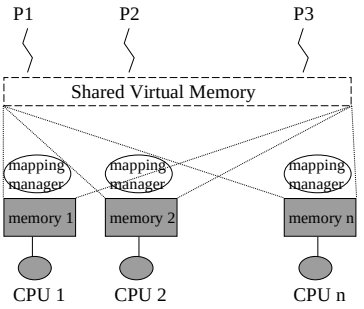
Distributed Shared Virtual Memory

- Concepts
- Memory coherence
- Page based coherence algorithms
- Implementation and experimental results

Different Ways of Sharing Remote Memory

- Network paging server
  - how would you implement it with Mach's data manager?
- Remote read/write
  - hardware assistance
- Multiprocessor architecture

Distributed Shared Memory



An Example

- read access
- write access
- read fault
- write fault

- Benefits of DSM

Memory Coherence

- Multiple copies of data accessed through different access paths: the value returned by a read should always be the value written by the most recent write
  - in uni-processor
  - in shared-memory multiprocessor
  - in distributed shared memory (loosely coupled multicomputer)

Solutions to Memory Coherence

- in the uni-processor context
- in the shared-memory multiprocessor context
- in DSM context
  - simple and inefficient solutions
  - design space of efficient solutions

Coherence Strategies in DSM

- invalidation-based versus update-based
- who owns (can write) a page
  - fixed versus dynamic
- who manages the ownership info
  - centralized versus distributed
  - distributed: fixed or dynamic

Implementation of Coherence Algorithms

- Changes in the page table operation
- sending/receiving invalidation messages
- "copy sets"

Centralized Manager Algorithms

- Info data structure: owner, copy sets, lock
- read fault handler
  - non-manager of the page: 4 messages
  - manager of the page: 2 messages
- write fault handler
- Optimization: nodes handle synchronization
  - page table entry: access, lock, copy set

Distributing the Manager

- Fixed distributed managers
- Using broadcasts
- Dynamic distributed manager algorithm
  - prob-Owner field
  - changing prob-Owner on read/write page faults
  - further reducing the forward links by using broadcast
- Tree-structured dynamic distributed managers

Granularity of Coherence Units

- protocol overhead => large unit is good
- false sharing => small unit is good

Implementation constraints:

- MMU based schemes => one page as a unit

Representation of copy sets

Experiments

- Applications
  - parallel Jacobi solver, parallel sort, matrix multiply, vector dot-product
- Speedup graphs
  - effect of large aggregate memory
  - conclusion: page-based DSM performs well when reference locality is good
- Comparison of coherence algorithms

Consistency Models

- Sequential consistency
- Weak consistency
- Release consistency
- Entry consistency

Fine-Grain Sharing: Munin

- Implements release consistency
- Sharing annotation:
  - read-only
  - migratory
  - write-shared
  - producer-consumer
  - reduction
  - result
  - conventional