Rethinking Visualization Frameworks for Extreme-Scale Computing

Ultrascale Visualization Workshop

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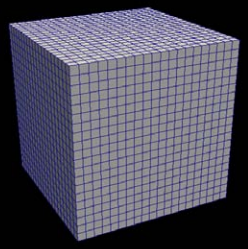
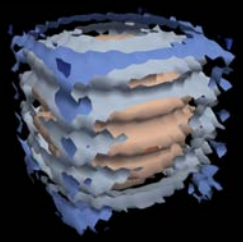
Serial Visualization Pipeline



Contour



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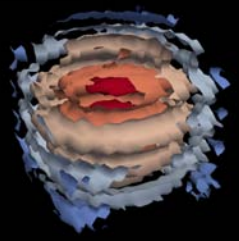
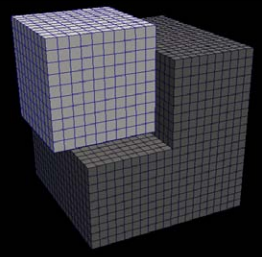
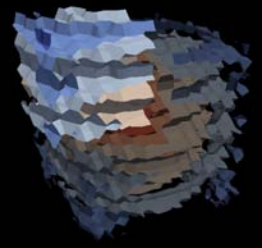


Parallel Visualization Pipeline



Contour | Contour | Contour



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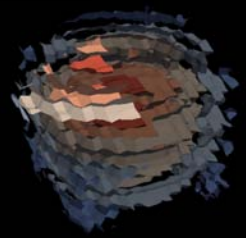

Exascale Projection

	Jaguar – XT5	Exascale*	Increase
Cores	224,256	100 million – 1 billion	~1,000×
Concurrency	224,256 way	10 billion way	~50,000×
Memory	300 Terabytes	128 Petabytes	~500×

*Source: International Exascale Software Project Roadmap, J. Dongarra, P. Beckman, et al.

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MPI Only?

Vis object code + state: 20MB

On Jaguar: 20MB × 200,000 processes = 4TB

On Exascale: 20MB × 10 billion processes = 200PB !

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Visualization pipeline too heavyweight?

On Jaguar: 1 trillion cells → 5 million cells/core

On Exascale: 500 trillion cells → 50K cells/core

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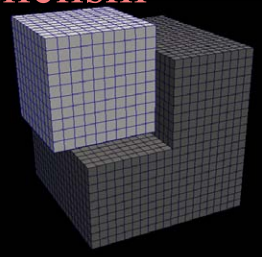
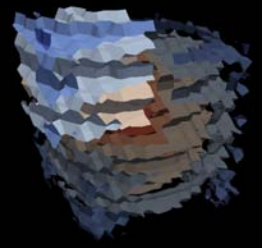
Hybrid Parallel Pipeline

