover article on the August 8 edition of the journal *Science*.

The researchers say TrueNorth in some ways outperforms today's supercomputers although a direct comparison is not possible because they operate differently.

But they wrote that TrueNorth can deliver from 46 billion to 400 billion "synaptic" calculations per second per watt of energy. That compares with the most energy-efficient supercomputer which delivers 4.5 billion "floating point" calculations per second and per watt.

The chip was fabricated using Samsung's 28-nanometer process technology.

"It is an astonishing achievement to leverage a process traditionally used for commercially available, low-power mobile devices to deliver a chip that emulates the human brain by processing extreme amounts of sensory information with very little power," said Shawn Han of Samsung Electronics, in a statement.

"This is a huge architectural breakthrough that is essential as the industry moves toward the next-generation cloud and big-data processing."

Modha said the researchers have produced only the chip and that it could be years before commercial applications become available.

But he said it "has the potential to transform society" with a new generation of computing technology. And he noted that hybrid computers may be able to one day combine the "left brain" machines with the new "right brain" devices for even better performance.

More information: "A million spiking-neuron integrated circuit with a scalable communication network and interface," by P.A. Merolla et al. *Science*, 2014. www.sciencemag.org/lookup/doi/ … 1126/science.1254642