CS223 : Computer Architecture & Organization

Lecture 33 [26.04.2022]

Network on Chip – Topology & Routing

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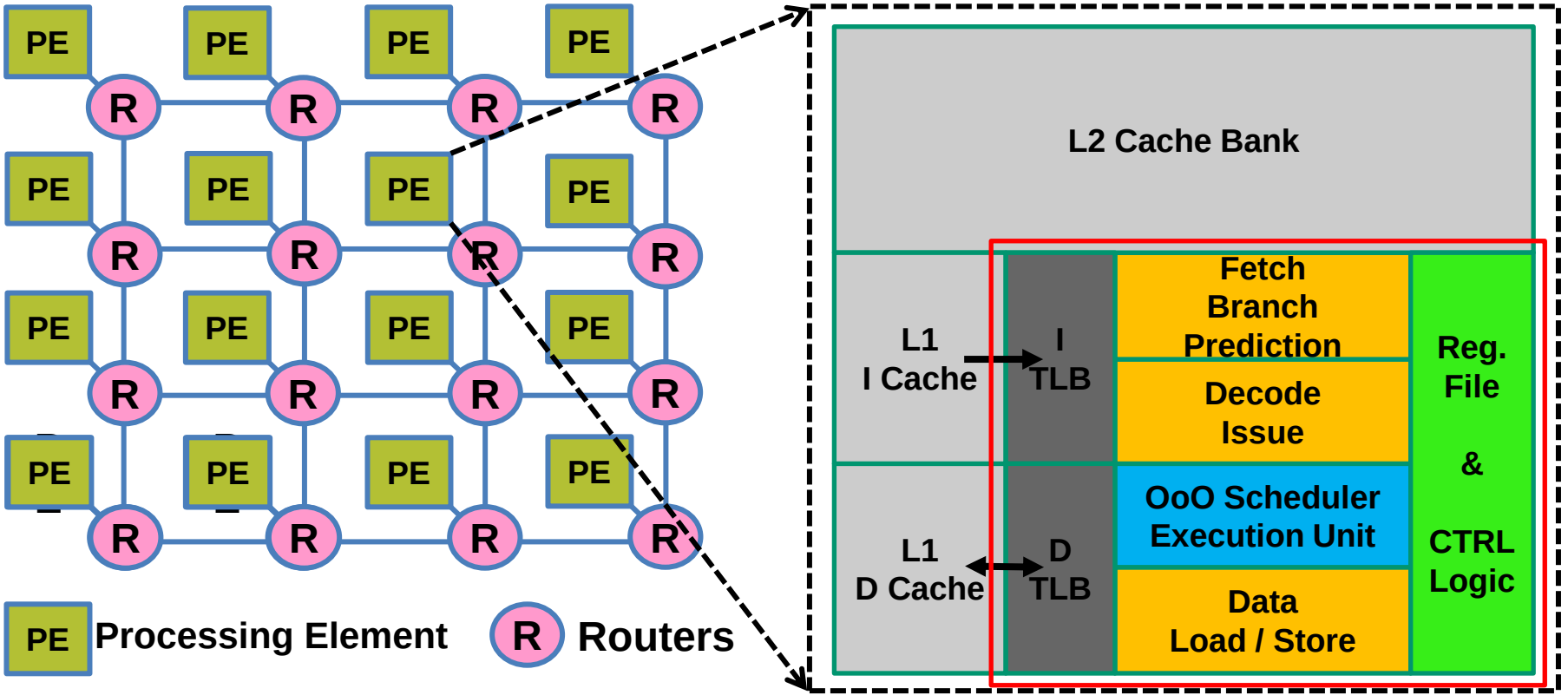
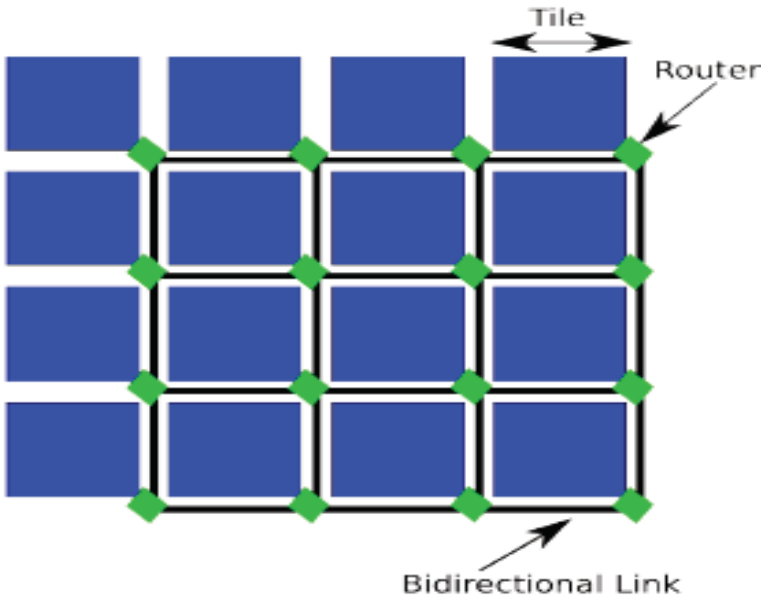
Tiled Chip Many-Core Processor (TCMP)

