Dual Streaming for Hardware-Accelerated Ray Tracing

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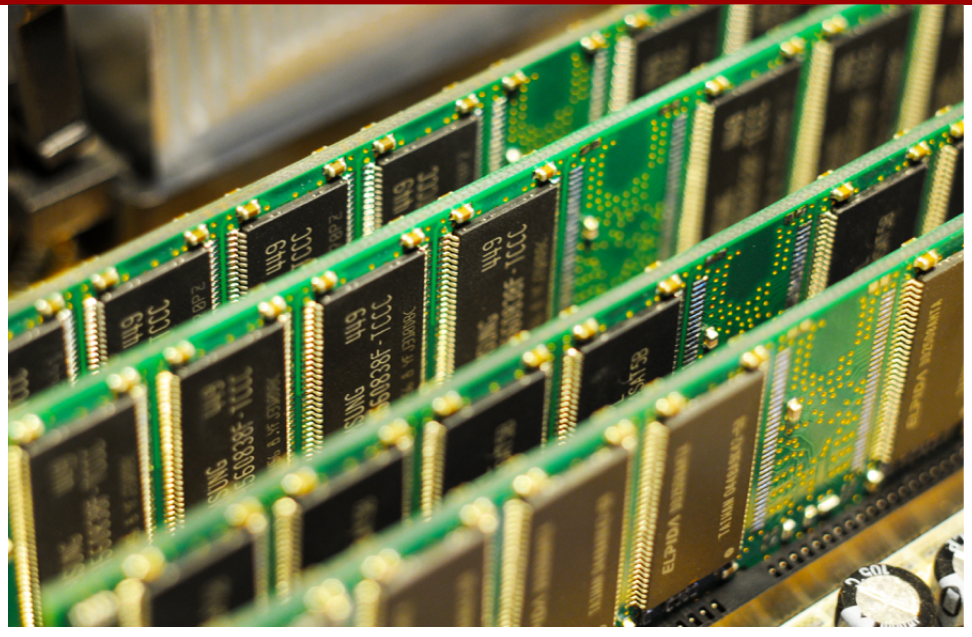
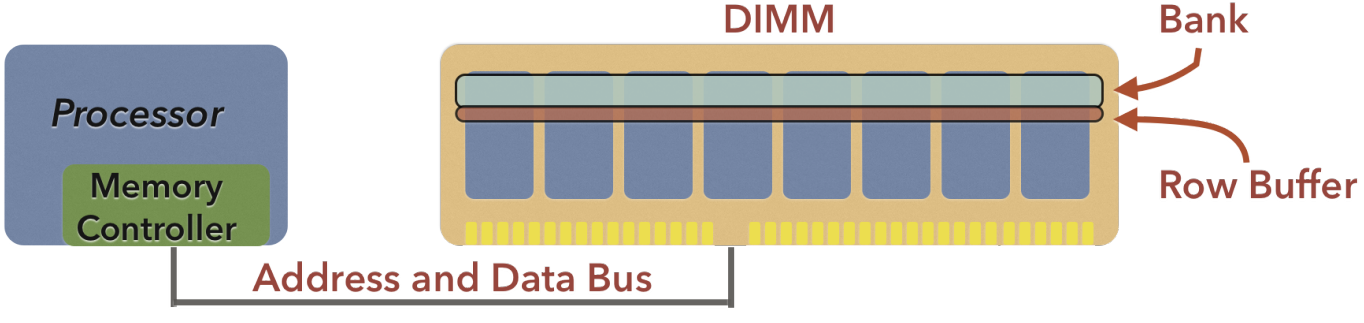
HPG '17 7.29.17

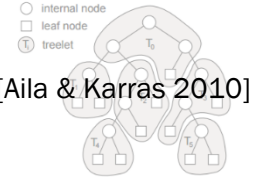
DRAM




DIMM
Bank
Processor
Memory Controller
Row Buffer
Address and Data Bus

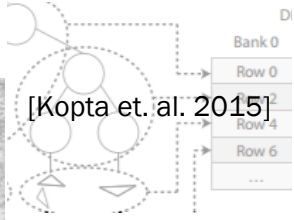
Previous Work

[Boulos et. al. 2007]

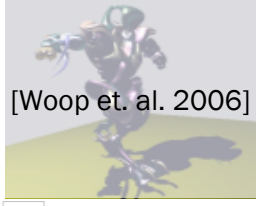


[Aila & Karras 2010]

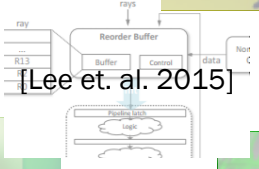
[Navratil et. al. 2007]



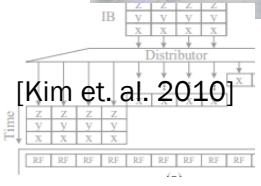
[Kopta et. al. 2015]


[Woop et. al. 2006]

[Wald et. al. 2014]



[Lee et. al. 2015]

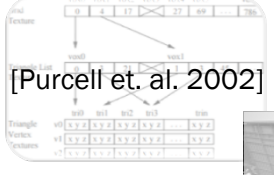


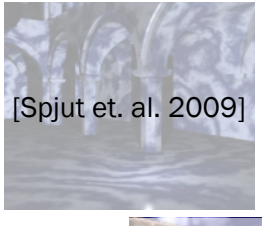
[Kim et. al. 2010]

[Eisenacher et. al. 2013]

[Moon et. al. 2010]

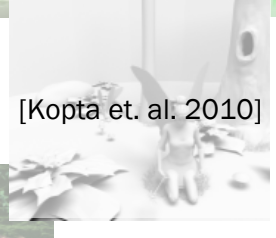
[Bigler et. al. 2006]

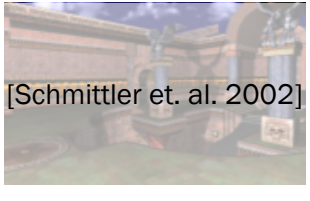

[Purcell et. al. 2002]


[Spjut et. al. 2009]

[Keely 2014]

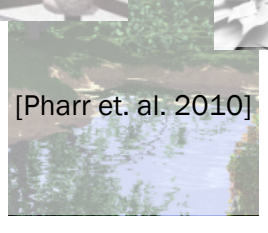
[Gribble & Ramani 2008]

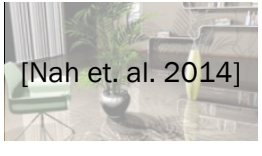

[Kopta et. al. 2010]


[Schmittler et. al. 2002]

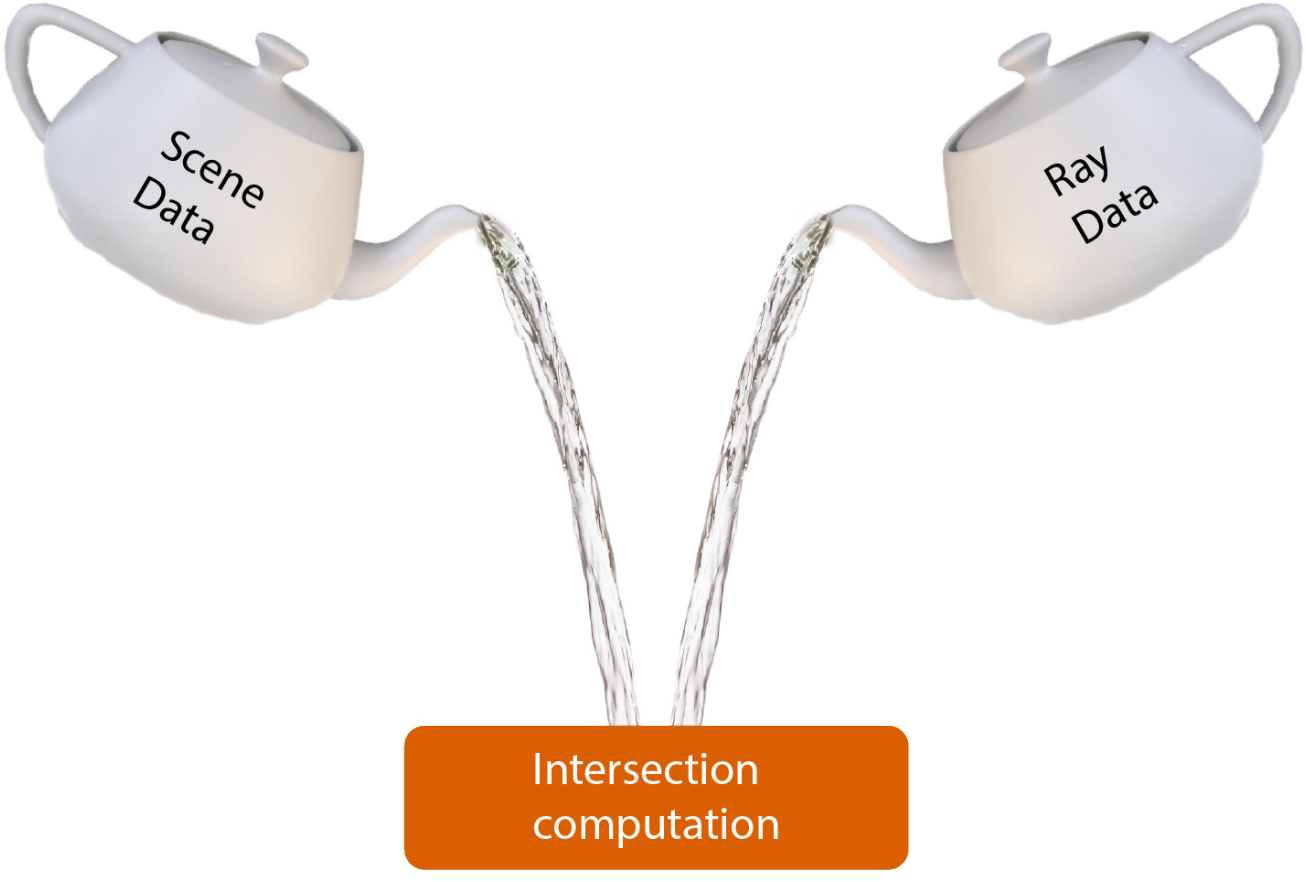
[Bikker 2012]

