Lucerne University of
Applied Sciences and Arts

HOCHSCHULE
LUZERN

Out-of-Core Photon Mapping: When More isn't Enough

CC Envelopes and Solar Energy
Lucerne University of Applied Sciences and Arts

Roland Schregle (until May 2016) - presented by C. Bauer -
Present: roland.schregle@gmail.com

15th Radiance Workshop

Padua, 29. - 31. August 2016

Motivation

Applications demand high photon counts

- Photon count is the key parameter for accurate simulations
- Contribution Photon Maps need higher counts than normal ones (demand approx. scales with numner of sources/source patches)
- Applications like EvalDRC with additional sun coefficients further increase the demand

Limitation

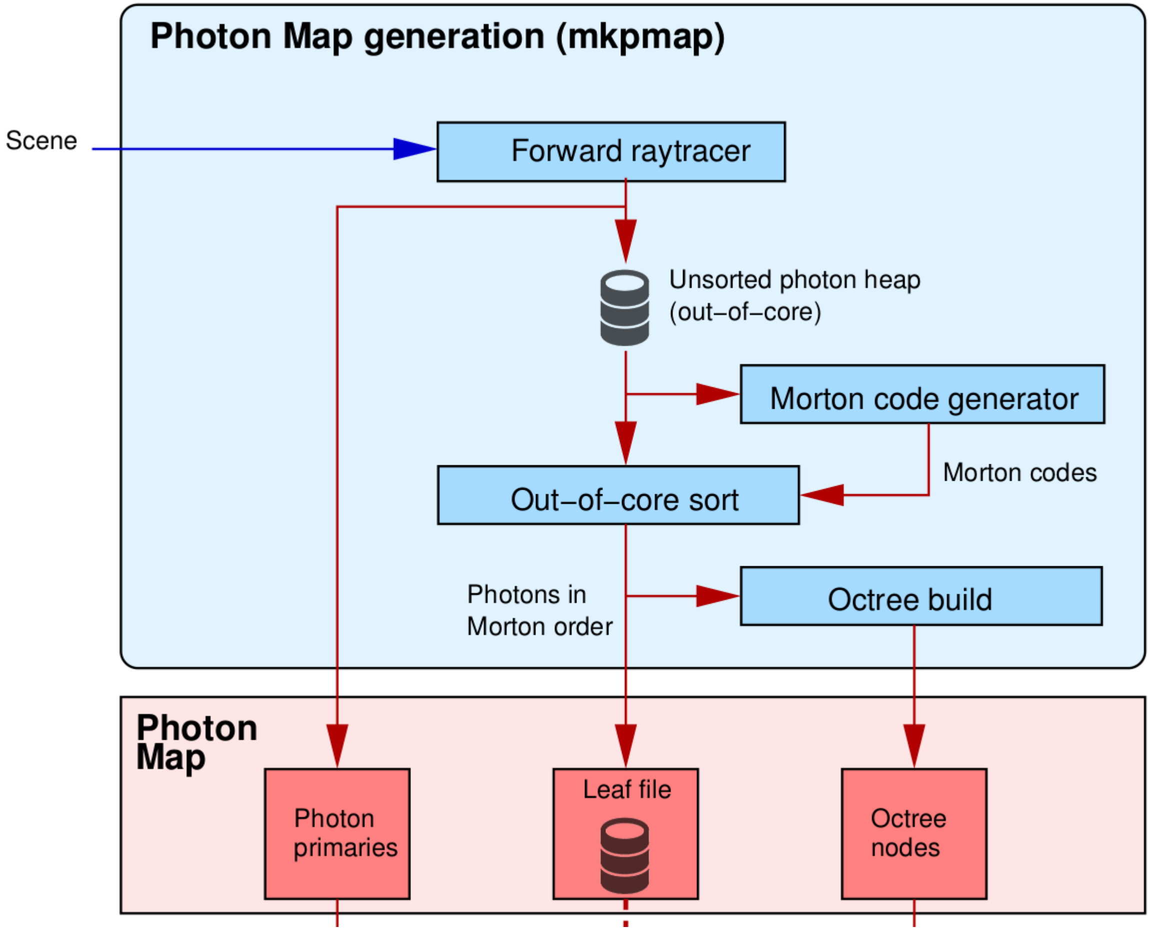
Photon counts of several 100 Million up to a few Billion use up too much memory on todays commodity hardware (8 GB RAM)