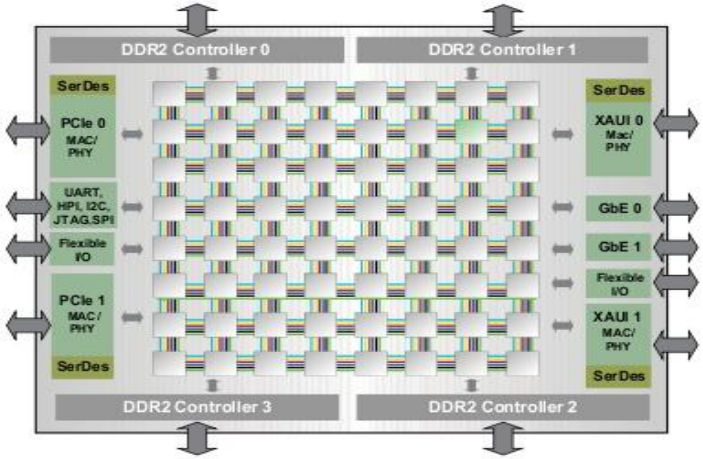


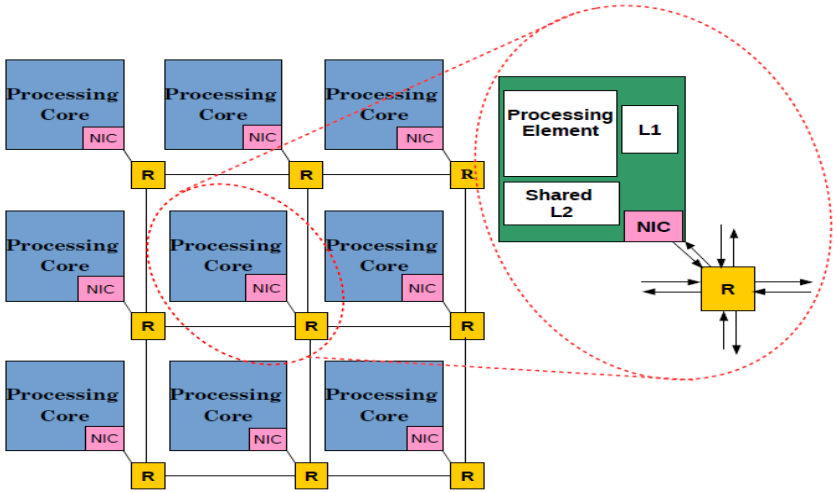
What is NoC ?

