EATS: Energy-aware Adaptive Topology Switching for Network-on-Chips

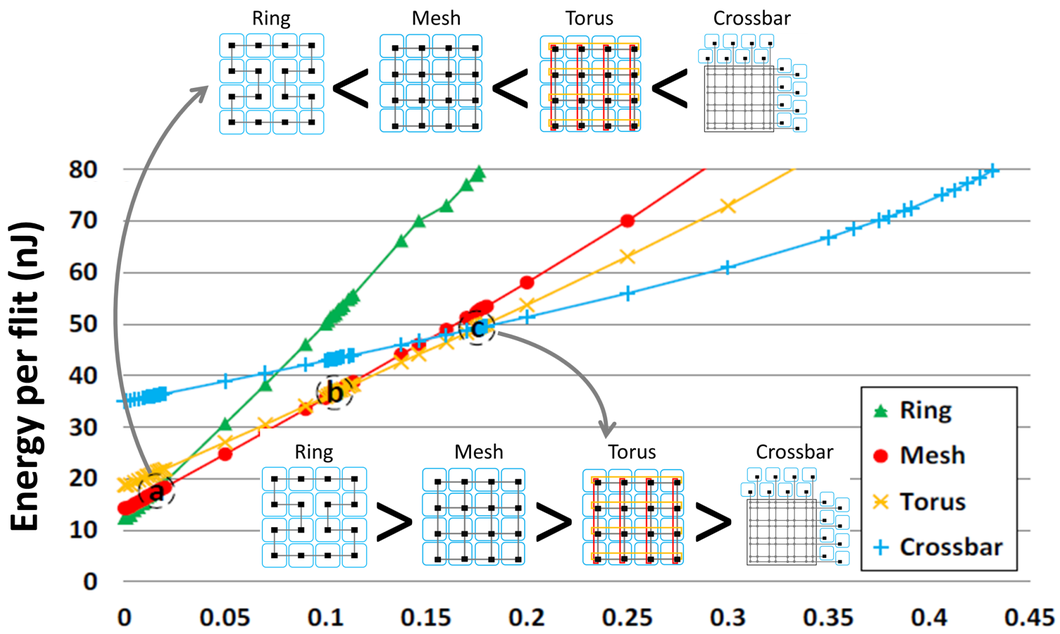
Man WU[1], **Shaswot SHRESTHAMALI[2]**, Xiaoman LIU[3], Yuan HE[1]
Keio University[1], Kyushu University[2], Shenyang University of Technology[3]

Why Dynamic Topology Matters

Network topology directly impacts the energy performance of Network-on-Chips (NoC).

The best topology depends on the traffic conditions which change with the **different phases within an application.**

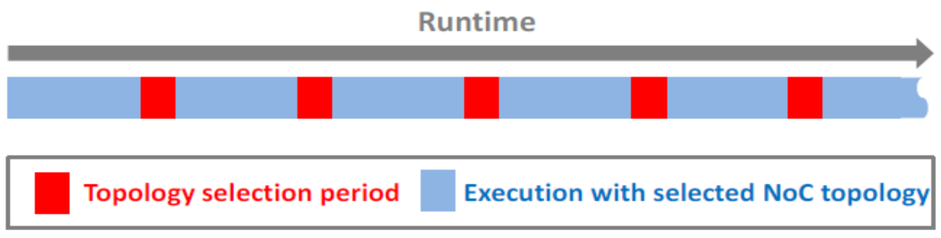
We propose **Energy-aware Adaptive Topology Switching (EATS)** that dynamically configures the NoC topology at runtime to enhance energy performance.