Strategy

Provide efficient mechanism for Out-of-Core storing and on demand loading of photon data

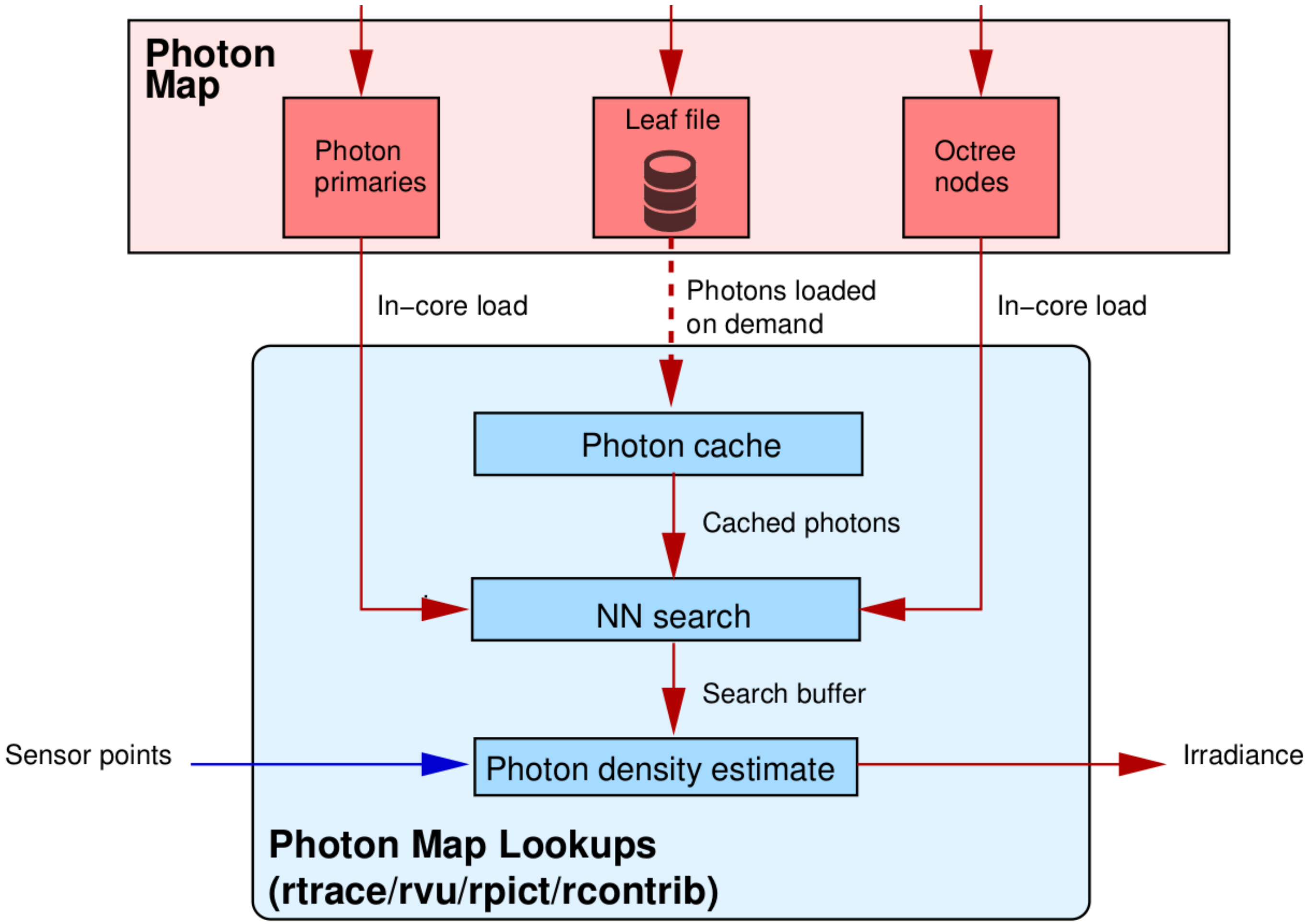
Overview

Out-of-Core Photon Map Generation



Overview

Out-of-Core Photon Map Use



Building Blocks of the Algorithm

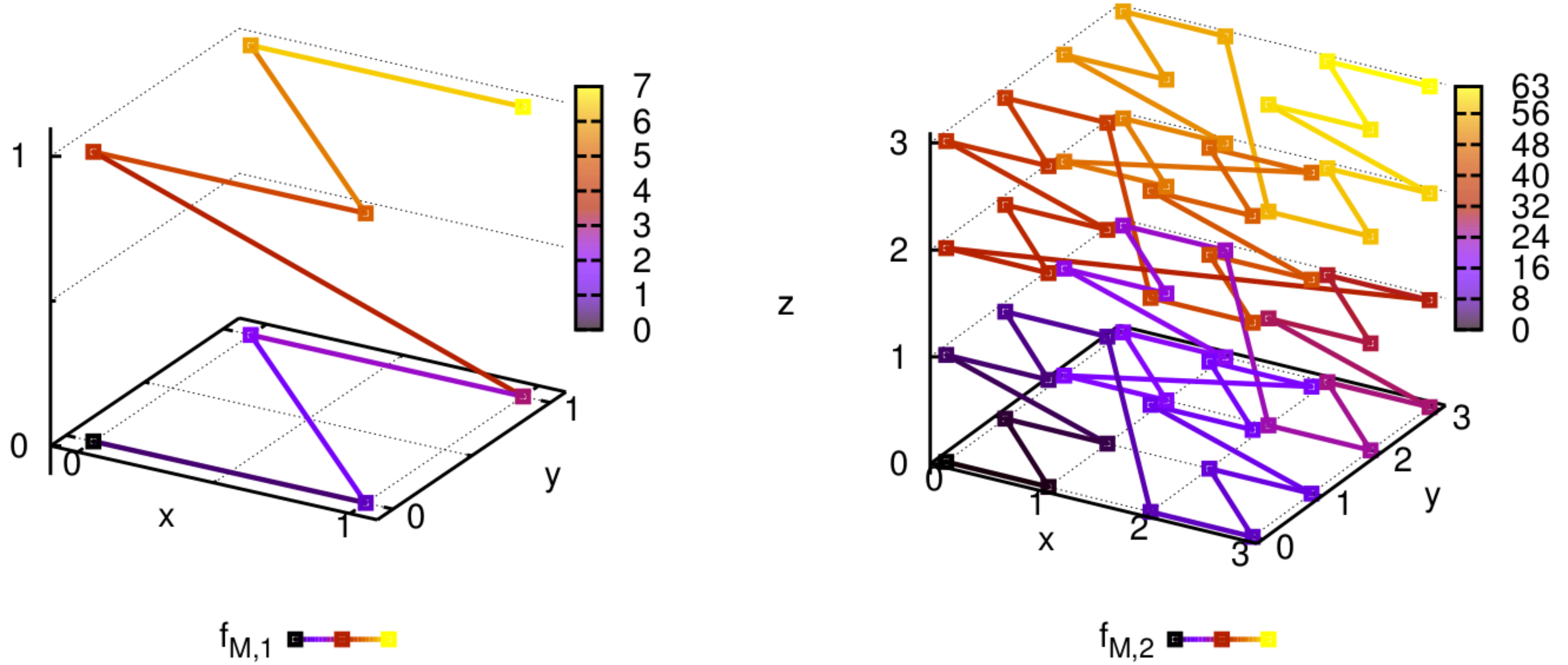
Photon Map Generation

- Photon indexing with Space Filling Curves / Morton Coding
- Photon sorting (external sorting algorithms for large datasets are a well studied area in computer science)
- Octree construction (hierarchical volume structure for nearest neighbour search)

Photon Map Use

- Paging mechanism for loading and unloading photon data from the disk (analog to the OS handling of main memory pages)
- Intelligent caching strategy to reduce load/unload operations
- Decisions on types of data which are kept in core (iC) or out-of-core (ooC)
- Efficient nearest neighbour searches

