Distributed Shared Memory

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Why is the Problem Important?

- Faster Data Processing
  - Processors are increasing exponentially
- Parallel Programming Accessibility
  - Dividing the work and distributing resources
- Large Data Sets
  - When memory cannot be confined to a single device
- Cloud Computing
  - Current trend in computing

Problem Characterization

- Concurrency
  - Large number of execution paths.
- Latency / Network
  - Increased Contention and Latency Limit Scalability
- Consistency / Coherence
  - Synchronized and correct output
- Design Issues

Trade-off Space for Solutions

- Software
  - Single Reader / Single Writer
  - Multi Reader / Single Writer
    - Centralized Manager Algorithm
    - Fixed Distributed Manager Algorithm
    - Broadcast Distributed Manager Algorithm
  - Multi Reader / Multi Writer - RISKY!
- Hardware
  - Cache Coherent Nonuniform Memory Architectures
  - Cache-only Memory Architectures
  - Reflective Memory Systems
- Hardware vs Software
  - Performance vs Cost / Scalability

Dominant Approaches

- Software Solutions
  - **Ivy**
    - Original Software Proposal
    - Very inefficient
  - **Mermaid**
    - First on Heterogeneous Environment
    - Needs Data Conversion
  - **Munin**
    - Uses multiple-consistency protocols
    - Supports multiple concurrent writers

Dominant Approaches Continued...

- Hardware Solutions
  - **Memnet**
    - Ring-based multiprocessor
    - Goal is to decrease communications
  - **Dash** (Directory Architecture for Shared Memory)
    - Scalable directory-based DSM
    - Breaks memory into 4-Processor clusters
  - **Merlin** (Memory Routed Logical Interconnection Network)
    - Provides scalability to bus-based systems
    - Able to handle a heterogenous environment

Insights

- Speeds up Performance
- No simple solution
  - Central-Server
- Software Solutions
  - Scalable and Portable
- Hardware Solutions
  - Less Congestion and higher Performance
- Hybrid Solution
  - Best of both worlds

Future Problem Space

- Quantum Entanglement
  - Two particles share state over long distance
  - Requires only initial physical interaction
- Instant point-to-point communication
  - No physical medium
- Scalable to large networks
  - Routers could distribute quantum pairs
- Already being tested
  - Quantum Cryptography already used in Switzerland
  - Quantum repeaters being developed

Trade-off Space and Future Solutions

- Range of Quantum Entanglement
  - 100m - not even a datacenter
- Inside range, location doesn't matter
  - No difference between same or different rack
- Quantum Entanglement is fragile
  - External forces on one particle breaks the connection
- Research could change this
  - Reliable repeaters and ion traps could keep entangled pairs connected indefinitely
- Quantum computing has no real downside
  - Faster, more secure, and smaller