CANSim: When to Utilize Synchronous and Asynchronous Routers in Large and Complex NoCs

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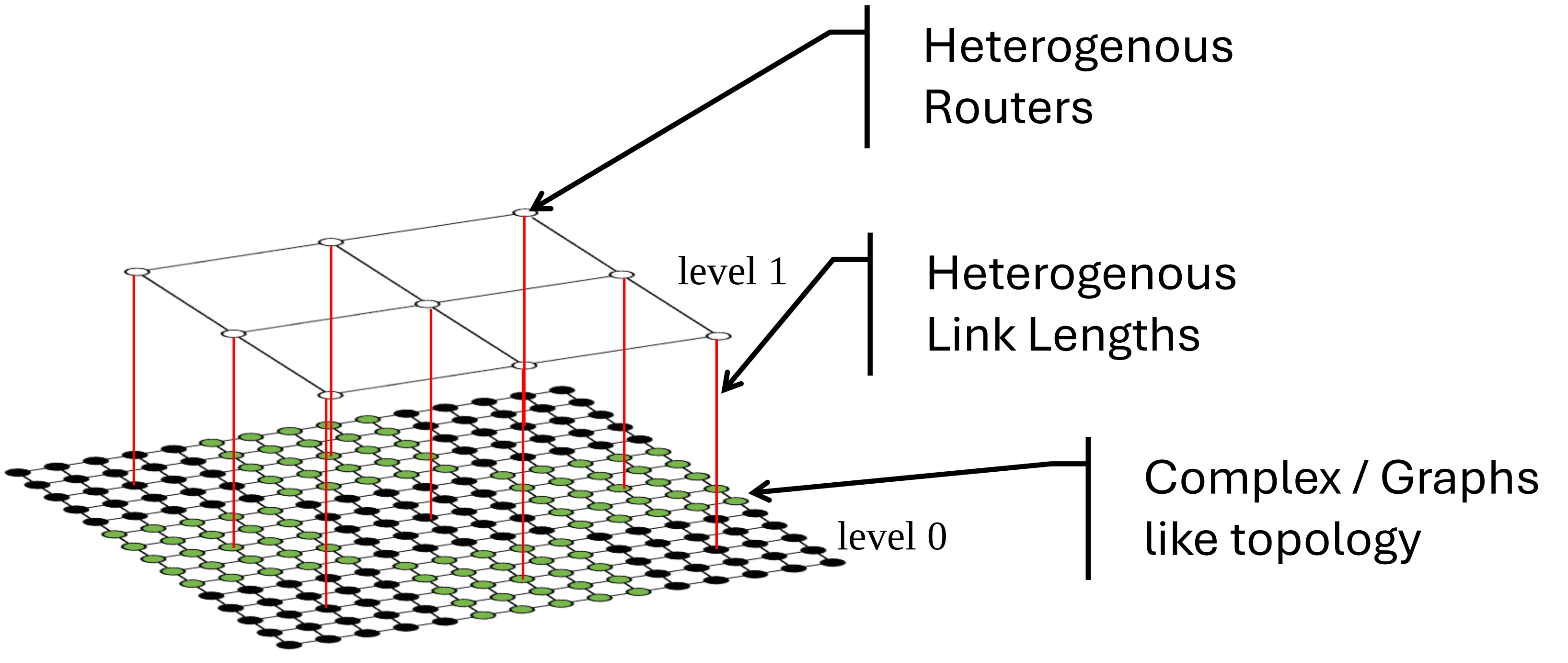
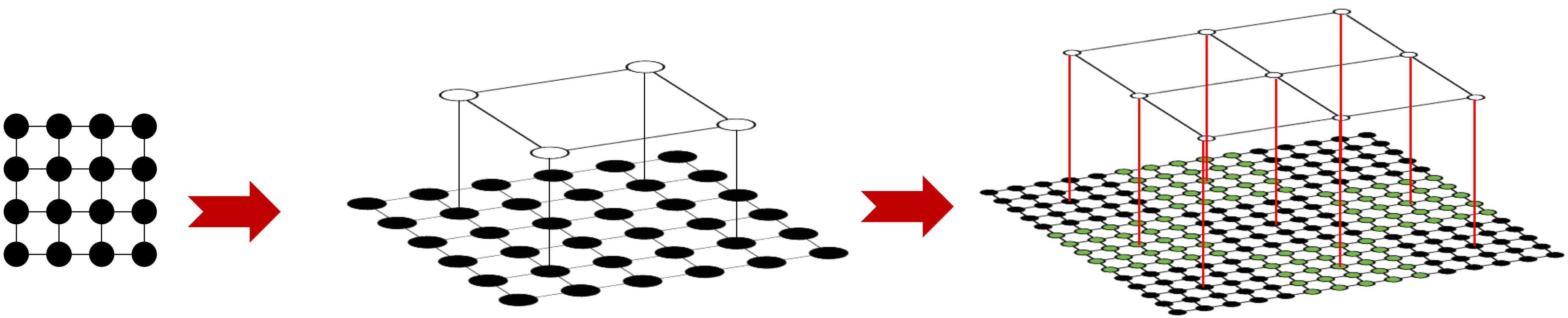
Proposal

- CANSim Framework: Fast and Accurate Simulator for Network on Chips with synchronous/asynchronous routers and complex topologies.



