Module-2
CSEN 3104
Lecture 15

Dr. Debranjan Sarkar

Interconnection Networks

Inter-PE Communication

- The design of the architecture of an interconnection network for an SIMD machine is based on
  - Operation modes
  - Control strategies
  - Switching methodologies
  - Network topologies

Operation Modes of Interconnection Network

- Synchronous mode
  - To establish synchronous communication path for
    - Data manipulating function
    - Data instruction broadcast
- Asynchronous mode
  - To have asynchronous communication when
    - Connection requests are issued dynamically
- Combined mode
  - To facilitate both synchronous and asynchronous processing
- SIMD machines work in synchronous operation mode, where lock-step operations among all PEs are enforced

Control Strategy

- Interconnection network consists of
  - A number of switching elements, and
  - Interconnecting links
- Interconnection functions are realized by properly setting control of the switching elements
- Two types of control
  - Centralized control -> the control setting function is managed by a centralized controller
  - Distributed control -> the control setting function is managed by the individual switching element
- SIMD machines have interconnection networks with centralized control on all switching elements by the control unit

Switching methodology

- Circuit switching
  - Physical path is actually established between a source and a destination
  - Much more suitable for bulk data transmission
- Packet switching
  - Data is put in a packet and routed through the interconnection network
  - No physical connection is established
  - More efficient for many short data messages
- Integrated switching
  - Includes the capabilities of both circuit switching and packet switching
- SIMD interconnection networks assume circuit switching

Network topology

- A network is depicted by a graph in which nodes represent switching points and edges represent communication links
- Static topology
  - Links between two processors are passive
  - Dedicated buses cannot be reconfigured for direct connections to other processors
- Dynamic topology
  - Can be reconfigured by setting the network's active switching elements
- SIMD interconnection networks are classified into two categories, based on network topologies:
  - Static networks
  - Dynamic networks

Static Networks

- Topologies in the static networks are classified according to the dimensions required for the layout
    - One-dimensional (Linear array)
    - Two dimensional (Ring, star, tree, mesh and systolic array)
    - Three dimensional (Completely connected, Chordal ring, 3-cube, 3-cube-connected cycle)
    - Hypercube
- Show the diagrams

Dynamic Networks

- Single stage dynamic network (show figure)
  - N number of input selectors (IS) and N output selectors (OS)
  - Each IS is essentially a 1-to-D demultiplexer ($1 \leq D \leq N$)
  - Each OS is essentially an M-to-1 multiplexer ($1 \leq M \leq N$)
  - To establish a desired path, different control signals are applied to all IS and OS selectors
  - Data items may have to recirculate through the single stage several times to reach the final destination
  - The higher is the hardware connectivity, the less is the number of recirculations required
  - Crossbar-switching network is a single-stage n/w with D=M=N
  - Crossbar is an extreme case in which only one circulation is required for any path

Mesh-connected Illiac Network

- Show figure
- Single stage recirculating network with N = 64 PEs
- In one circulation step, each PE_i is allowed to send data to any one of PE_{i+1}, PE_{i-1} , PE_{i+r} and PE_{i-r}
- In practice, N is a perfect square and r = sqrt(N). For Illiac IV, r = 8
- The interconnection network of Illiac IV is characterized by the following four routing functions:
  - $R_{+1}(i) = (i+1) \bmod N$
  - $R_{-1}(i) = (i-1) \bmod N$
  - $R_{+r}(i) = (i+r) \bmod N$
  - $R_{-r}(i) = (i-r) \bmod N$

Where $0 \leq i \leq (N-1)$

Mesh-connected Illiac Network

- In the reduced Illiac network, the outputs of IS_i are connected to the inputs of OS_j for j = i+1, i-1, i+r, and i-r
- In other words, OS_j gets its inputs from IS_i for i = j-1, j+1, j-r, and j+r respectively
- Each PE_i is directly connected to its four nearest neighbours in the mesh network
- Permutation Cycle (a b c) (d e) represents the permutation a→b, b→c, c→a and d→e, e→d in a circular fashion within each pair of parentheses
- We may write for Horizontal PEs

$$R_{+1} = (0\ 1\ 2\ \ldots\ N\text{-}2\ N\text{-}1)$$

$$R_{-1} = (N\text{-}1\ N\text{-}2\ \ldots\ 2\ 1\ 0)$$

- When the routing function is executed, data is routed as per above only if all PEs in the cycle are active

Thank you