HIGH PERFORMANCE DATA ANALYTICS

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Neuromorphic Computing

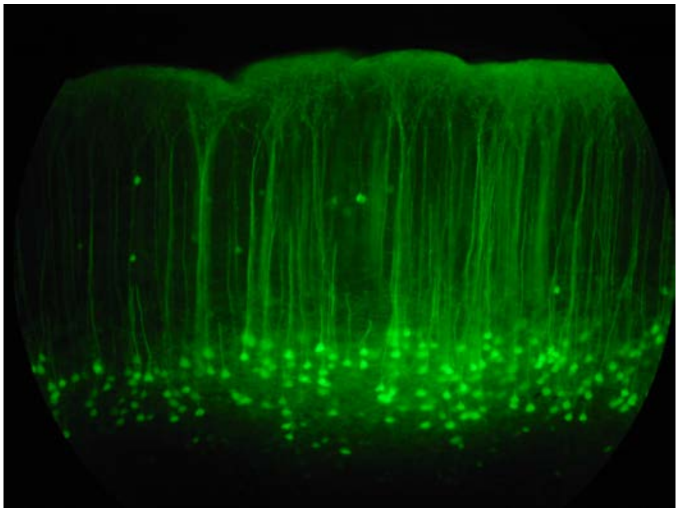
CHALLENGE

Neuromorphic computing is poised to become a disruptive technology for the field of high-performance computation. The goal is to represent brain structure and function using specially designed computer chips, realizing the benefits of human computation, such as continuous learning, fault tolerance, and the ability to deal with noisy input.

Neuromorphic computing represents a fundamental change from classic von Neumann architecture computing. It is built on a computational model patterned on the human brain, incorporating an interconnected network of nodes, or "neurons," that make it possible to encode information far more efficiently than classic computer chips. Computers that incorporate a neuromorphic approach promise to excel at pattern recognition with far less energy use (and heat) than conventional chips and have the potential to overcome looming barriers to increased computing speed. Researchers expect a neuromorphic processor will provide superior performance for identifying and responding to error messages and in processing sensor, image, and video data.

Cybersecurity is an example of a critical problem with extremely high data rates and volumes. A neuromorphic computing approach could have immediate, high impact in this domain. As opposed to reactionary nature of current network management and cybersecurity protocols, a higher level of functionality in anomaly detection and the ability to correlate multiple, seemingly unrelated features using a flexible, online learning approach could enable new methods to manage and maintain networks at varying scales of deployment.

Applying neuromorphic computing to anomaly analysis for NetFlow data.



Neuromorphic computing is based on a computational model patterned on the human brain with an interconnected network of nodes.

CURRENT PRACTICE

NetFlow is an analysis method to characterize cyber traffic through a network. Additional investigations can expose information about traffic behavior over time. NetFlow records are captured (or sampled), compiled, and moved to a storage device for subsequent analysis. Many tools use query- and visualization-based investigation. These techniques allow analysts to pick apart NetFlow streams to establish situational awareness and identify potentially

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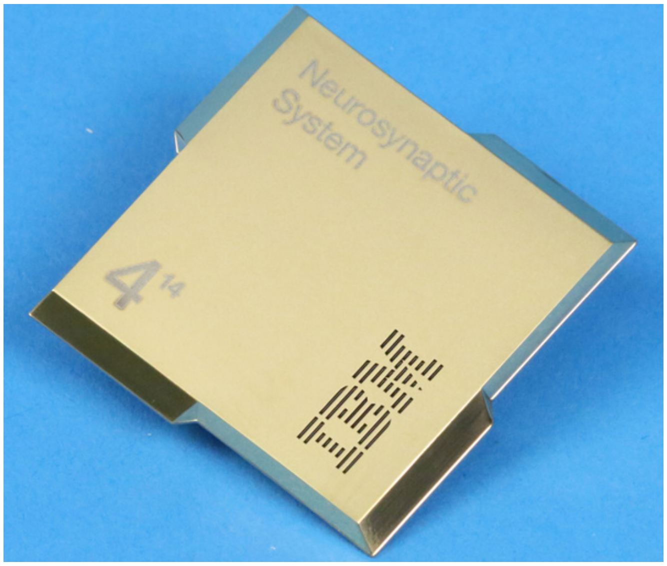
problematic Internet protocol (IP) addresses, activities, and trends. Visual analytic tools, such as Secure Decision's VIAssist, use manual filters and queries combined with visual displays to assist a user in identifying potential problems.

TECHNICAL APPROACH

To examine NetFlow data for anomalous behaviors, we will apply the Numenta Hierarchical Temporal Memory (HTM) model. HTM uses an unsupervised Hebbian-like learning approach to perform sequence learning. HTM can learn multiple variable-order temporal sequences, which enables it to maintain multiple predictions as evidence is collected. The approach also has the added advantage of continuous online learning, robustness to sensor noise, and fault tolerance. Specifically, we intend to:

- Explore neuromorphic computing as an alternative high-performance computing architecture. We will establish a neuromorphic computing testbed at PNNL with one or more different neuromorphic processors. The first choice for the testbed will be the IBM TrueNorth system. Other systems to be considered may come from Stanford University, HRL Laboratories, or the European Human Brain Project.
- Explore promising neuromorphic models, such as Numenta NuPIC, to examine application of the HTM model to NetFlow analysis. These will be used as a basis to determine requirements about developed algorithms for a hardware platform.
- Obtain and explore a neuromorphic hardware platform, such as IBM's TrueNorth, and determine requirements for performing a neuromorphic-based anomaly analysis.
- Develop benchmarks and metrics for NetFlow behavior analysis.
- Run and analyze results using an existing large NetFlow data set with known ground truth that includes adversary actors.

As currently implemented, the IBM TrueNorth system focuses on low-energy, real-time applications and does not include an unsupervised learning model on the chip or extensive neural plasticity. Thus, the application developer must exercise care in planning for development. The IBM team developed both a simulator and a programming environment for TrueNorth. The simulator, Compass, may be useful in better understanding the workings of a set of TrueNorth cores executing in parallel. The programming environment, Corelet, would be required to develop TrueNorth "programs" using the new paradigm of working with the neuromorphic chip. We will assess the TrueNorth chip and programming environment, to determine the requirements and metrics for analyzing NetFlow stream data.



One of a number of neuromorphic processors being tested as an alternative high-performance computing architecture. (Photo courtesy of IBM Research)

IMPACT

Neuromorphic processing is envisioned to be a leap ahead in computational performance and capability. Our proposed exploration of this technology will pave the way toward demonstrating the impact of neuromorphic computing in a broad range of applications. While research is still in its early stages, a hybrid neuromorphic computer-supercomputer could deliver outstanding computational performance, along with reduced size and speed profiles.

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