



Scout: Case Studies

Patrick M^cCormick

Advanced Computing Lab

Los Alamos National Laboratory



Overview

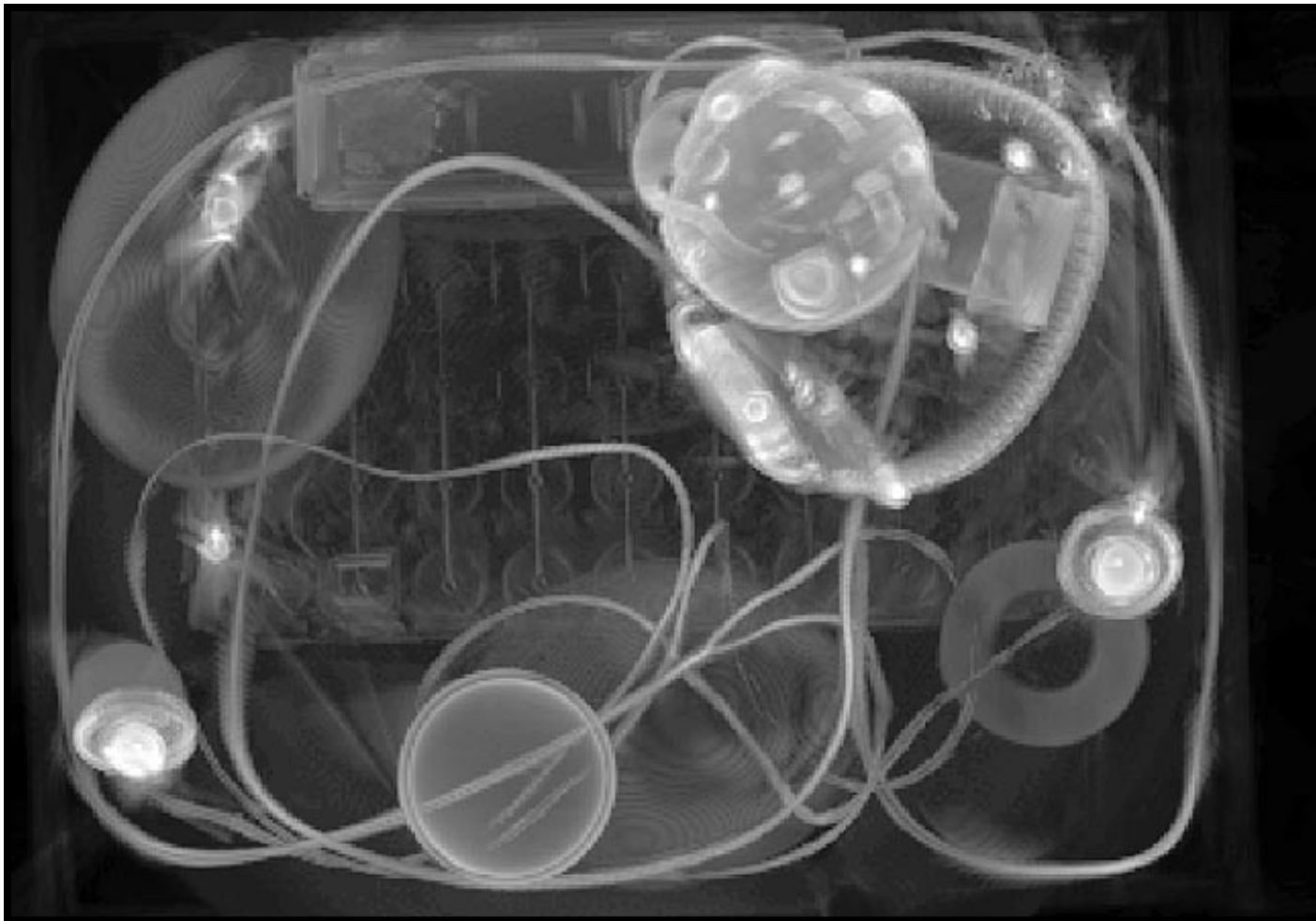
- **“Pandora’s Box”**
 - Ray casting Example
- **Simple heat diffusion application**
 - Compute and visualization in one program
- **Large data, multiple GPUs, etc...**

