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Massive Model Rendering with Super Computers

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1:30 - 1:50pm

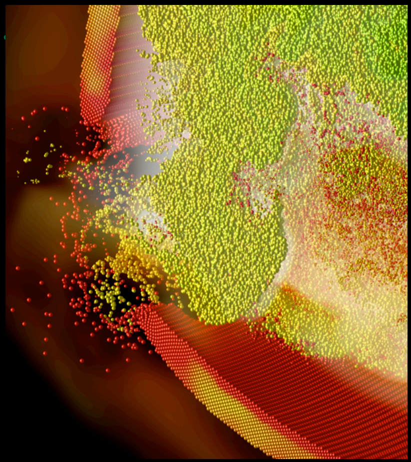
Speaker affiliations: SCI Institute, University of Utah and Intel Corporation.

Overview

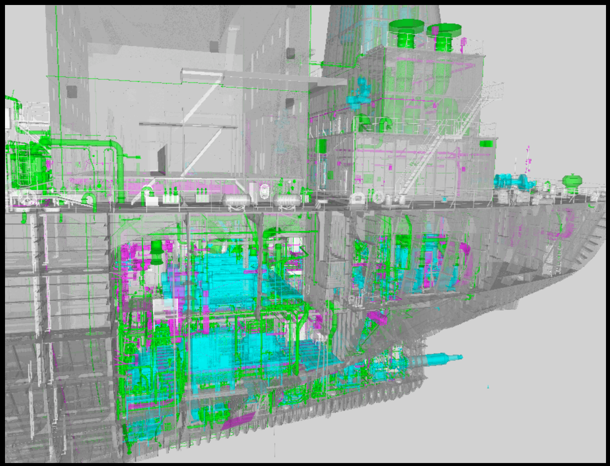
Focus on shared-memory/multi-core software design.

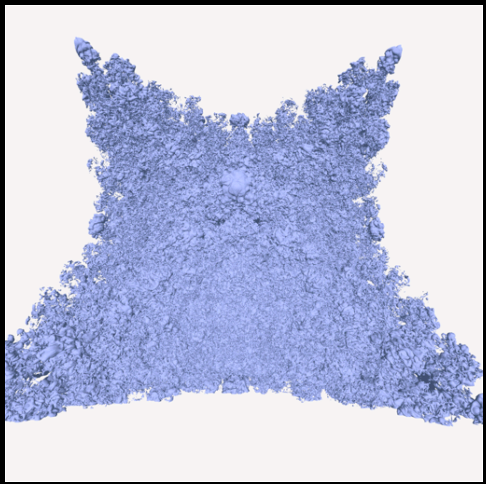
- Massive models? Why use super computers?
- Challenges: parallel build & rendering.
- Manta architecture.
- Applications & conclusions.

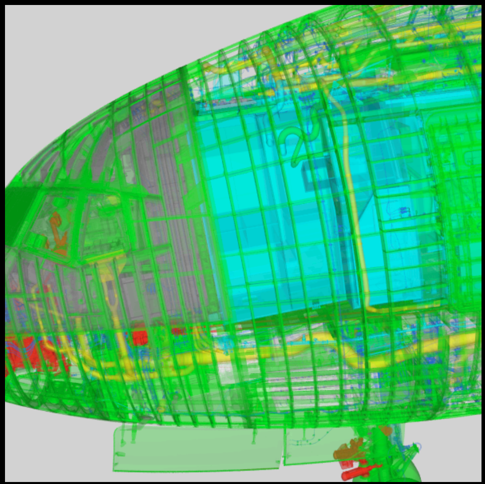
Massive Model Visualization



- Hundreds of millions of primitives.
- Scientific data, CAD, architectural.
- Principle task is static inspection.







Image/Data credits: James Bigler/CSAFE, SGI/Newport News Shipbuilding, Aaron Knoll/LLNL, The Boeing Company. Rendered using Manta Ray Tracer.

