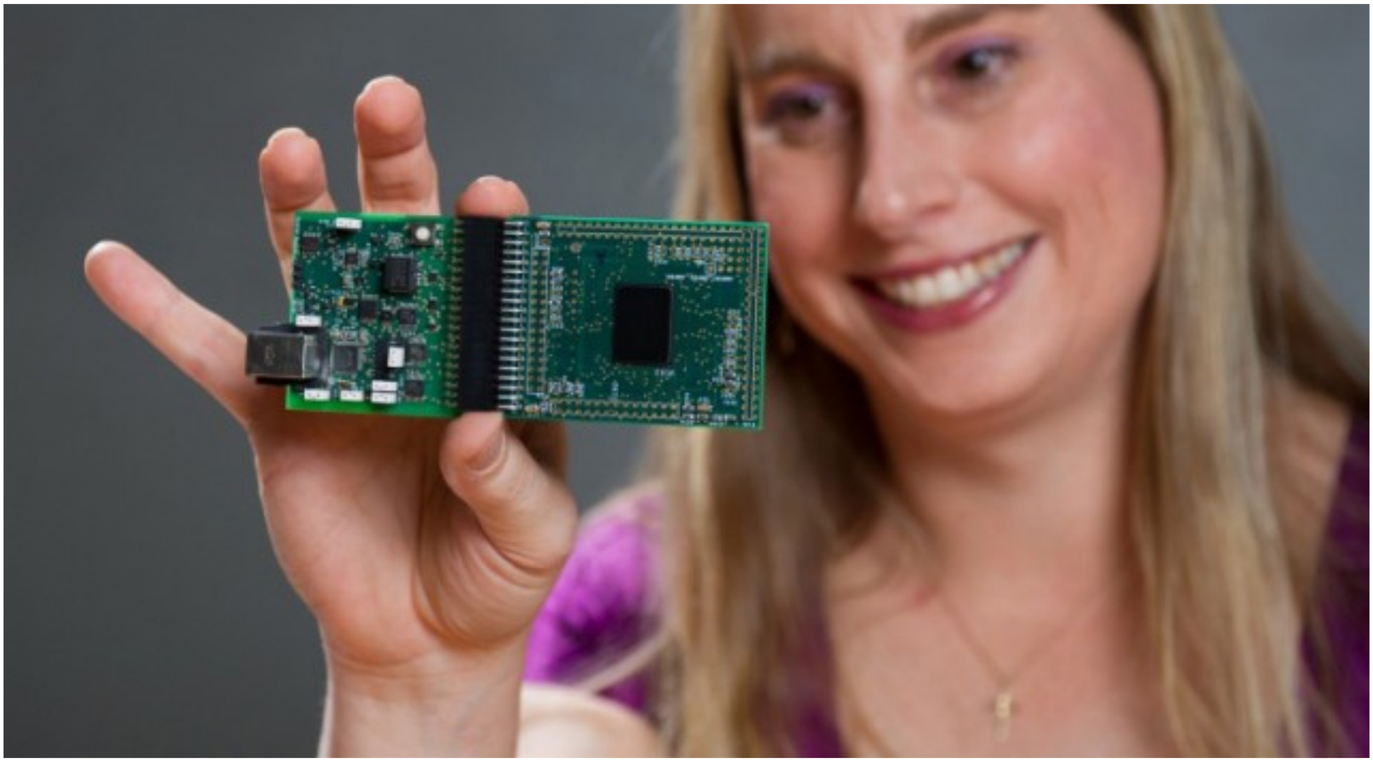
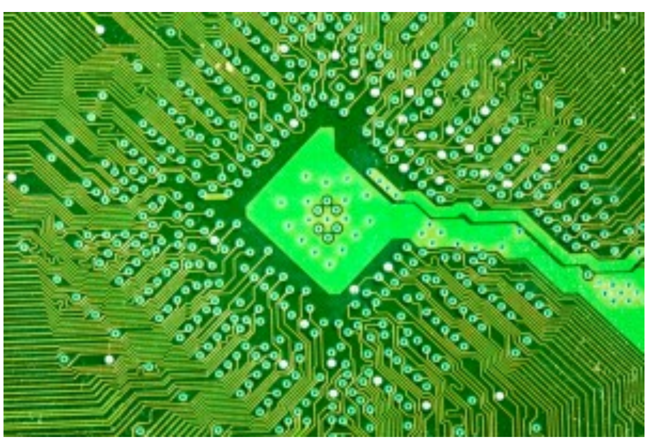
# Researchers create a roadmap for neuromorphic brain-like CPUs