Pandora's Box

- What's in the CT scanned box?
 - Original data set is 2048x2048x1024...
 - We've down sampled to 512x512x256
 - Simple raycasting approach - maximum intensity...

```
// Maximum intensity example.  
raycast with (shapeof(density)) {  
    float maxVal = density;  
    // For each ray-cell intersect keep tabs on  
    // the maximum density.  
    intersect() {  
        where (density > maxVal)  
            maxVal = density;  
    }  
  
    // Finally assign the pixel values..  
    image = rgba(maxVal, maxVal, maxVal, 1.0);  
}
```

Pandora's Box...



Heat Transfer

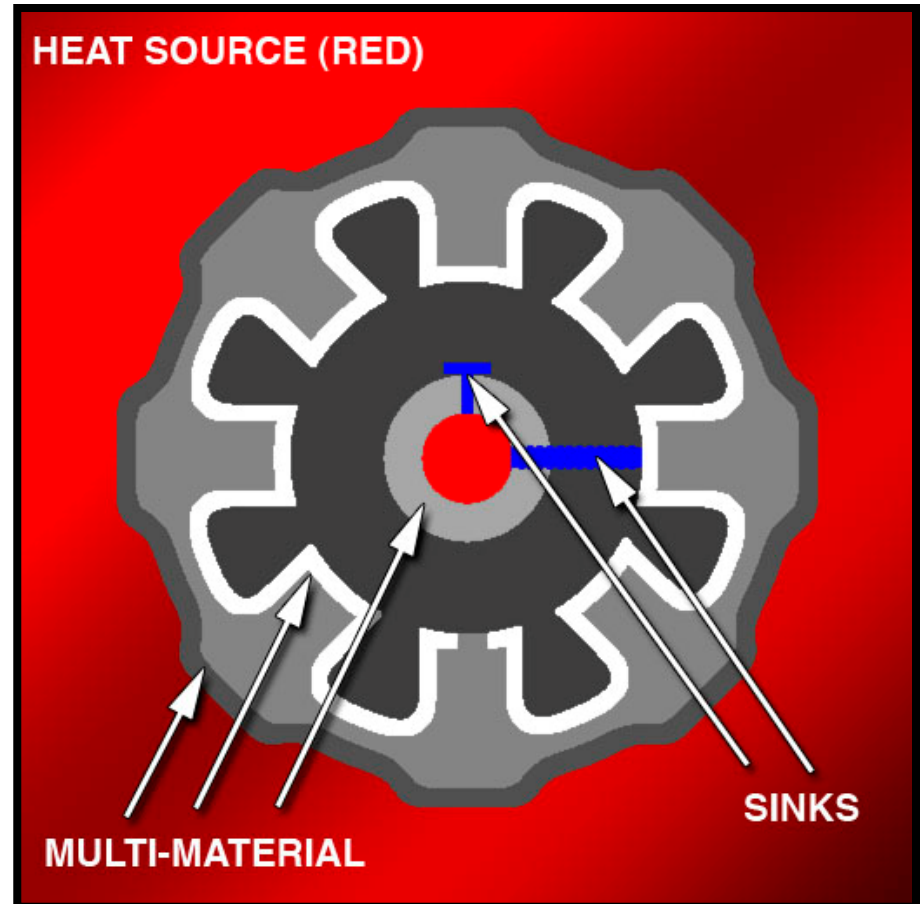
- How does heat propagate through an object
- Need to solve the heat diffusion equation

$$\frac{\partial T}{\partial t} = k \left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} \right)$$

- We'll use an finite differences approach...