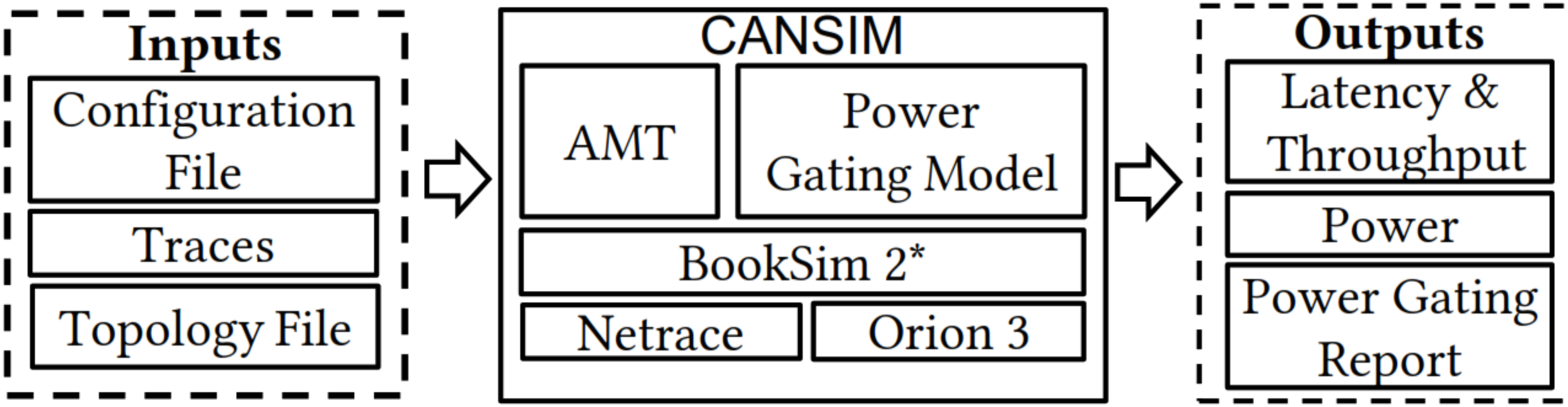
Motivation

- Davide Bertozzi, et al. have shown that asynchronous routers are faster and more energy and area efficient than synchronous router.
- Tool Limitation – simulations limited to 4x4 topology.
- Need for comparing NoCs with asynchronous routers with complex topologies for emerging applications.

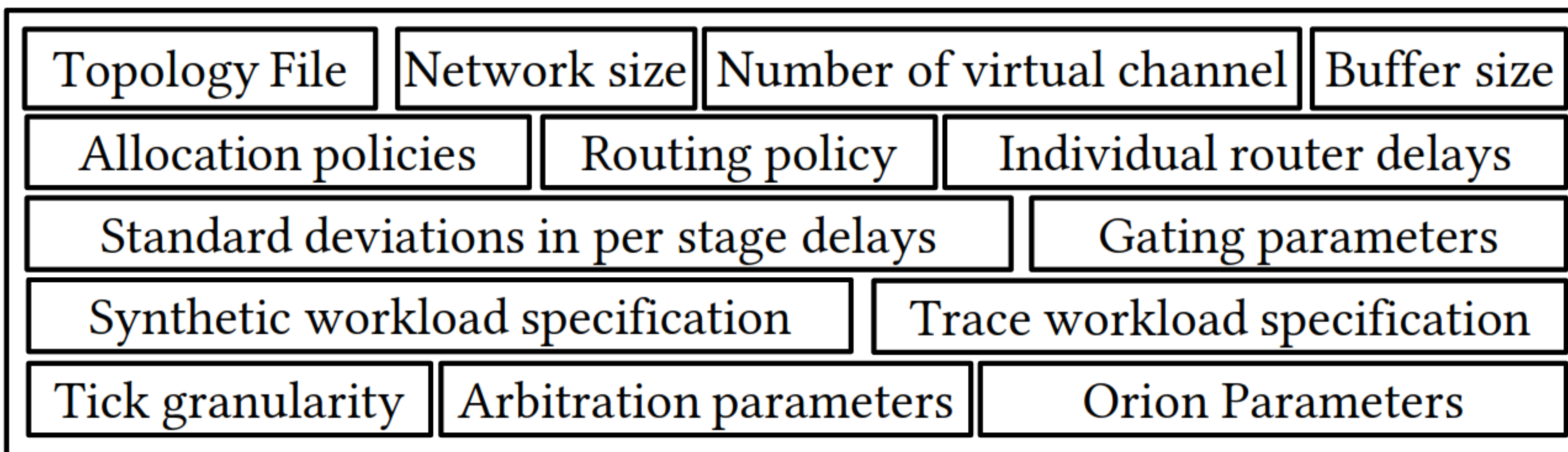


Bertozzi, Davide, et al. "Cost-effective and flexible asynchronous interconnect technology for GALS systems." IEEE Micro 41.1 (2020): 69-81.

