MinBD: Minimally-Buffered Deflection Routing for Energy-Efficient Interconnect

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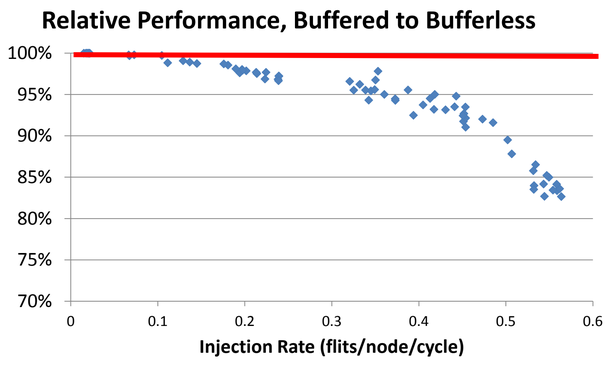
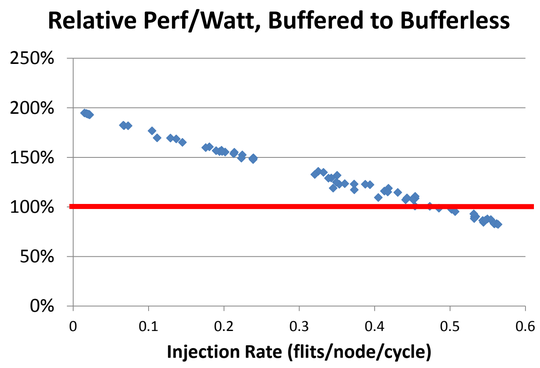
Bufferless Routing Reduces Power But Also Degrades Performance

- Pure **bufferless deflection routing** (CHIPPER) reduces network throughput → reduced application performance
- But, reduced power and area are desirable





- Bufferless routers **eliminate buffers** → less static power
- Bufferless routers **introduce deflections** → higher dynamic power and lower performance at high load

Combine Deflection and Buffering for the Best of Both Worlds

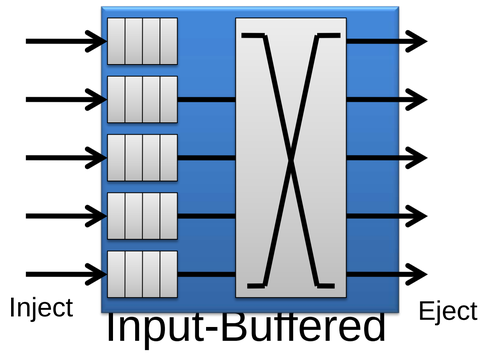
- **Key Insight**: Starting with pure bufferless deflection routing (CHIPPER), adding a **small buffer** allows router to buffer some flits and deflect other flits at fine granularity.
  - Deflection rate reduces relative to bufferless routers which **deflect all contending flits**
  - Buffer is more efficiently used relative to input-buffered routers which **buffer all flits**

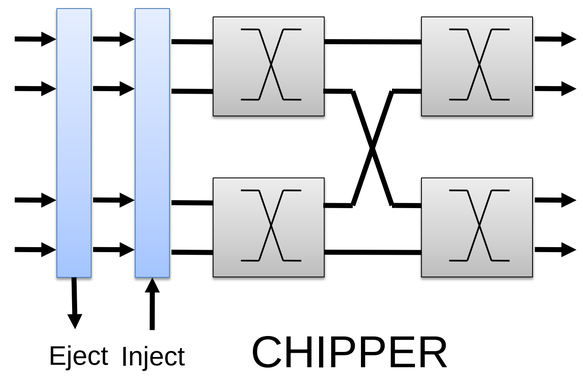
Shortcomings in Prior Bufferless Deflection Routers

