A Comparative Evaluation of Xeon Phi Platforms Based on a Hodgkin-Huxley Neuron Simulator

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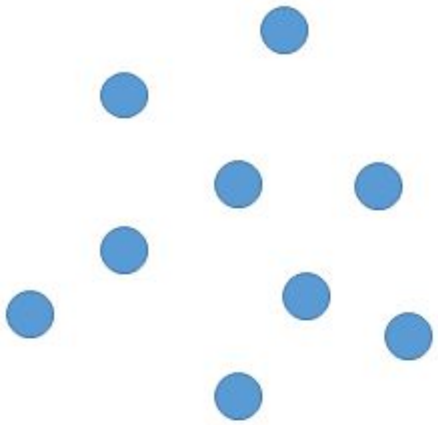
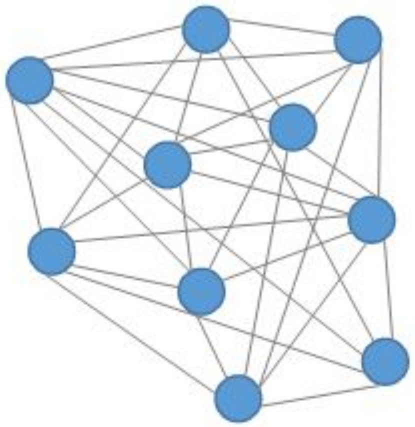
Source: Dr. Greg Dunn
nd Dr. Brian Edwards - *Self*
eflected