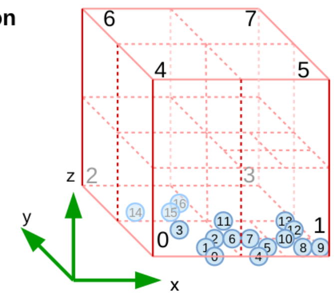
Morton Code Example



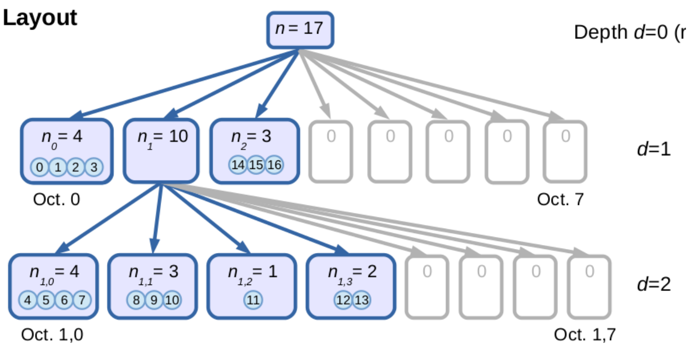
Octree Generation

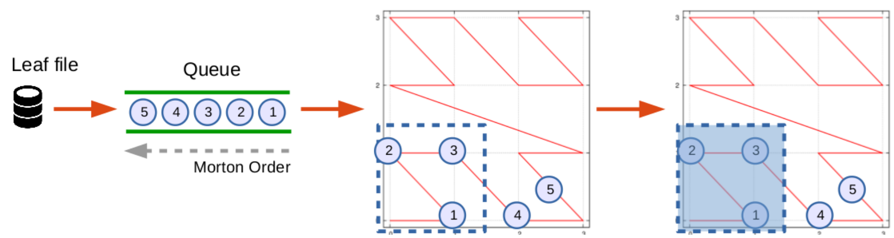
Ordered photons / Morton indices facilitates 1-pass octree generation

