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High Performance Hierarchical Torus Network

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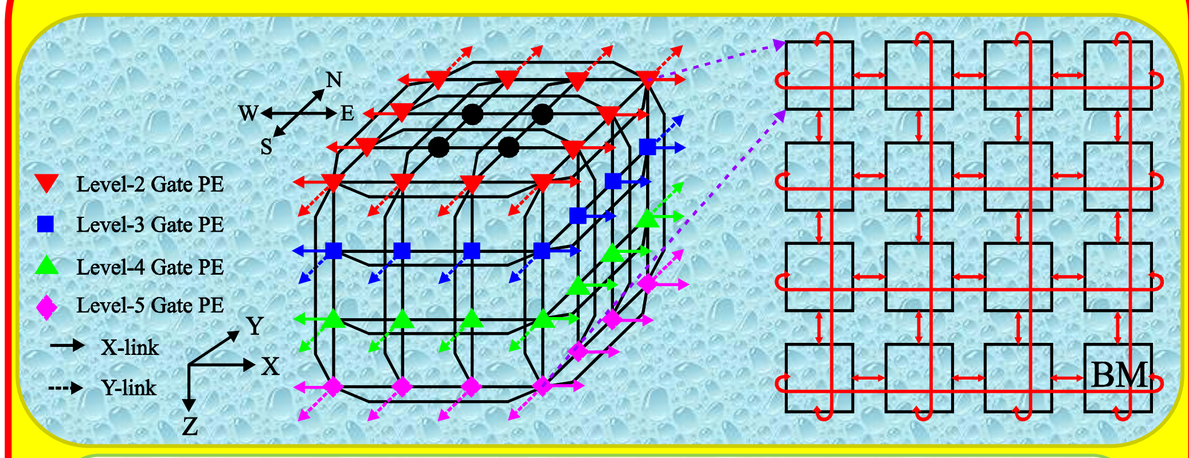
Abstract

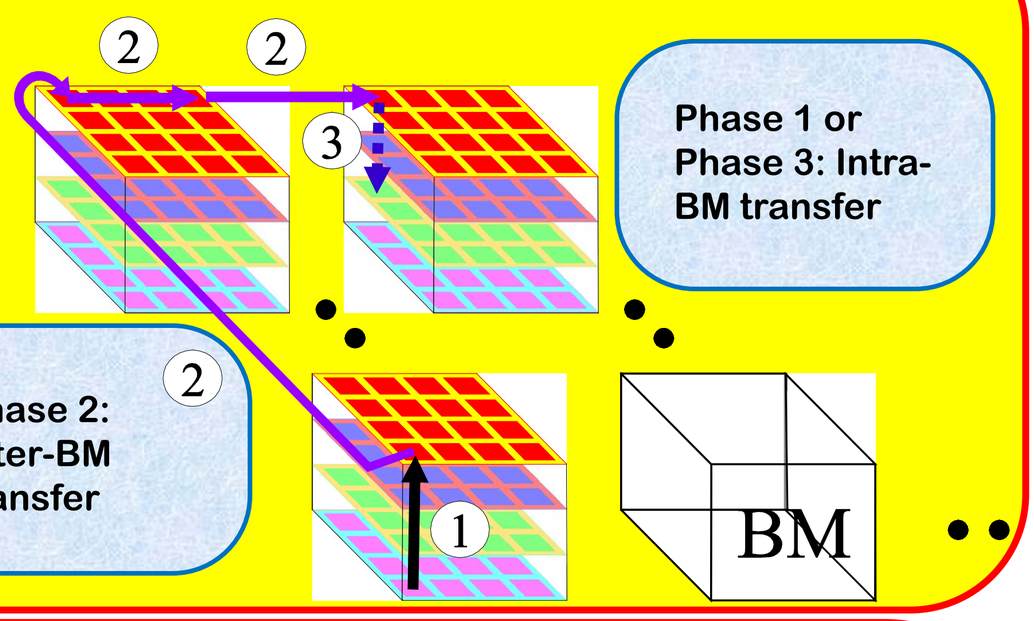
A Hierarchical Torus Network (HTN) is a 2D-torus of multiple basic modules, in which the basic modules are 3D-torus that are hierarchically interconnected for higher level networks. This research addresses the architecture of the HTN, deadlock-free dimension-order and adaptive routing algorithms, static network performance, and dynamic communication performance (DCP). The static network performances are derived from the graph model and the DCP is evaluated by using dimension-order routing and newly proposed adaptive routing algorithms under various traffic patterns. It is shown that the HTN possesses several attractive features, including constant node degree, small diameter, low cost, small average distance, moderate (neither too low, nor too high) bisection width, and high throughput and low latency, which provide better DCP than that of other conventional and hierarchical interconnection networks. It is also found that the DCP of an HTN using the proposed adaptive routing algorithms are better than when the dimension-order routing is used, in terms of network throughput.

