The 6D Mesh/Torus Interconnect of K Computer

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Interconnect of K computer

- Tofu: Fujitsu’s original 6D mesh/torus interconnect
  - High communication performance
  - High system scalability
  - High fault-tolerance
Node construction

- Single CPU and single interconnect controller
- 10 links for inter-node connection
- 10GB/s per link
- Total 100GB/s of off-chip bandwidth
  - Feeds sufficient data to high performance CPU

CPU
SPARC64 VIIfx™
128 GFlops

Interconnect controller

10 GB/s x 10 links
Network construction

- 6 links $\Rightarrow$ Scalable $xyz$ 3D torus
- 4 links $\Rightarrow$ Fixed size $abc$ 3D mesh/torus
  - $|a|=2$, $|b|=3$, $|c|=2 \Rightarrow 12$ nodes
- Total topology is 6D mesh/torus
  - Cartesian product of $xyz$ and $abc$ mesh/torus
Network construction cont.

- From the other perspectives...
  - Overlaid twelve $xyz$ torus
  - $X \times Y \times Z$ array of $abc$ mesh/torus

- Twelve times higher scalability than the 3D torus network
Each pair of adjacent $abc$ mesh/torus is interconnected with twelve links
Routing algorithm

- Extended dimension order routing
  - Additional $abc$ traversal
  - $abc \Rightarrow xyz \Rightarrow abc$
  - The first $abc$ traversal is path selection
Example routing

Routing from (x=0, y=0, z=0, a=0, b=0, c=0) to (3, 2, 1, 1, 1)

Traverses $b + a + x \times 3 + y \times 2 + z + c$
Detouring faulty nodes

- Multipath routing allows to detour faulty nodes.
Conclusion

- Tofu: 6D mesh/torus interconnect architecture

- High communication performance
  - 100GB/s off-chip bandwidth feeds enough data to high performance CPU

- High system scalability
  - 12x higher scalability compared with 3D torus

- High fault-tolerance
  - Multipath routing algorithm allows to detour faulty nodes