Virtualizing Local Stores
Enabling Software-Managed Memory Hierarchies in Mainstream Computing
Henry Cook

PROBLEM STATEMENT
Software-managed local stores are more efficient than hardware-managed caches for some apps, yet their use has been confined to embedded systems. Local stores are problematic in general-purpose systems because they add to process state on context switches, and because they require fast data memory close to the processor that might be better spent as cache. We propose the use of virtualized local stores to provide the benefits of a software-managed memory hierarchy in a general-purpose system. A VLS is mapped into the virtual address space of a process to allow software management, but is kept in a partition of the hardware-managed cache when active.

RELATED WORK
Smart Memories, TRIPS, ALP all provide heavyweight reconfigurability. Various embedded processors have used way-based partitioning and locking, but generally are uni-purpose/uni-process.

POSSIBLE MEMORY CONFIGURATIONS

ADDRESS SPACE MAPPINGS
Mapping of virtual local stores from the VA space to physical pages, and how data in those pages is indexed in the on-chip memory hierarchy.

VLS MECHANISMS
1. Request is identified based on target address as being a VLS access
2. pbase holds physical base address, used instead of TLB lookup
3. Multiple way lookups avoided on a VLS access
4. Replacement policy respects partitioning
5. pbound holds number of pages given to VLS
6. Special network allows direct VLS-to-VLS data streaming via DMA engines

FUTURE WORK
• More multithreaded application use cases
• Use of VLS in multiple levels of hierarchy
• VLS-to-VLS communication
• Energy efficiency

METHODOLOGY
We used a combination of Virtutech Simics and Wisconsin GEMS to evaluate the detrimental effects of a fixed allocation between hardware and software-managed local memories on various computational kernels. General-purpose multiprocessor workloads will consist of all of these kernels and more.

BENCHMARKS
Hand-tuned versions of several kernels designed to run on pure cache or LS machines. Parallelized with pthreeds. Run to completion.

MACHINE
16 cores, 800MHz
16 KB 2-way L1-Cache
32 KB 4-way L1-D-Cache
with VLS up to 3-way
512 KB 16-way unified L2
1 DMA engine per core

MICROBENCHMARK RESULTS
Some kernels perform better with local stores, some do not. Static allocations that limit the size of each partition are detrimental to both.

SPEECH APPLICATION RESULTS
Each phase of the algorithm sees different benefits under HW or SW-man. VLS allows us to pick between them per-phase.

Load caused by context switches is reduced: VLS data is backed by phys. mem.