[Liktor & Vaidyanathan 2016]


[Pharr et. al. 2010]


[Nah et. al. 2014]

Dual Streaming



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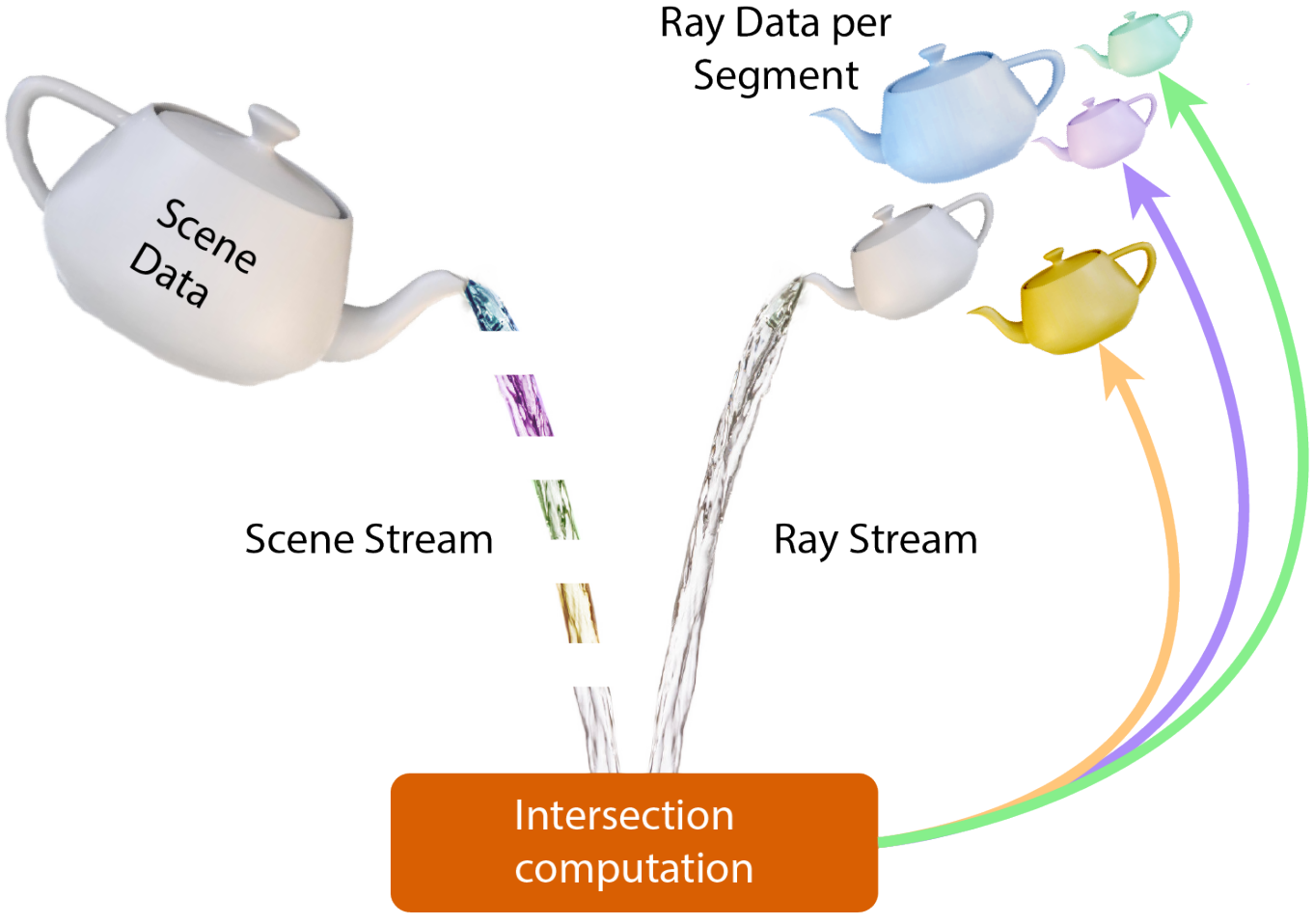
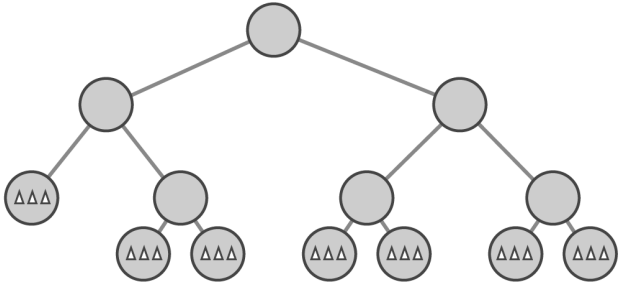


Contributions

- First fully streamed formulation of ray tracing
  - scene, ray streams
  - predictive memory access
  - new traversal order
  - scene traffic at absolute minimum
- Hardware architecture

Predictive Traversal Order



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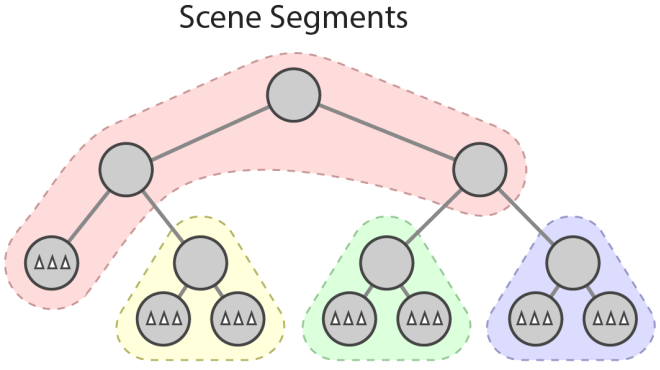

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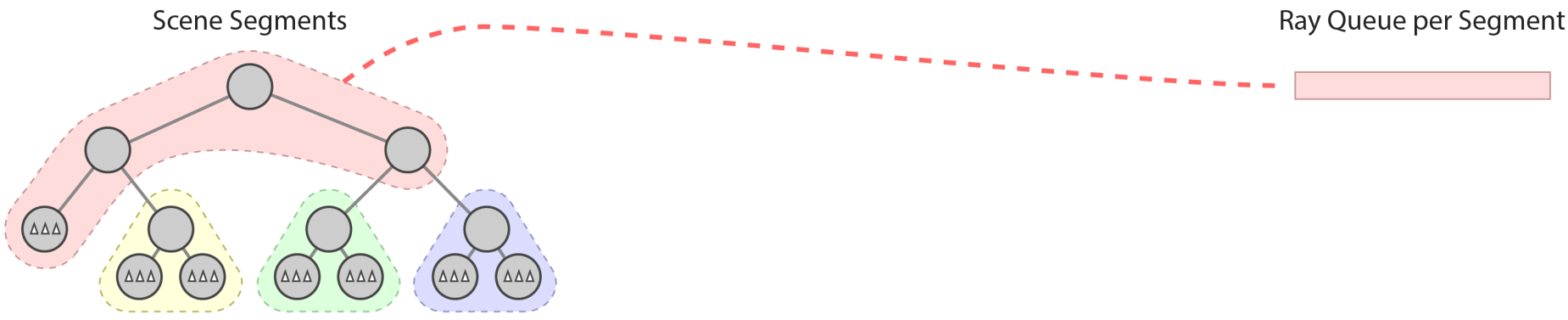

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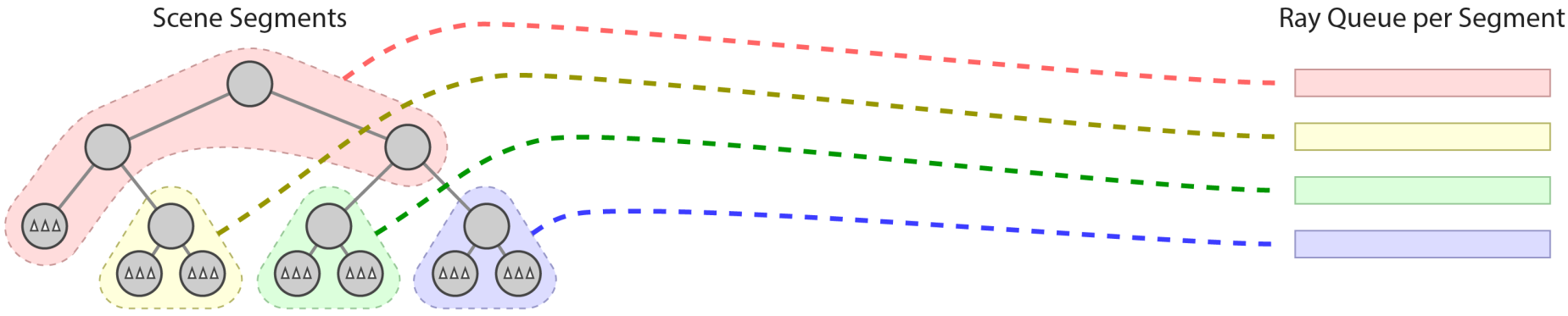

