A Neuromorphic Compute Node Architecture for Reproducible Hyper-Real-Time Simulations of Spiking Neural Networks

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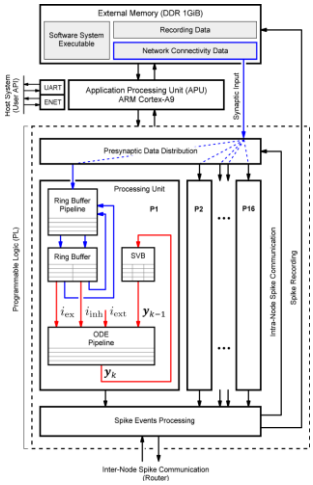
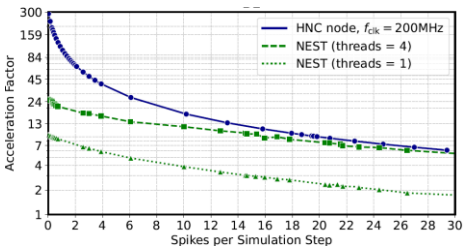
Despite the great strides neuroscience has made in recent decades, the underlying principles of brain function remain largely unknown. Advancing the field strongly depends on the ability to study large-scale neural networks and perform complex simulations. In this context, simulations in hyper-real-time are of high interest, but even the fastest supercomputer available today is not able to meet the challenge of accurate and reproducible simulation with hyper-real acceleration. The development of novel neuromorphic computer architectures holds out promise. Advances in System-on-Chip (SoC) device technology and tools are now providing interesting new design possibilities for application-specific implementations. We propose a novel hybrid software-hardware architecture approach for a neuromorphic compute node intended to work in a multi-node cluster configuration [1]. The node design builds on the Xilinx Zynq-7000 SoC device architecture that combines a powerful programmable logic gate array (FPGA) and a dual-core ARM Cortex-A9 processor extension on a single chip [2]. Although high acceleration can be achieved at low workloads, the development also reveals current technological limitations that also apply to CPU implementations of neural network simulation tools.





Neuromorphic compute node high-level architecture and its performance characteristics in comparison with NEST.

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References

1. Trensch, G., and Morrison, A. (2022). A System-on-Cip Based Hybrid Neuromorphic Compute Node Architecture for Reproducible Hyper-Real-Time Simulations of Spiking Neural Networks. [manuscript submitted to Frontiers in Neuroinformatics for publication]
2. Zynq-7000 SoC Technical Reference Manual (UG585). Available online at: www.xilinx.com.