1. Architecture of a HTN

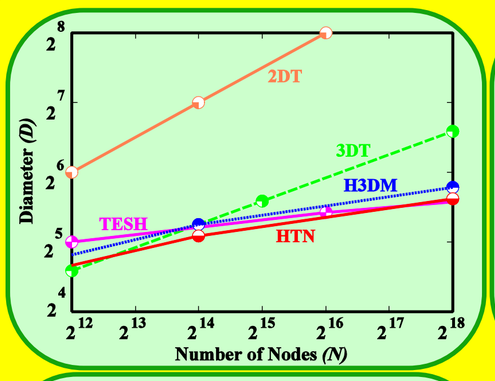


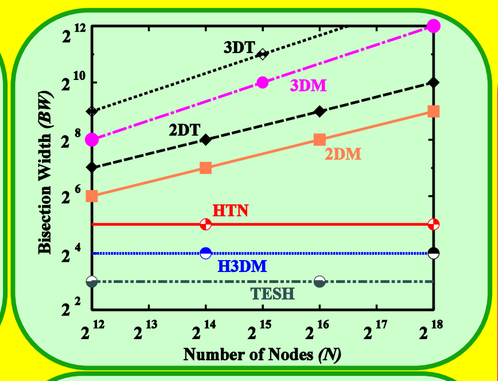
- Basic Module is a 3D-torus network *(m × m × m)*
- Higher level network is a 2D-torus network *(n × n)*.

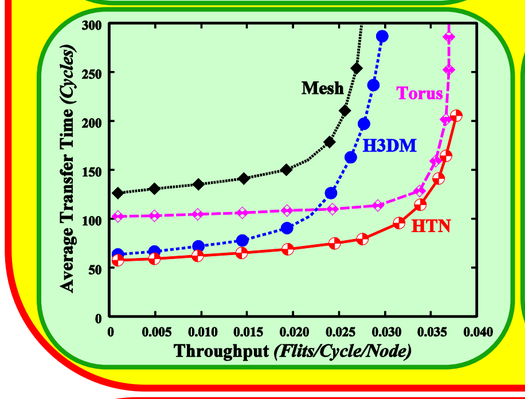
2. Dimension Order Routing (DOR)