Problem Complexity

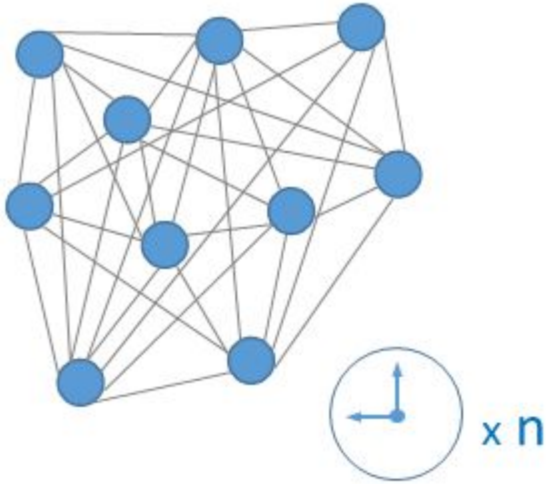
Many FLOPs per neuron



Massive network

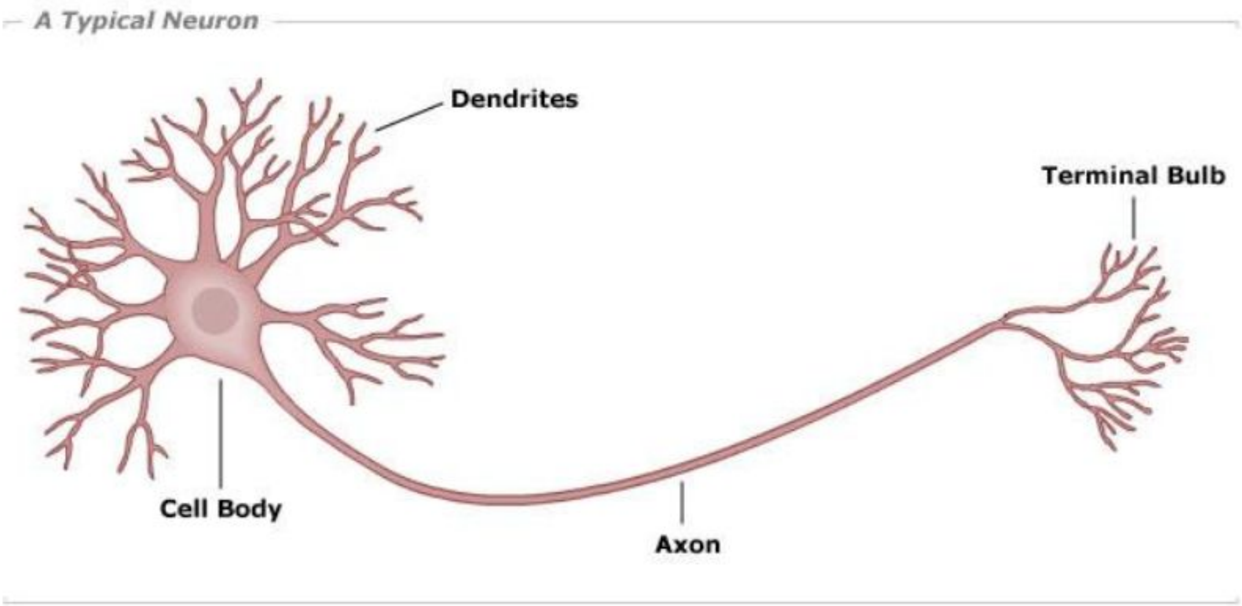


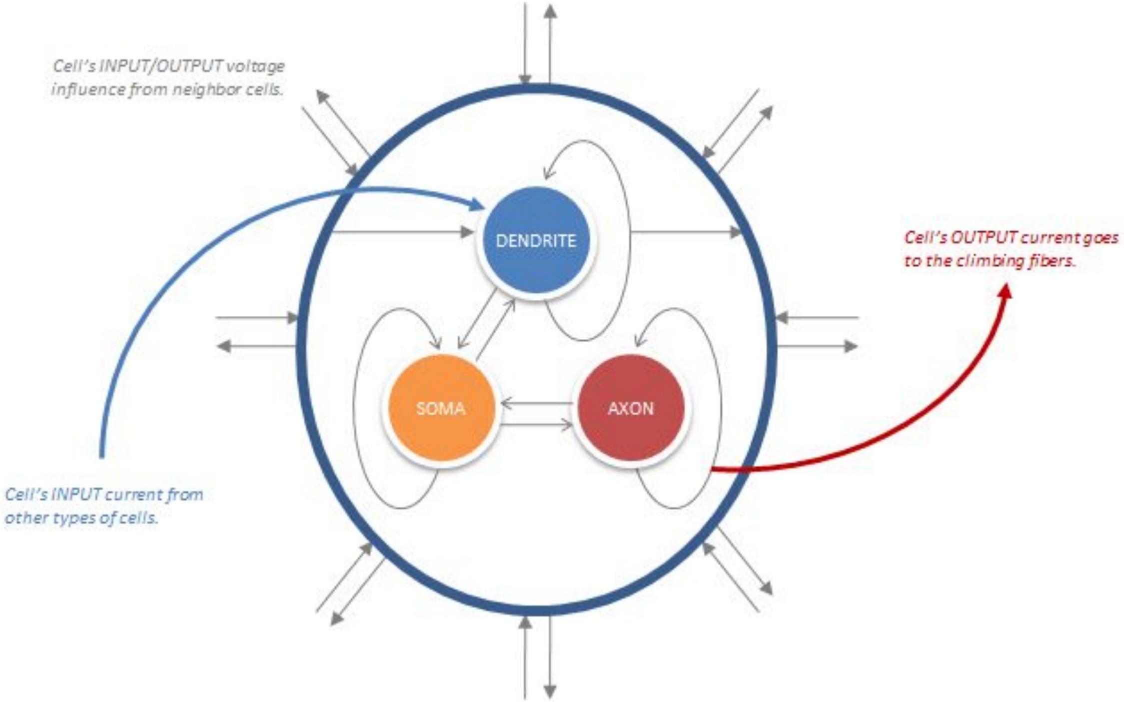
Densely connected networks



Real-time response is currently impossible

Infoli Simulator - Description