Framework Overview



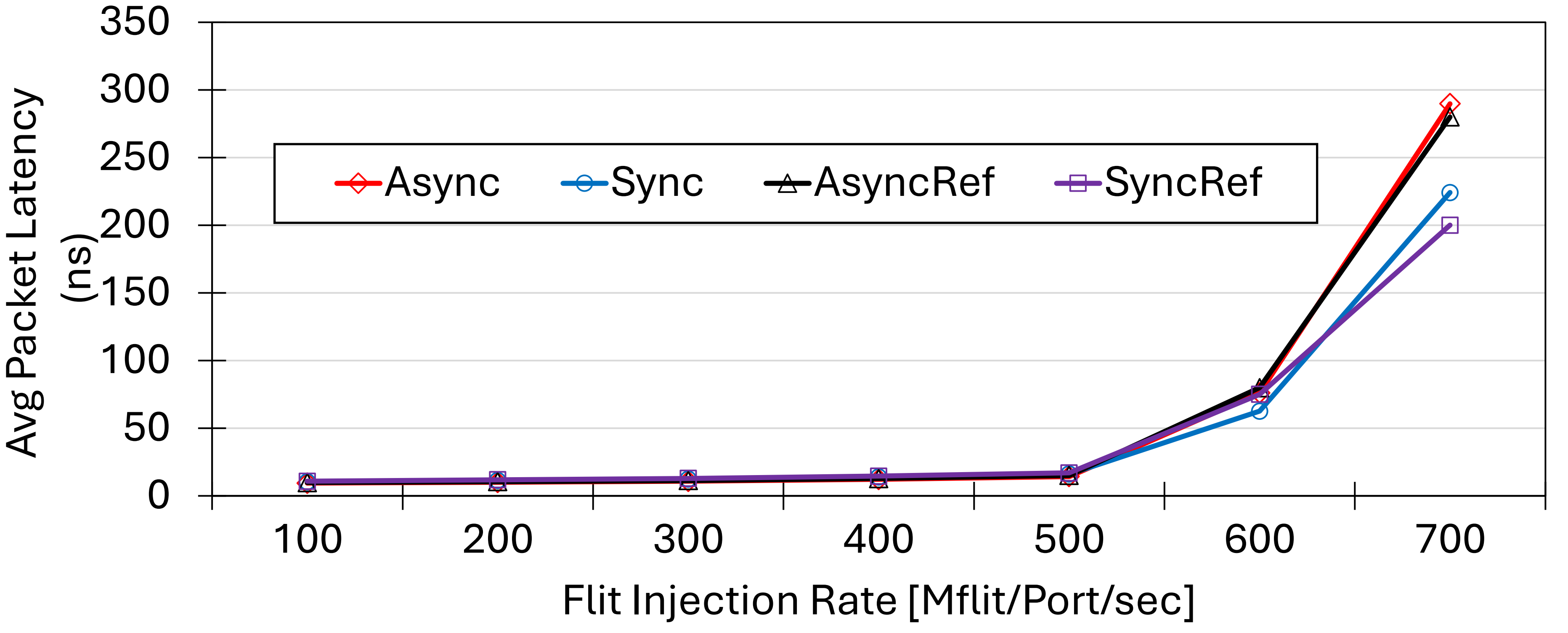
(a) High level design of CANSim



(b) Configuration File

Validation

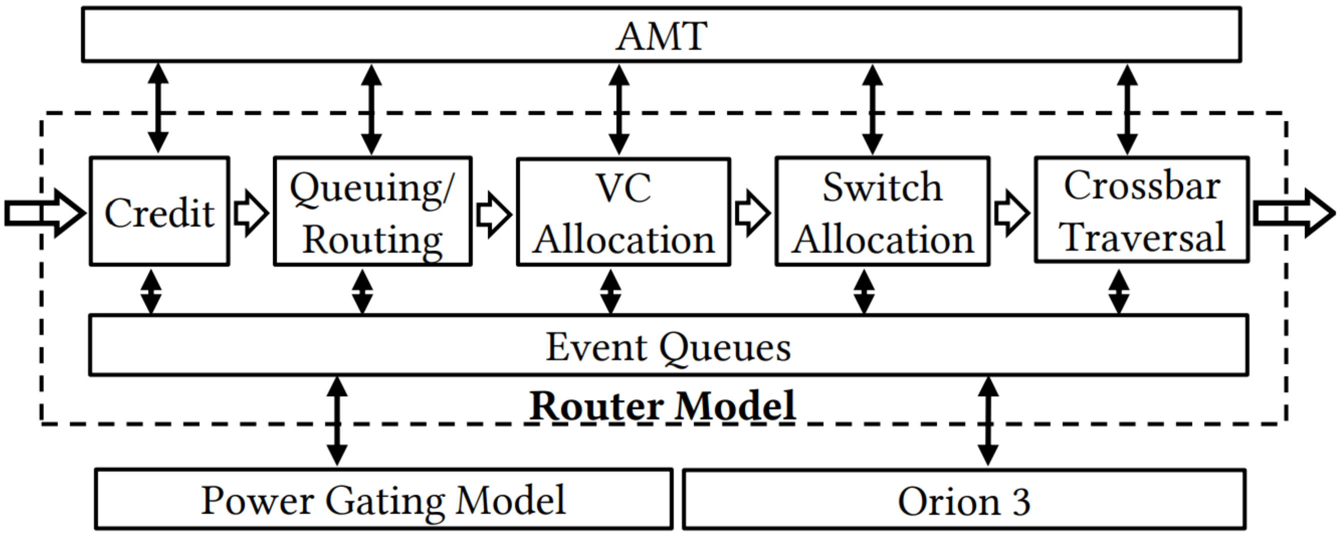
- Validated against synthesized 4x4 topology
  - TaBuLA (Async) & xpipes (Sync) routers [1]



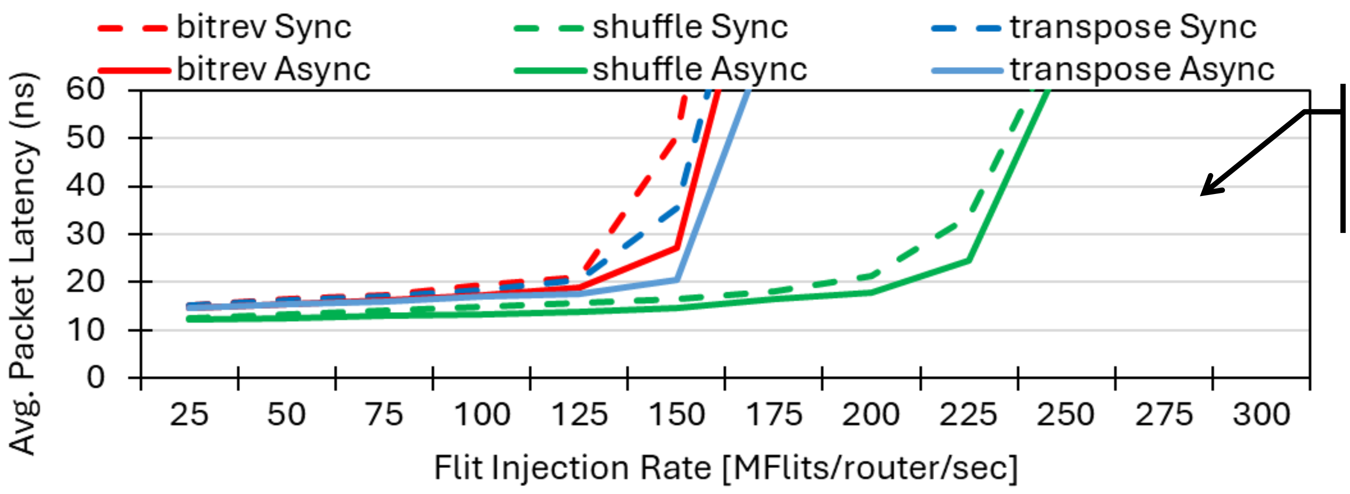
[1]ertozzi, Davide, et al. "Cost-effective and flexible asynchronous interconnect technology for GALS systems." IEEE Micro 41.1 (2020): 69-81.