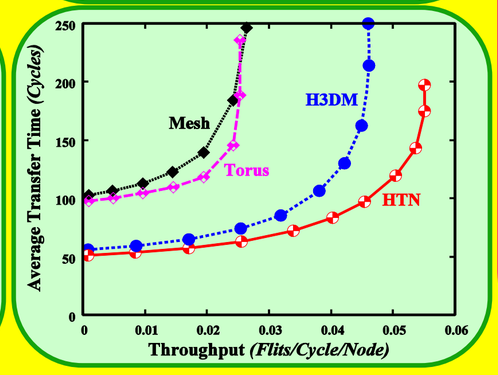


3. Performance Evaluation



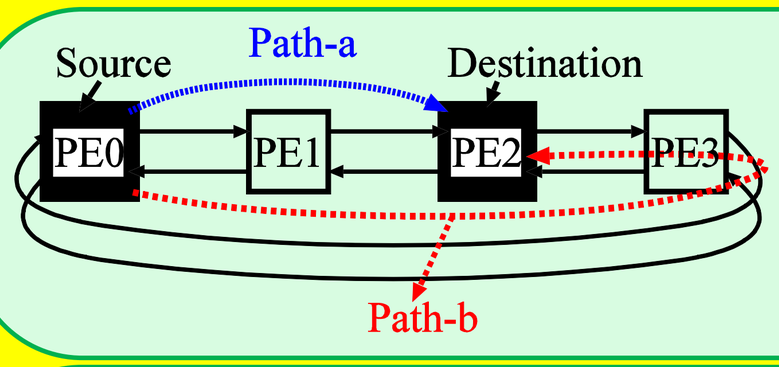






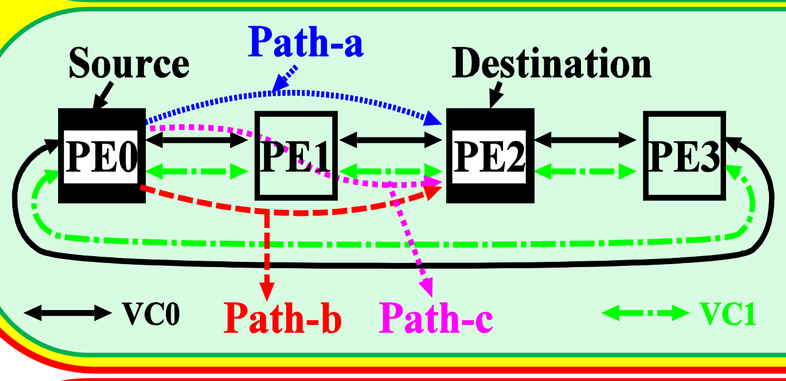
- Good static network performance
- Low latency and high throughput

4. Adaptive Routing Algorithm



LS ALGO

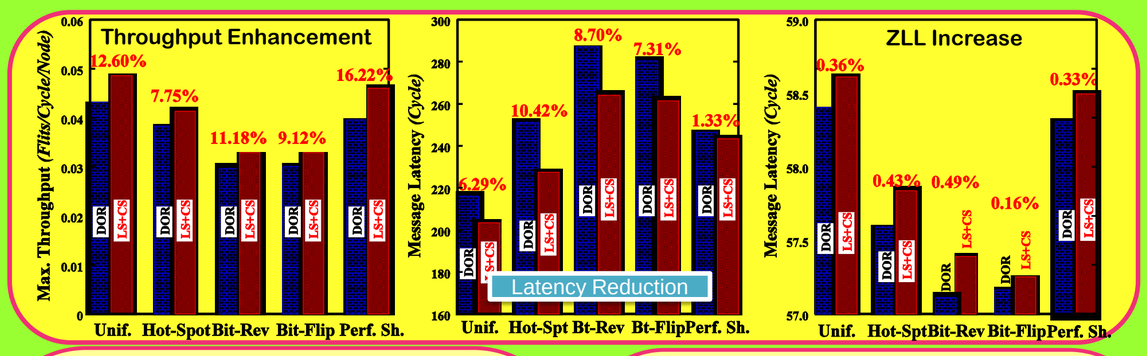
$$|s-d| = \begin{cases} \frac{m}{2} \\ \frac{n}{2} \end{cases}$$

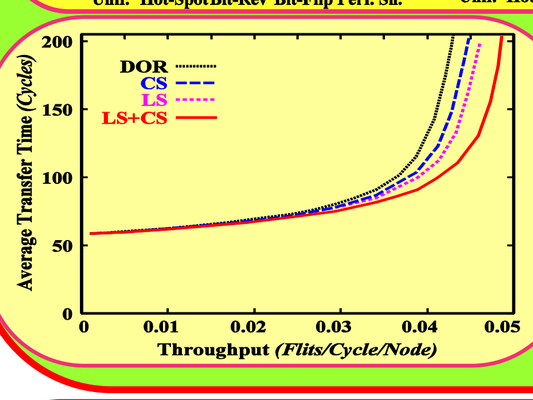


CS ALGO

- If VC1 is idle
- Switched to VC1
- Select VC1 initially

5. DCP using Adaptive Routing





- Substantial throughput enhancement
- Significant latency reduction
- With trivial increase of zero load latency

6. Applicability and Novelty

- HTN is suitable for 3D-WSI realization
- HTN is a suitable in computing intensive applications like FFT, bitonic sort, etc.
- HTN is suitable for adverse traffic pattern

- HTN would be a good choice of inter-connection network for next generation massively parallel computer systems .

7. Conclusions

- Attractive features of HTN includes constant degree, small diameter, low cost, small average distance, moderate bisection width.
- HTN yields low message latency and high network throughput, which provide better dynamic communication performance.
- The DCP of an HTN using the proposed adaptive routing algorithms are better than when the dimension-order routing is used.