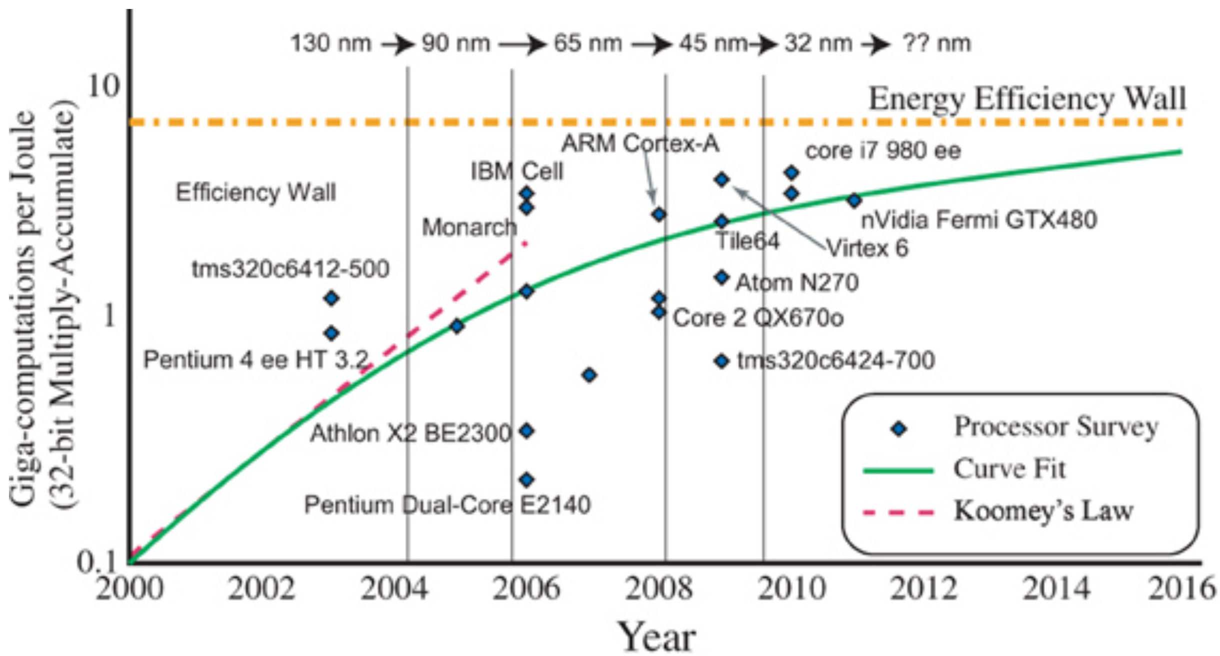


Like a startup company in search of a mission statement, neuromorphic engineering has yet to define for itself a clear path forward. There have been advances in a few select pockets — Synaptics' touchpads, Foveon's CMOS color imagers, or Sonic Innovation's hearing aids may come to mind — but as a whole, the field knows neither what it wants exactly, nor how to do it. A roadmap to the future has recently been published by researchers from Georgia Tech, with the end goal being nothing less than human-brain equivalent processing.



Jennifer Hasler, lead author of the roadmap [doi: 10.3389/fnins.2013.00118], has sorted through the many different approaches for the ultimate embodiment of neurons *in silico* and come up with the technology that she thinks is the way forward. Her answer is not digital simulation with FPGAs or GPUs, memristors, nor even neuristors, but rather the lesser known technology of FPAAs (Field-Programmable Analog Arrays). FPAAs are similar to digital FPGAs, but also include reconfigurable analog elements. They have been around on the sidelines for a few years (you can buy one from a company called Anadigm), but they have been used primarily as so-called "analog glue logic" in system integration.

Traditionally glue logic meant the components that glued together the protocols and buses of the various digital chips. Systems increasingly require things like multiple power planes, voltage levels, power sequencing, sleep mode power, high-voltage LED drivers, or quality audio processing. The "system glue" often requires analog functions that don't readily fit on 90 and 65nm silicon. System-on-a-chip solutions (SoC) have led to the demand for mixed signal ASICs to gather together many different analog functions in one place.




Energy efficiency of CPUs over the last few years.

Jennifer outlines an approach where desktop neuromorphic systems will use SoC approaches to emulate billions of low-power neuron-like elements that compute using learning synapses. Each synapse has an adjustable strength associated with it and is modeled using just a single transistor. Her FPAA boards house hundreds of thousands of programmable parameters which enable systems-level computing on a scale that dwarfs other FPAA designs. At the moment, she predicts that human brain-equivalent systems will require an eight order of magnitude power reduction over the digital supercomputers currently used to simulate neuromorphic systems.

Jennifer believes that migrating to FPAAs will make up four of those orders of magnitude, but the other four will have to come from elsewhere. She forecasts that using soon to be available 10nm processes, a desktop system with human-like processing power that consumes just 50 watts of power may eventually be a reality. Chips with millions of neuron-like skeletons connected by billion of synapses firing to push each other over the edge should be capable of doing something. But what? Systems available now, like the special purpose silicon retinas used in the Curvace camera still make do without complex spiking neurons. Migrating to systems based on spikes will entail a steep learning curve.