Transparent Offloading and Mapping (TOM)
Enabling Programmer-Transparent Near-Data Processing in GPU Systems

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Processing data directly in 3D-stacked memories is a promising direction.
However, it requires significant programmer effort.
Key Challenge 1

3D-stacked memory (memory stack)

```c
__global__
void applyScaleFactorsKernel(uint8_T * const out,
const uint8_T const * const in, const double *factor,
size_t const numRows, size_t const numCols )
{
  // Work out which pixel we are working on.
const int rowIdx = blockIdx.x * blockDim.x + threadIdx.x;
const int colIdx = blockIdx.y;
const int sliceIdx = threadIdx.z;

  // Check this thread isn't off the image
if( rowIdx >= numRows ) return;

  // Compute the index of my element
size_t linearIdx = rowIdx + colIdx*numRows +
sliceIdx*numRows*numCols;
```
Key Challenge 1

• **Challenge 1**: Which operations should be executed on the logic layer SMs?

3D-stacked memory (memory stack)

Main GPU

Logic layer

SM

Vault

Ctrl

Crossbar switch

Vault

Ctrl

---

```
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    // Compute the index of my element
    size_t linearIdx = rowIdx + colIdx*numRows +
                      sliceIdx*numRows*numCols;
```
Key Challenge 2

- **Challenge 2:** How should data be mapped to different 3D memory stacks?
Our Approach: TOM

• A new mechanism to identify and decide what code portions to offload.
  • The compiler identifies code portions to potentially offload based on memory profile.
  • The runtime system decides whether or not to offload each code portion based on runtime characteristics.
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  • The compiler identifies code portions to potentially offload based on memory profile.
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• A new, simple, programmer-transparent data mapping mechanism to maximize code/data co-location.
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  • The compiler identifies code portions to potentially offload based on memory profile.
  • The runtime system decides whether or not to offload each code portion based on runtime characteristics.

• A new, simple, programmer-transparent data mapping mechanism to maximize code/data co-location.

• Key Results: 30% average (76% max) performance improvement in GPU workloads.
Talk at Monday 2:50pm (Session 3B)

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