- Processing units interconnected via packet based network
- Each resource is called as a ***'tile'***
- All resources organized as rectangular tiles on the chip.
- Each tile have an address **- *(X,Y)***
- Tiles interconnected by network of routers
- Communication by packet transmission



Routers and Tiles

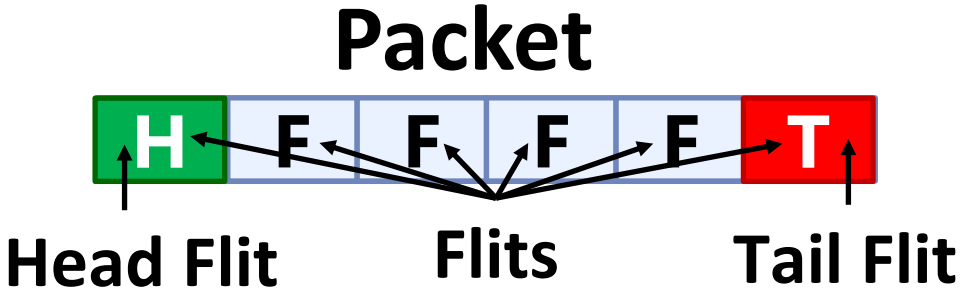




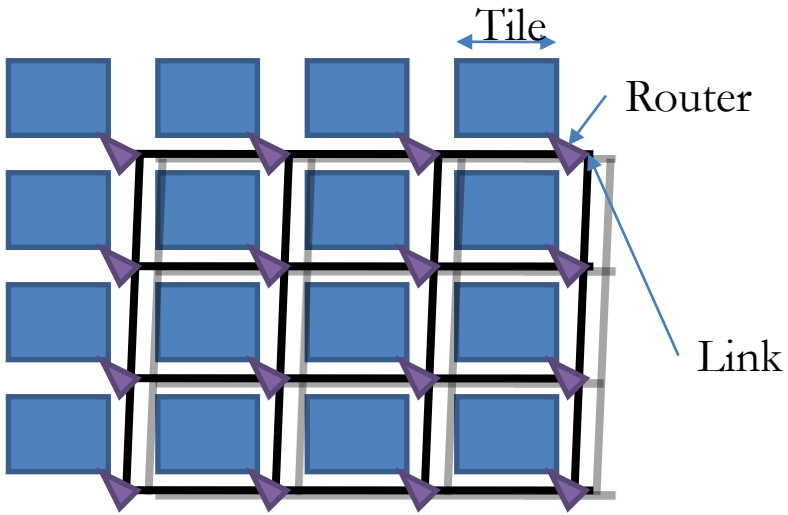
- East, West, North and South neighbors
- Packets are divided into flow control units called flits
- L1 and L2 cache misses create NoC traffic packets

Packets & Flits

- **Packet**
  - Unit of transfer for network
- **Flit**
  - Basic unit of transfer between a pair of routers
  - Unit of flow control within network