Distributed Memory Parallelism

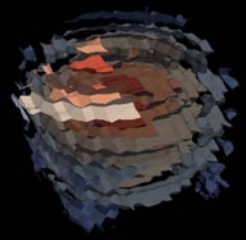


Contour | Contour | Contour



Shared Memory
Parallel Processing

Clip | Clip | Clip



Threaded Programming is Hard
Example: Marching Cubes

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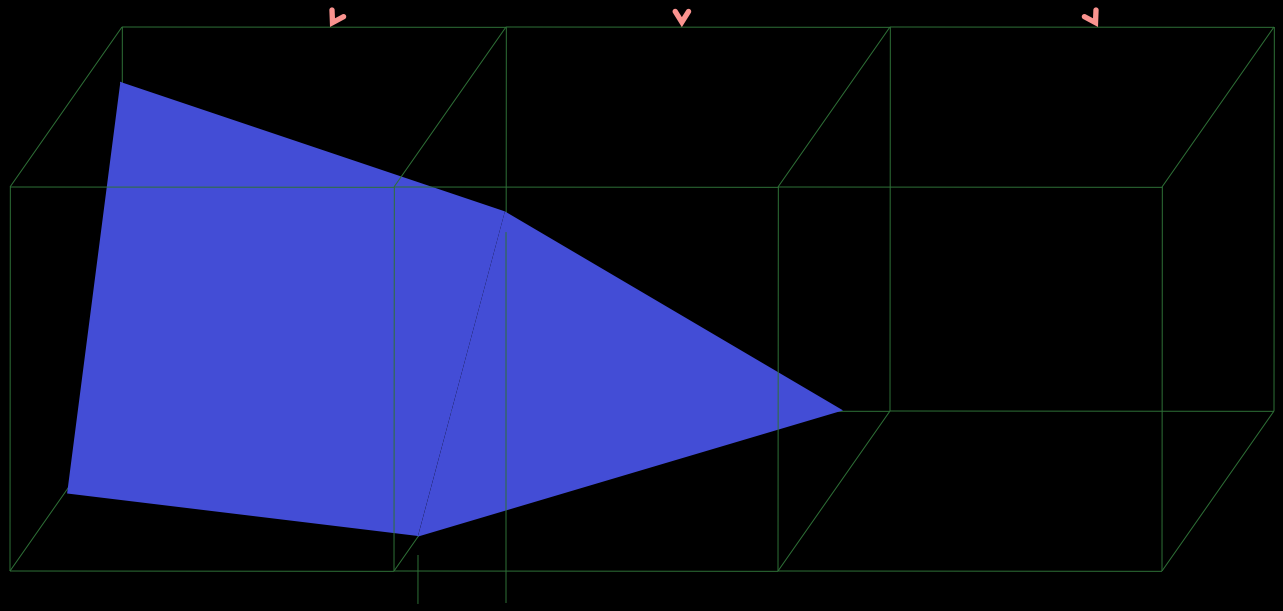
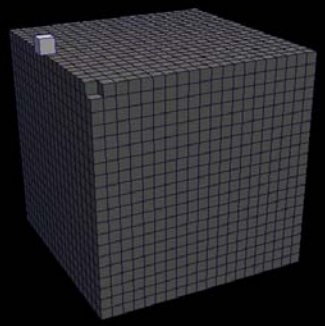
Easy because cubes can be processed in parallel, right?



How do you resolve coincident points?
How do you capture topological connections?

How do you pack the results?

Revisiting the Pipeline



- Lightweight Object
- Serial Execution
- No explicit partitioning
- No access to larger structures
- No state

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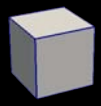
function (in  , out )

