Many-Core Virtual Machines
Decoupling Abstract From Concrete Concurrency

**Abstract**
- VM support is minimal
  - only one specific concurrency model is supported
  - only few ILs provide notion of concurrency
  - no comprehensive abstraction
- concurrency support is limited
- VM Intermediate Languages (ILs)
  - often defined as bytecodes
  - expressive abstraction for various target languages
  - abstract concurrency model are defined by languages or libraries
  - used by application developers

**A VM has to:**
- Decouple abstract concurrency models
- Concrete concurrency models are provided by the underlying system
- wide range of models supported by VM is necessary
  - Implementing unsupported models on top is hard
  - Restrictions hinder efficient implementation
  - Support at VM-level allows reuse and optimization

**Concurrency by ILs**
- VM Intermediate Languages (ILs)
  - powered by fast JIT compilers, and great GCs
  - foundation for multi-language VMs
  - allow to reuse existing infrastructure
  - require huge investments
  - reuse is economically necessary

**Experiments**
- Apple MacPro
  - 2 CPUs
  - 4 cores per CPU
  - 1024 threads
  - JIT fixed
  - 1024 threads
- Rubinius
  - 2 CPUs
  - 4 cores per CPU
  - 1024 threads
  - JIT variable
  - 64 threads

**Virtual Machines**
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**Concurrent Models**
- Single-Core
  - Instruction-level parallelism
  - Thread-level parallelism
  - VM challenges
  - Deep cache hierarchies
  - Cache-consciousness required
- Multi-Core
  - Shared memory access
  - Native support for thread-level parallelism
  - Shared cache coherence
  - Scalability and cache coherency must be considered
- Many-Core
  - Non-uniform memory access
  - Scalable implementation

**what to include in ILs?**
- there are various ways to express concurrency
- Data Parallelism
- Non-shared Memory
- Shared Memory

**Extending ILs**
- for shared memory: fuzzy/split-phase barriers
- MPI
- CUDA
- OpenMP
- other experiments:
  - an IL for threads and locks, and an IL for Actors

**our VM**
- A Smalltalk VM for many-core systems
  - runs on the 64-core Intel Xeon chip
  - runs on standard Intel systems
  - supports Linux and OS X

**Virtual Machines**
- Stefan Marr et al.
  - Towards Comprehensive Concurrency Support
- Hans Schippers, Tom Van Cutsem, Stefan Marr, Michael Haupt, and Robert Hirschfeld
  - Towards an Actor-based Concurrent Machine Model