Massive Model Visualization

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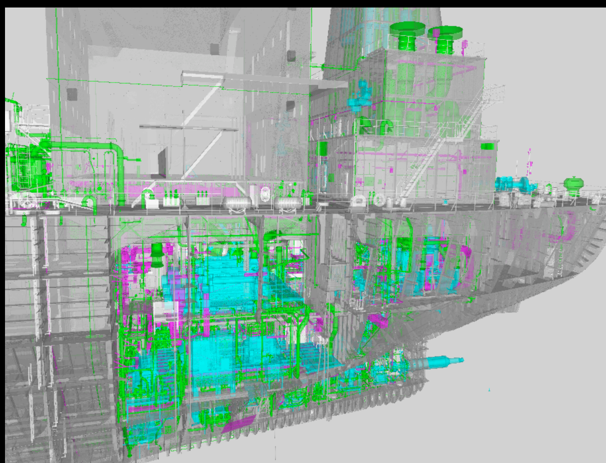
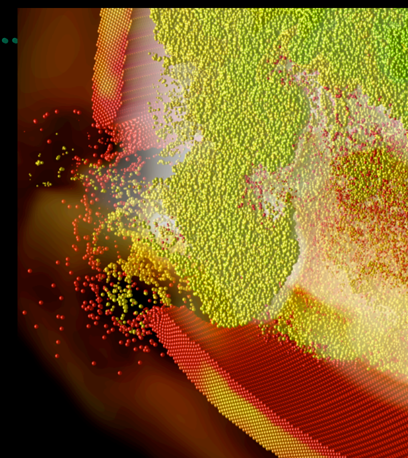


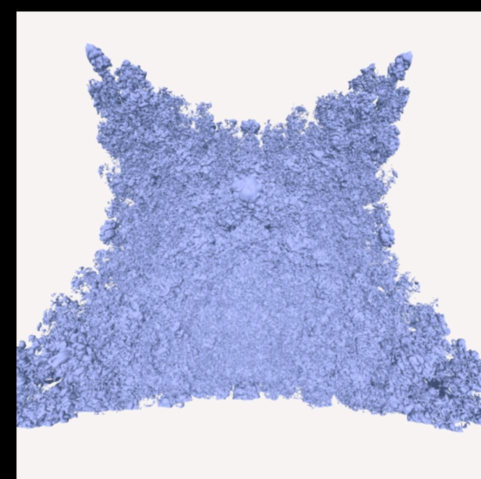
Double Eagle Tanker
85 M Triangles

CSAFE Container
2.8 million particles
2.1 voxel volume
450 timesteps



Boeing 777
350 M Triangles

Richtmyer-Meshkov
8 GB volume
272 timesteps



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Application Scenario

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- Quality Engineers use ray tracer to visualize problems with aircraft assembly.

A. Stephens, S. Boulos, J. Bigler, I. Wald, and S. G. Parker *An Application of Scalable Massive Model Interaction using Shared Memory Systems* Proceedings of the Eurographics Symposium on Parallel Graphics and Visualization, 2006