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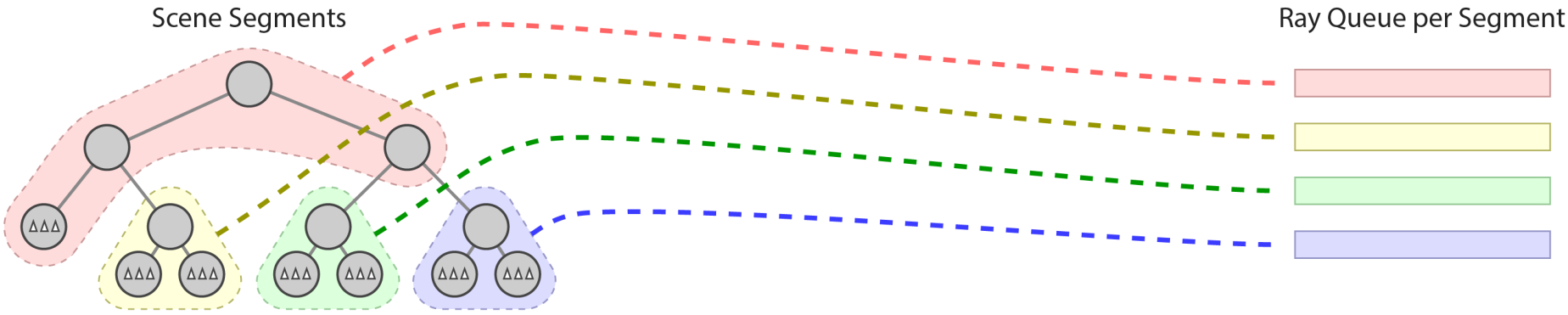
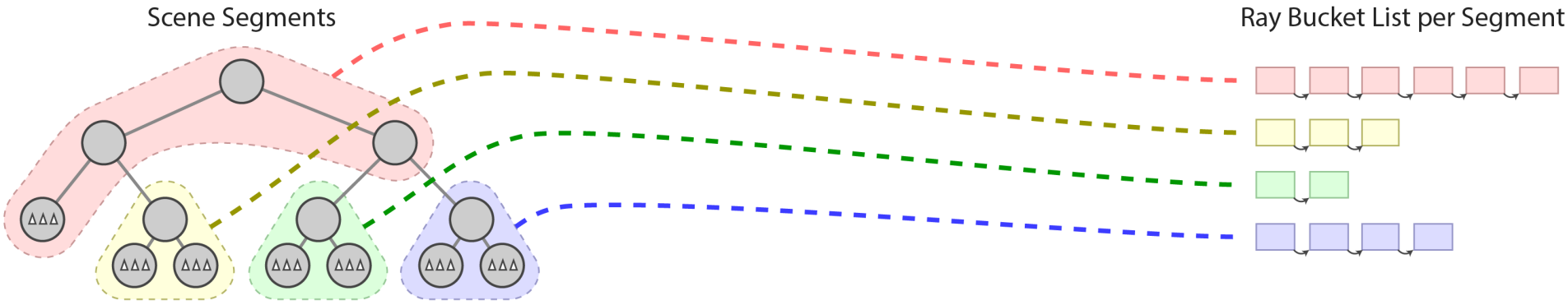


Rays can be duplicated

No traversal stack stored

Stream Layout in DRAM



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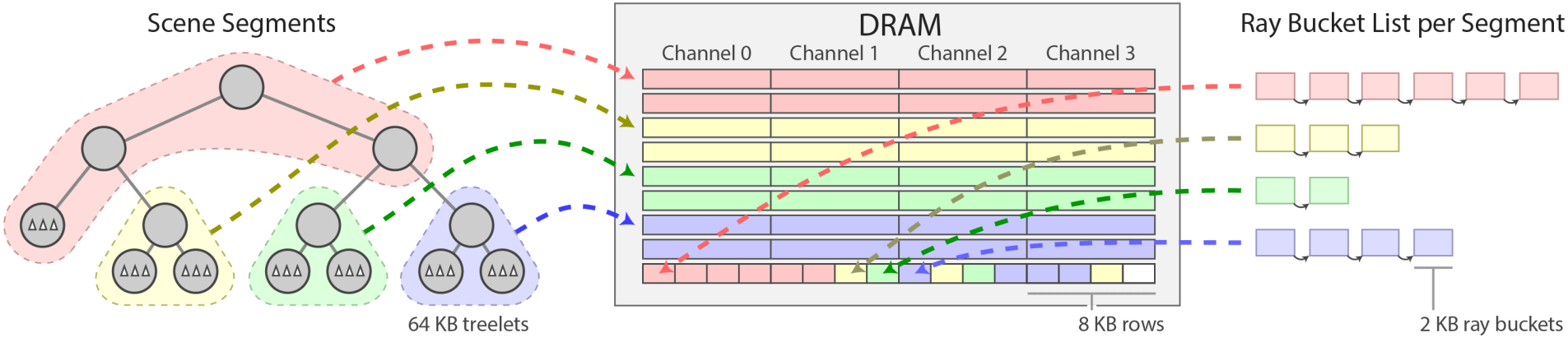
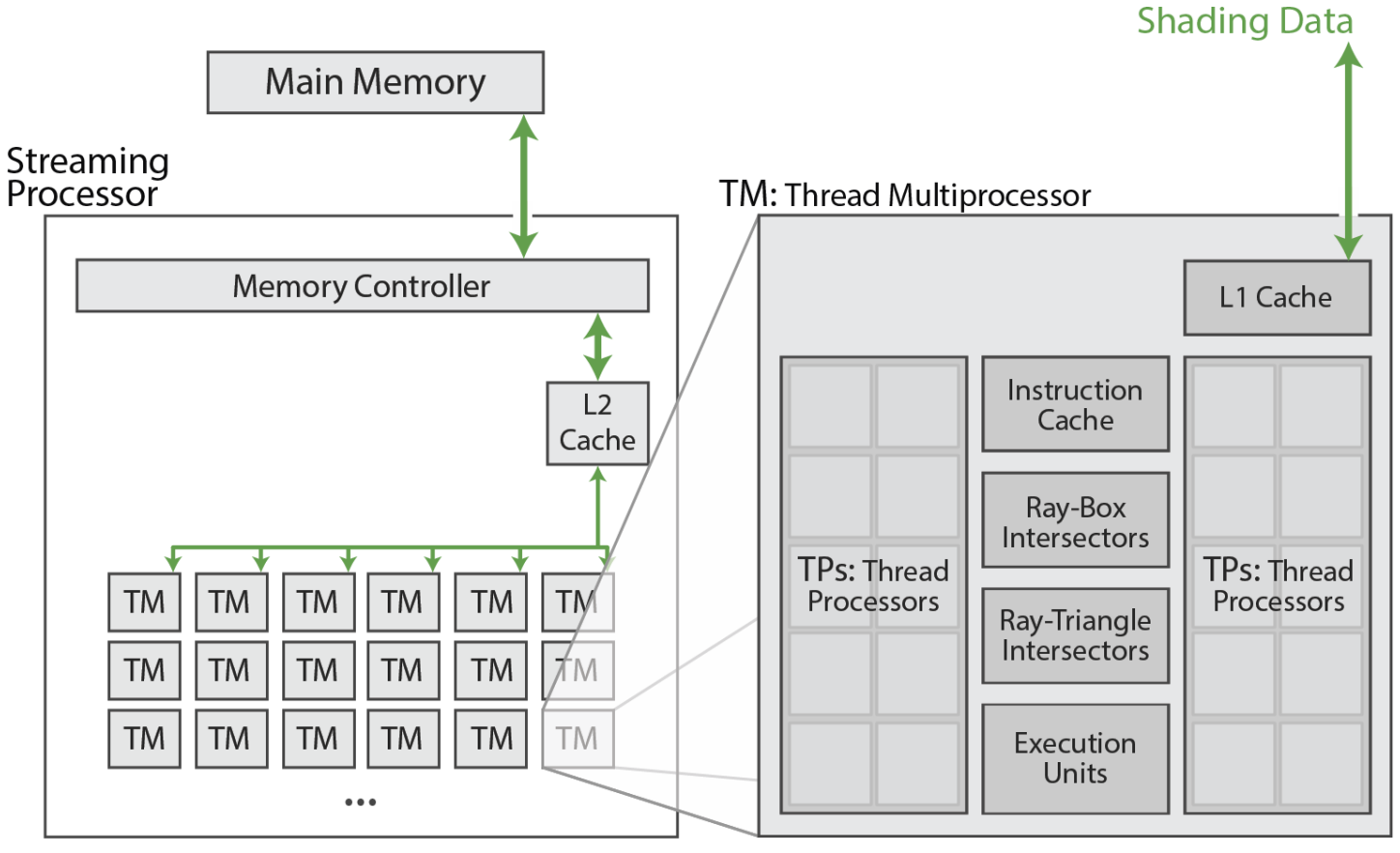