Configurability

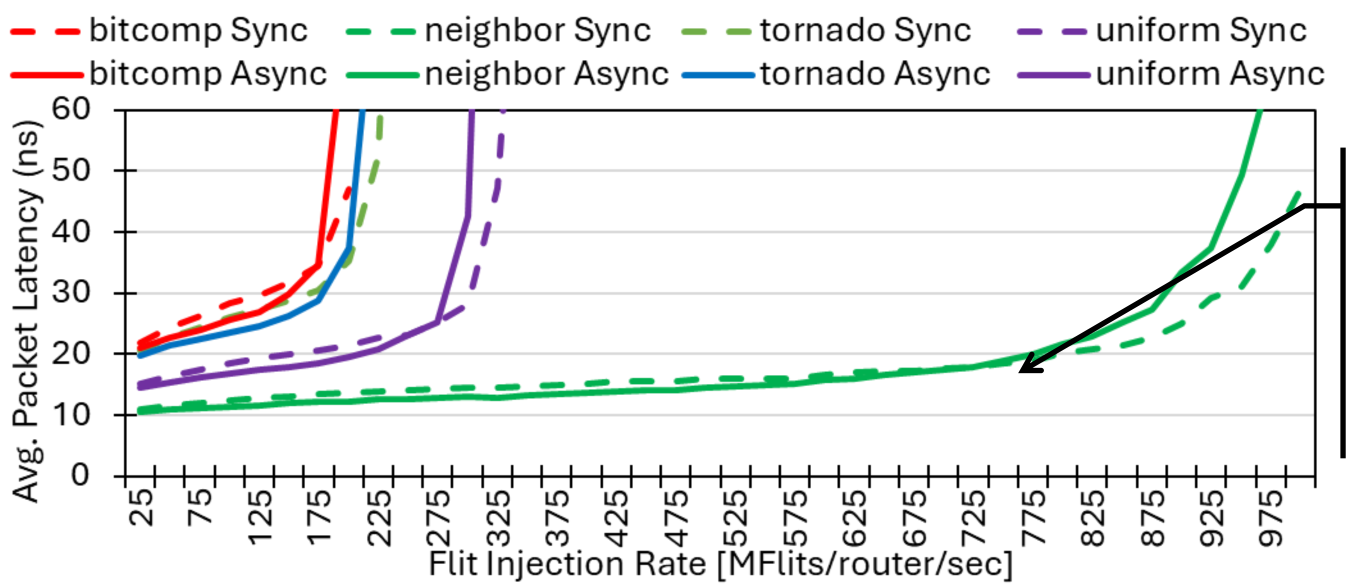
- Complete control of the asynchronous router's timing and behavior
- Addressable individual router