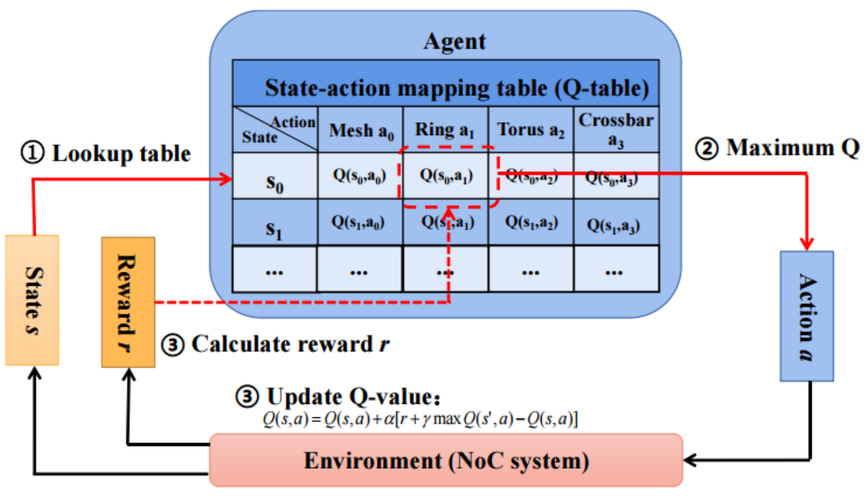
EATS Framework

EATS has two decision engines: **A) RL- EATS** and **B) Threshold-EATS**.

Network topology is reconfigured at runtime through on/off links and fine-grained PG in the network.



A. RL-EATS: Reinforcement Learning-EATS



Algorithm: *Tabular Q-learning*

State : *Avg. energy per flit* OR *injection rate*

Action : *topology* ∈ {*mesh, ring, torus, xbar*}

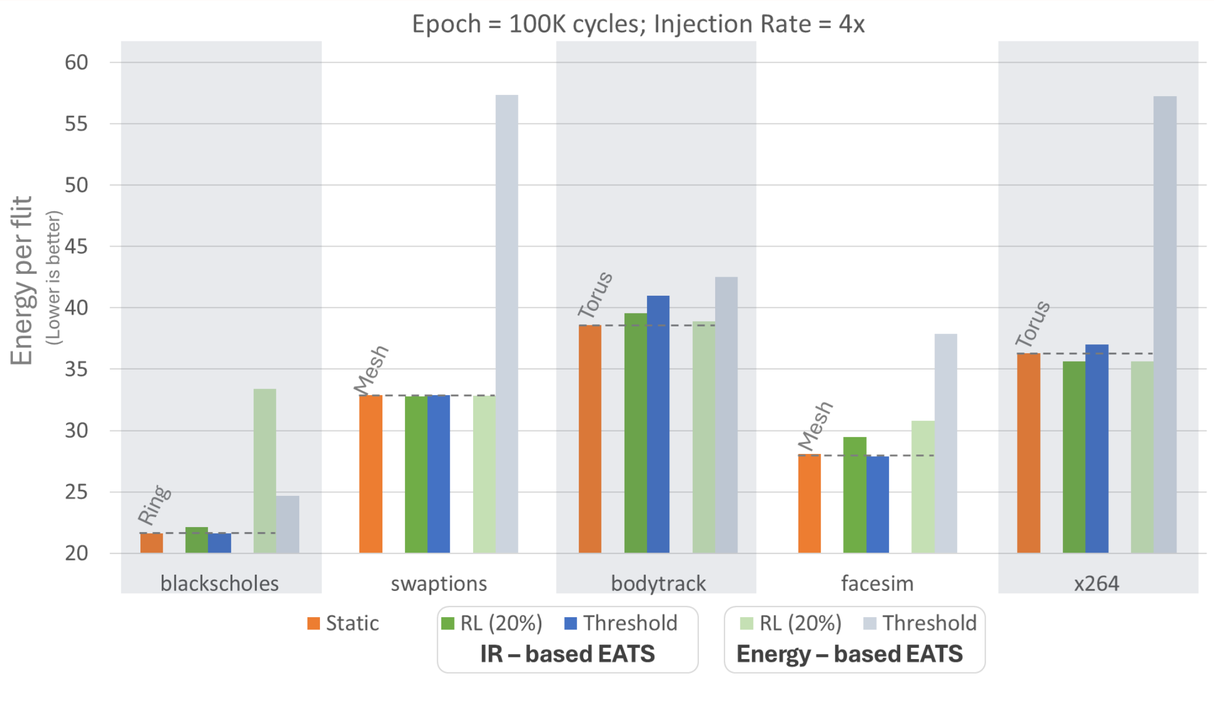
Reward: $r = -$ *Energy per flit*

B. Threshold-EATS

Injection Rate (flits/link/cycle)	Energy per flit (nJ)	Topology
< 0.025	< 16.73	***Ring***
0.025 – 0.110	16.73 – 36.37	***Mesh***
0.110 – 0.175	36.37 – 49.15	***Torus***
> 0.175	> 49.15	***Crossbar***

