Interactive and offline rendering in Blender Cycles using MPI and Intel® Xeon Phi™ Offload

Blender & Cycles
- Blender is an open source 3D creation suite. It has two render engines: Blender Internal and Cycles.
- Cycles is a raytracing based render engine with support for interactive rendering, shading node system, and texture workflow.

Algorithm for image rendering
- For each pixel, a ray is cast into a scene.
- A ray from a camera hits a glossy surface (D), then a diffuse surface (L), and it bounces into a random direction.
- The color of the ray is calculated depending on all materials of the surfaces.
- The process is repeated by the value of samples.
- In the end, the mean value of all samples is used for the color of the pixel.

Task decomposition (interactive)
- The synthesized image with resolution $x\times y$ is decomposed into tiles by number of compute nodes.
- The tile is sent to one node using MPI.
- The tile $x\times y$ is divided by the number of devices on one node.
- In our cases, there are four devices: CPU (12+12 cores), Intel Xeon Phi / MIC (61+61 cores).

Task decomposition (offline)
- The synthesized image with resolution $x\times y$ is decomposed to rows $y=1$.
- In our cases, there are four devices: CPU (12+12 cores), Intel Xeon Phi / MIC (61+61 cores).
- One node reads the stack and gets four rows (each row for one device).
- The Load Balancing is provided by the stack.

Blender’s environment

Collective communication routine
- $\text{Buffer} \rightarrow \text{mg_state}$
- $\text{mg_state} \rightarrow \text{root}$
- $\text{root} \rightarrow \text{Bcast}$
- $\text{Bcast} \rightarrow \text{Send new jobs to clients with Scatter}$
- $\text{Bcast} \rightarrow \text{Send the initial values of $mg_{state}$ to all nodes with Bcast}$
- $\text{Node} \rightarrow \text{Send the information about the size of buffer (rendered pixels) and size of $mg_{state}$ (random number generator state) to all nodes with Bcast}$
- $\text{Start rendering with Bcast message}$
- $\text{Read the current results from MIC and send the buffer to root with Gather}$
- $\text{Send new jobs to clients with Scatter}$
- $\text{View results in Blender}$

References
- Frederik Steinmetz, Gottfried Hofmann: The Cycles Encyclopedia
- Source available at: ghl@code.it4.cz/blender/cyclesphi.git

Salomon (IT4Innovations)

Computational Nodes With MIC Accelerator
- 432 nodes
- 10,368 cores in total
- two Intel Xeon E5-2680v3, 12-core, 2.5GHz processors per node
- 128 GB of physical memory per node
- MIC accelerator 2x Intel Xeon Phi 7120P per node, 61-core,
- 16GB per accelerator
- Computational Nodes Without Accelerator
- 576 nodes

Benchmark (Tatra T87, Worm)
- The benchmark was run on 1-64 computing nodes of the Salomon supercomputer equipped with two Intel Xeon E5-2680v3 CPUs and two Intel Xeon Phi 7120P.
- Tatra T87 scene has 1.2 million triangles and uses the HDR lighting (Interactive rendering, Resolution: 1920x1080, Samples: 1).
- Worm scene has 13.2 million triangles (Offline rendering, Resolution: 4096x2048, Samples: 1024).

Strong Scalability Test (interactive)
- Benchmark (Tatra T87): The comparison of OpenMP CPU (OMP24) and hybrid (CPU+MIC Offload) implementations.

Strong Scalability Test (offline)
- Benchmark (Worm): The comparison of OpenMP CPU (OMP24) and hybrid (CPU+MIC Offload) implementations.

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