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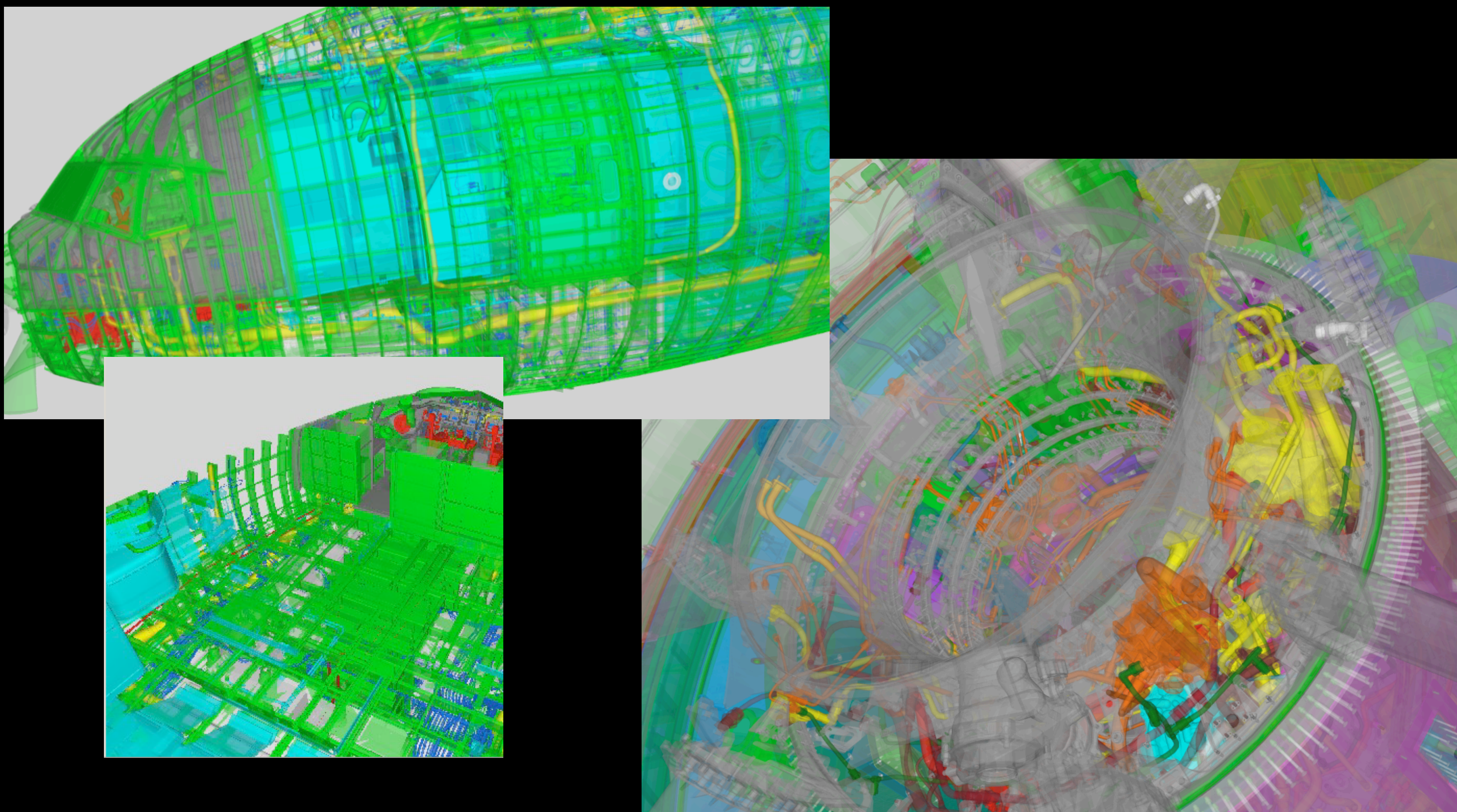
Application Scenario



Why parallel computers?

- Large amount of processors and memory.
- The same system used for scientific computing and visualization.
- Becoming smaller and cost less.
- Faster multi-core clusters require fewer nodes.

16 core Opteron system. (top)
16 processor SGI Itanium (half rack).

Parallel Acceleration Structure Build

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- Example parallel KD-Tree build.
  - Strategies for offline build
    - Multi-thread sorting and merging.
    - Evaluate split candidates in parallel.
    - Build sub-trees in parallel.

Reduced 777 build time from one day to several hours.

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Parallel Ray Tracing

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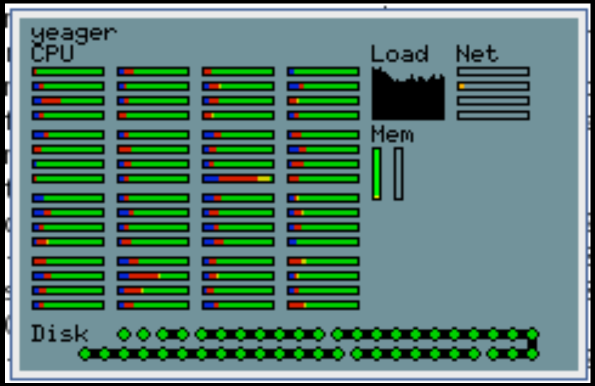
- Easy to break ray tracing into parallel pieces.
- Parallel architecture must focus on scalability.
  - User input coordination.
  - Thread safe state changes.
  - Display overhead.
  - Acceleration structure update.



Processor utilization (green is unused capacity)

- Both thread level parallelism and instruction level parallelism effect design.

