Programming Models for Parallel and Distributed Systems

Panel Session

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Michael Scott, Univ. of Rochester (moderator)
How did we get here?

✅ Tons of work on parallel languages and models in the late 70s and 80s

✅ Some of it bad, but much of it good, from a conceptual point of view

✅ But nobody offered a really big win, and they often insisted on complete religious conversion

✅ We couldn’t get good performance with good models, so we settled for good performance with poor models
And where exactly are we?

✓ To first approximation
  - nobody uses explicitly parallel languages (other than Java)
  - nobody uses parallelizing compilers
  - the tightly coupled and distributed worlds use completely different programming models
  - but they all take the form of library calls -- no significant language or compiler support
Moreover

✓ Programmers aren’t getting any smarter
✓ The environment keeps getting messier
  - machines are growing more complex
  - e-commerce, the GRID, and technological
dern trends are pulling parallel and distributed
  systems together
  - HPC is going mainstream
ASPLOS: Architectural Sabotage of Programming Languages and Operating Systems

✓ relaxed memory models
✓ HW synchronization
✓ threaded and clustered processors
✓ deep memory hierarchies
✓ prefetching, self-invalidation, etc.
✓ communication/computation gap
✓ PIM
✓ sensor motes
✓ active disks
✓ user-level NICs
✓ programmable NICs
✓ etc., etc., etc.
Emerging Applications

✓ Simulation
  - weather, economics, biological systems, games

✓ Modeling and rendering
  - 3D photography, immersive virtual environments, augmented reality, telepresence, games

✓ Intelligent interfaces
  - vision / recognition / pattern matching / search
  - language and knowledge -- statistical speech models, modeling of user intent

→ These are HPC!
Belligerent opinions

✓ Pthreads are sort of ok
✓ MPI, OpenMP, and the M4 macros are not!
  - too hard to use
  - not applicable to non-HPC-style systems
✓ RPC/RMI is sort of ok
✓ Sockets are not!

✓ Parallel programming is (still) ‘way, ‘way harder than it “ought” to be.
Recommendation #1

✓ Recognize that both shared memory and message passing have a place
  - Shared memory good for passive communication
  - Message passing good for active communication
  - Much of the time you can use either (matter of taste)
  - Sometimes you need one or the other; witness
    • events in shared memory systems
    • put() and get() in message passing systems
→ Many applications would benefit from both
Recommendation #2

✓ Make the easy stuff easy

- coherent shared memory (CC-NUMA, S-DSM, or DSS) for
  • fast prototyping
  • non-performance critical code
- global address space with put() and get() for performance tuning of shared memory code
- transactions for atomic update (Maurice)
- 2-ended message passing for active communication

- These models can comfortably co-exist within a single application
Recommendation #3

✓ Leverage the compiler
  - parallelize what you can (Mary)
  - provide language support for the explicitly parallel stuff (Eric)
    • typesafe communication
    • invariant checking
    • exception handling
    • transactions
    • data placement when necessary
    • parallel operations (e.g. loops)
Recommendation #4

✓ Don’t embed HPC assumptions (Kathy)
  - can’t afford to assume
    • fixed number of processes
    • single process per processor
  - must accommodate
    • availability / replication
    • fault tolerance / recovery
    • language and machine heterogeneity
  - potential big wins for grid computing today; enormous wins for pervasive / ubiquitous computing tomorrow
Closing Thoughts

✓ HPC is going mainstream
✓ The applications will be *really* exciting
✓ We need programming models that merge
  - explicit and implicit parallelism
  - shared memory and message passing
  - data-parallel and distributed / mobile components
  - automatic and manual locality management
✓ These ideas are mutually compatible