A High-Performance Software Framework for Memory on Commodity GPUs
Naoya Maruyama, Akira Nukada, Satoshi Matsuoka (Tokyo Institute of Technology)
Contact: naoya@matsulab.is.titech.ac.jp

Background

Problem: No ECC for GPU DRAM (yet?)
- Radiation-induced bit-flip errors are inevitable
- SEC-DED ECC in DRAM is a “must” in server memory
- Redundancy must be implemented

Observation & Idea
- Compute-intensive kernels → Little performance effects
- Memory-intensive kernels → Compute units are available
  - Exploit idle units for data coding

Method

Software-only framework for DRAM error tolerance
- Error detection in CUDA global memory + Checkpoint/Restart
- Works with existing NVIDIA CUDA GPUs

Lightweight Error Detection
- “Dual Parity” for 128B blocks of data
  - Detects a single-bit error in a 4B word
  - Detects a two-bit error in a 128B block
  - No on-the-fly correction → Rollback upon errors
- Per-block xor reduction exploiting shared memory
- Generates a vertical parity and diagonal parity for each block
  - Vertical parity: 4B of bits to store xor of 32 4B words
  - Diagonal parity: 4B of bits to store xor of 32 rotated 4B words

Integration to Applications
- Input transfer
  - Generates dual-parity codes on host and transfer them to global memory
  - Operates in the background of the original data transfer to hide the overhead
- Kernel execution
  - Global memory reads: detect errors by computing the dual-parity codes for the read data
  - Global memory writes: write dual parity for the written data
- Output transfer
  - Detects errors by running a separate error-checking kernel after the original kernel execution

Results

N-Body Problem
- Checks current positions and velocities by a separate kernel
- Encodes new positions and velocities
- Highly compute intensive kernel
- 2% overheads at most

Matrix Multiplication
- Checks two input matrices by a separate kernel
- Encodes results
- Compute intensive kernel
- <10% overheads

256³ 3D FFT
- Inline checking of read data
- Encodes transformed data
- Bandwidth intensive but compute resources are also exercised
- 35% overheads

Histgram of the number of bit-flips on GeForce 8800
GTS 512 running Memtest for 72 hours

Integration to Applications

Contact: naoya@matsulab.is.titech.ac.jp

NVIDIA Research Summit’09, Sep 2009.