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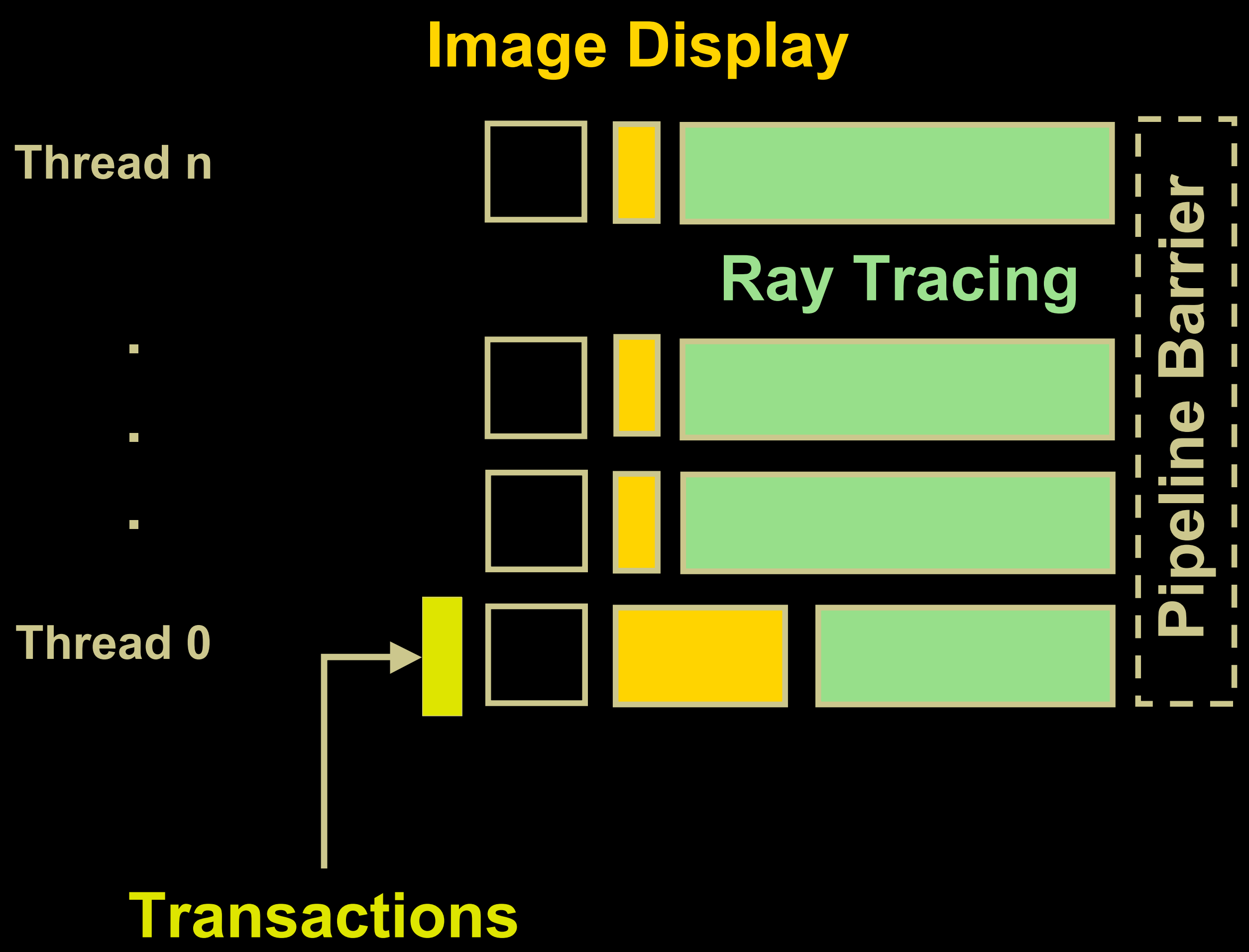
Manta Software Architecture