Support for different synthetic traffic



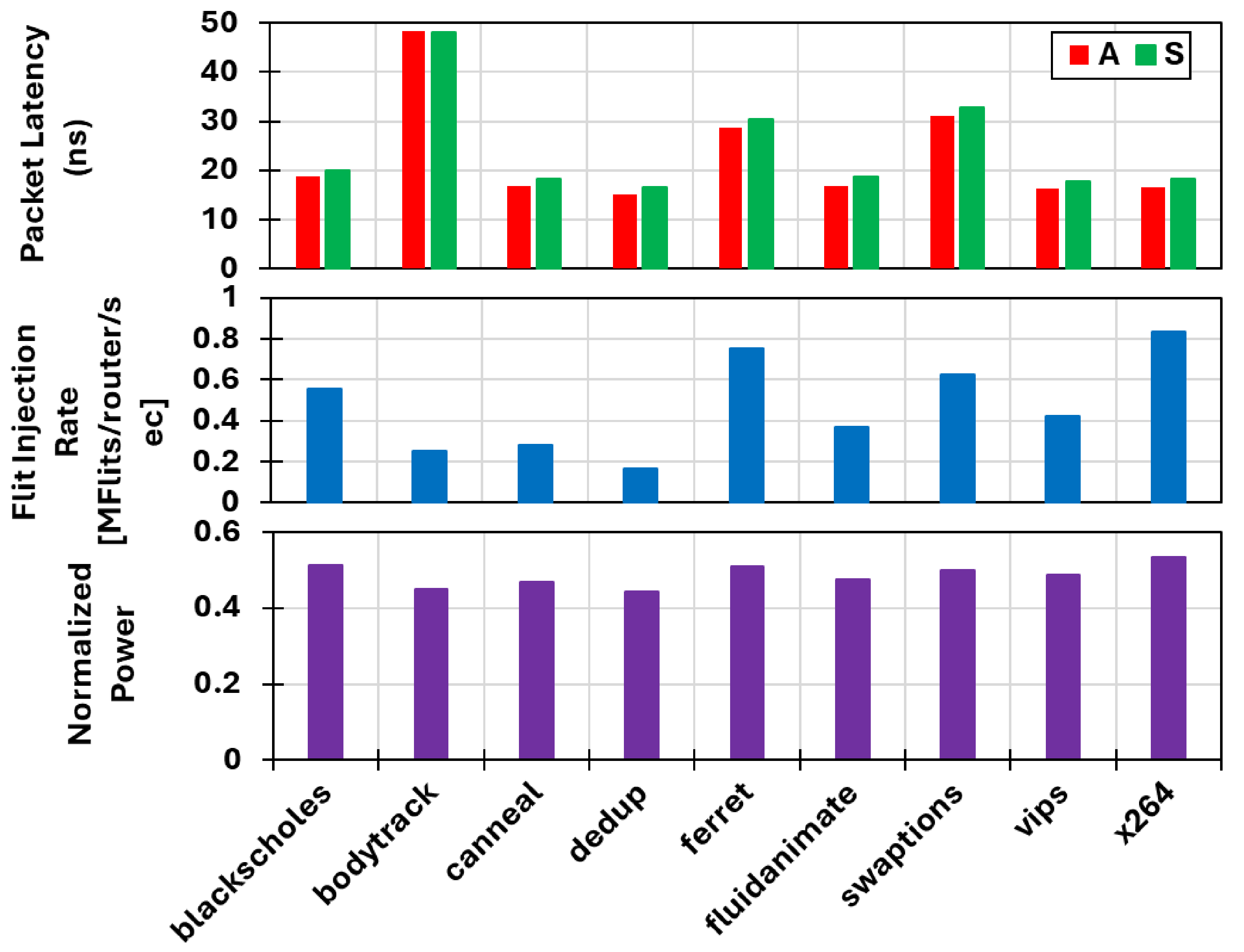
Async always better



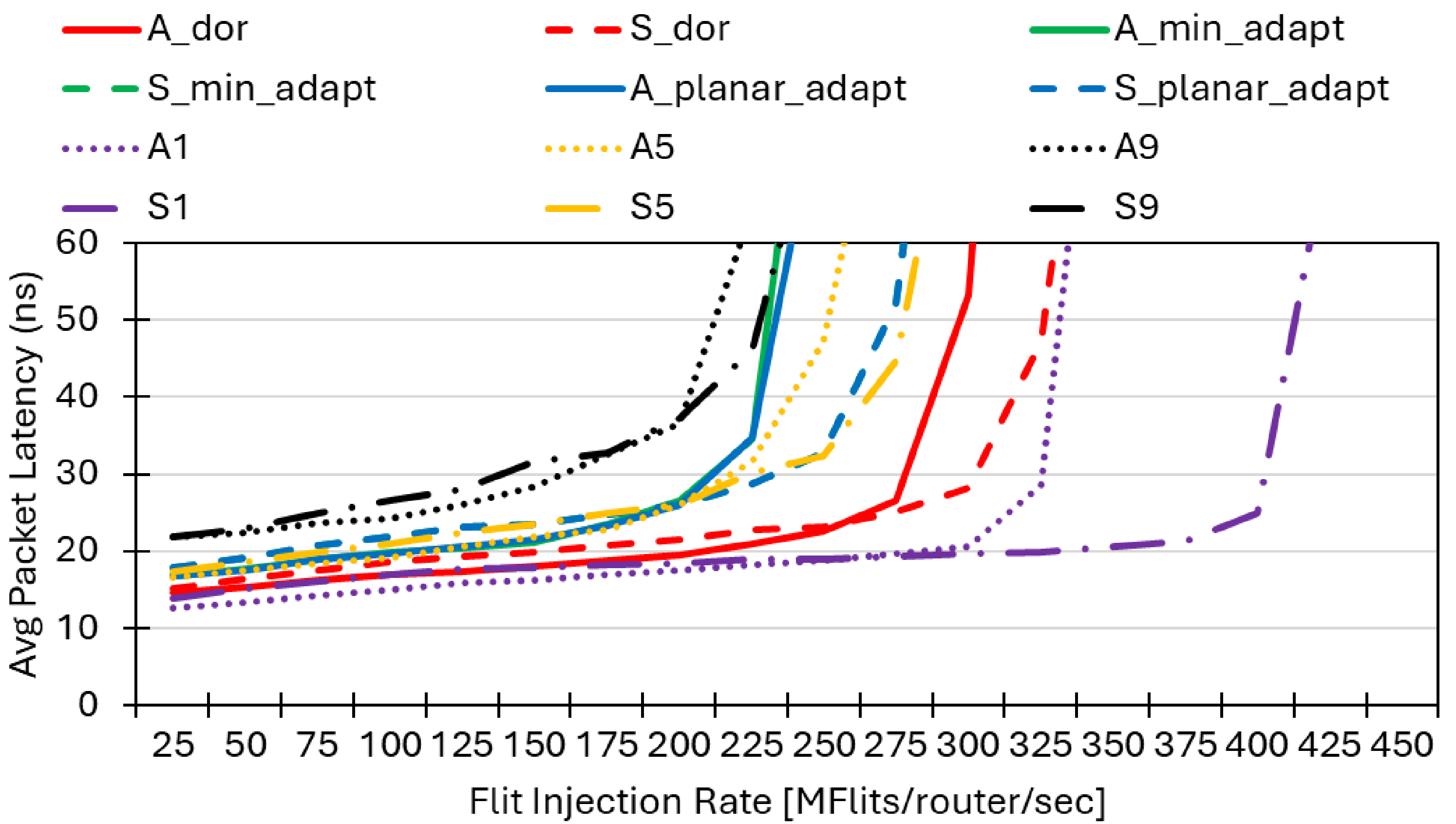
Trend Inversions

For these type of workloads at high injection rate

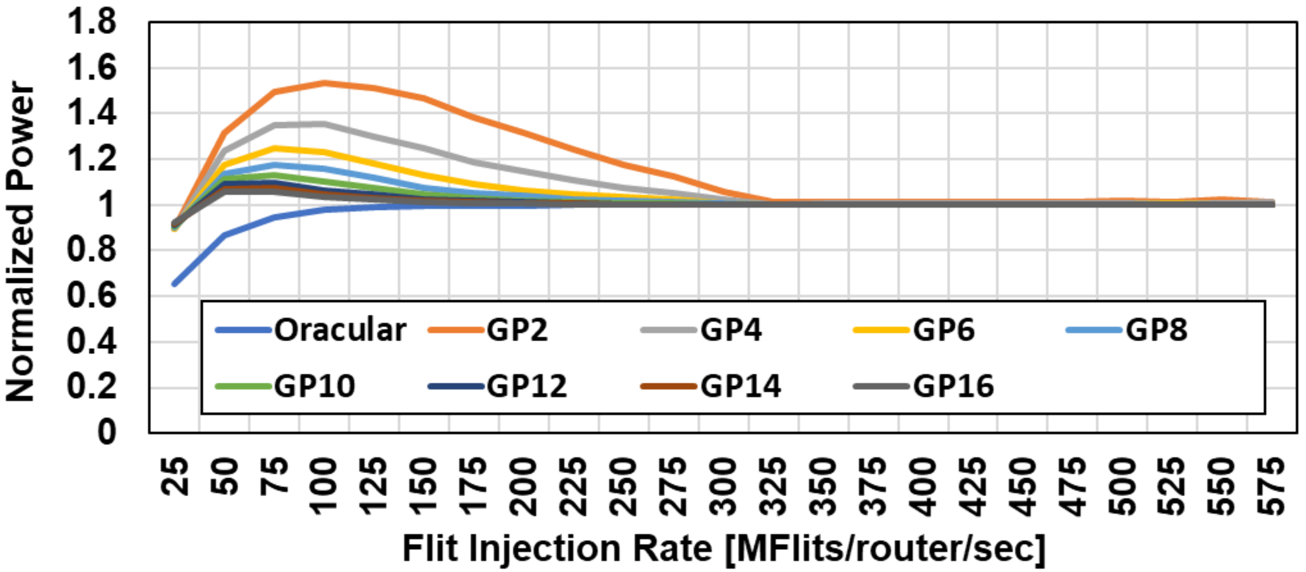