Hardware Architecture



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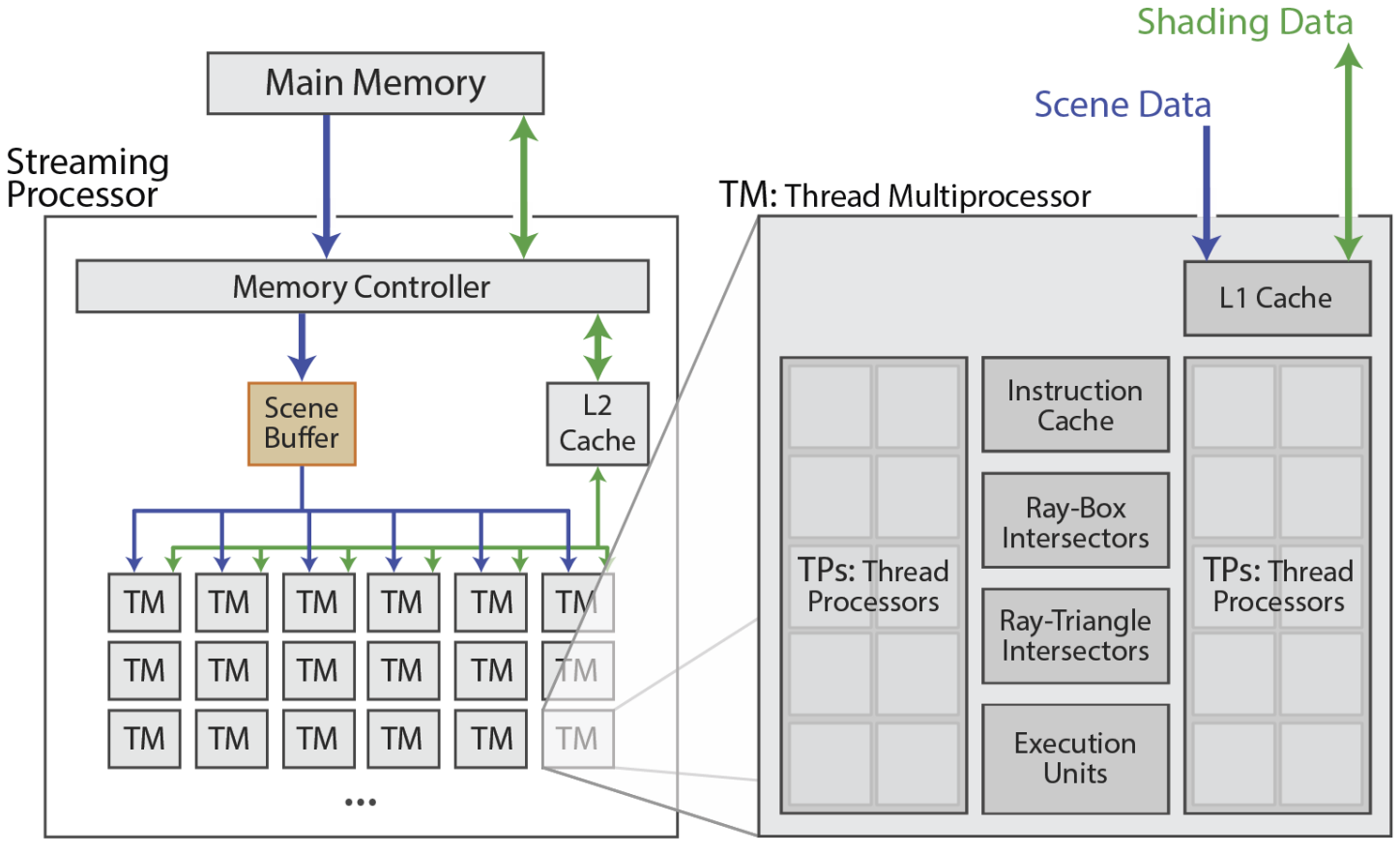

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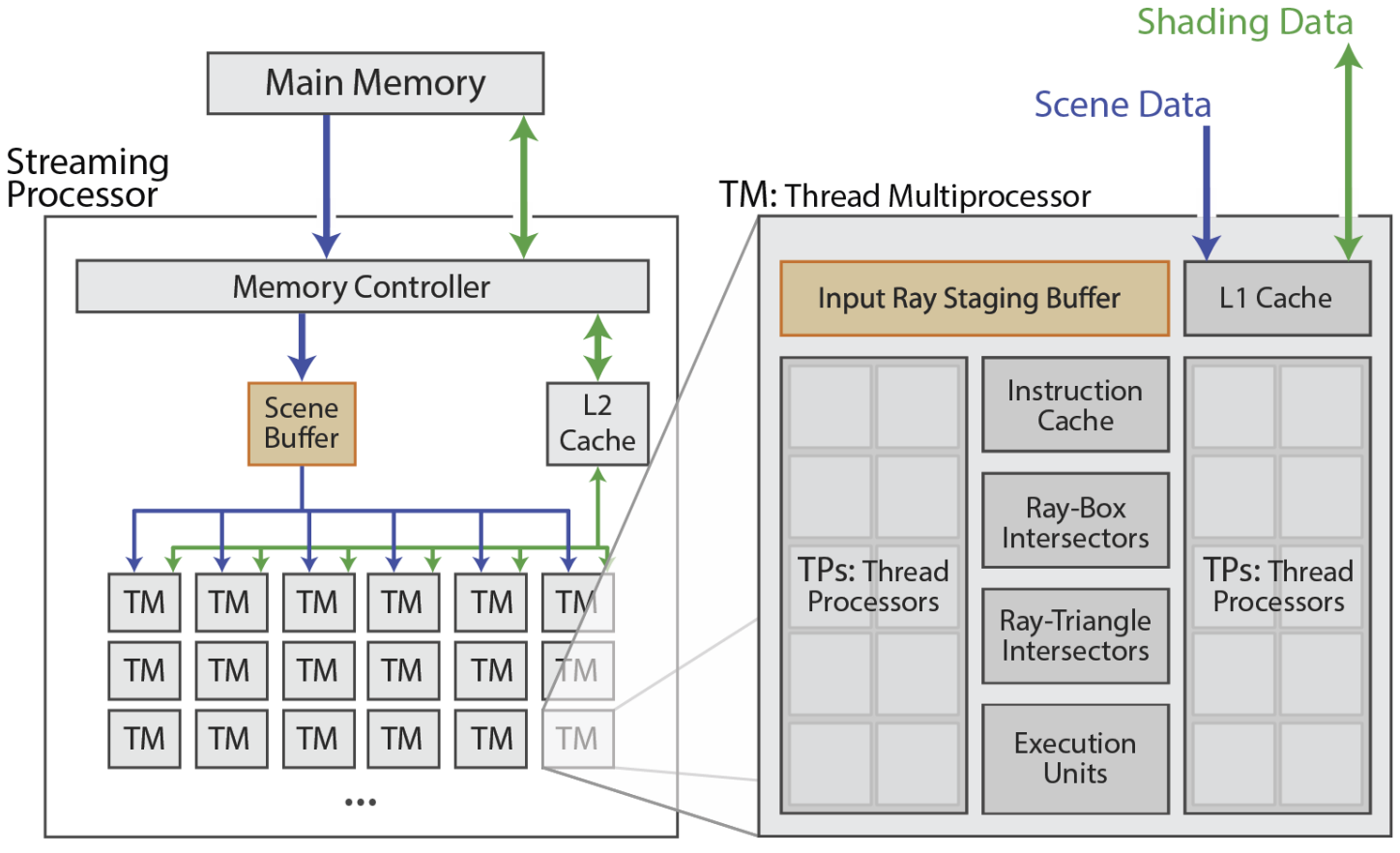

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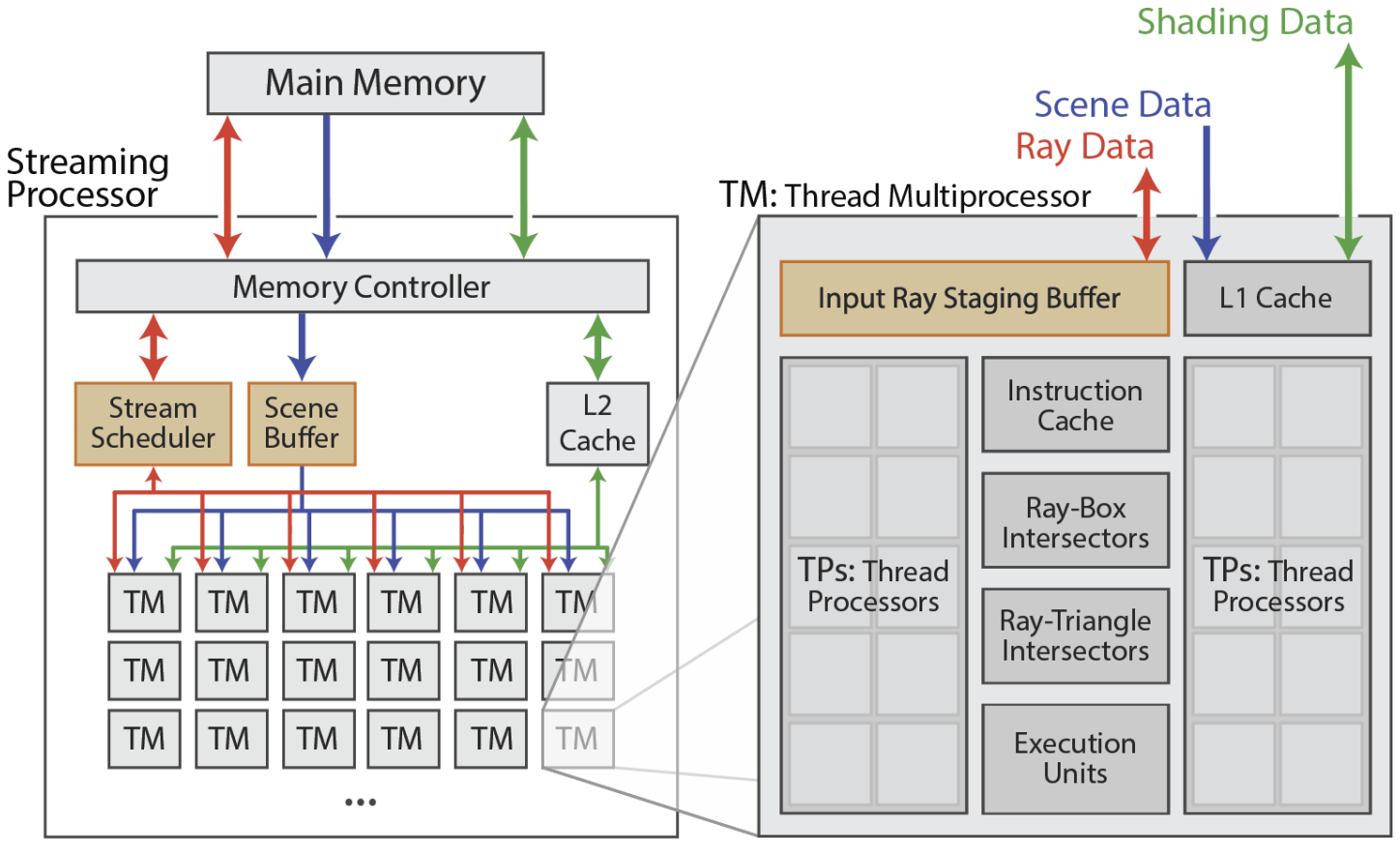