Photon distribution

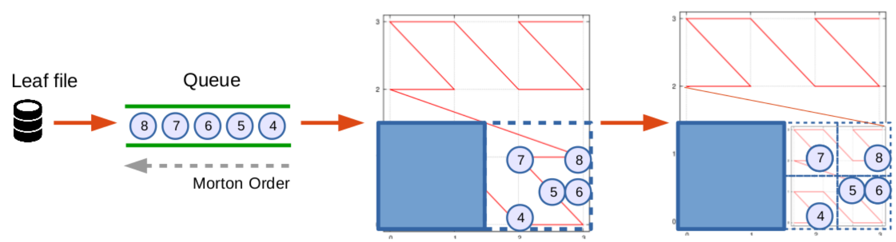


Logical Layout



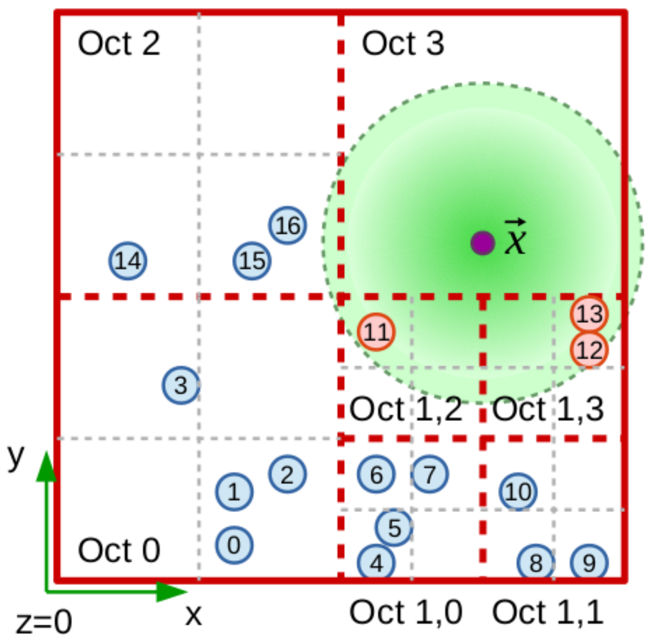


1: Last photon outside bbox → new leaf at depth 1

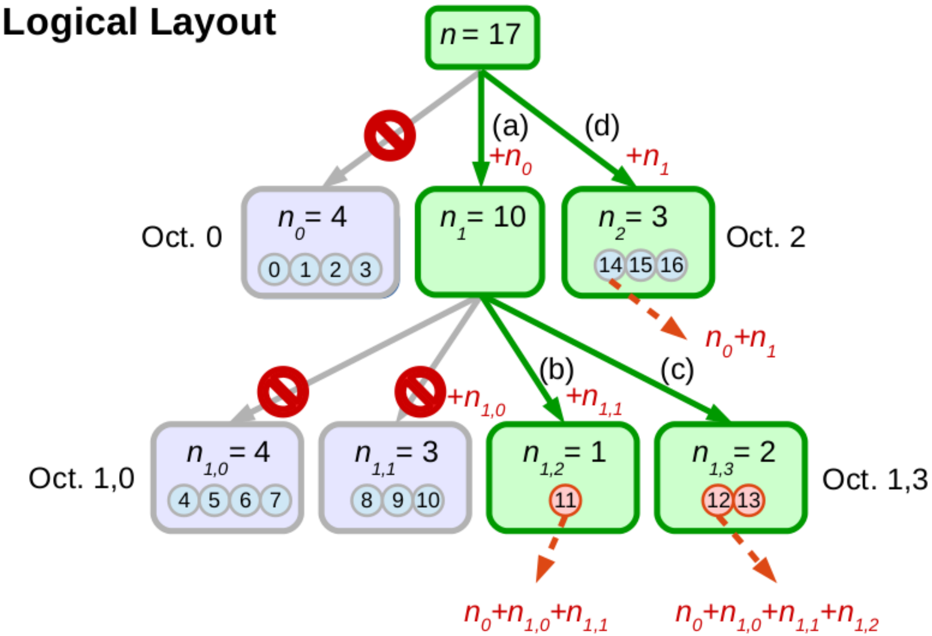


2: Last photon in bbox → divide & recurse at depth 2

Nearest Neighbour Search



Logical Layout



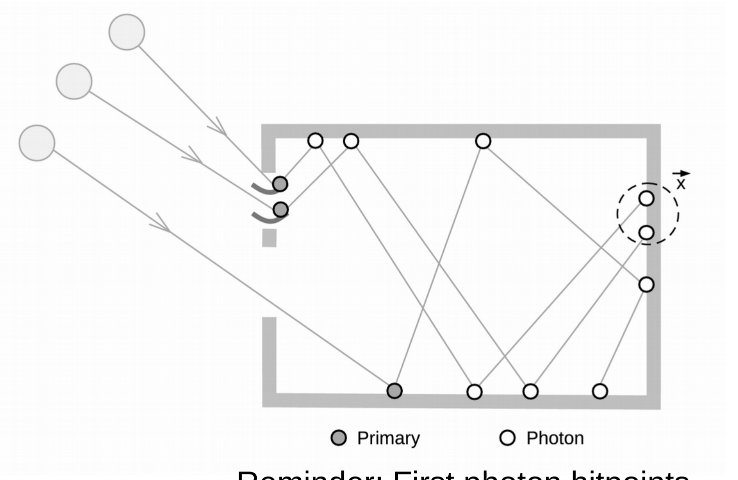
Paging Mechanism

→ cf. Techn. Report

In and Out

Permanently in Memory

- Octree Structure (Nodes)
- Photon Primaries



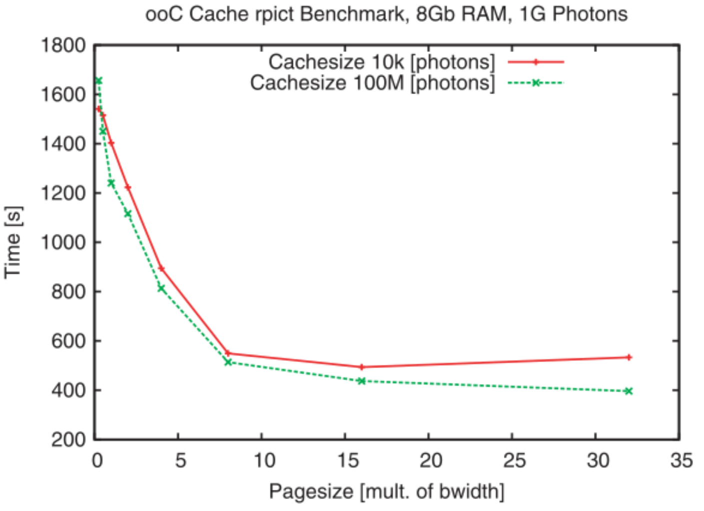
Reminder: First photon hitpoints ('Primaries') play a special role

