Hetero Streams: easing the way to task parallelism and platform features

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What's unique about my tuning work

**Applications**
- Matrix multiply and Cholesky
  - These are the most common linear algebra operations in manufacturing, e.g. Simulia, MSC, Siemens
  - Shown in host-only, native, offload-only and host+offload modes
- 3DFT Reverse Time Migration
  - RTM is one of the most common algorithms for seismic analysis
  - MPI ranks benefit from async offload

**hStreams plumbing layer makes task parallelism easy**
- Separation of concerns: scientist exposes parallelism, tuners map it to platforms
- Same tasking interface for host and device yields much greater productivity (vs. OpenMP)
- Makes it easy to support concurrency among a few small tasks
- Pipelining of computation and communication helps even when tasks span whole device
- OmpSs: “hStreams is easier to use, has fewer APIs than CUDA Streams”
- Library/C ABI: no pragmas, no task graph (CnC, TBB), no ownership of main (OCR, CHARM++)
- Available in MPSS 3.6; leverages COI, like offload compiler
Tiled Cholesky – MAGMA, MKL AO

MAGMA* uses host only for panel on diagonal, hStreams balances load to host more fully
hStreams optimizes offload more aggressively
MAGMA tunes block size and algo for smoothness
hStreams is jagged since block size is less tuned

2 cards + host vs. host only: 2.7x
1 card + host vs. host only: 1.8x

Compared favorably with MKL automatic offload, MAGMA after only 4 days’ effort

System info:
Host: E5-2697v3 (Haswell) @ 2.6GHz, 2 sockets
64GB 1600 MHz; SATA HD;
Linux 2.6.32-358.el6.x86_64; MPSS 3.5.2, hStreams for 3.6
Coprocessor: KNC 7120a FL 2.1.02.0390;
uOS 2.6.38.3; Intel compiler v16/MKL 11.3, Linux
Average of 4 runs after discarding the first run

*MAGMA MIC 1.4..0 data measured by Piotr Luszczek of U Tenn at Knoxville

Optimization notice
SC15 MIC Tuning BoF
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Tiled matrix multiply – impact of load balancing

Good scaling across host, cards
Load balancing (LB) matters more for asymmetric perf capabilities (IVB vs. KNC)

**HSW:**
- 2 cards + host vs. host only: 2.89x
- 1 card + host vs. host only: 1.80x

**IVB:**
- 2 cards + host vs. host only: 3.95x
- 1 card + host vs. host only: 2.45x

System info:
- Host: E5-2697v3 (Haswell) @ 2.6GHz, v2 (Ivy Bridge) @ 2.7GHz,
  Both 2 sockets, 64GB 1600 MHz; SATA HD;
- Linux 2.6.32-358.el6.x86_64; MPSS 3.5.2, hStreams for 3.6
- Coprocessor: KNC 7120a FL 2.1.02.0390;
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**Simulia Abaqus Standard**

- Offload to one card, from IVB or HSW
- Showing modest gains from using 2 cards in addition to host on more-capable HSW
- Up to 2x at app level for A on IVB
- Part of IPDPS16 submission

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**Simulia Abaqus Standard preproduction v2016 results measured by Michael Wood of Simulia**

There are no guarantees that the formal release will have the same performance or functionality.

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Petrobras* HLIB (Heterogeneous library)

- Petrobras's current code executes one task at a time, across a whole card, and doesn't yet use the host
- This graph shows the benefit, ~1.1x, from using asynchronous pipelining
- Part of IPDPS16 submission

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Petrobras data from preproduction HLIB code measured by Paulo Souza of Petrobras
There are no guarantees that the formal release will have the same performance or functionality

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Insights

- **Performance**
  - Solid speedups are easily achieved over Ivybridge, Haswell
    - Petrobras: 1.52x, 6.02x for 1 card, 4 cards for pure offload vs. Haswell
    - Simulia: 1.57x-2.41x for solver vs. IVB alone, 1.15x-1.34x vs. Haswell alone
  - Pipelining computation and communication
    - Matters more when communication is less hidden by computation: 1.10x vs. 1.07x
  - Load balance matters more when host and card have uneven performance
    - Load balanced vs. round robin has a 1.6x advantage on IVB and 2 cards for matrix multiply

- **Ease of use**
  - Cholesky on hStreams beat MKL Automatic Offload and MAGMA in 4 days of tuning

- **Further tuning opportunities**
  - Matching the tile (block) size to target machine helps smooth performance

- **Collaborating with several manufacturing and seismic vendors**
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