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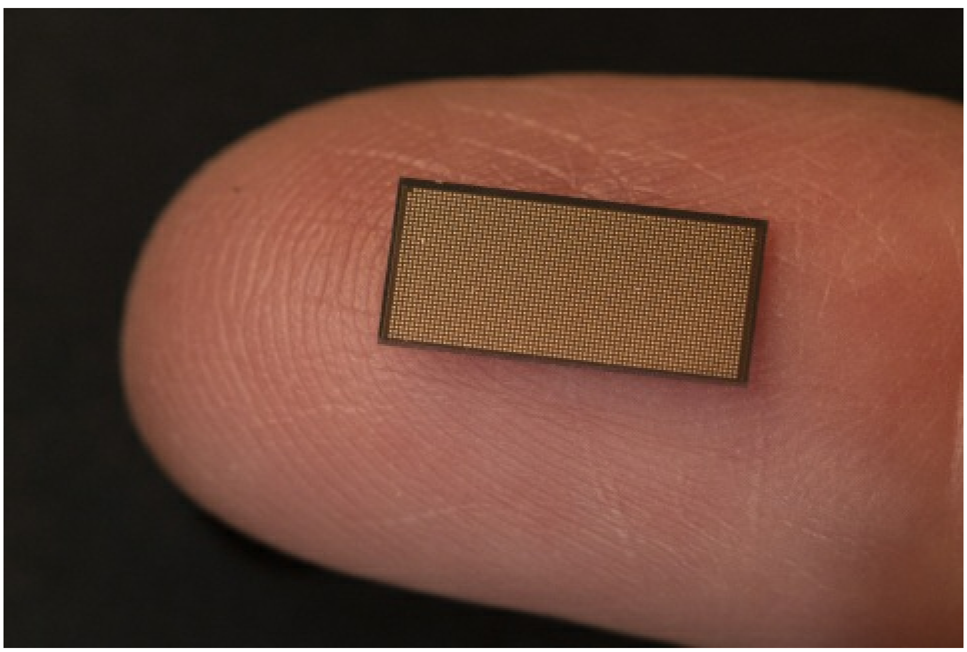
Intel Advances Neuromorphic with Loihi 2, New Lava Software Framework and New Partners

Second-generation research chip uses pre-production Intel 4 process and grows to 1 million neurons. Intel adds open software framework to accelerate developer innovation and path to commercialization.

SANTA CLARA, Calif.--(BUSINESS WIRE)-- **What's New:** Today, Intel introduced Loihi 2, its second-generation neuromorphic research chip, and Lava, an open-source software framework for developing neuro-inspired applications. Their introduction signals Intel's ongoing progress in advancing neuromorphic technology.

This press release features multimedia. View the full release here: https://www.businesswire.com/news/home/20210930005258/en/



A photo shows Intel's Loihi 2 neuromorphic chip on the tip of a finger. Loihi 2 is Intel's second-generation neuromorphic research chip. It supports new classes of neuro-inspired algorithms and applications, while providing faster processing, greater resource density and improved energy efficiency. It was introduced by Intel in September 2021. (Credit: Walden Kirsch/Intel

"Loihi 2 and Lava harvest insights from several years of collaborative research using Loihi. Our second-generation chip greatly improves the speed, programmability, and capacity of neuromorphic processing, broadening its usages in power and latency constrained intelligent computing applications. We are open sourcing Lava to address the need for software convergence,

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benchmarking, and cross-platform collaboration in the field, and to accelerate our progress toward commercial viability.”
-- Mike Davies, director of Intel’s Neuromorphic Computing Lab

Why It Matters: Neuromorphic computing, which draws insights from neuroscience to create chips that function more like the biological brain, aspires to deliver orders of magnitude improvements in energy efficiency, speed of computation and efficiency of learning across a range of edge applications: from vision, voice and gesture recognition to search retrieval, robotics, and constrained optimization problems.

Applications Intel and its partners have demonstrated to date include robotic arms, neuromorphic skins and olfactory sensing.

About Loihi 2: The research chip incorporates learnings from three years of use with the first-generation research chip and leverages progress in Intel’s process technology and asynchronous design methods.

- **Advances in Loihi 2** allow the architecture to support new classes of neuro-inspired algorithms and applications, while providing up to 10 times faster processing[1], up to 15 times greater resource density[2] with up to 1 million neurons per chip, and improved energy efficiency. Benefitting from a close collaboration with Intel’s Technology Development Group, Loihi 2 has been fabricated with a pre-production version of the Intel 4 process, which underscores the health and progress of Intel 4. The use of extreme ultraviolet (EUV) lithography in Intel 4 has simplified the layout design rules compared to past process technologies. This has made it possible to rapidly develop Loihi 2.
- **The Lava software framework** addresses the need for a common software framework in the neuromorphic research community. As an open, modular, and extensible framework, Lava will allow researchers and application developers to build on each other’s progress and converge on a common set of tools, methods, and libraries. Lava runs seamlessly on heterogeneous architectures across conventional and neuromorphic processors, enabling cross-platform execution and interoperability with a variety of artificial intelligence, neuromorphic and robotics frameworks. Developers can begin building neuromorphic applications without access to specialized neuromorphic hardware and can contribute to the Lava code base, including porting it to run on other platforms.