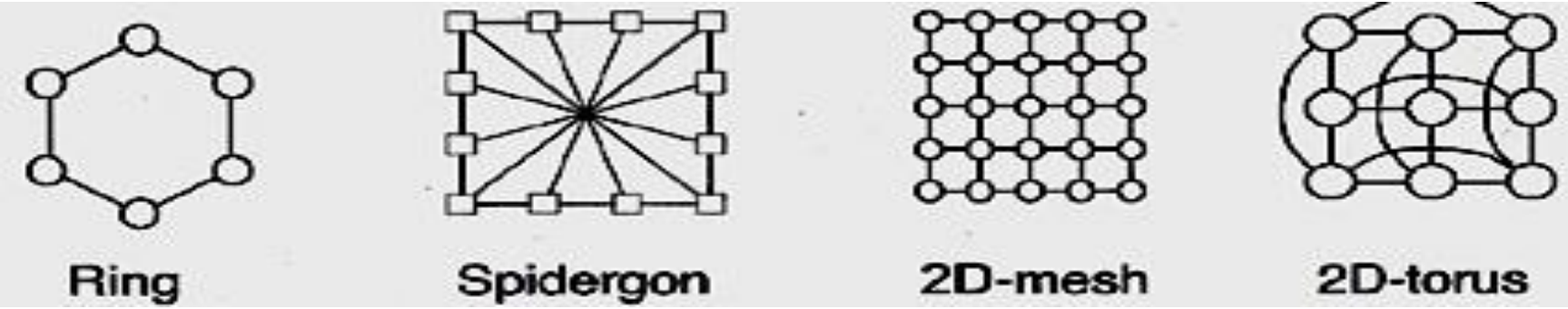
Building Blocks of NoC



- Topology
- Routing
- Flow control
- Router micro-architecture

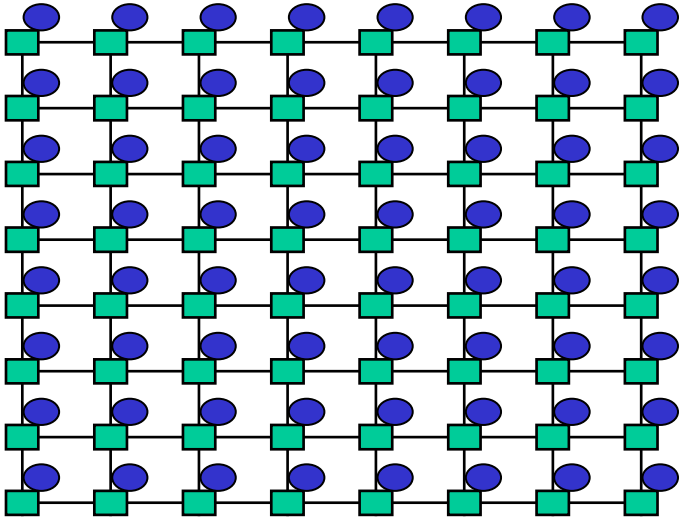
Topology

- Determines the physical layout and connection pattern between nodes and channels in the network.



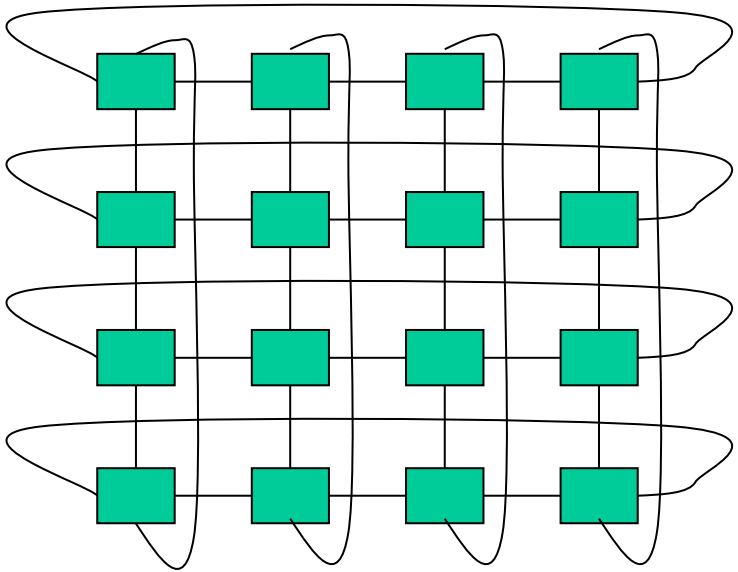
Mesh

- Each node connected to 4 neighbors (N, E, S, W)
- Easy to layout on-chip: regular and equal-length links
- Path diversity: many ways to get from one node to another