Heat Diffusion

- Problem configuration
 - Heat source(s) in red
 - Uneven heating
 - Heat sinks in blue
 - Multi-material
 - Grayscale



SkamCo Fermangulator #42

Compute Code

```
float:shapeof(temp) new_temp; // time step result goes here..
// Data parallel computation of the diffusion..
compute with(shapeof(temp)) {
  // Don't compute over boundary conditions ...
  where(mask > 0) {
    float temp_x;
    temp_x = (alpha/(dx*dx))*(temp [i+1] [j]-2*temp [i] [j]+
      temp [i-1] [j]);
    temp_y = (alpha/(dy*dy))*(temp [i] [j+1]-2*temp [i] [j]+
      temp [i] [j-1]);
    new_temp = dt * (temp_x + temp_y) + temp [i] [j];
  } else {
    new_temp = temp; // boundary conditions stay constant..
  }
}
// New temperatures need to become our initial conditions for
// the next pass.
temp = new_temp;
```

High Level Code Structure

CPU Loop

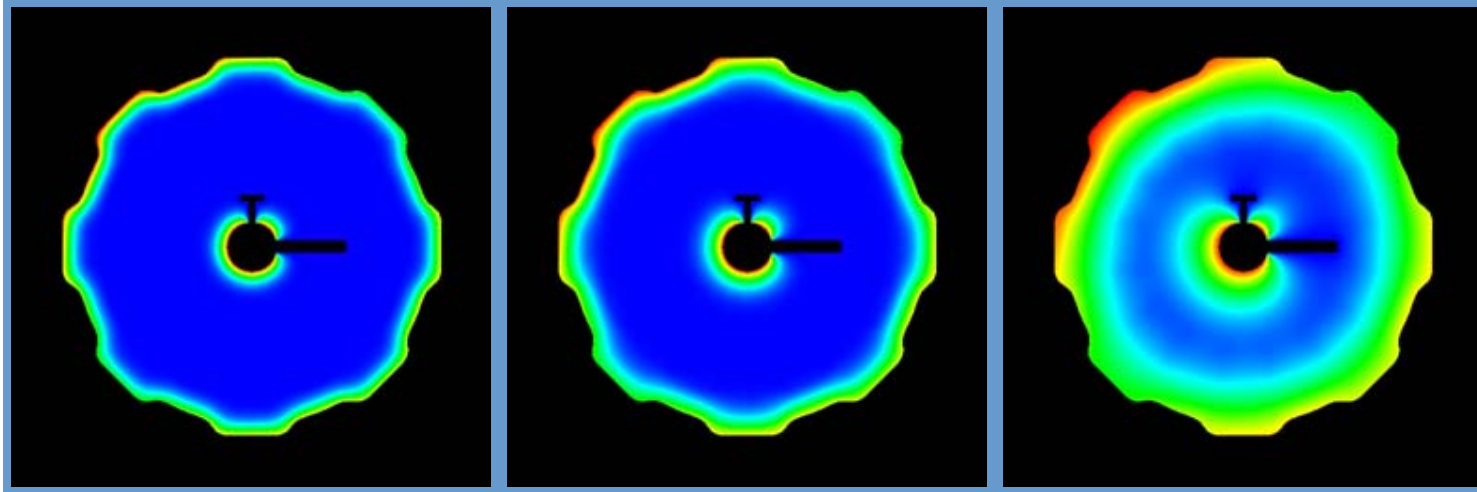
```
// Simulation loop ...
for(float time = 0.0; time <= SIM_TIME; time += dt) {
  // Data parallel compute block.
  compute with(shapeof(temp)) {
    ...
  }

  // Render the results of current time step.
  render with(shapeof(temp)) {
    image = ...;
  }
}
```

