Interprocessor Communication seen as load/store instruction generalization

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Summary

• Central importance of Interprocessor Communication
• Must go from low-speed I/O to high-speed p2p commun.
• Data Transfer Primitives: Remote DMA, Remote Queues
• Cache operations on top of Network Interface primitives?
• Combined Translation/Routing Tables – Data Migration
Communication Primitives: Intra-Node, Inter-Node

- Processor to Memory communication:
  - Load/Store primitives

- Interprocessor communication:
  - Read/Write (send/receive) data transfer primitives
Remote DMA as generalization of single-word Instr’ns

(a) Store Instruction

(b) Remote Write DMA

(c) Load Instruction

(d) Remote Read DMA

- block size is chosen so as to reduce overheads relative to data payload
Remote DMA is for One-to-One Communication

- Independent (unsynchronized) transfers have to occur into distinct memory regions
- Expensive when many potential senders but few actual ones
  – buffer reservation cost, polling-for-completion overhead
Multi-Party Synchronization: Remote Queues

- Atomic enqueue into shared space, unlike dedicated sp. with RDMA
- Space reserved only for # of actual senders – not potential senders
- Speeds up polling / waiting on multiple receive channels
- Appropriate for synchronization (remote enqueue) & job dispatching (remote dequeue) – generalization of atomic operations
Cache Operations related to RDMA

- Network interface as close to the processor as (L1) cache
- Messages or RDMA commands composed via \textit{store} instr’ns
- Cache line eviction is a case of Remote Write DMA
- Is there potential for the cache controller to use the primitives supplied by the network interface?
Cache Read Misses are like Remote Read DMA’s

- Network Interface as close to the processor as (L1) cache
- Should the NI be combined with the cache controller?
- Should portions of cache coherence protocols be left to the software, with NI hardware assistance for the rest?
Network Routing as Generalization of Address Decoding

- (a) Physical address decoding in a uniprocessor
- (b) geographical address routing in a multiprocessor
Two methods to support data migration:

(a) Translation table: first consult an indirection/routing table/directory
(b) Cache style: search multiple places in parallel
Progressive Translation: Localize Migration Updates

- Packets carry global virtual addresses
- Tables provide physical route (address) for the next few steps
- When page 9 migrates within D, only tables in that domain need updating
- Variable-size-page translation tables look like internet routing tables (longest-prefix matches if we want small-page-within-big-region migration)
- Tables that partition the system, for protection against untrusted operating systems, look like internet firewalls
Conclusions

• Hardware should provide “Primitives” – not “solutions”
  – few, simple, general-purpose, flexibly combinable primitives

• Data transport primitive: Remote DMA
• Synchronization primitive: Remote Enqueue

• Cache operation on top of Network Interface primitives?
• Translation/Routing Tables for Data Migration support