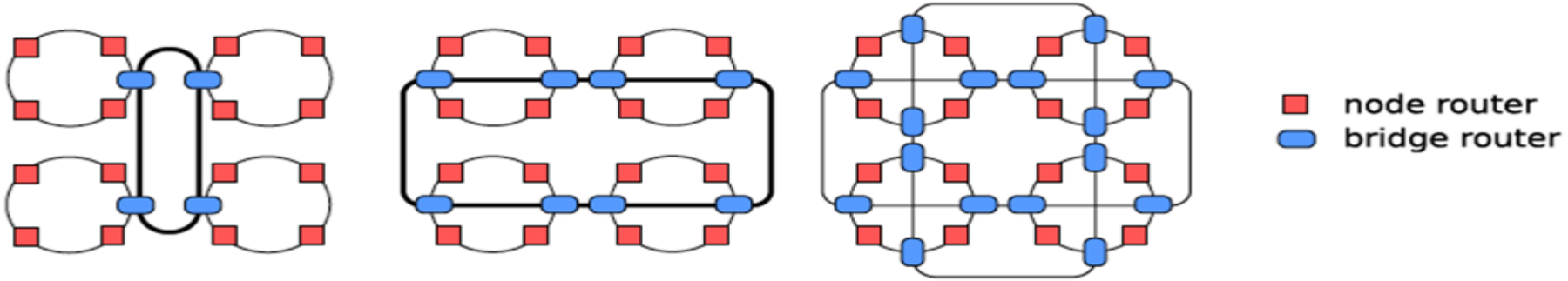


Torus

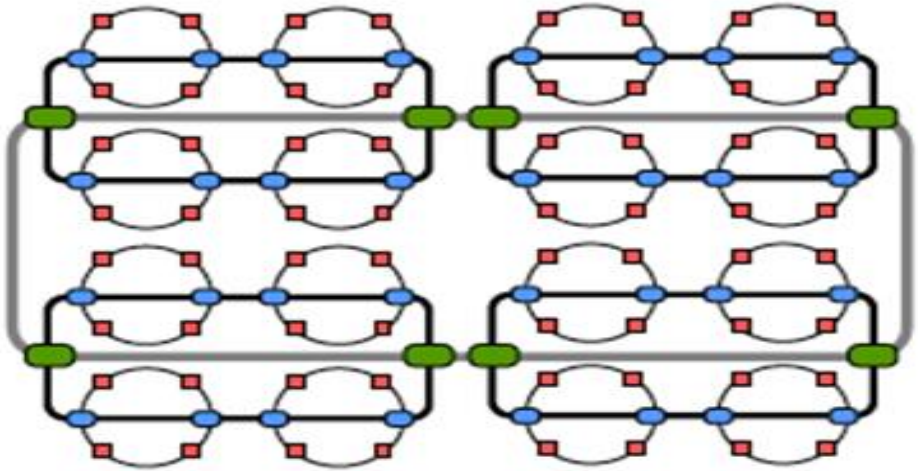
- Mesh is not symmetric on edges: performance very sensitive to placement of task on edge vs. middle
- Torus avoids this problem
- Harder to lay out on-chip
- Unequal link lengths



Hierarchical Rings

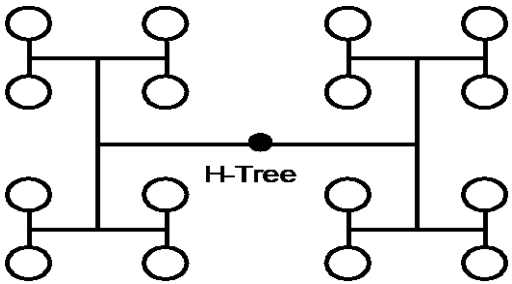


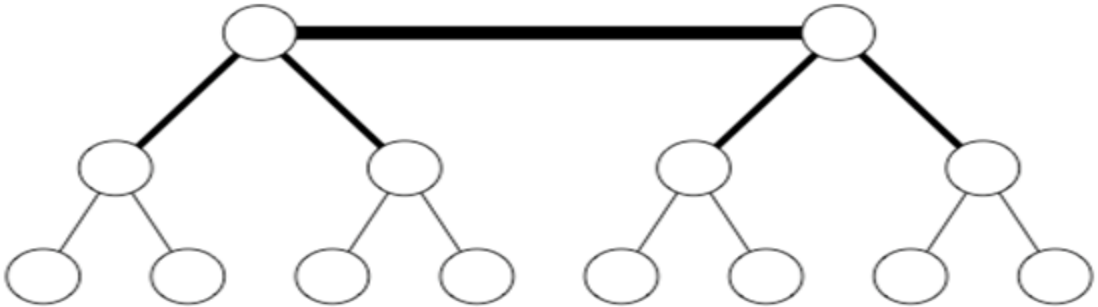
- More scalable
- Lower latency
- More complex