Compute pass

Render pass

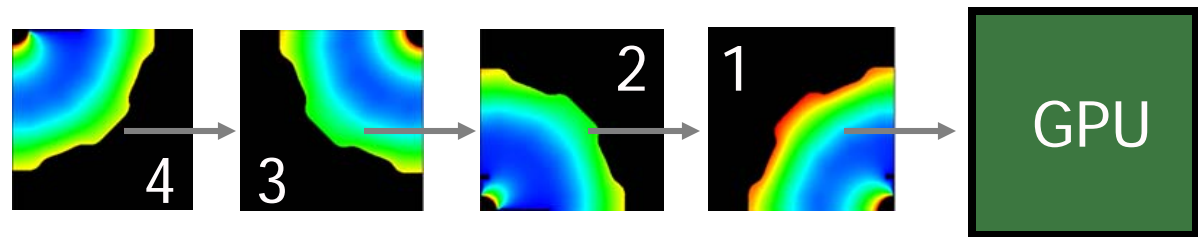
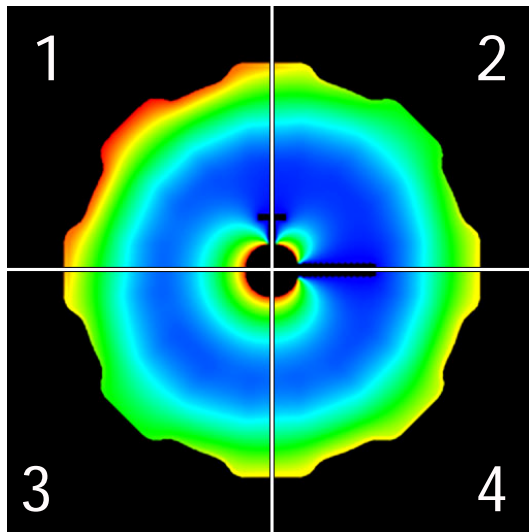
Heat Diffusion Example



- Results for 512x512
 - 3,482 time steps (0.3 sec.)
 - CPU (2.2 GHz Opteron) with -O3: 92.8 sec.
 - GPU (GeForce 7800): 6.7 sec.
 - *For compute and render...*

