Connectivity of a Cognitive Computer Based on the Macaque Brain
Emmett McQuinn, Pallab Datta, Myron D. Flickner, William P. Risk, and Dharmendra S. Modha, IBM Research - Almaden

The ghostly neon swirl nearly stumped the judges when they first looked at this illustration. Biologist and judge Michael Reddy says that a cognitive computer is “the last thing on Earth” he would have guessed that the image represented at first glance. Inspired by the neural architecture of a macaque, it is the wiring diagram for a new kind of computer that, by some definitions, may soon be able to think.

Over the past 2 years, IBM’s cognitive computing group in San Jose, California, has made great strides toward designing a computer that can detect patterns, plan responses, and learn from its mistakes, says Emmett McQuinn, a hardware engineer at IBM who designed the image. In 2011, the company demonstrated a new kind of computer chip, based on neural circuitry, that combines memory and computational processing for nimbler problem-solving in areas where traditional computers fall short, such as pattern recognition. Then, the company used data from studies of macaque brains to see how those “neurons” should link up, and simulated neural networks with billions of neurons and trillions of axons and synapses.

The first step in creating an illustration to communicate the new wiring system was to reduce trillions and billions of data points to less overwhelming numbers. Even roughly 4000 nodes and 300,000 connections was challenging to get on a single page, McQuinn says. “Fortunately, nature has already thought of this.” First, he clustered and colored the nodes based on the 77 different functional regions that neuroscientists have identified in the macaque brain. Then, after many draft layouts, he found a circular arrangement that pleased him.

“They took something that we know works fantastically efficiently in nature—the circuitry of the brain—and applied that geometry to computing. Then, they found an elegant and beautiful way to display it,” judge Thomas Wagner says.

Cerebral Infiltration
Maxime Chamberland, David Fortin, and Maxime Descoteaux, Sherbrooke Connectivity Imaging Lab

A malignant brain tumor (red mass, left) in this person’s brain is wreathed by fine tracts of white matter. The red fibers signal danger: If severed by the neurosurgeon’s scalpel, their loss could affect the patient’s vision, perception, and motor function. Blue fibers show functional connections far from the tumor that are unlikely to be affected during surgery. Together, the red and blue fibers provide a road map for neurosurgeons as they plan their operations.

Computer science graduate student Maxime Chamberland of the Sherbrooke Connectivity Imaging Lab in Canada produces images like these on a weekly basis, he says. Using an MRI technique that detects the direction in which water molecules move along the white matter fibers, he generates a three-dimensional image of functional connections in the brain. In addition to the image’s haunting beauty, people respond to the frightening immediacy of the tumor, he says: “They want to know if the patient is ok.” Fortunately, this story has a happy ending: The tumor was removed with no functional damage.