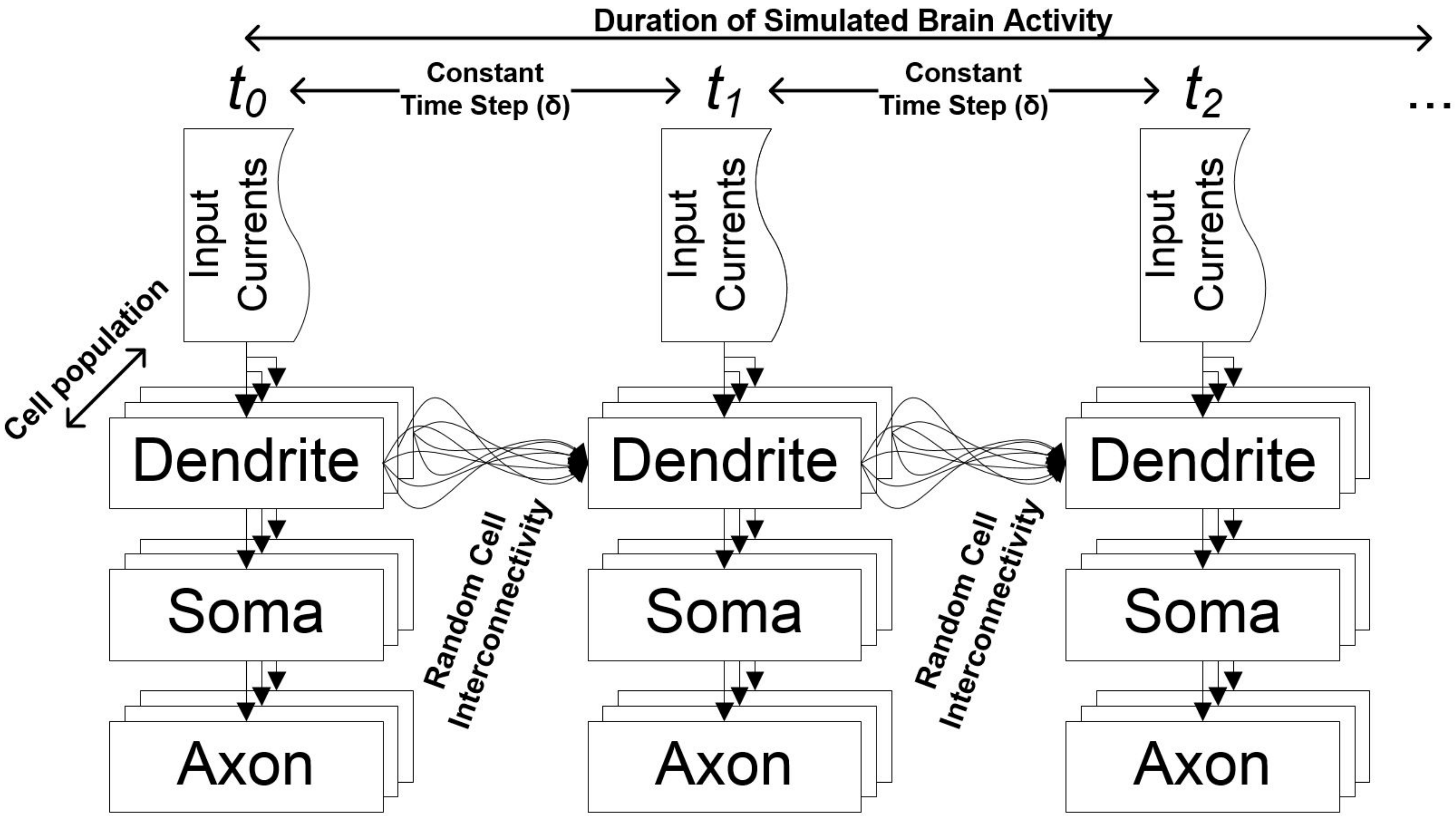


- Tri-compartmental model:
  Dendrite: communication
  Soma (body): computation
  Axon: output

- Gap Junction mechanic
  The communication between dendrites in the network

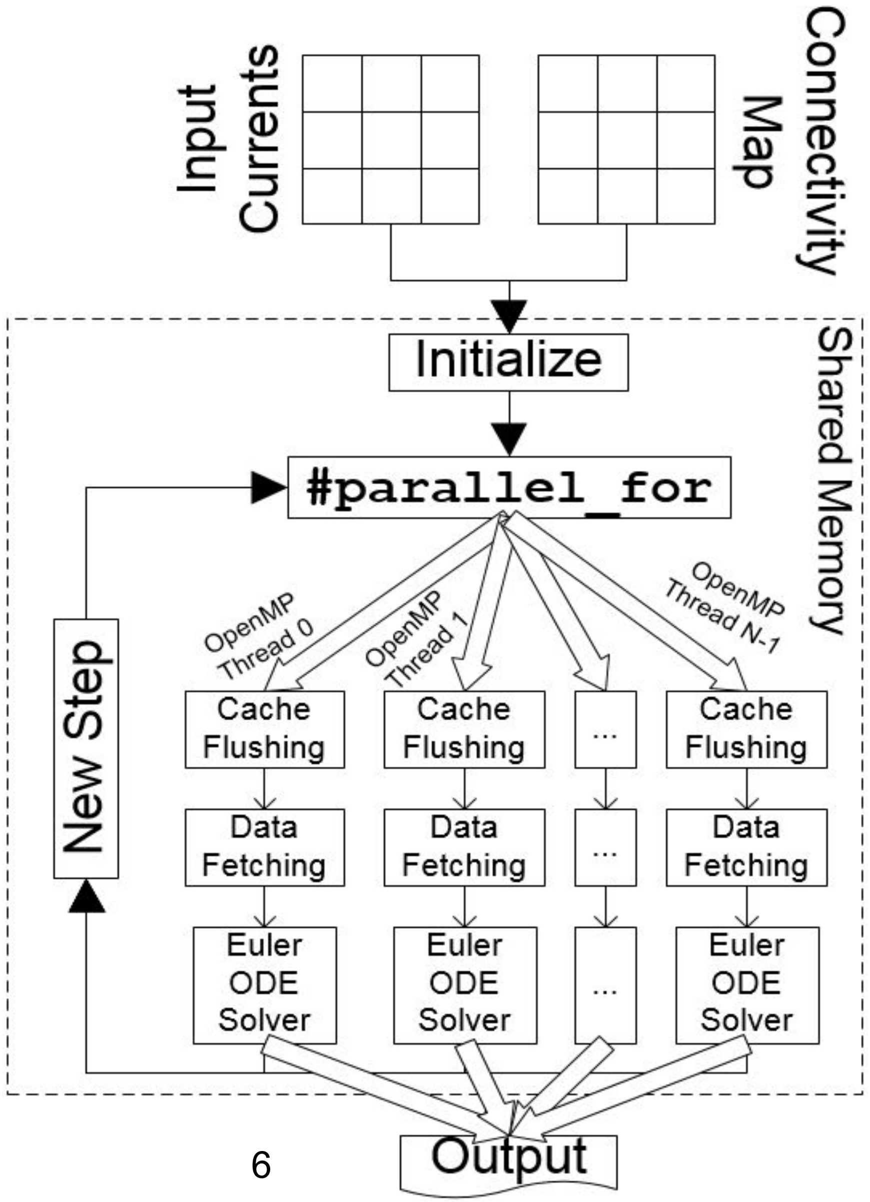
Performance Bottleneck!

