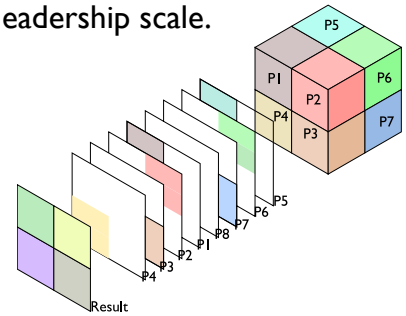
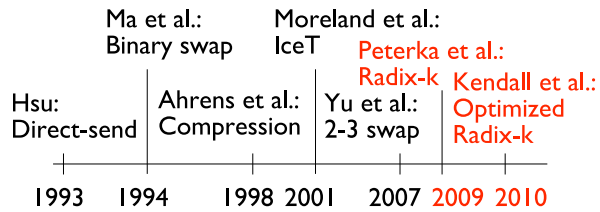
Image composition is the final stage in sort-last parallel visualization algorithms. Its cost can dominate the run-time of these algorithms at leadership scale.



Example of 8 processes merging their output images into one composite image.

Binary swap and direct-send are the accepted ways to do image compositing. Both date to the mid 1990s when HPC architectures were very different than today.

Timeline of image compositing milestones



RADIX-K: Large-Scale Parallel Image Compositing for Sort-Last Rendering

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Radix-k is a configurable algorithm that outperforms earlier compositing algorithms such as direct-send and binary swap.

- Tunable to architectures
- More message concurrency
- Avoid message contention
- Tunable to optimizations

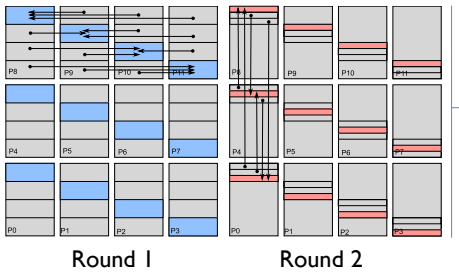


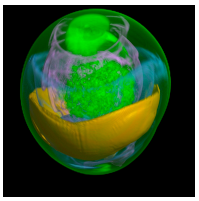
Illustration of Radix-k on 12 processes, factored into two rounds of k = [4, 3].

Selection of k-values depends on architecture, image size, and process count. After testing various machines, target k-values are tabulated and looked up at run time.

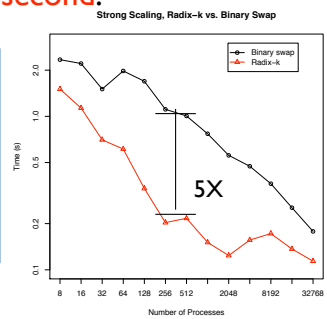
Table of target k-values for Intrepid BG/P and Jaguar XT5

Processes \ Megapixels	Intrepid 4	Intrepid 8	Intrepid 16	Intrepid 32	Jaguar 4	Jaguar 8	Jaguar 16	Jaguar 32
8	8	8	8	8	4	4	4	4
16	16	16	16	16	4	4	4	4
32	32	32	32	32	16	8	16	16
64	64	64	64	64	16	16	16	16
128	64	128	128	128	8	8	8	8
256	64	128	128	128	16	8	8	8
512	64	128	128	128	16	32	8	8
1 K	64	128	128	128	64	32	32	8
2 K	32	128	128	128	8	32	32	32
4 K	32	32	32	32	8	16	32	64
8 K	32	32	32	32	4	8	32	64
16 K	32	32	32	32	4	32	32	8
32 K	32	32	32	32	16	16	64	8

Radix-k with bounding box & run-length encoding accelerations enabled 64 megapixels to be composited on 32 K processes in 12.5 frames per second.



Supernova volume rendering with Radix-k is 3 – 5X faster than binary swap.



Ongoing and future work: we are implementing Radix-k in the IceT image compositing library that both ParaView and VisIt use. This research can positively impact countless visualizations.

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