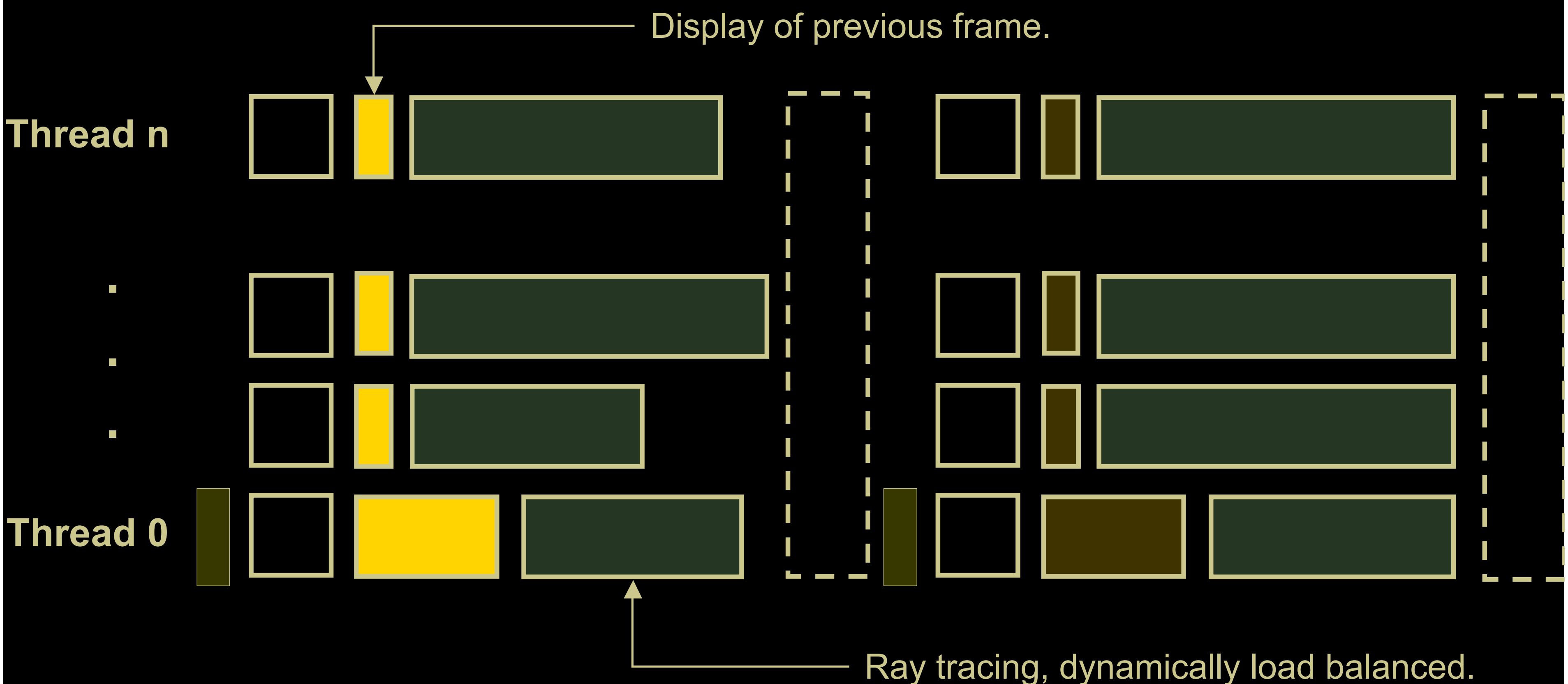
- Addresses both thread level parallelism and instruction stream optimization.
- Provides a scalable foundation to solve a variety of rendering problems.
- Modular software components and Python bindings.