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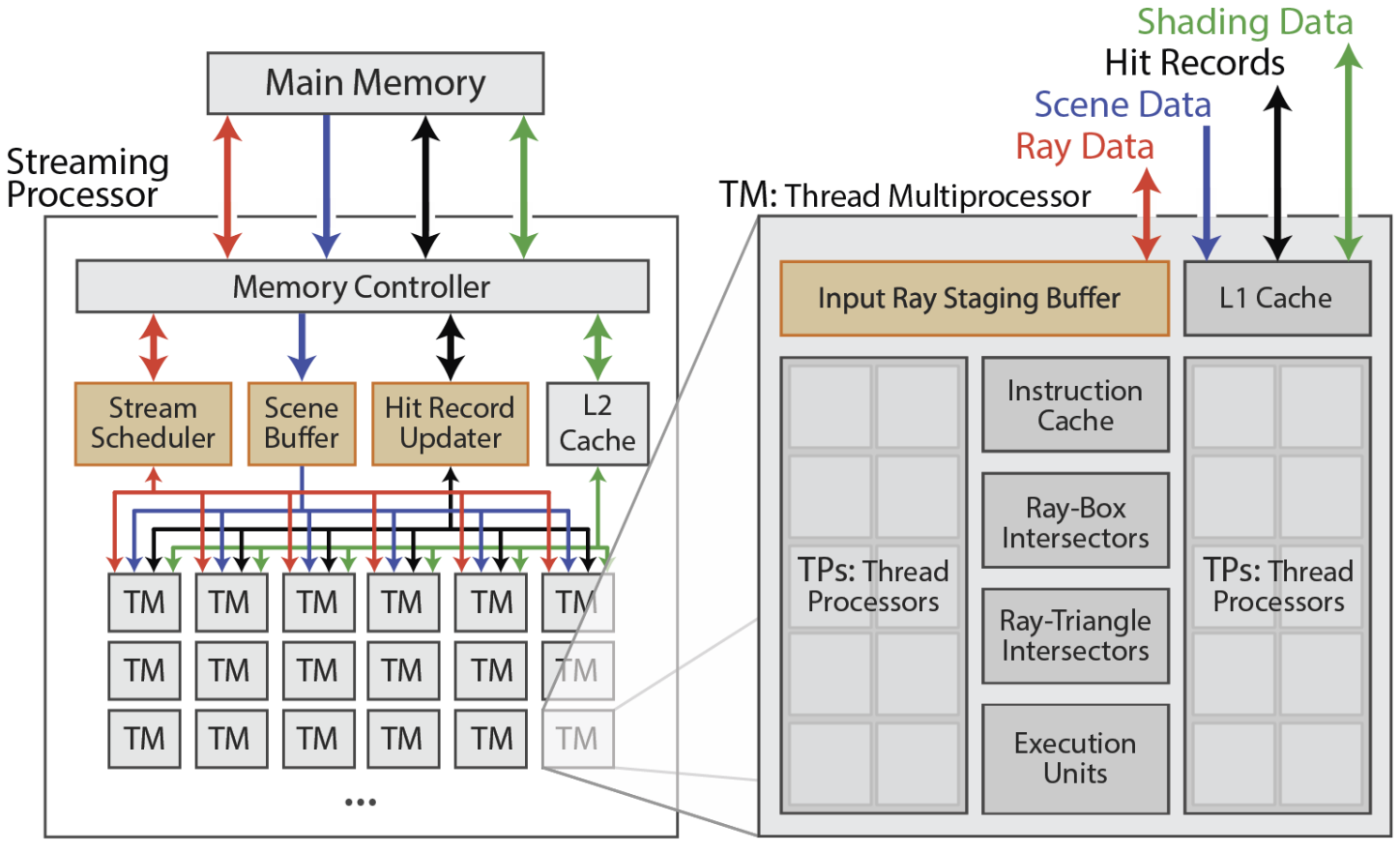
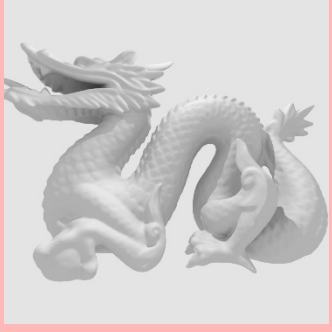