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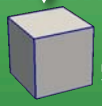
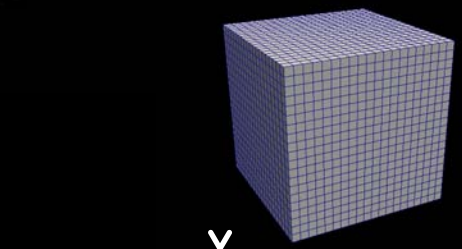
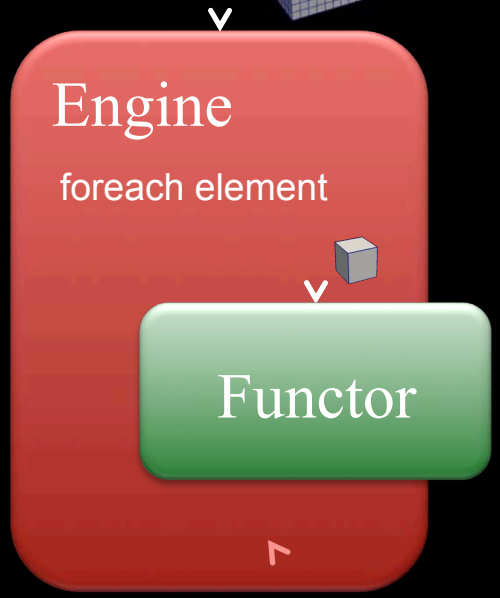
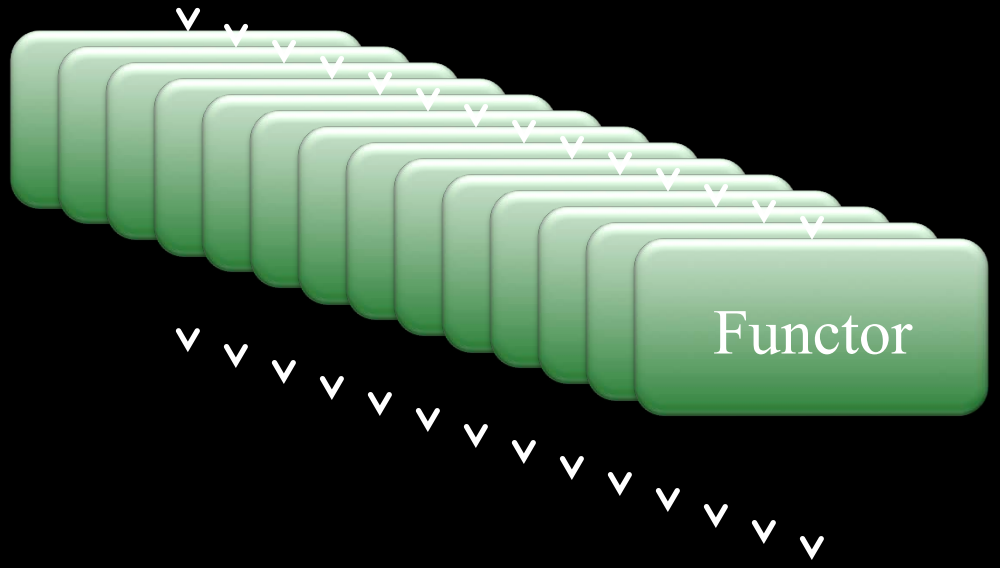
Functor

function (in  , out )

Iteration Mechanism



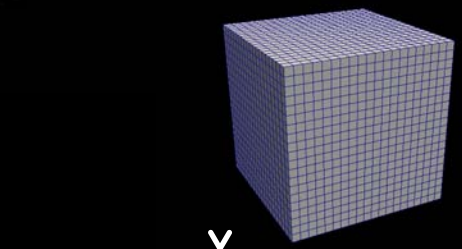




Conceptual Iteration

Reality: Iterations can be scheduled in parallel.