Support for real workloads over trace

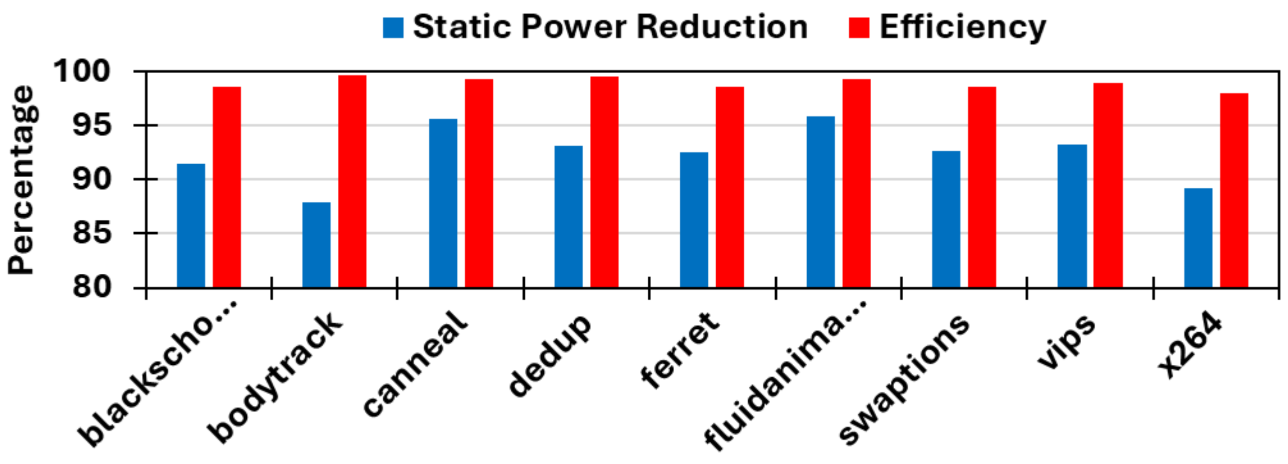


Support for routing algos and packet sizes

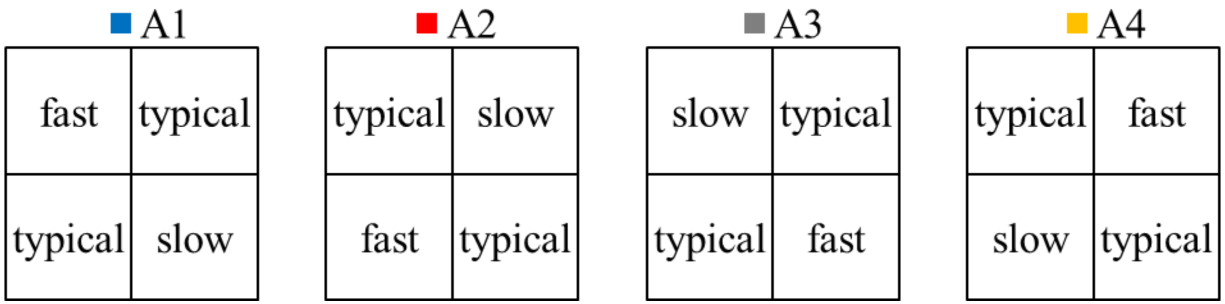


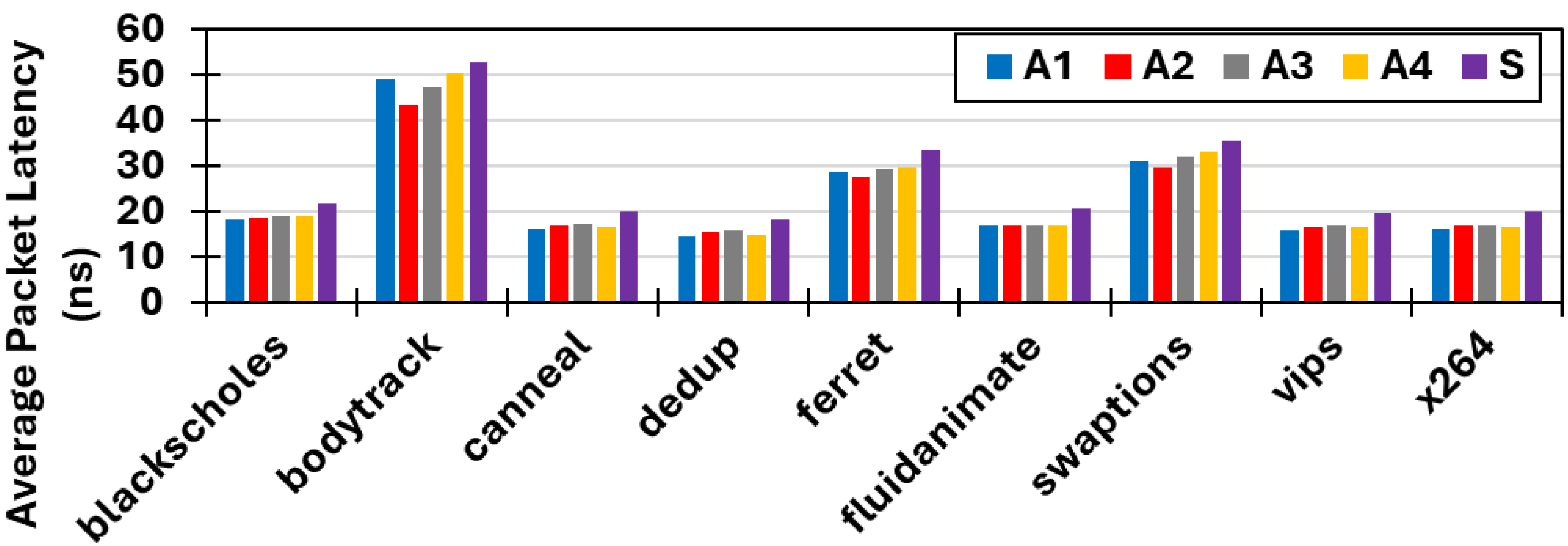
Support for user defined power gating policies