Infoli Simulator - Description



Infoli Simulator - Parallelization

- *OpenMP threads, up to 240 on the KNC and 256 on the KNL*
- Data Partitioning:
  - ■Each thread handles a subnetwork
  - ■Network is divided as evenly as possible
- *Need for data exchange between threads*
- Neurons are calculated independently:
  - ■Threads operate in parallel
  - ■Each thread vectorizes calculation for more parallel neuron processing



From Knights Corner to Knights Landing

Intel's 1st Generation Xeon Phi: Knights Corner Coprocessor Card

Model: 3120p

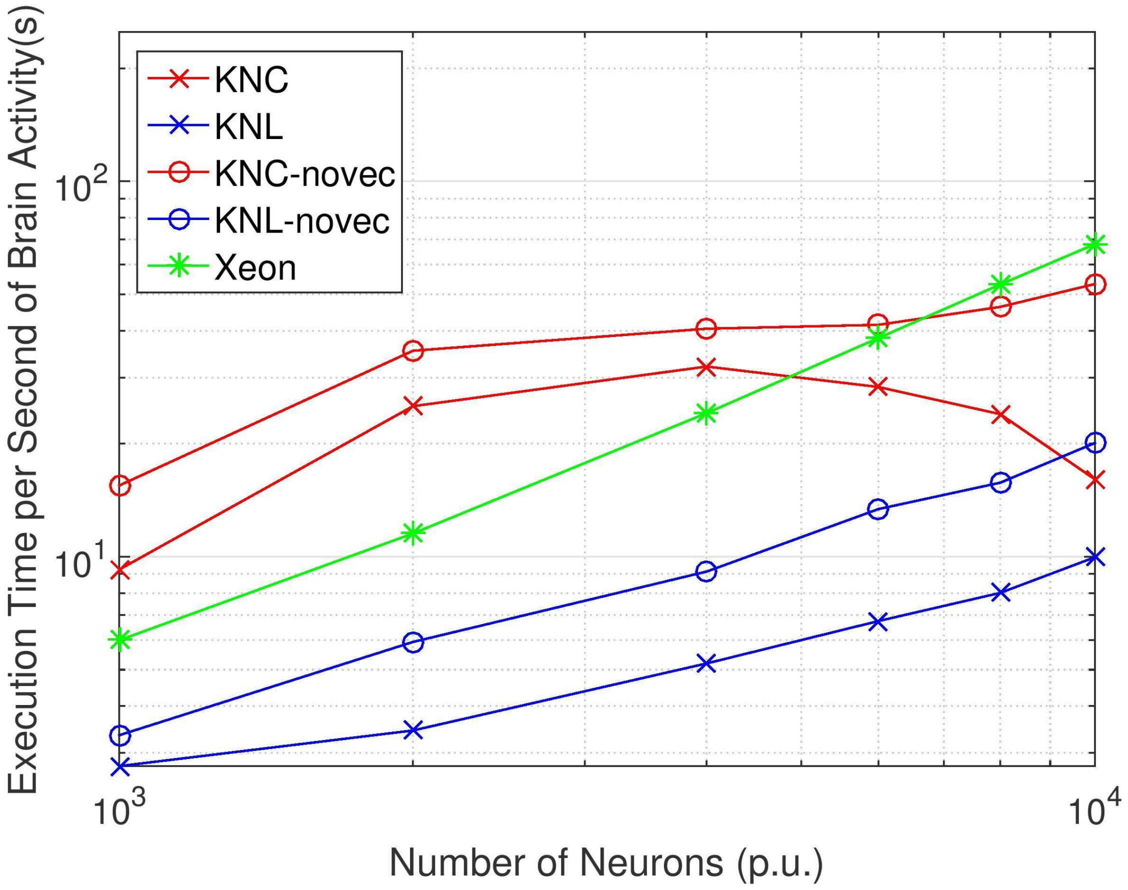
Intel's 2nd Generation Xeon Phi: Knights Landing Processor