"Investigators at Los Alamos National Laboratory have been using the Loihi neuromorphic platform to investigate the trade-offs between quantum and neuromorphic computing, as well as implementing learning processes on-chip,” said Dr. Gerd J. Kunde, staff scientist, Los Alamos National Laboratory. “This research has shown some exciting equivalences between spiking neural networks and quantum annealing approaches for solving hard optimization problems. We have also demonstrated that the backpropagation algorithm, a foundational building block for training neural networks and previously believed not to be implementable on neuromorphic architectures, can be realized efficiently on Loihi. Our team is excited to continue this research with the second generation Loihi 2 chip."

About Key Breakthroughs: Loihi 2 and Lava provide tools for researchers to develop and characterize new neuro-inspired applications for real-time processing, problem-solving, adaptation and learning. Notable highlights include:

- **Faster and more general optimization:** Loihi 2's greater programmability will allow a wider class of difficult optimization problems to be supported, including real-time optimization, planning, and decision-making from edge to datacenter systems.
- **New approaches for continual and associative learning:** Loihi 2 improves support for advanced learning methods, including variations of backpropagation, the workhorse algorithm of deep learning. This expands the scope of adaptation and data efficient learning algorithms that can be supported by low-power form factors operating in online settings.
- **Novel neural networks trainable by deep learning:** Fully programmable neuron models and generalized spike messaging in Loihi 2 open the door to a wide range of new neural network models that can be trained in deep learning. Early evaluations suggest reductions of over 60 times fewer ops per inference on Loihi 2 compared to standard deep networks running on the original Loihi without loss in accuracy[3].
- **Seamless integration with real-world robotics systems, conventional processors, and novel sensors:** Loihi 2 addresses a practical limitation of Loihi by incorporating faster, more flexible, and more standard input/output interfaces. Loihi 2 chips will support Ethernet interfaces, glueless integration with a wider range of event-based vision sensors, and larger meshed networks of Loihi 2 chips.

More details may be found in the Loihi 2/Lava technical product brief.

About the Intel Neuromorphic Research Community: The Intel Neuromorphic Research Community (INRC) has grown to nearly 150 members, with several new additions this year, including Ford, Georgia Institute of Technology, Southwest Research Institute (SwRI) and Teledyne-FLIR. New partners join a robust community of academic, government and industry partners that are working with Intel to drive advances in real-world commercial usages of neuromorphic computing. (Read what our partners are saying about Loihi technology.)

"Advances like the new Loihi 2 chip and the Lava API are important steps forward in neuromorphic computing," said Edy Liongosari, chief research scientist and managing director at Accenture Labs. "Next-generation neuromorphic architecture will be crucial for Accenture Labs' research on brain-inspired computer vision algorithms for intelligent edge computing that could power future extended-reality headsets or intelligent mobile robots. The new chip provides features that will make it more efficient for hyper-dimensional computing and can enable more advanced on-chip learning, while the Lava API provides developers with a simpler and more streamlined interface to build neuromorphic systems."

About the Path to Commercialization: Advancing neuromorphic computing from laboratory research to commercially viable technology is a three-pronged effort. It requires continual iterative improvement of neuromorphic hardware in response to the results of algorithmic and application research; development of a common cross-platform software framework so developers can benchmark, integrate, and improve on the best algorithmic ideas from different groups; and deep collaborations across industry, academia and governments to build a rich, productive neuromorphic ecosystem for exploring commercial use cases that offer near-term business value.

Today's announcements from Intel span all these areas, putting new tools into the hands of an expanding ecosystem of neuromorphic researchers engaged in re-thinking computing from its foundations to deliver breakthroughs in intelligent information processing.

What's Next: Intel currently offers two Loihi 2 based neuromorphic systems through the Neuromorphic Research cloud to engaged members of the INRC: Oheo Gulch, a single chip system for early evaluation and Kapoho Point, an eight-chip system that will be available soon. The Lava Software Framework is available for free download on GitHub. A presentation and tutorials on Loihi 2 and Lava will be featured at the upcoming Intel Innovation event in October.

More Context: Neuromorphic Computing – Next Generation of AI (Intel.com) **|** Neuromorphic Computing at Intel (Press Kit)

About Intel

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[1] Based on Lava simulations in September, 2021 of a nine-layer variant of the PilotNet DNN inference workload implemented as a sigma-delta neural network on Loihi 2 compared to the same network implemented with SNN rate-coding on Loihi. The Lava performance model for both chips is based on silicon characterization using the Nx SDK release 1.0.0 with an Intel Xeon E5-2699 v3 CPU @ 2.30 GHz, 32GB RAM, as the host running Ubuntu version 20.04.2. Loihi results use Nahuku-32 system ncl-ghrd-04. Loihi 2 results use Oheo Gulch system ncl-og-04. Results may vary.
[2] Based on the Loihi 2 core size of 0.21 mm2 supporting up to 8192 neurons compared to the Loihi core size of 0.41 mm2 supporting up to 1024 neurons.
[3] Based on measurements of the nine-layer PilotNet DNN inference workload referenced above, with a sigma-delta neural network implementation on Loihi 2 achieving a mean-squared error (MSE) of 0.035 with 323,815 synaptic operations compared to a rate-coded SNN on Loihi 1 achieving MSE of 0.0412 with 20,250,023 synaptic operations.

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