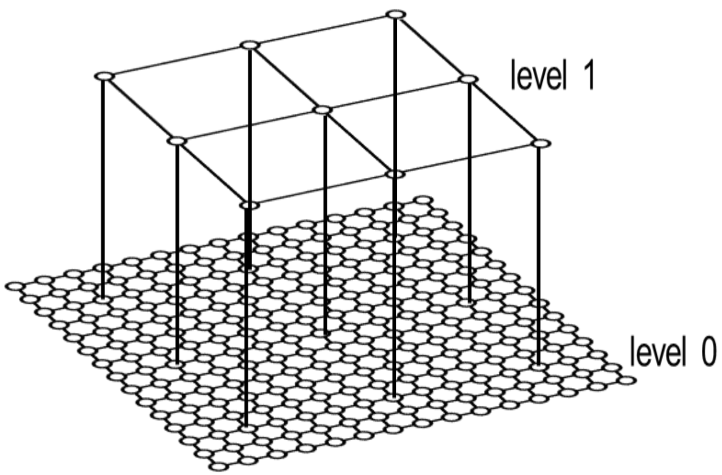


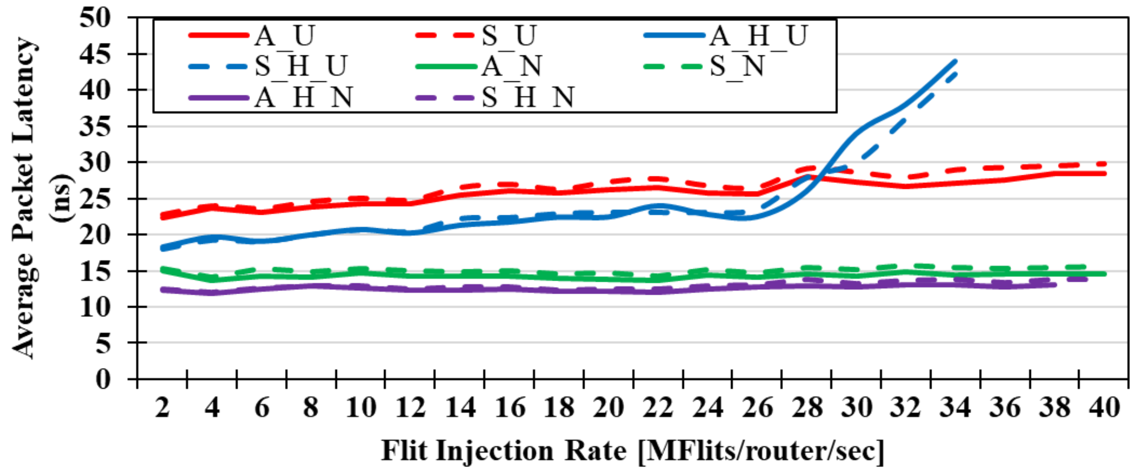
Support for process variations

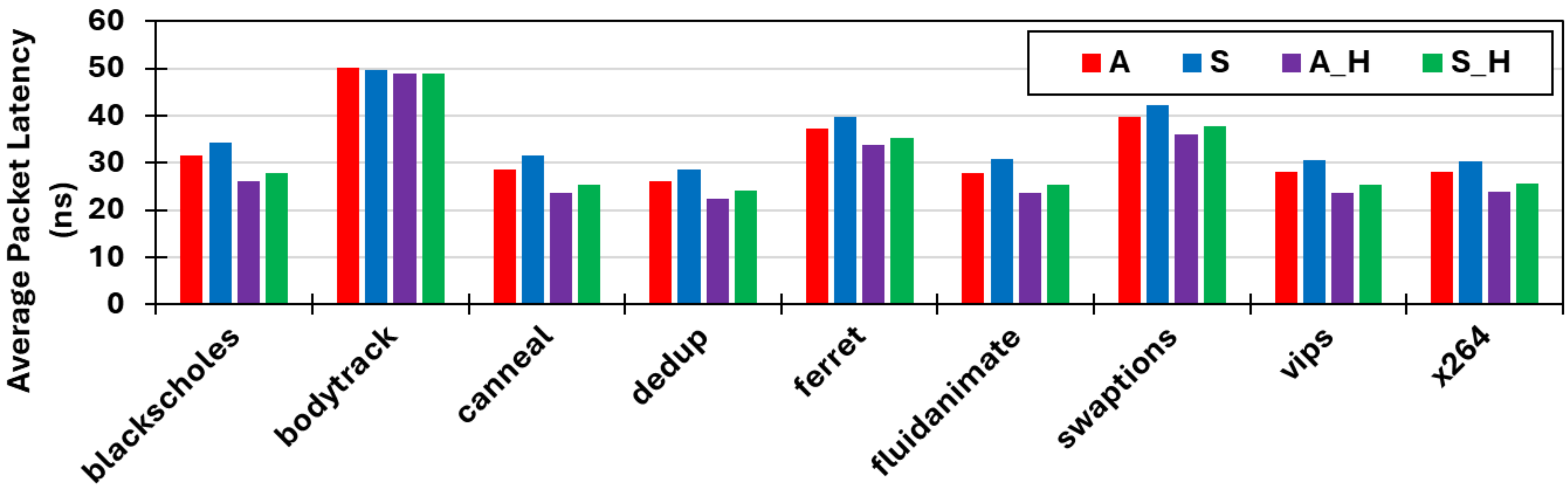




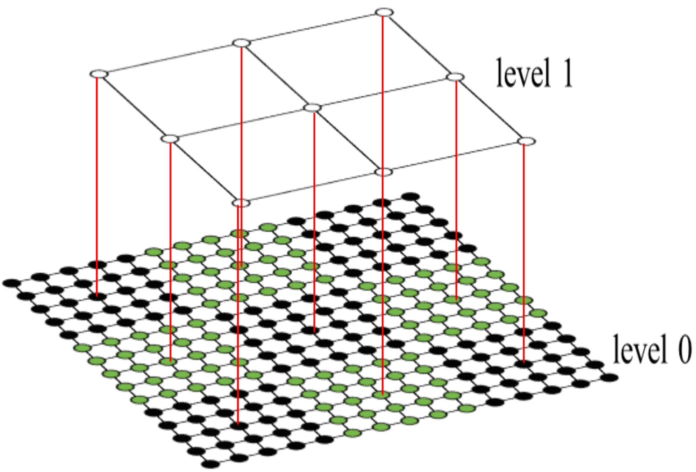
Support for Hierarchical Topology

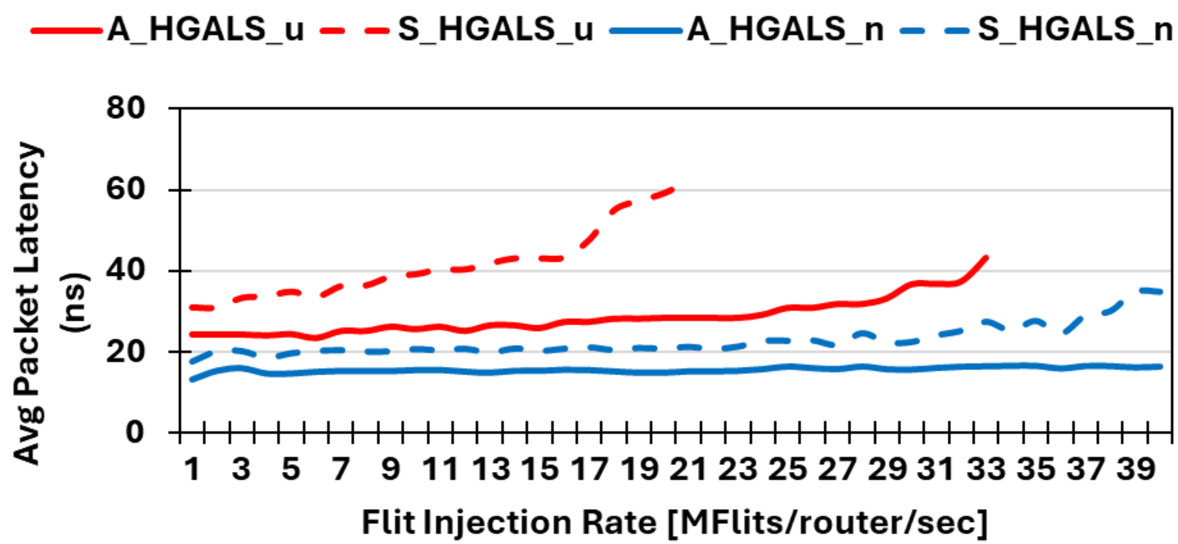


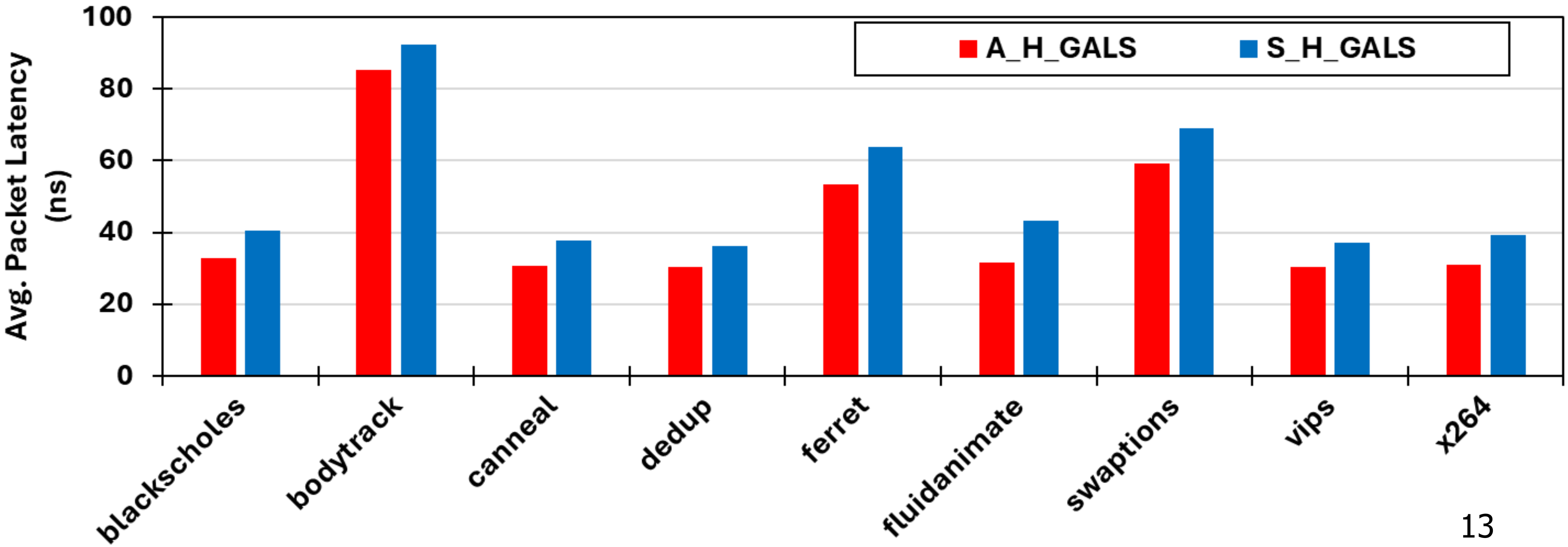




Support for complex GALS Networks







Major Observations

- asynchronous NoCs have about 10% lower average packet latency at no-load conditions:
  - saturate 20% earlier under specific traffic patterns
  - display consistently lower average packet latency across all injection rates for bitrev, shuffle, and transpose patterns
- asynchronous NoCs mitigate the latency increase due to complex routing by about 23%
- under uniform traffic, both synchronous and asynchronous hierarchical NoCs show similar latencies
- In GALS NoCs:
  - asynchronous versions are 36% faster for uniform traffic
  - under PARSEC traffic, asynchronous NoCs are 8% faster and consume 52% less power
  - despite process variation, they maintain a 15% speed advantage
  - asynchronous GALS NoCs are 20% faster than their synchronous counterparts under PARSEC traffic

Key Takeaways

- CANSim supports event-level simulation of each router stage for accurate modeling of router operations.
- Each router in the NoC can have separate timing constraints to model heterogeneous NoCs.
- Support for variability in the timing path allows for modeling data-dependent delays.
- Complex NoCs, including heterarchical NoCs, can be specified in the form of a graph.
- CANSim can generate various synthetic traffic patterns and supports dependency-driven real-world benchmarks.
- Activity tracking to create power and power-gating reports.
- CANSim is verified against synthesis models at both no-load conditions and saturating conditions.

QUESTIONS

THANK YOU