http://code.sci.utah.edu/Manta
Open Source

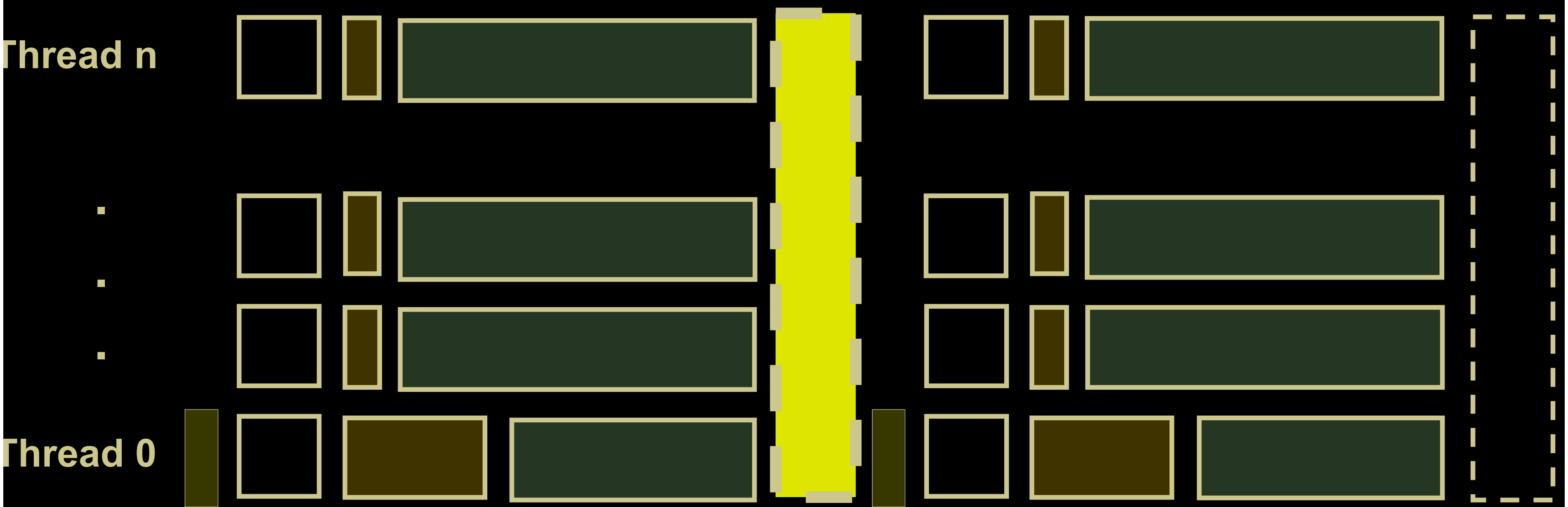
Manta Parallel Pipeline



Manta Parallel Pipeline

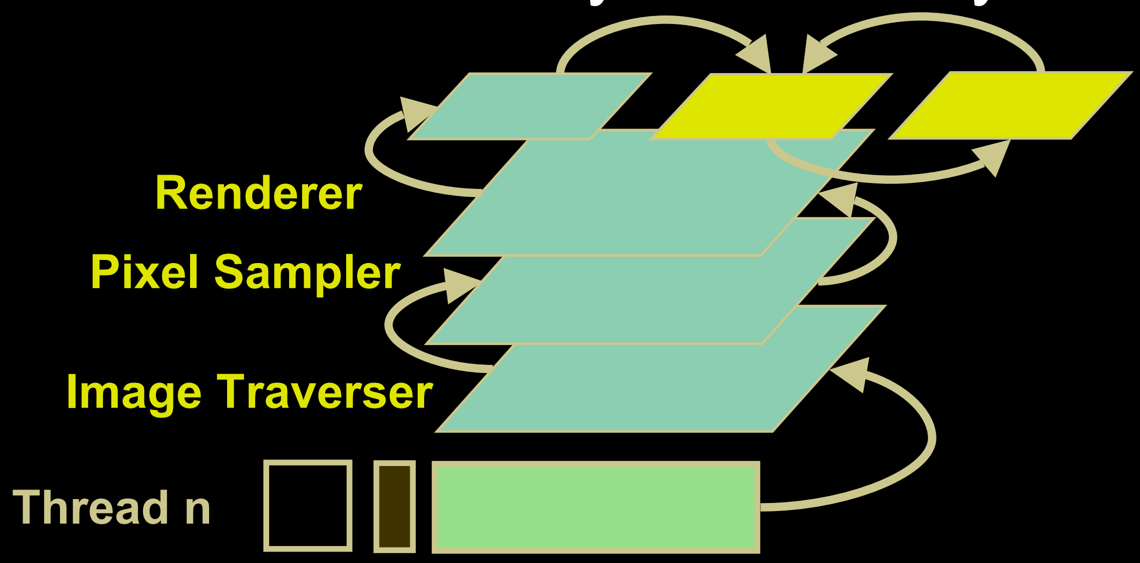


Manta Parallel Pipeline

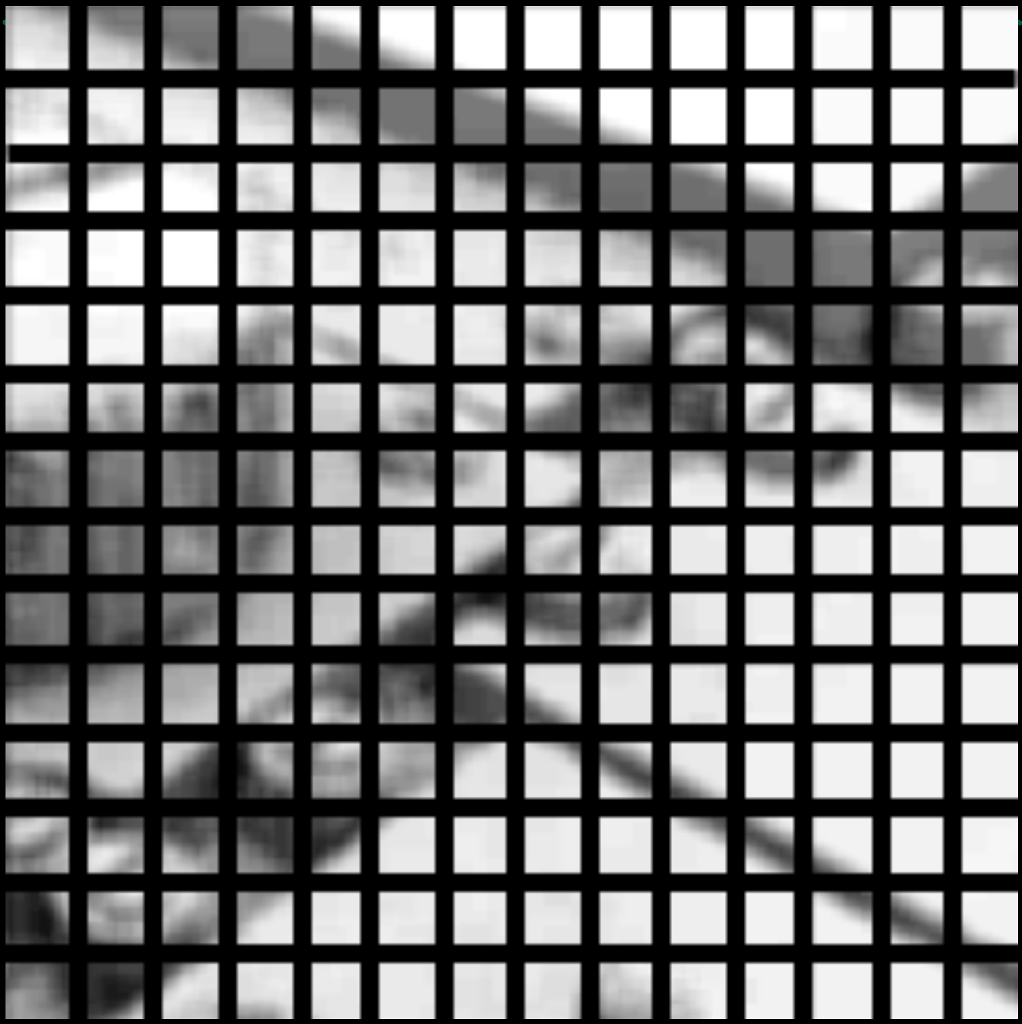


Manta Rendering Stack

- Stack of modular sampling and ray tracing components.
- Only global synchronization in pipeline.
- Threads execute stack asynchronously.



Load balancing



Load balancer tile division, requires thread safety.

Code Example

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```
void Pipeline::inner_loop( int frame,
    int proc, int numProcs ) {
   // Global synchronization.
  pipeline_barrier.waitFor( numProcs );

  // Inherently load balanced.
  parallel_animation_callbacks();

  // Imbalanced.
  if (proc == display_proc)
    image_display->
      displayImage( buffer[frame-1] );

  // Dynamically balanced.
  image_traverser->
     render_image( buffer[frame], proc );
}
```

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Code Example

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```
void Raytracer::traceRays(const Context&
    context,
                  RayPacket& rays) {
  context.camera->makeRays(rays);

  rays.resetHits();
  context.scene->getObject()->intersect(context,
    rays);

  for(int i = rays.begin();i<rays.end();){
   if(rays.wasHit(i)){
    const Material* hit_matl =
    rays.getHitMaterial(i);
    int end = i+1;
    while(end < rays.end() && rays.wasHit(end)
    &&
       rays.getHitMaterial(end) == hit_matl)
     end++;
RayPacket subPacket(rays, i, end);
    hit_matl->shade(context, subPacket);
    i=end;
  } else {
    int end = i+1;
    while(end < rays.end() &&
    !rays.wasHit(end))
     end++;
    RayPacket subPacket(rays, i, end);
    context.scene->getBackground()-
    >shade(context,
                         subPacket);
    i=end;
  }
 }
}
```