Results: Scenes

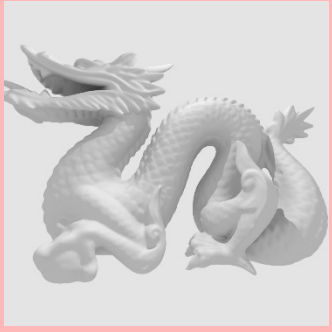
Benchmark

Dragon 870 K	Dragon Box 870 K	Dragon Sponza 6.6 M	San Miguel 10.5 M
			

Results: Scenes

Benchmark

Dragon
870 K

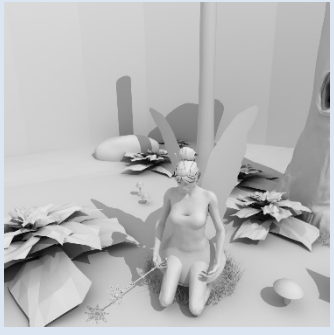


Dragon Box
870 K

Dragon Sponza
6.6 M

San Miguel
10.5 M

Small



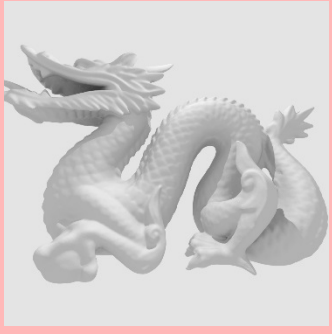
Fairy Forest
174 K

Crytek Sponza
262 K

Results: Scenes

Benchmark

Dragon
870 K

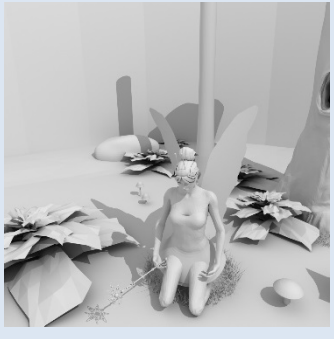


Dragon Box
870 K

Dragon Sponza
6.6 M

San Miguel
10.5 M

Small



Fairy Forest
174 K

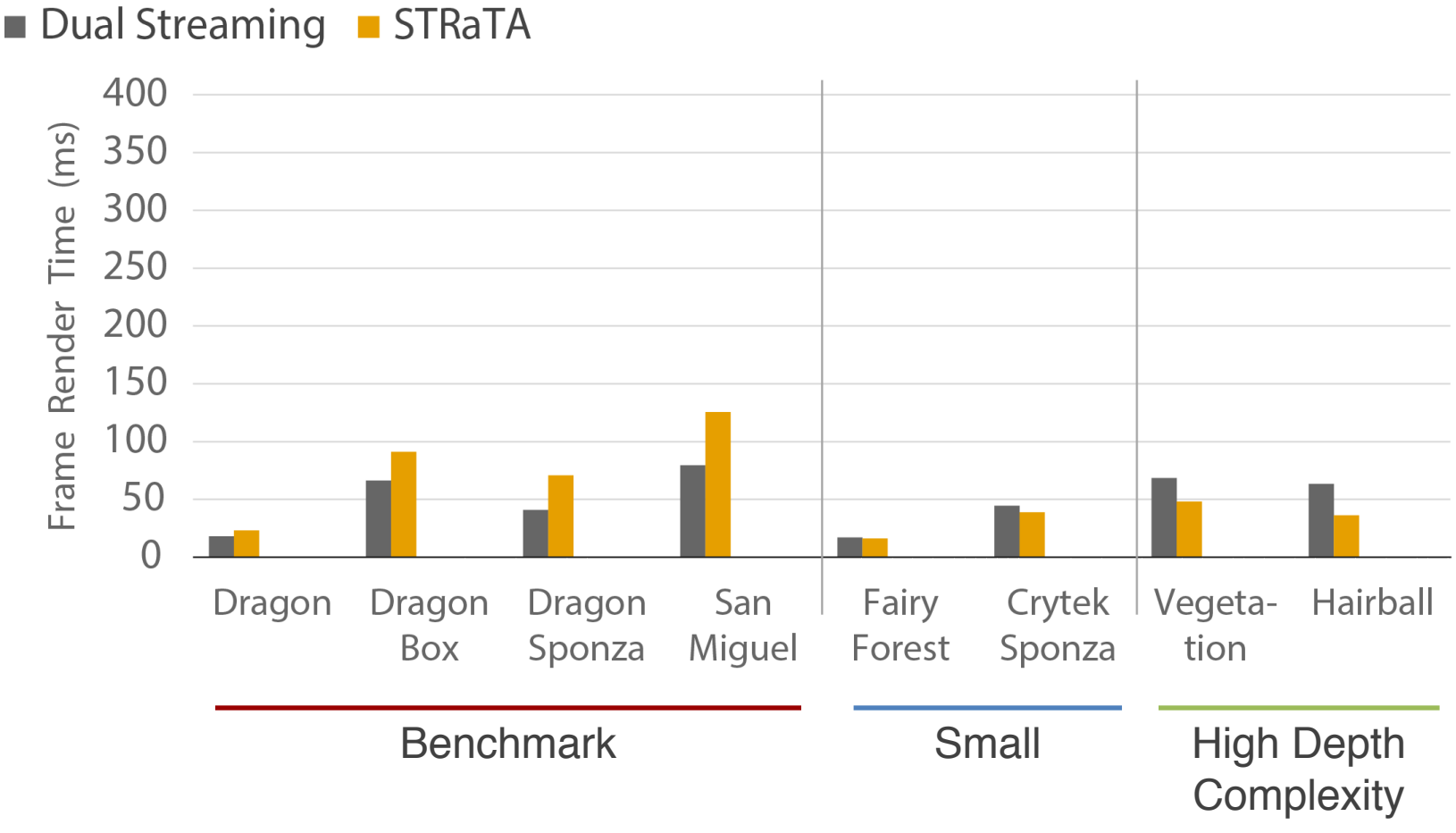
Crytek Sponza
262 K

Vegetation
1.1 M

Hairball
2.9 M

High Depth Complexity

Results: Render Time



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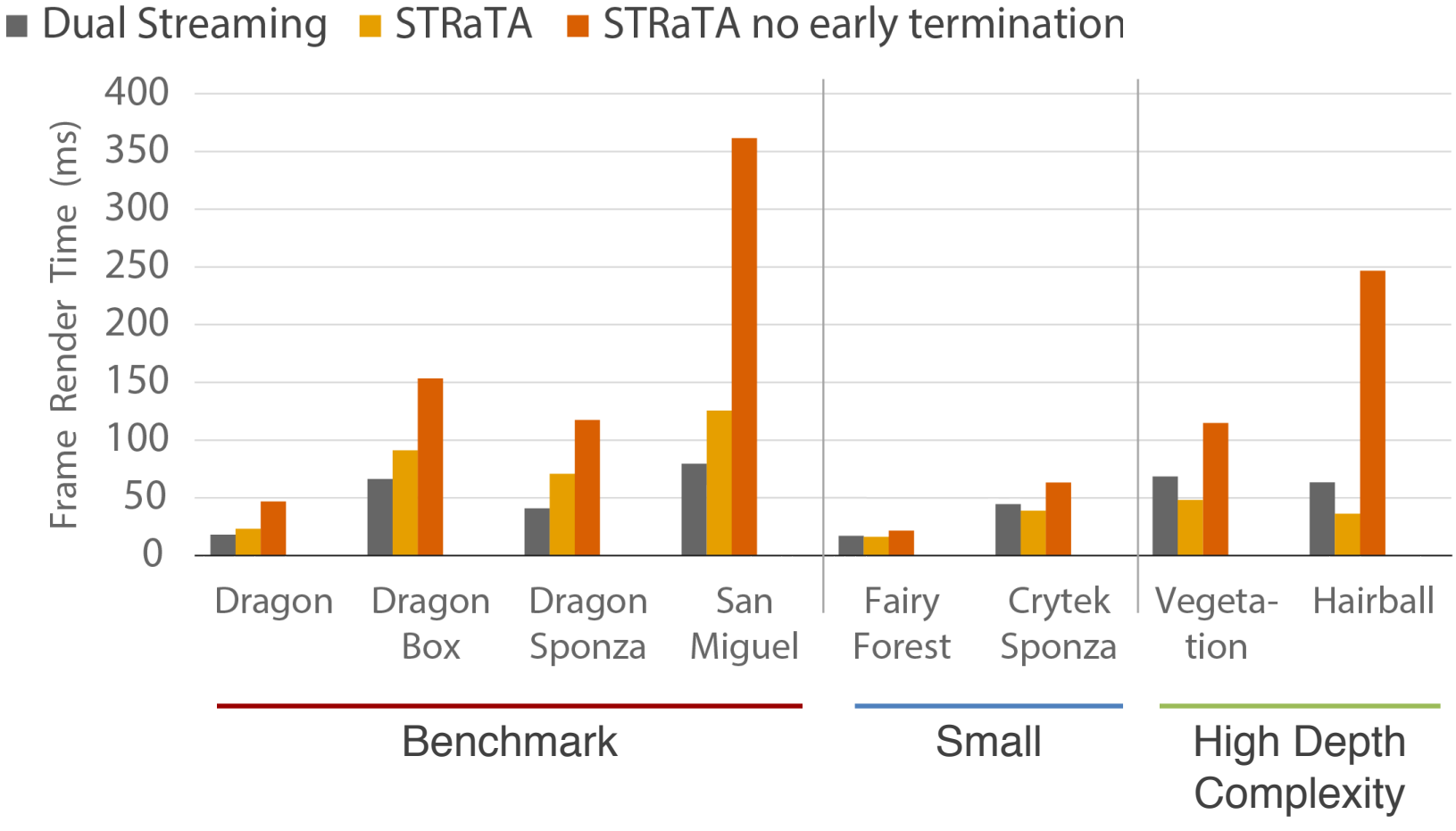

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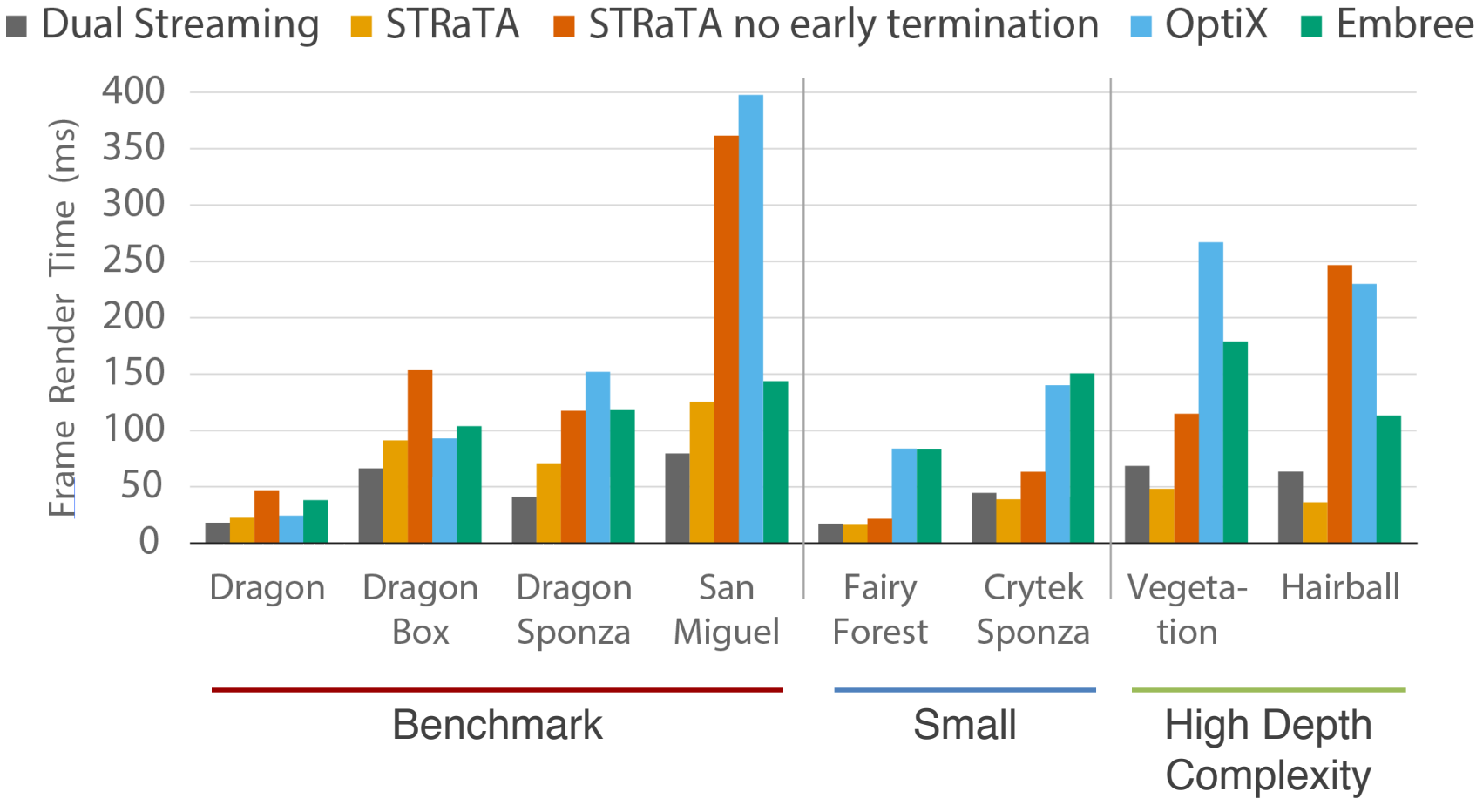
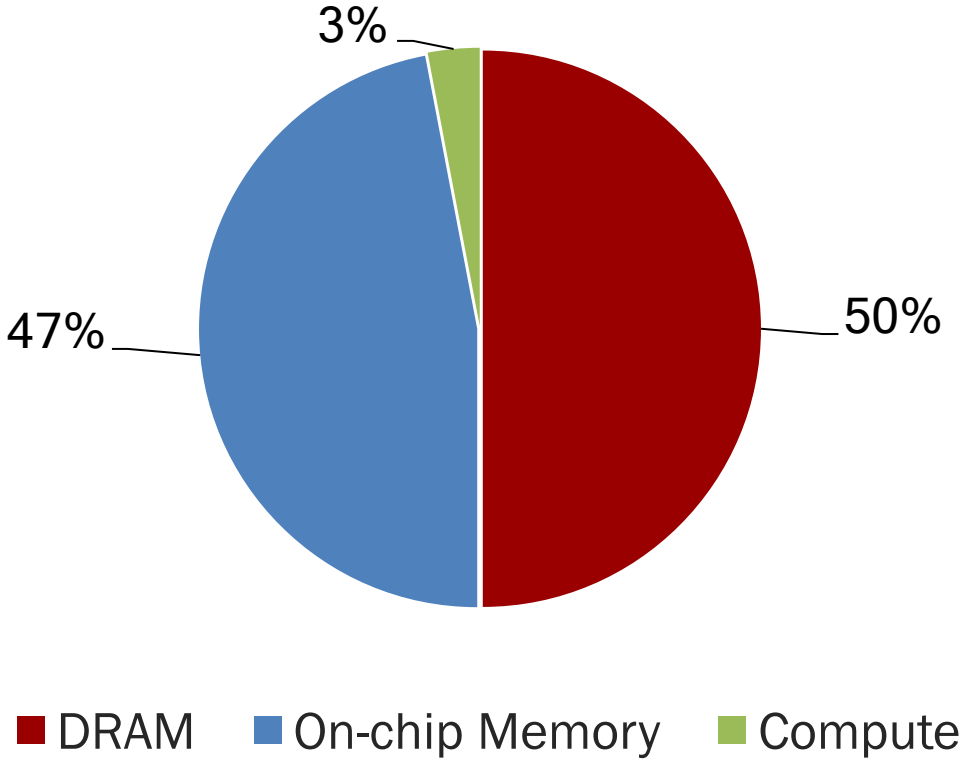


