

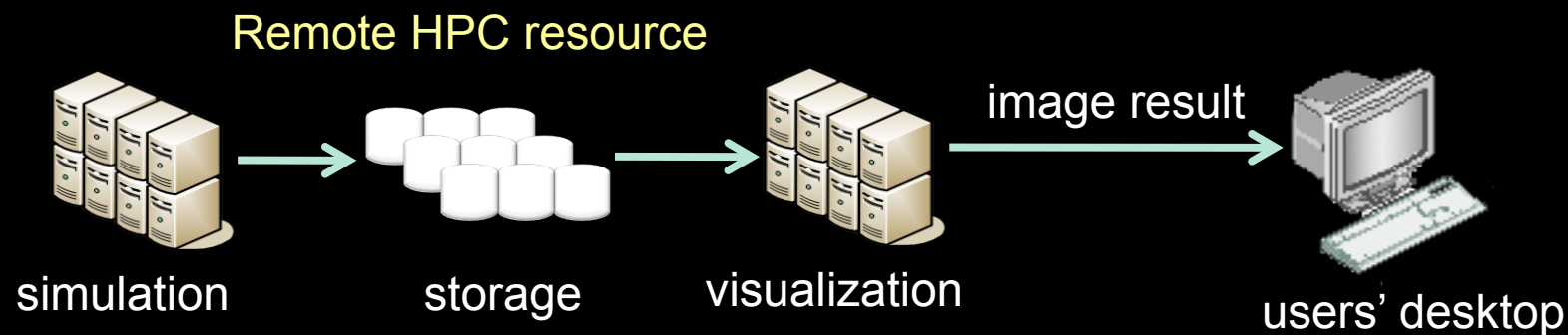
Remote Visualization of Large Scale Data for Ultra-High Resolution Display Environment

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Introduction

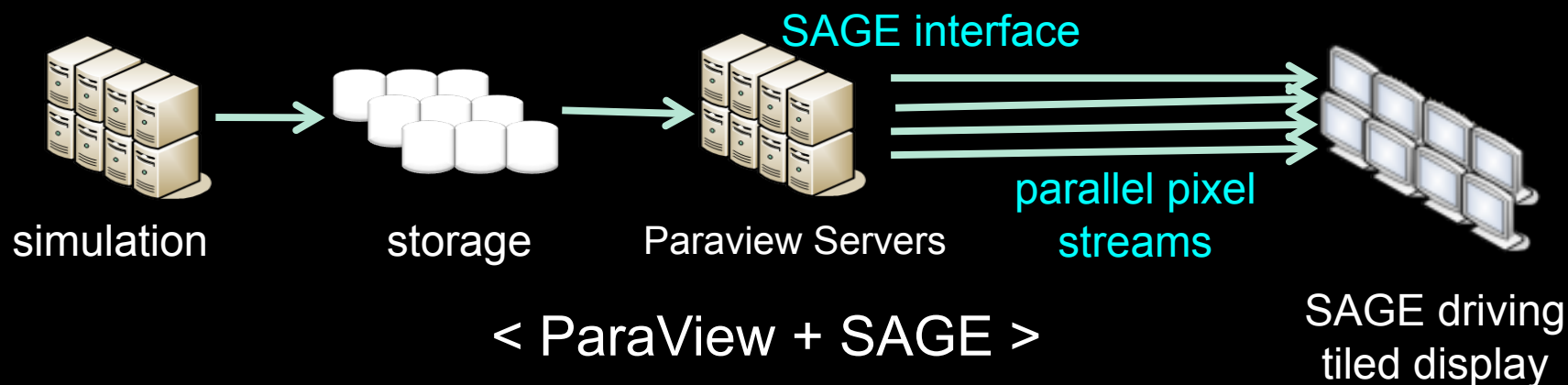
- Explosive scientific data size increase
 - Very difficult to transfer the data
 - Exceed the capacity of modest visualization systems
- Remote visualization using cyber-infrastructure
 - Depend on remote HPC resource for retrieving, handling and analyzing (visualization) data
 - Users see the result streamed over high-speed networks to their desktop computer