Loading on demand (out-of core)

Gross photon data

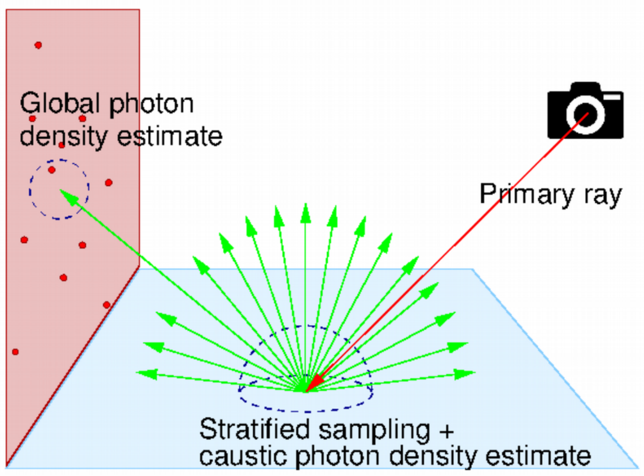
Critical aspects

- Page and Cache sizes (amount of photons to load and buffer)
- I/O bottleneck / contention



Do's and Don'ts with ooC

In principle, the ooC scheme needs coherent data (i.e. photon) accesses for an efficient operation. This is generally the case for direct photon density evaluation, which can be enabled with the RADIANCE parameter -ab -1



Global photons

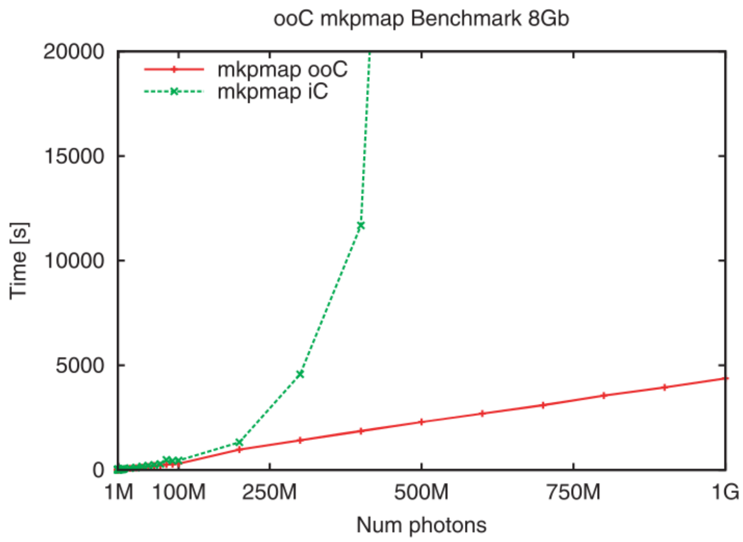
All indirect irradiance on diffuse surfaces → relayed density estimate via ambient rays

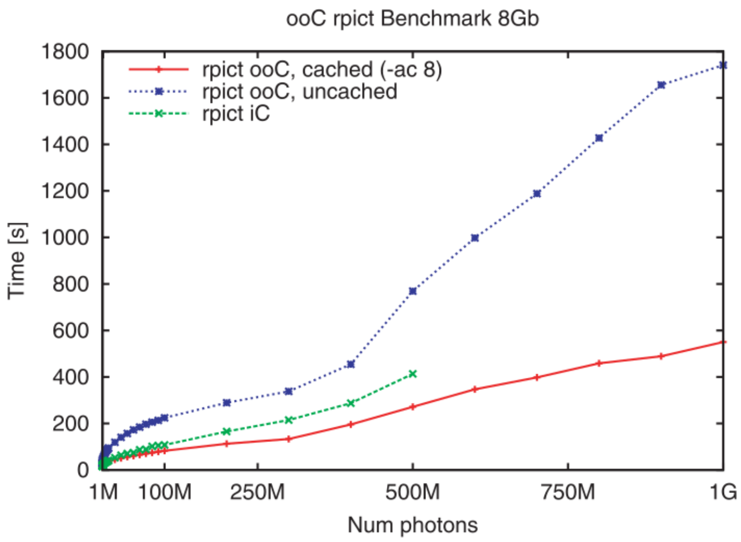
Caustic photons

Specular irradiance on diffuse surfaces only → direct density estimate at primary rays