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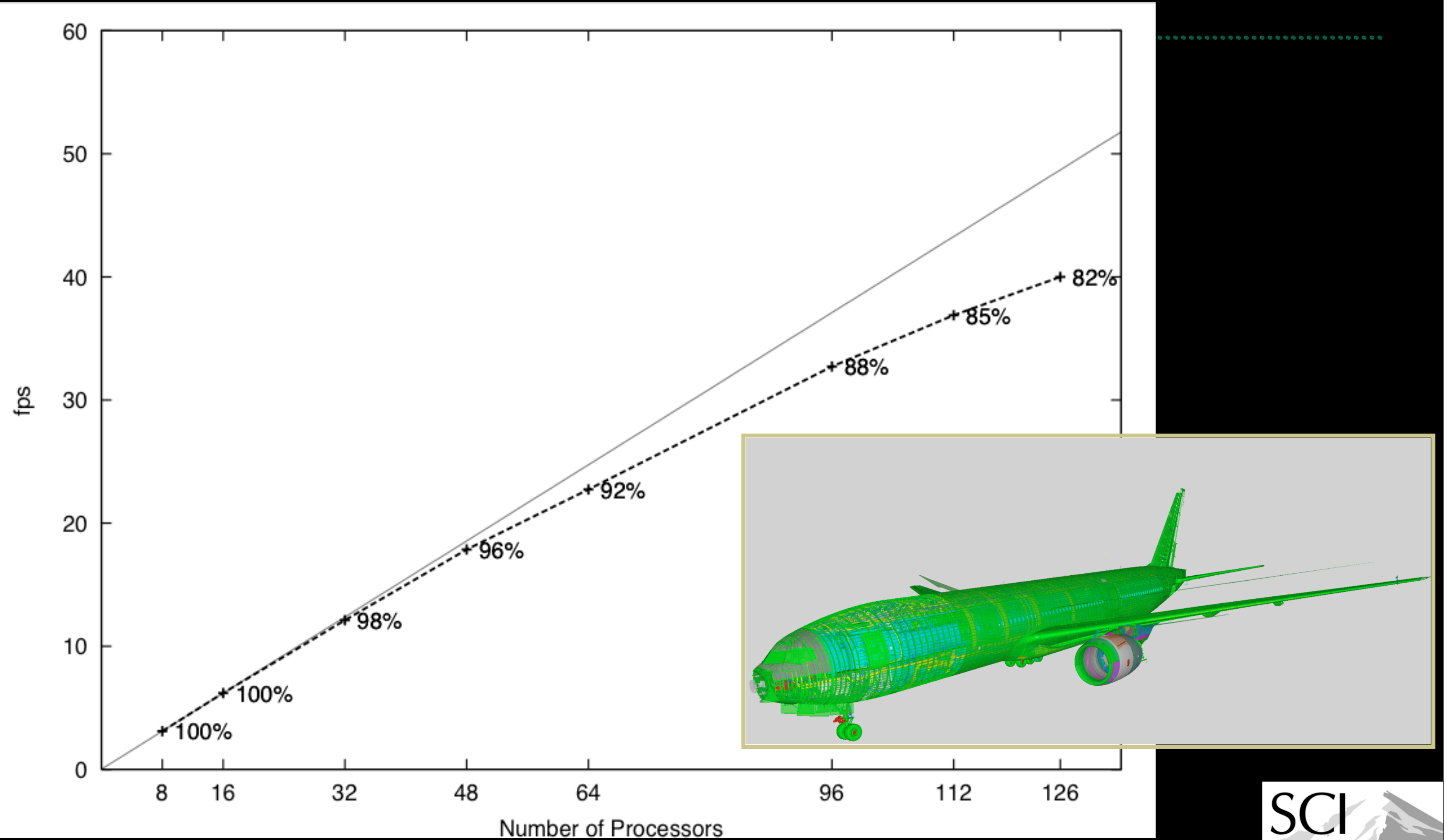
Scalability - 128 processors



Bottom Line

- To achieve scalable multi-threadperformance:
  - Use a parallel pipeline with limited synchronization points.
  - Use asynchronous display.
- Optimize for single processor performance.
  - Use packet properties for instruction optimization.
- Not really “big iron” any more.

Questions?

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A. Stephens, S. Boulos, J. Bigler, I. Wald, and S. G. Parker *An Application of Scalable Massive Model Interaction using Shared Memory Systems* Proceedings of the Eurographics Symposium on Parallel Graphics and Visualization, 2006

A. Knoll, I. Wald, S. G. Parker, C. Hansen. *Interactive Isosurface Ray Tracing of Large Octree Volumes.* Scientific Computing and Imaging Institute, University of Utah. Technical Report No UUSCI-2006-026. (submitted)

J. Bigler, A. Stephens, S. G. Parker. *Design for Parallel Interactive Ray Tracing Systems.* Scientific Computing and Imaging Institute, University of Utah. Technical Report No UUSCI-2006-027. (submitted)

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