Interconnection Network-III (Mesh NOC)

Dr. A. Sahu
CSE, IIT Guwahati

Lecture Note Scribing

- Email Your Choices/Preferred Topics
  - If M choices given by a student, we assume rest (21-M) topics are to be preferred randomly by the student
- If your 1st choice is not chosen by others then you will be allocated to that topics
- Lottery will be on Friday 5th Oct, at 5PM-6PM for resolving conflict cases (Venue Class Room : 2001)
- Latex and Xfig/eps format is mandatory
- TAs will takes 3 days to give you feedback
- 8 Marks (Initial Draft) + 8 Marks (Intermediate) + 14 Marks (final Draft)

Network on Chip: MESH

Mesh Network : Router

Crossbar Switch

NoC Routing-Table

- Unlike regular SoC placement, NoC placement is not complete without a Routing Table.
- The Routing Table determines for each PE the route via which it will send packets to other PEs.
- The routing table directly influences traffic in the NoC.
- Here we can also distinguish between 2 methods:
  - Static routing
  - Dynamic (adaptive) routing
**Static Routing**

- The Routing Table is constant.
- The route is embedded in the packet.
- Routers simply forward the packet to the direction indicated by the header.
- The routers are passive in their addressing of packets
  - Simple routers

**Dynamic Routing**

- The routing table can change dynamically during operation.
- Logically, a route is changed when it becomes slow due to other traffic.
- Possibly out-of-order arrival of packets.
- Usually requires more virtual channels.
- In this method, we can identify 2 systems
  - Routing altering decisions are made in the routers (smart routers).
  - Routing altering decisions are made in a dedicated central unit that receives traffic information from all the routers and can decide to change the routing table.

**Routing in a 2D-mesh NoC – XY routing**

- Determined completely from their addresses.
- Message travels “horizontally” (in the X-dimension) from source node to the “column” containing the destination, where the message travels vertically.
  - X direction is determined first, next Y direction.
- Four possible direction pairs, east-north, east-south, west-north, and west-south.
- Advantages for X-Y routing:
  - Very simple to implement
  - Deterministic
  - Deadlock-free

**Designing Adaptive Routing**

- Every routing scheme must guarantee eventual packet delivery thus it must avoid two pitfalls.
- Live lock: Packet advances indefinitely
  - Trying to reach Tezpur but sitting on a train to NJP.
- Dead lock: Packets cannot advance due to circular dependency
  - Solution: Avoid circular dependency

**Partially Adaptive Wormhole Routing: Turn Model**

- Partially adaptive routing
  - Deadlock avoidance
  - XY Routing: eliminate a ½ of the turns to avoid deadlock.
  - Lets manage with elimination ⅓ of the turn.

Interview Question: Finding your Friend near Chowk.

- Solution: Minimal routing
  - Productive Hop: Choose a Hop near destination
  - If many possible choose the least congested one
  - Bounds no number of HOPS
  - Can be prevented by limiting the number of misrouting operations

- Dead lock
  - Packets cannot advance due to circular dependency
  - Solution: Avoid circular dependency

fully adaptive, 8 turns  
XY routing, 4 turns  
Not a Good Choice
Partially Adaptive Wormhole Routing: Turn Model

- Partially adaptive routing
  - Deadlock avoidance with 6 turns
- Lets manage with elimination ¾ of the turn
  - West First: Travel West Direction first after that West is not allowed
  - Other direction allowed after west (it make 6 turn)
  - North Last: Travel any direction, but if North travelled other direction are not allowed
  - Initially other direction allowed (it make 6 turn)
  - Negative First:
    - Preferred negative side of one dimension after another

Odd-Even Wormhole Routing

- In Previous methods, at least half of S/D pairs are restricted to having one minimal path, while full adaptiveness is provided to the others
  - Unfair!
- Odd-even turn routing offers solution:
  - Even column: no EN or ES turn
    - East going packet allowed to turn on only odd column
  - Odd column: no NW or SW turn
    - West packet allowed to turn at Even column
Out-of-Order Arrival

- Packet-level adaptation breaks arrival order
- Naive adaptive routing requires **reorder buffer** at every node
- Design of reorder buffer is a challenge:
  - Small size is required to reduce the area/power overhead
  - If the buffer is too small it will suffer from frequent overflows

Adaptive Routing in Two Dimensions: Reducing Virtual Channel

Increasing Network $D_{i+1}$

Decreasing Network