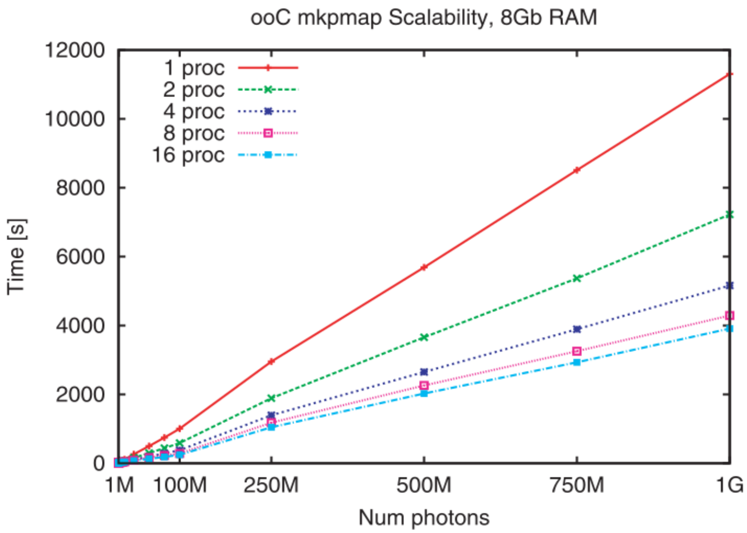
The evaluation of photon density via 1 ambient bounce (as recommended in the original Photon Map version) will lead to excessive loading/unloading of photon data in the ooC variant.

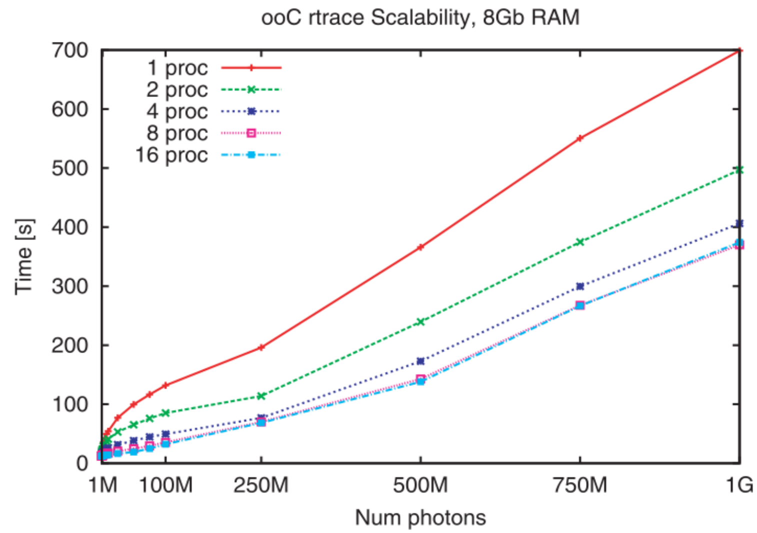
ooC vs. iC - Benchmarks





ooC Parallel Processing Benchmarks





Radiance with ooC Photon Map

- Default Version: in Core Map
- ooC Version needs Rebuild with -DPMAP_OOC
- ooC Photon Map produces 2 Files: xyz.pmap and xyz.pmap.leaf
- iC and ooC Photon Maps are not compatible
- additional ooC Photon Map parameters: -ac/-aC for cache and page size adjustment (cf. Tech.Report)

Thank you for your attention!

Our website: http://www.hslu.ch/ccease

References / Suggested further reading:

Roland Schregle, The Radiance Out-of-Core Photon Map – Technical Report (2016), CC Envelopes and Solar Energy, Lucerne University of Applied Sciences and Arts.

R. Schregle, L.O. Grobe & S. Wittkopf (2016): An out-of-core photon mapping approach to daylight coefficients, Journal of Building Performance Simulation
DOI: 10.1080/19401493.2016.1177116

This research was supported by the FNSNF

FONDS NATIONAL SUISSE
SCHWEIZERISCHER NATIONALFONDS
FONDO NAZIONALE SVIZZERO
SWISS NATIONAL SCIENCE FOUNDATION