Model: 7210

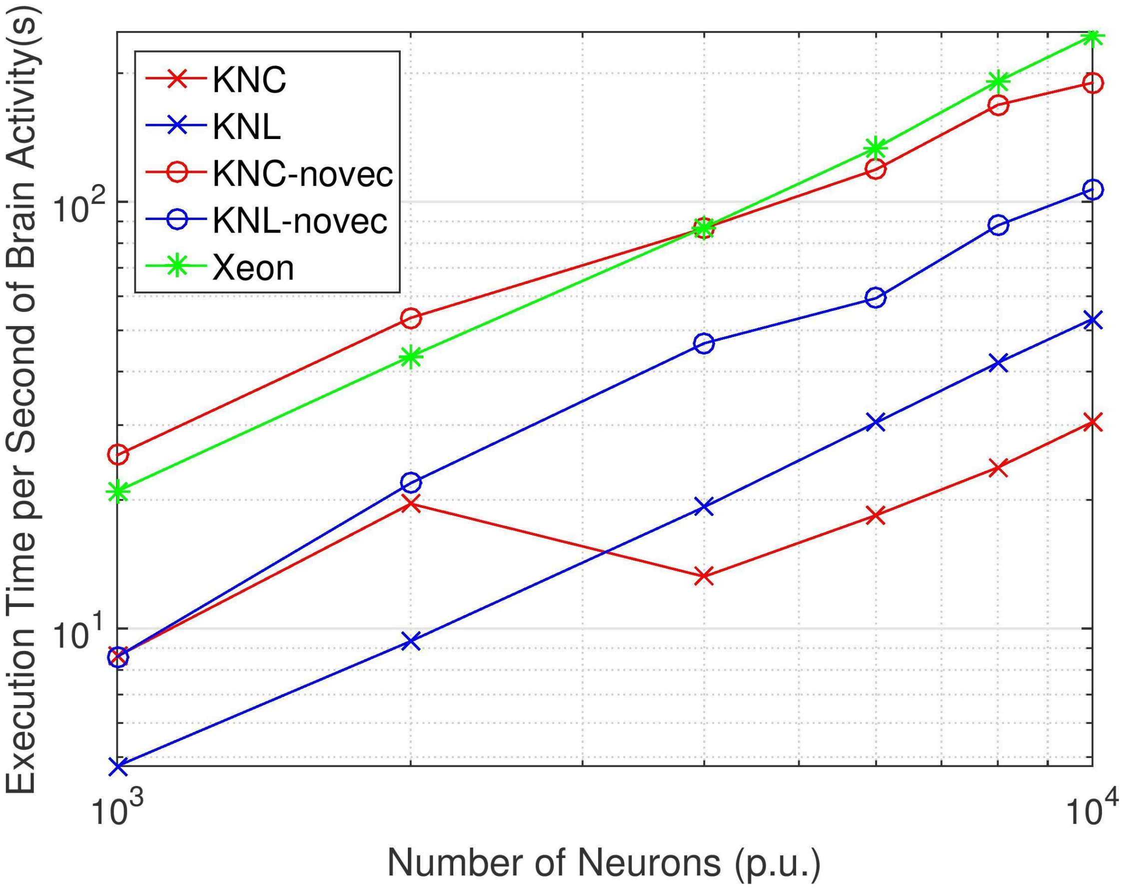
Xeon Baseline model: E5-2609-v2 (4 cores, Ivy Bridge)

- *Out-the-box measurements from the KNC on the KNL.*
- **Ease of transferring:** only recompilation needed
- KNL vs KNC?
  - Better single-threaded performance (3x TFPs)
  - More VPUs, better vectorization support
  - High Bandwidth MCDRAM (set to cache mode)
  - Increased amount of cores, maximum amount of threads
- Experimental evaluation
  - Small (1000) to large (10k) neuron networks
  - Connectivity densities: from 0 up to 1 k GJs per neuron.
  - Exploration of simulation speed, energy used and thread efficiency.