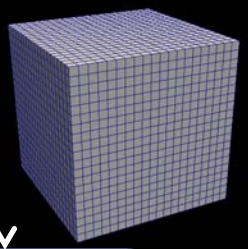
Comparison



Engine

foreach element

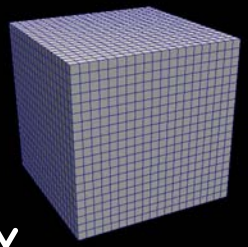
Functor



Filter

foreach element

Comparison

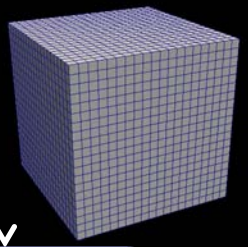


Engine

foreach element

Functor 1

Functor 2



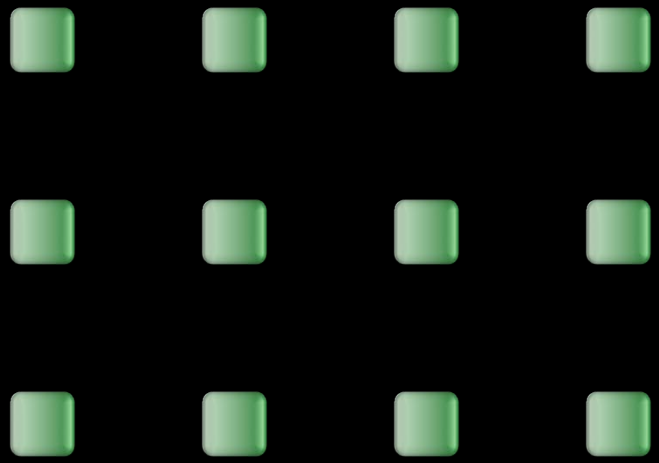
Filter 1

foreach element

Filter 2

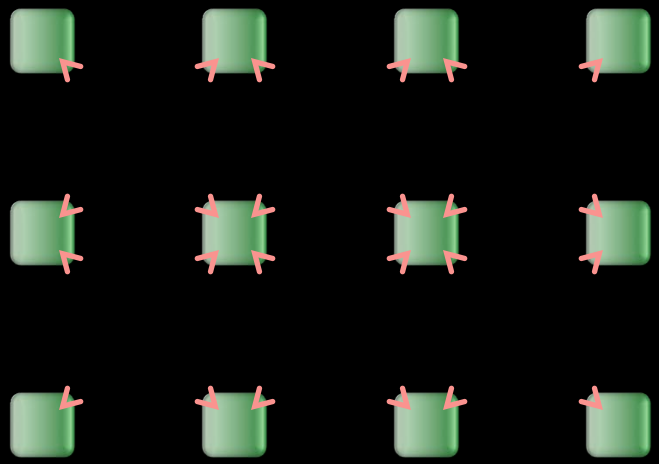
foreach element

Engine Types: Map



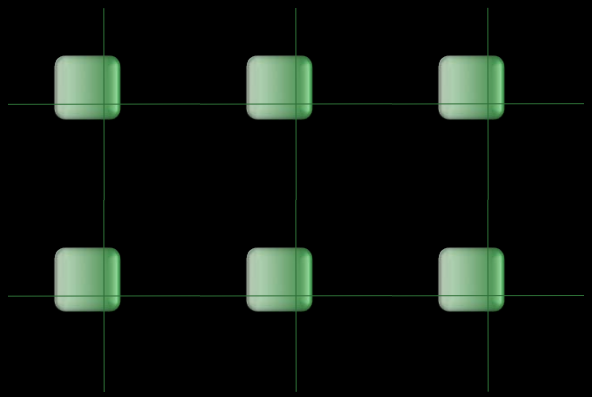
Example Usage: Vector Magnitude

Engine Type: Topological Reduce



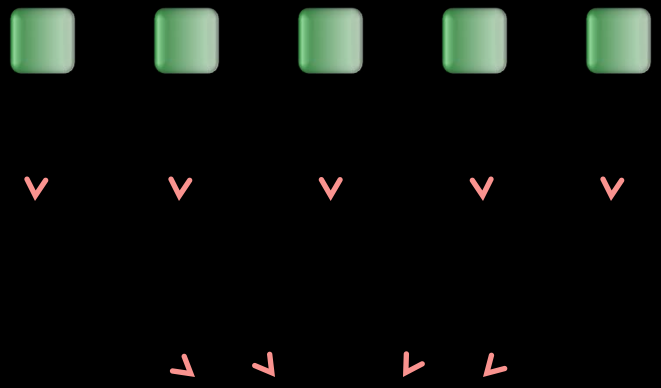
Example Usages: Cell to Point, Normal Generation

Engine Types: Generate Geometry



Example Usages: Subdivide, Marching Cubes

Engine Types: Compress



Example Usage: Marching Cubes

Conclusion

- Why now? Why not before?
  - Rules of efficiency have changed.
- Concurrency: Coarse → Fine
- Execution cycles become free
- Minimizing DRAM I/O critical
- The current approach is unworkable
  - The incremental approach is unmanageable
- Designing for exascale requires lateral thinking