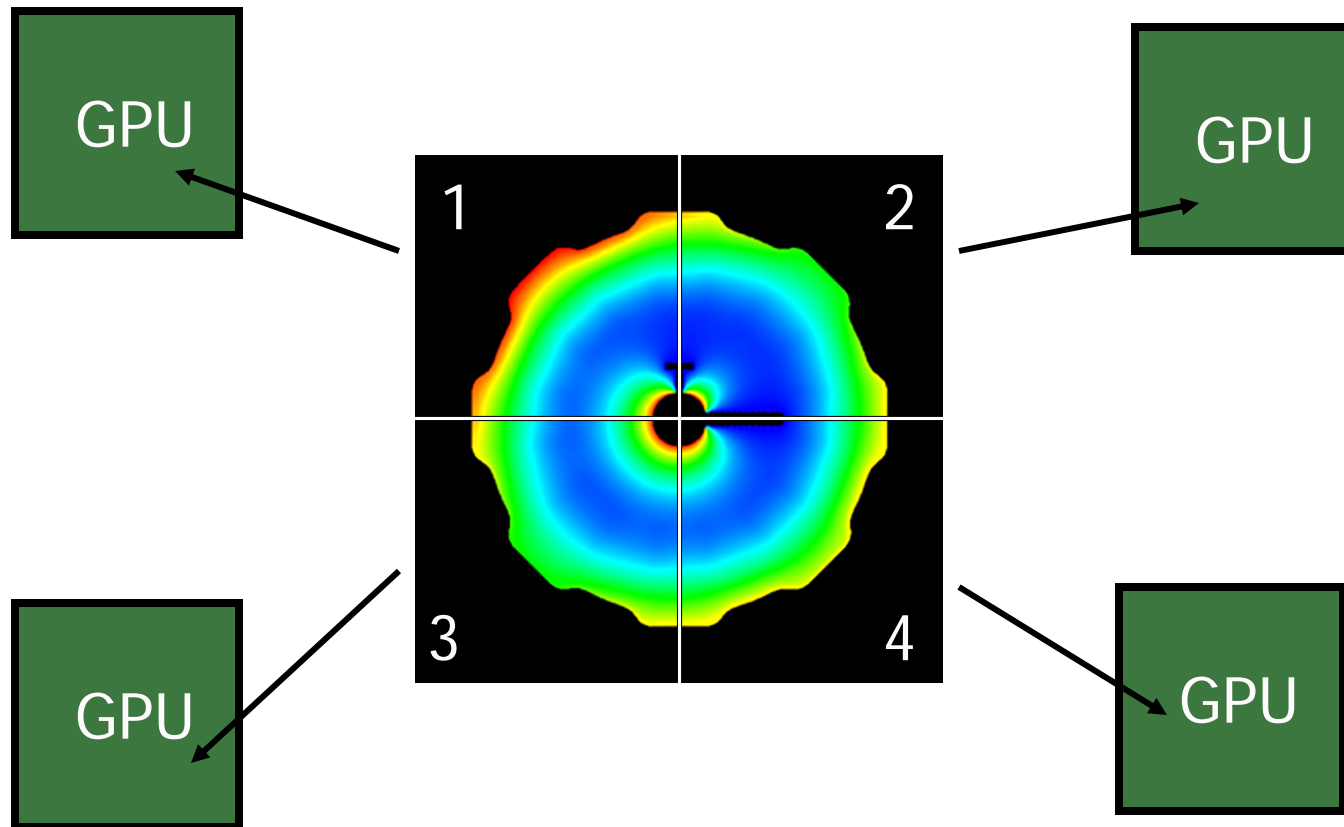
Large Data - Texture Paging

- GPUs have a lot of memory - still not enough!
- What to do?
 - Manage texture paging on your own...
 - Page/stream data through the GPU one subset at a time



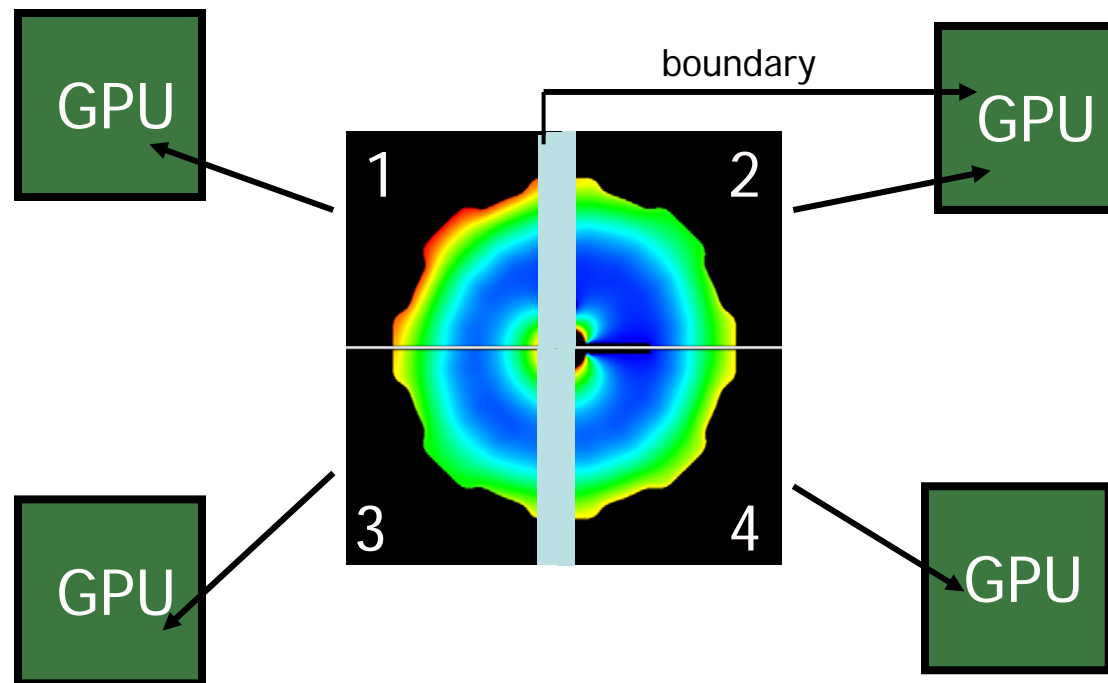
Texture Paging - Parallelism

- Stepping stone for parallelism



Issues

- For some computations boundaries must be shared. Distributed memory...
- What about arbitrary indexing?



Parallel Scout

- **Dual PCI-E, GPU clusters**
 - Work in progress - collaboration with UC Davis
 - MPI based
 - Basic support will be part of source release
 - Stay tuned to gpgpu.org for details!
- **Scout Team:**
 - LANL
 - Pat McCormick, Jeff Inman, Jim Ahrens, Nehal Desai
 - UC Davis
 - Adam Moershell, John Owens
 - Utah
 - Greg Roth, Chuck Hansen