Results - Execution time

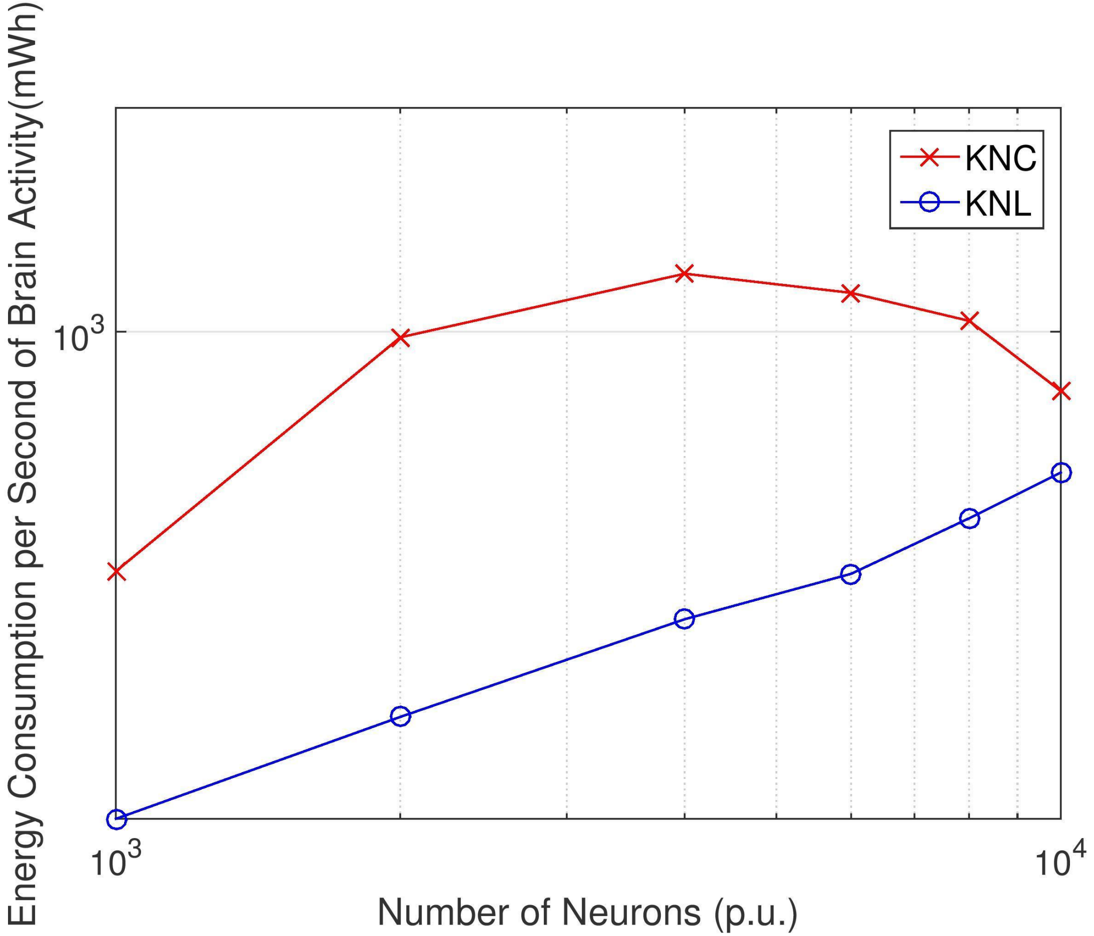


Low-density networks

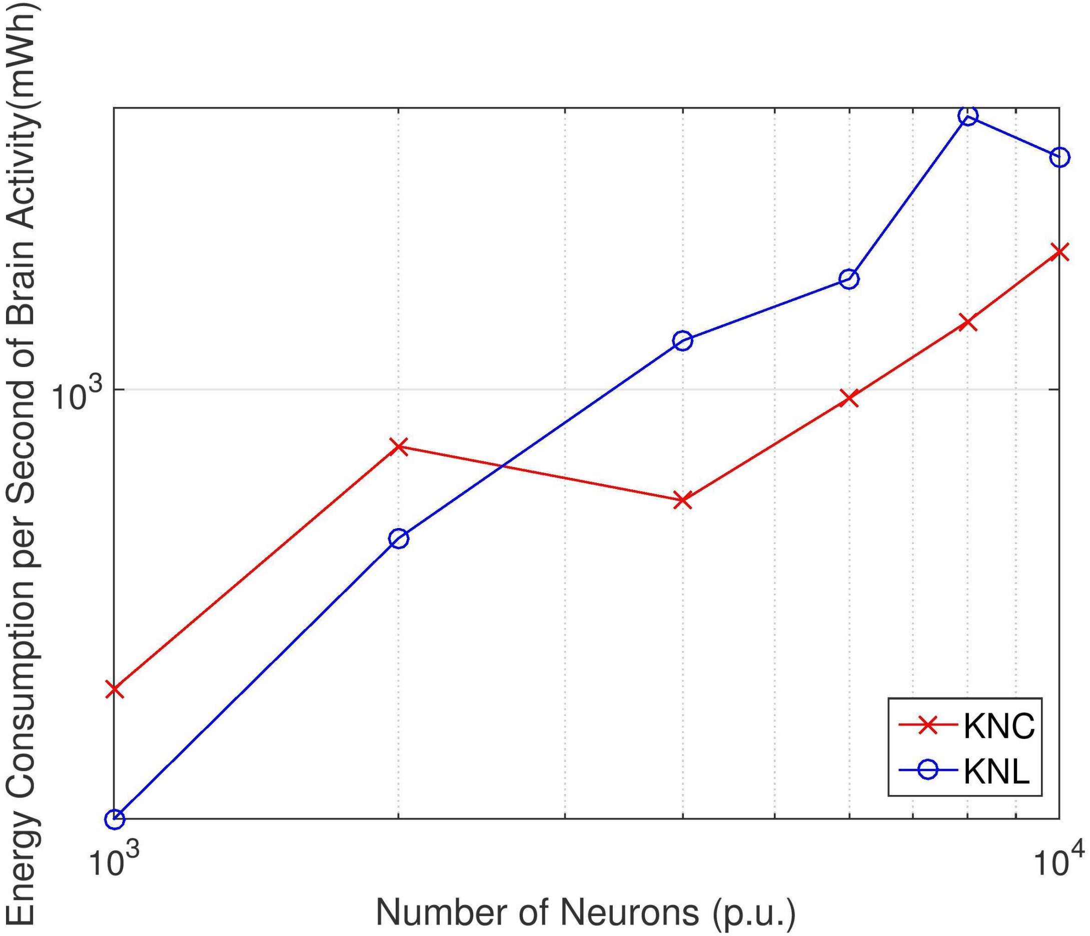


High-density networks

Results - Energy Consumption

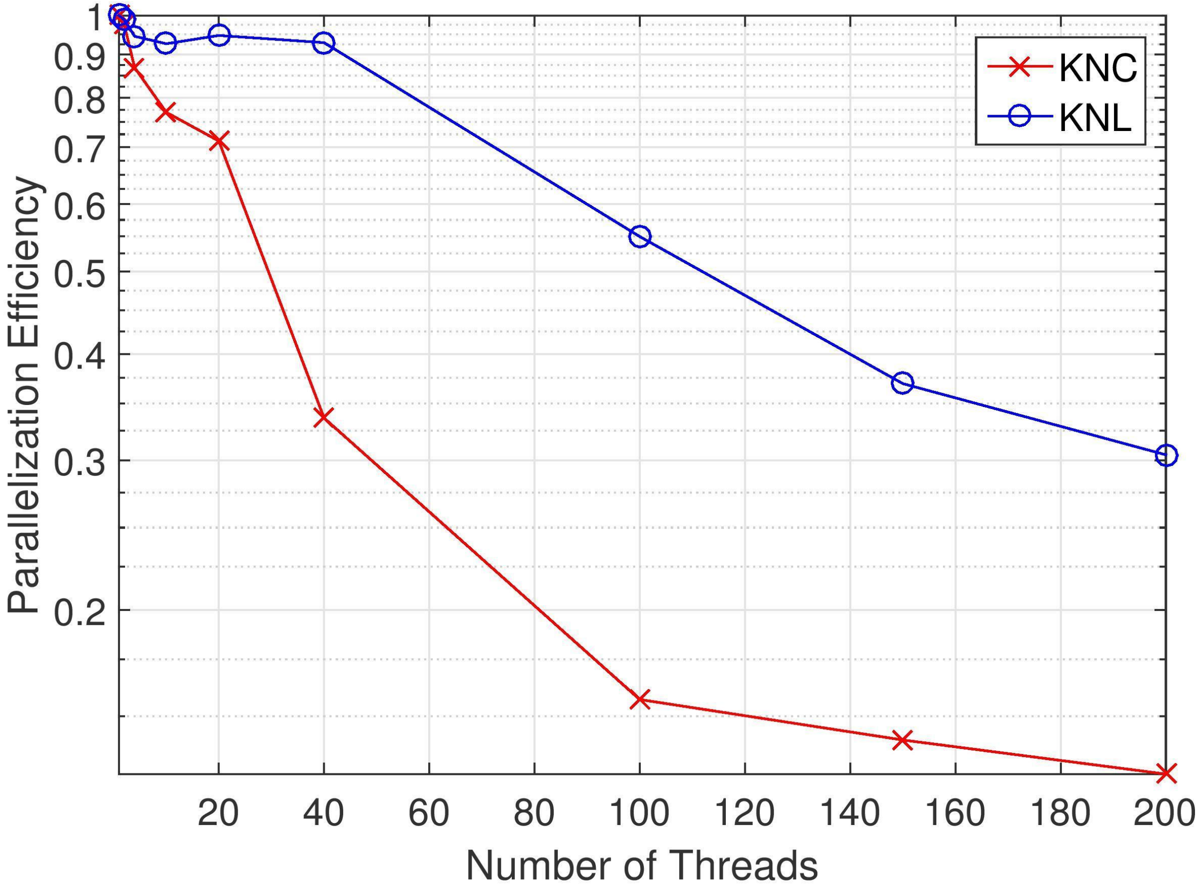


Low-density networks

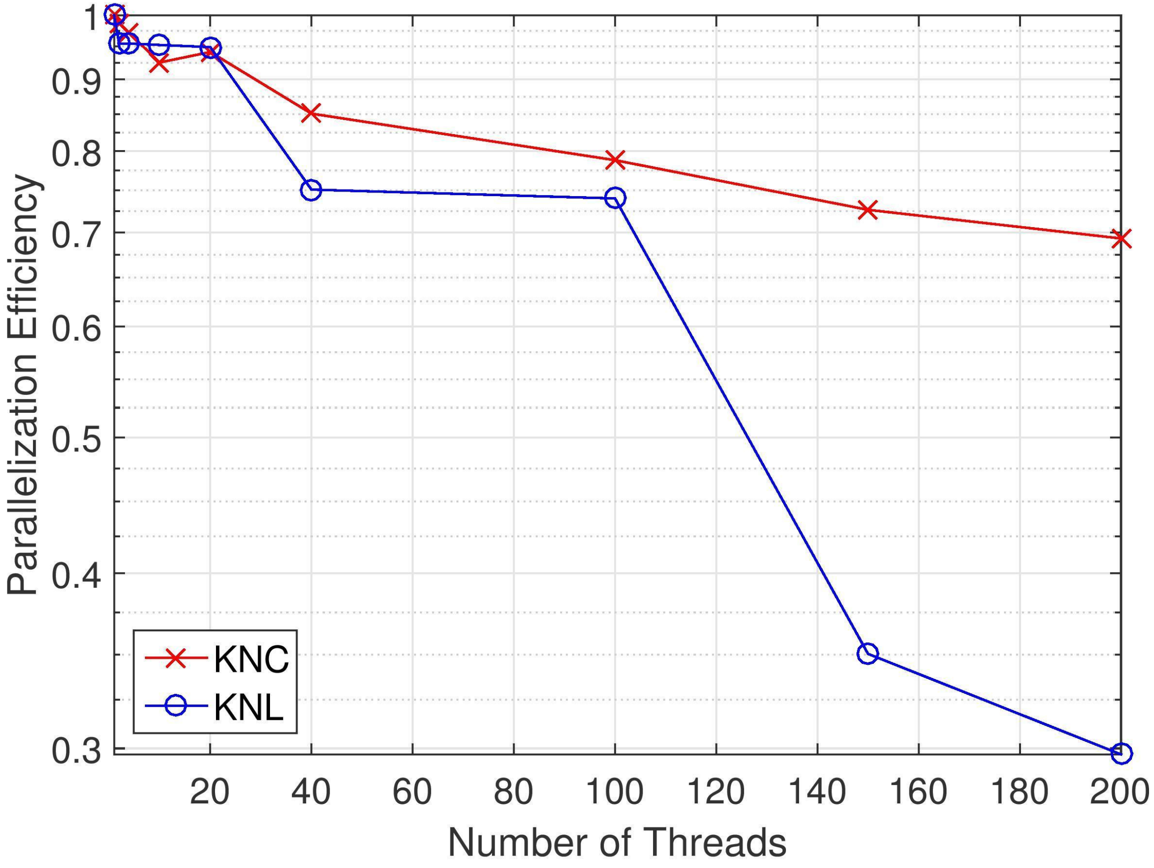


High-density networks

Results - Efficiency



High-density network of 1000 neurons



High-density network of 10k neurons

Results - Analysis

- Sparse networks are more serial in nature, so they operate well on KNL (superior single-threaded performance).
- Denser networks heavily favor vectorization-enabled implementations:
  - Vectorization on the KNC is significantly better after a certain point.
  - KNL performance is worse for some of the heaviest workloads.
- KNL´s lower TDP leads to significant energy gains.
  - Gap lessens with higher workload.
  - On heavier workloads, KNL´s lower TDP offset by increased simulation times.
- KNL very efficient for 1 thread per core, however efficiency takes a significant hit past 100 threads.
- KNC retains acceptable efficiency for 200 threads.

Conclusions and Insights

- On average, 2.4x speedup, comparable to expected single thread performance upgrade of KNL over KNC (3x).
- Lower TDP leads to overall energy savings (~50%) on KNL. Up to 75% saving on low density networks!
- Thread efficiency suffers on the KNL possibly because of lack of fine-tuning of the application to the architectural details of the platform.
    - Best practice suggests ~2 threads per KNL core.
- KNL displays greater predictability in performance.

Future Work

- Fine tuning for the KNL:
  - VPU optimal usage
  - Thread efficiency

- Exploration of MCDRAM modes and clustering modes

- Hybrid MPI + OpenMP for multinode systems
  - Usage of Intel’s Omnipath technology

Thank you!