Trees

- Planar, hierarchical topology
- Good for local traffic
- Easy to Layout
- Root can become a bottleneck
- Fat trees avoid this problem





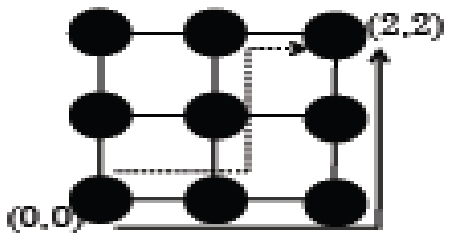
Fat Tree

Routing Algorithm

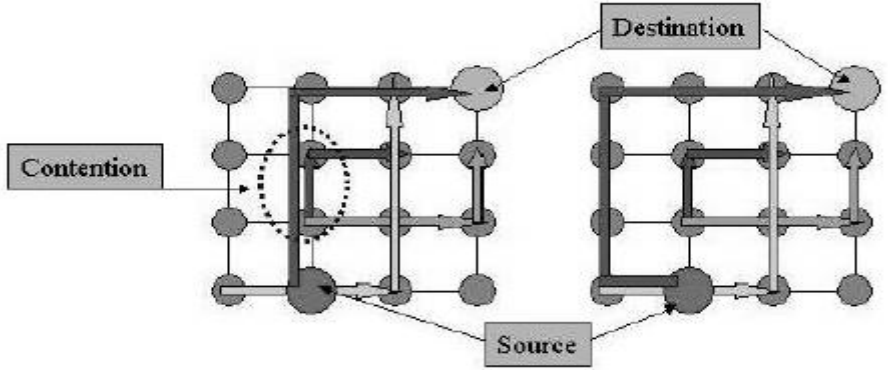
- Compute the path route for packets to reach destination.
  - **Deterministic:** always chooses the same path for a communicating source-destination pair
  - **Oblivious:** chooses different paths, without considering network state
  - **Adaptive:** can choose different paths, adapting to the state of the network
- Minimal Routing vs Non-Minimal Routing
- Source Routing vs Node Routing
- Deterministic Routing vs Adaptive Routing

Minimal & Non-Minimal Routing

- **Profitable route:** The route that always leads the packet closer to the destination.
- **Misroute:** A route that leads the packet away from the destination.



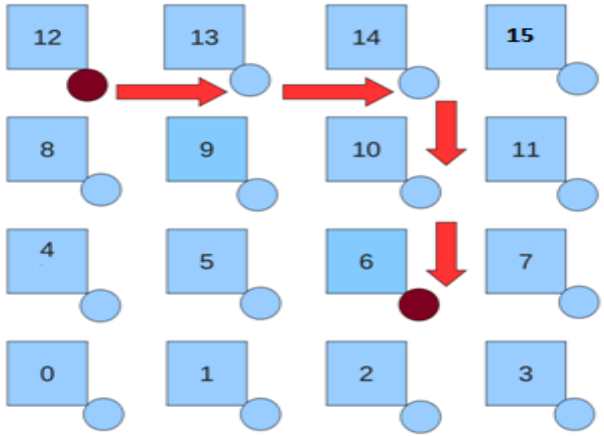
Minimal routing



Non-Minimal routing

Deterministic Routing

- All packets between the same (source, dest) pair take the same path
- Dimension-order routing – Eg. XY routing
  - First traverse dimension X, then traverse dimension Y
  - Simple
  - Deadlock freedom
  - Could lead to high contention
  - Does not exploit path diversity



Reference

- **Route Packets not wires, William J. Dally, Brian Towles**

  https://dl.acm.org/doi/10.1145/378239.379048.

- **NPTEL Video Links:**
  - **https://tinyurl.com/ybwpo99z**
  - **https://tinyurl.com/yjq85rym**
  - **https://tinyurl.com/yhclb2xd**

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