RESULTS

1. EATS beats Static Configuration

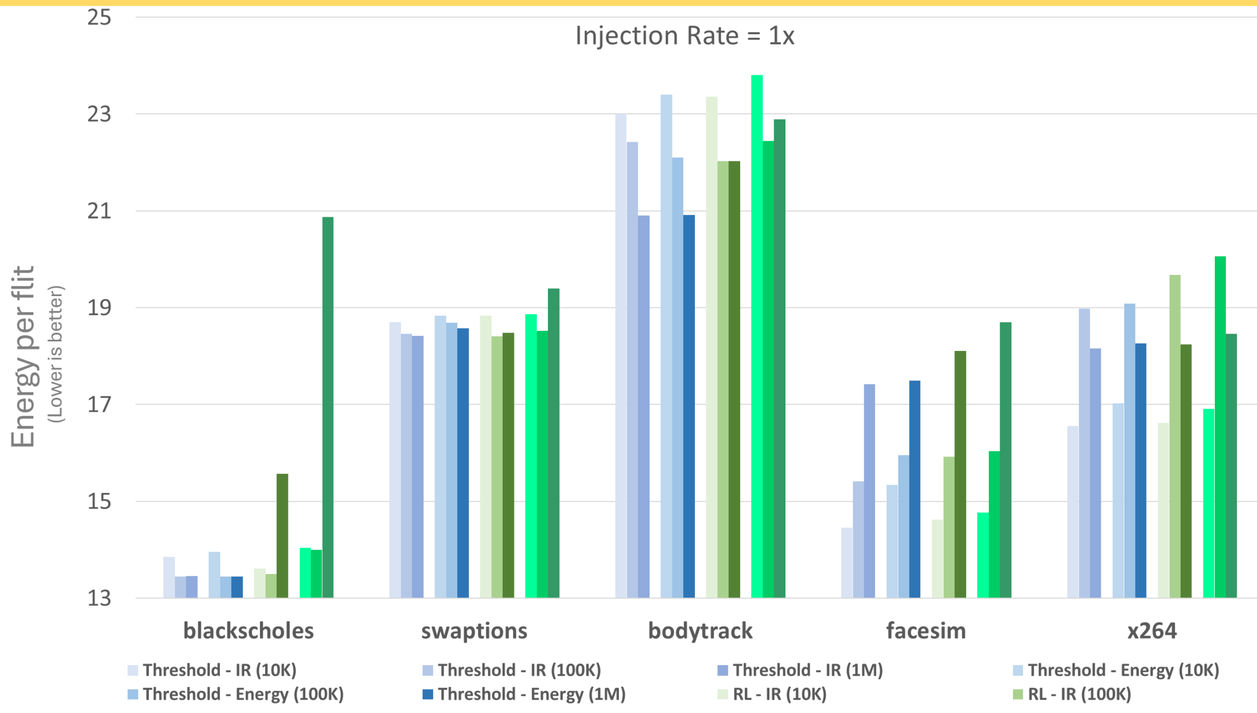


Dynamic Topology configuration using EATS has **better energy performance** (up to ~24%) than the best static topology configuration.

RL-based EATS is usually **better or on-par** with the best topology configuration. This shows that a learning-based topology configuration scheme is a promising alternative.

Injection Rate (IR)-based EATS is generally better than Energy-based i.e., the **injection rate is the determining factor** for choosing the best topology configuration rather than the average energy per flit.

2. Dynamic Configuration Overhead Tradeoffs



The ***Energy per flit*** includes the energy for flit transport AND switching the topology.

Shorter epochs presents more opportunities for EATS to adapt to the network traffic. However, this also may result in immature non-optimal decisions and larger switching overhead. More frequent topology reconfiguration (shorter epochs) should generally increase energy per flit.

`facesim` and `x264` are more sensitive to the topology and **more frequent reconfiguration with EATS compensates for the overhead of topology reconfiguration.**

This work was supported in part by JSPS KAKENHI Grants JP24K20843, JP22K21285, JP20K23315, and by the Okawa Foundation for Information and Telecommunications under Grant 21-04