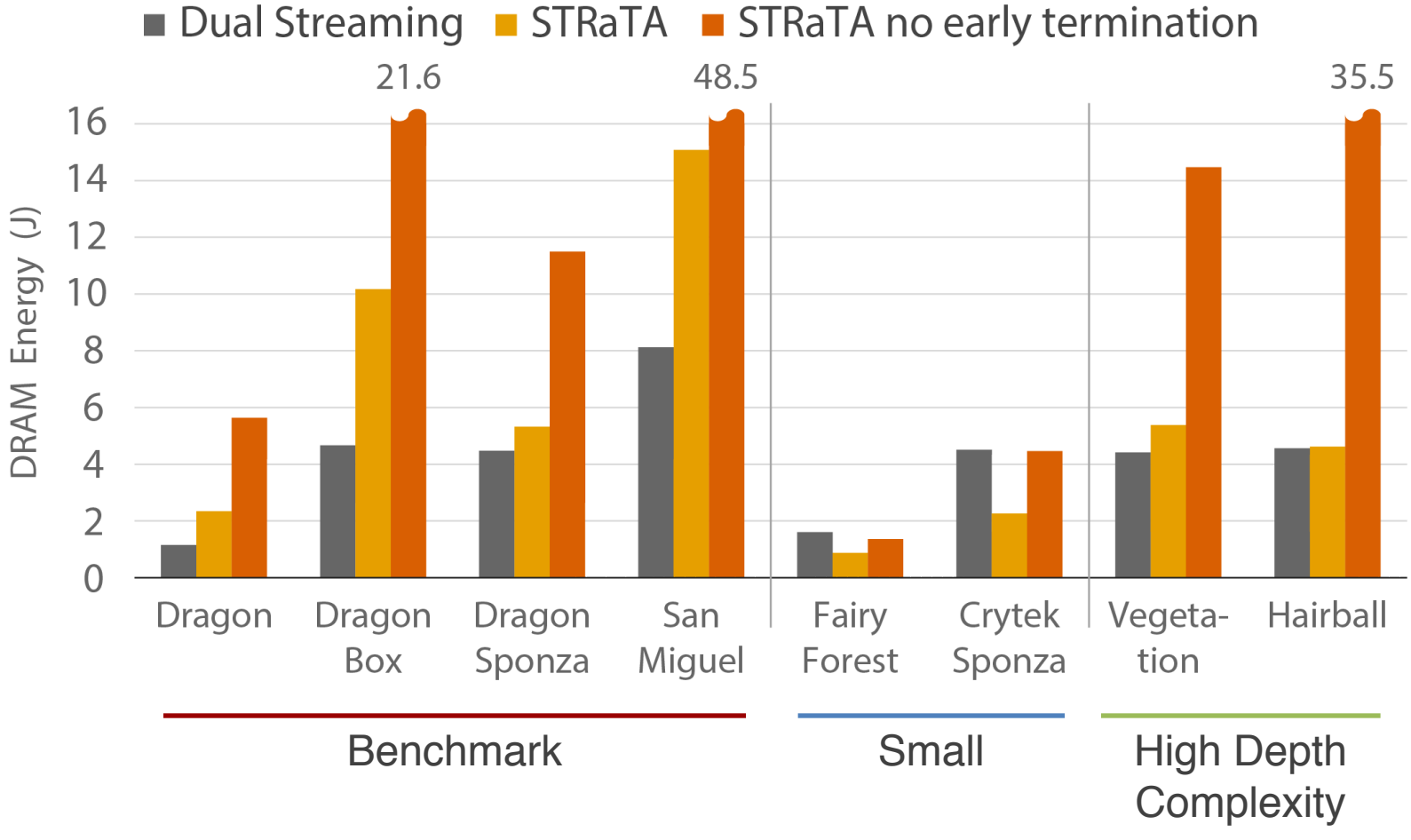
Results: Configurations

	Dual Streaming	STRaTA	OptiX	Embree
Processor	custom	custom	NVIDIA GTX Titan	Intel i7-5960X
# cores	2048	2048	2688	8 (16)
frequency	1 GHz	1 GHz	0.9 GHz	4.6 GHz
on-chip memory	7.7 MB	9.2 MB	5.9 MB	22.5 MB
DRAM bandwidth	512 GB/s	512 GB/s	288 GB/s	75 GB/s