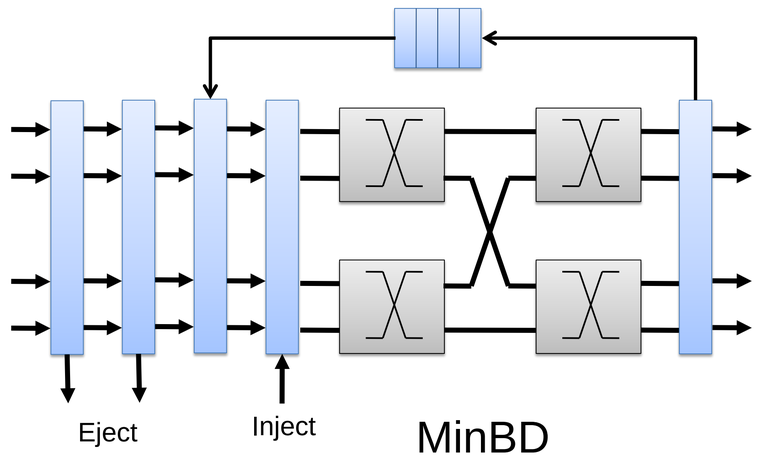
1. **All contending flits are deflected**: high dynamic power and low performance at high load (when many flits contend)
   - **Deflection rate** in CHIPPER is 28% on average
2. **Only one flit can be ejected per cycle**: when multiple flits arrive simultaneously, some must be deflected
   - **Ejection bottleneck** causes deflections in 9% of all cycles in CHIPPER on average (4x4 network)
3. **Uncoordinated prioritization unnecessarily deflects**: pseudorandom arbitration under Golden Packet leads to priority inversions inside routers

MinBD: Buffered Deflection Routing

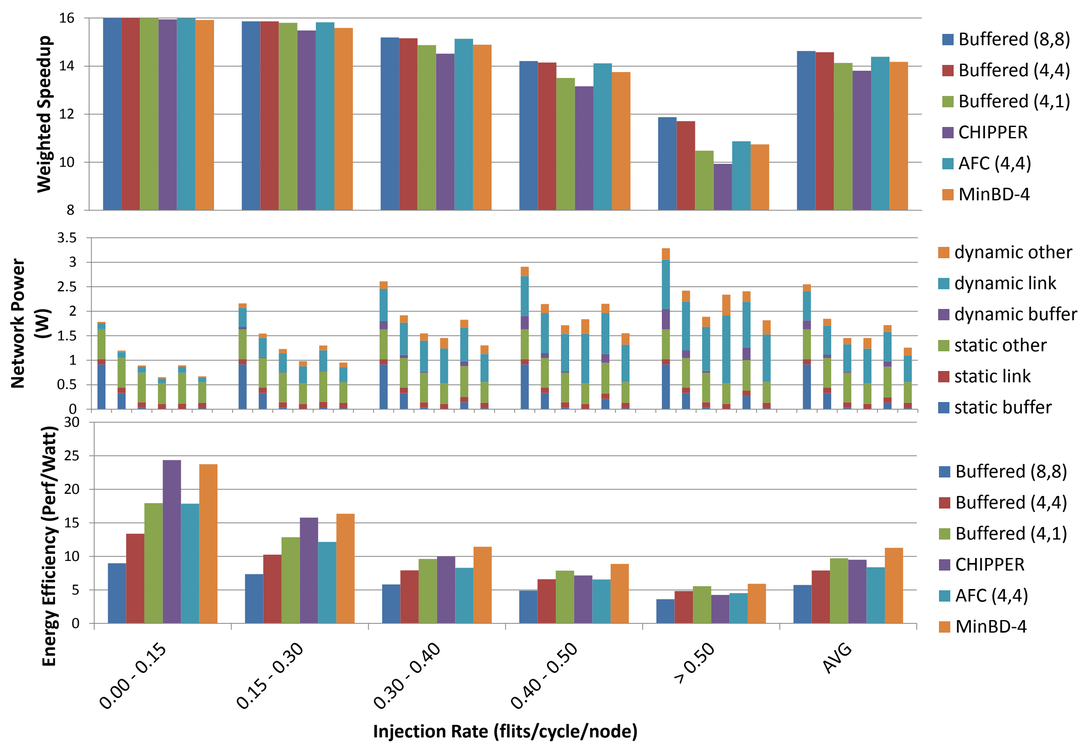
- **Side Buffering**
  - When flits arrive, **perform deflection routing first**.
  - Buffer **up to one deflected flit** in a small "*side buffer*".
  - Re-inject side-buffered flits when space is available.
- **Dual-width Ejection**
  - Replicate ejector module to allow **two flits/cycle** to eject (captures most demand, eliminates bottleneck)
- **Silver-Flit Prioritization**
  - Introduce lower **Silver Flit** priority locally at router
  - Does not interfere with **Golden Flit** correctness
  - Allows for coordinated deflection arbitration







Results



- **Best energy efficiency** of all evaluated designs
- **Close to buffered performance** for lower cost

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