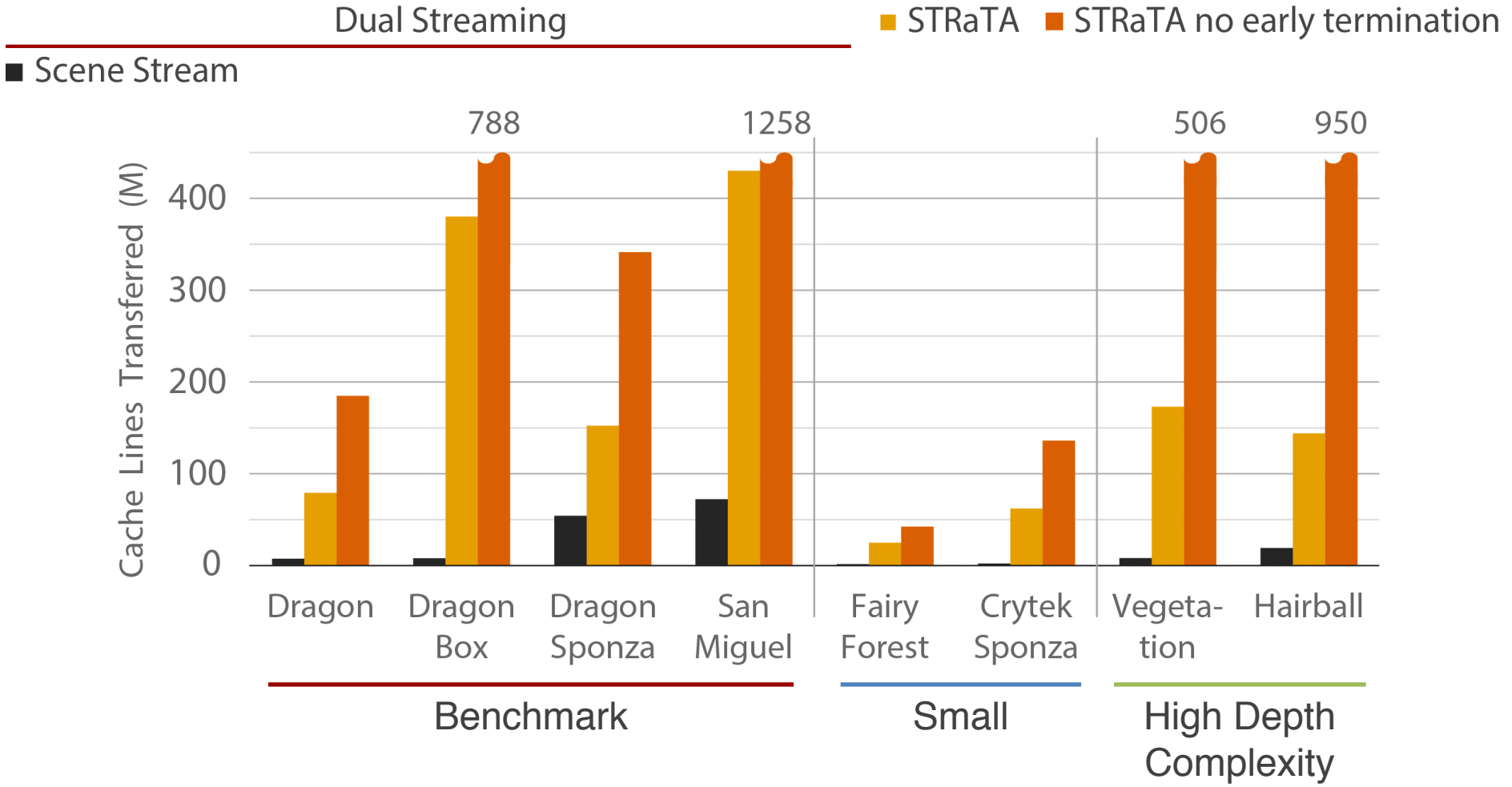
Results: Frame Energy



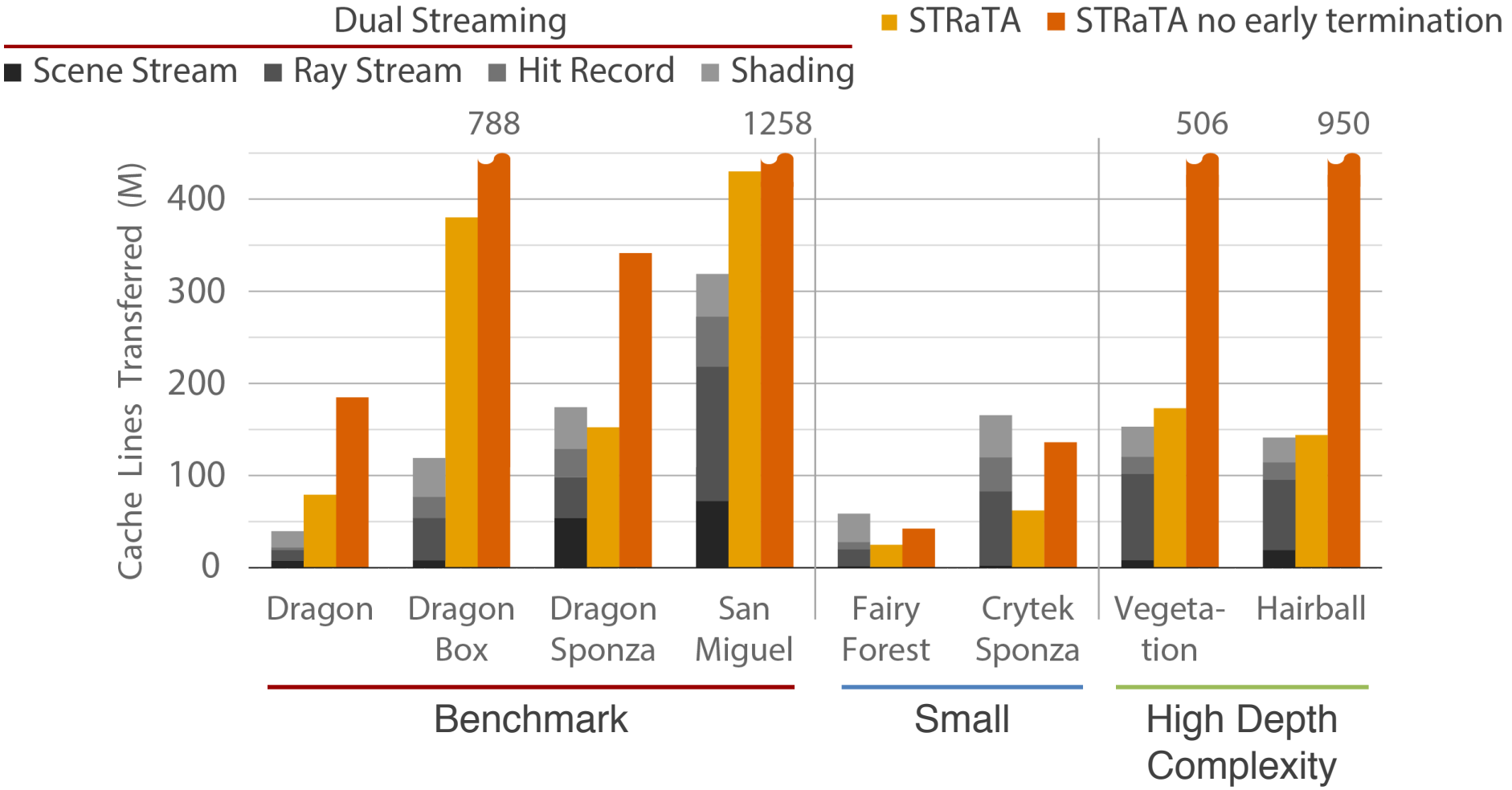
Results: DRAM Energy



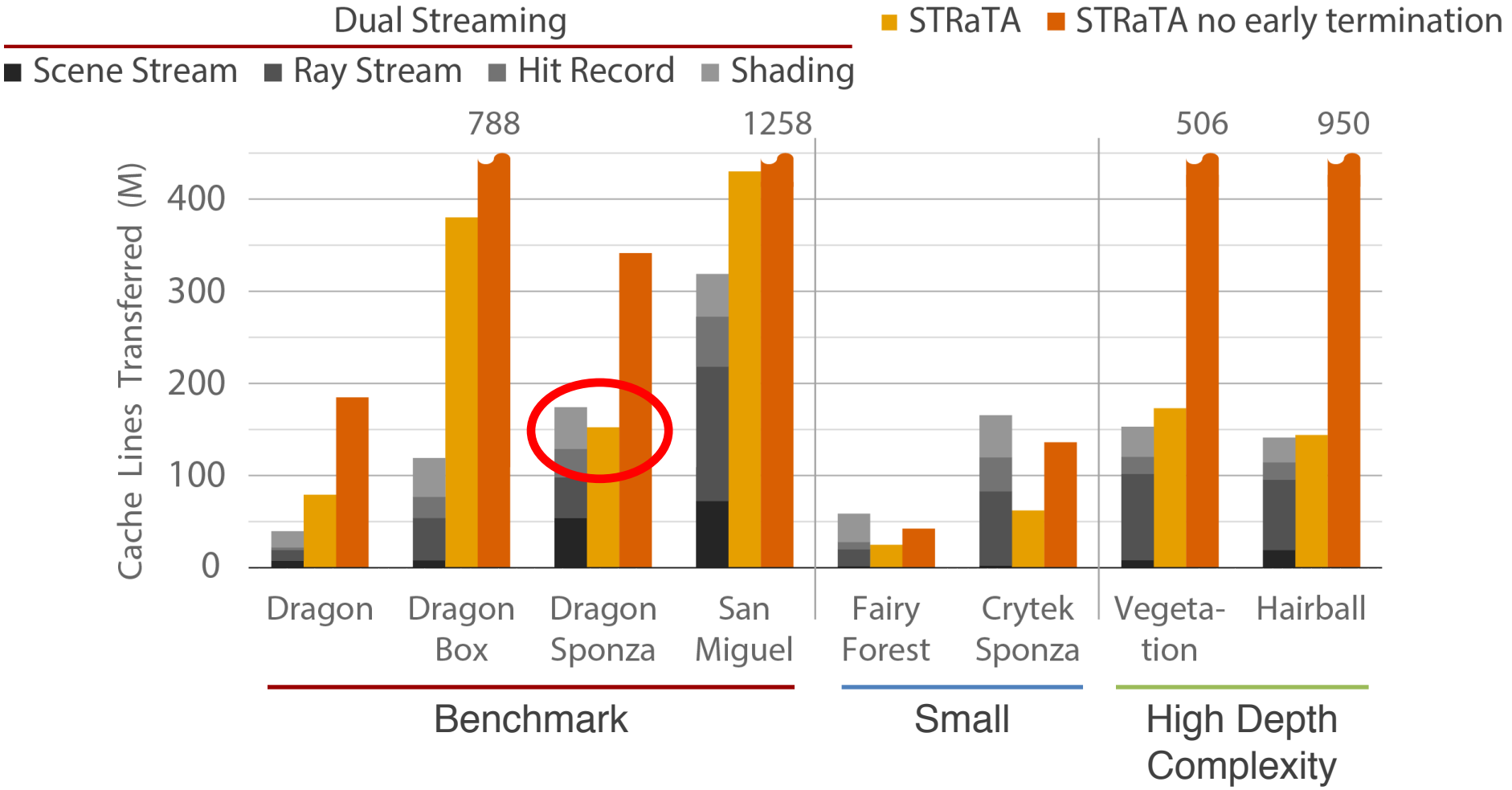
Results: Scene Traffic



Results: All Traffic



Results: All Traffic



Future Work

- Early ray termination

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- Early ray termination
- Dynamic traversal order

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- Early ray termination
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- Treelet assignment

Future Work

- Early ray termination
- Dynamic traversal order
- Treelet assignment
- Data compression

Conclusion

- First fully streamed formulation of ray tracing
  - scene, ray streams
  - predictive memory access
  - new traversal order
  - scene traffic at absolute minimum
- Hardware architecture

Acknowledgments

- Josef Spjut
- Elena Vasiou
- Frank Meinl
- Marko Dabrovic
- Samuli Laine
- Guillermo Leal Llaguno
- Cem Yuksel
- Anonymous reviewers
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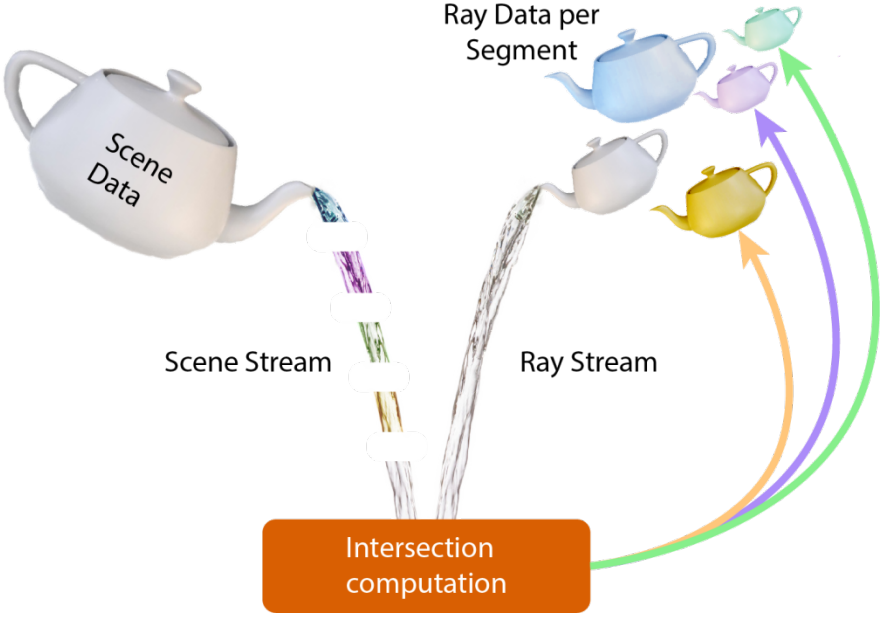
Thank you!


Ray Data per
Segment
Scene
Data
Scene Stream
Ray Stream
Intersection
computation