ParaView and SAGE

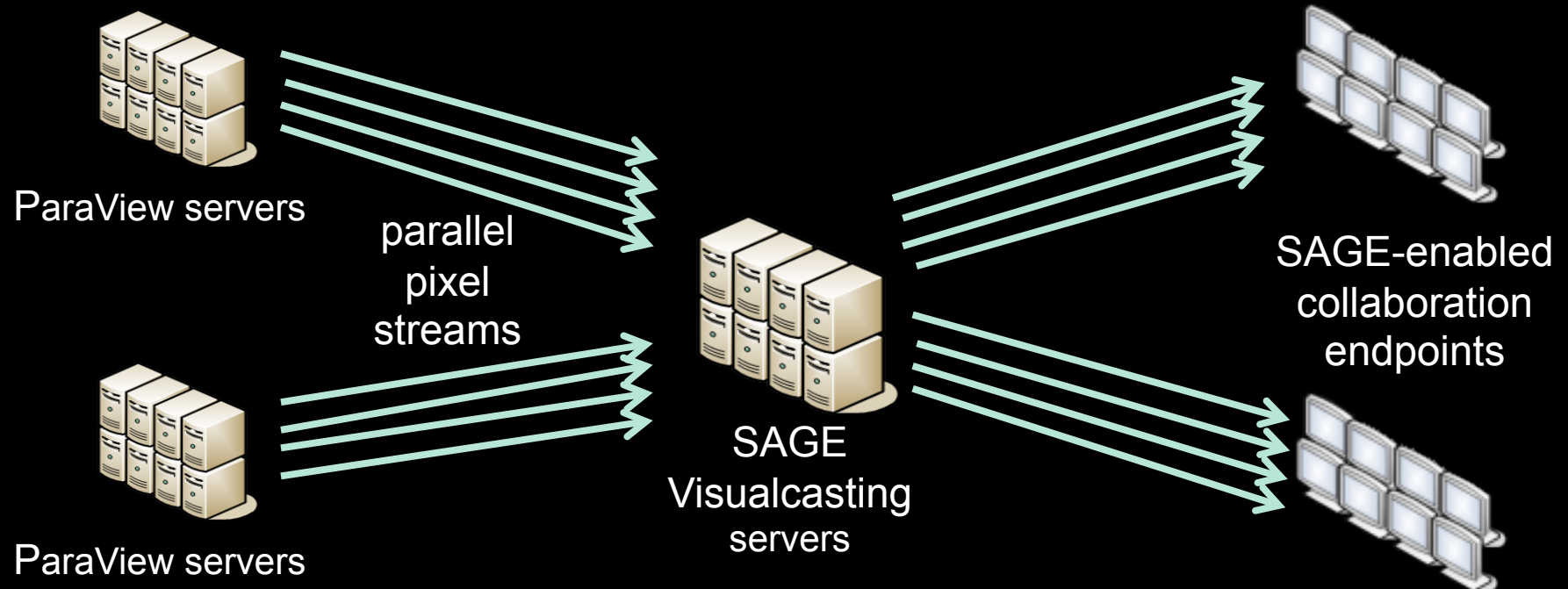
- **ParaView** : one of the major scientific visualization tools
 - Well fit to the cyber-infrastructure model
 - Designed for large-scale parallel visualization
 - Rendering resolution is limited by remote client and network
- **SAGE** : Scalable Adaptive Graphics Environment
 - Assuming ultra-speed network (at least gigabits per second)
 - High-resolution display helps scientific discovery
 - Enable remote visualization on ultra-resolution tiled display
 - Allow users to juxtapose multiple high-resolution visualizations
- **ParaView and SAGE integration**
 - Enable remote visualization of multiple large-scale data-sets in ultra-resolution display environments

ParaView and SAGE Integration



- ParaView servers visualize large-scale data in parallel
- Resulting imagery generated on each server is composited and streamed as a single image to the client (ParaView only)
- SAGE interface captures the pixel data from each server and streams in parallel (ParaView + SAGE)

Benefits of the Integration



- Juxtapose multiple remote ultra-resolution visualizations
- Distribute the visualizations to multiple tiled displays at collaboration endpoints

Related Work

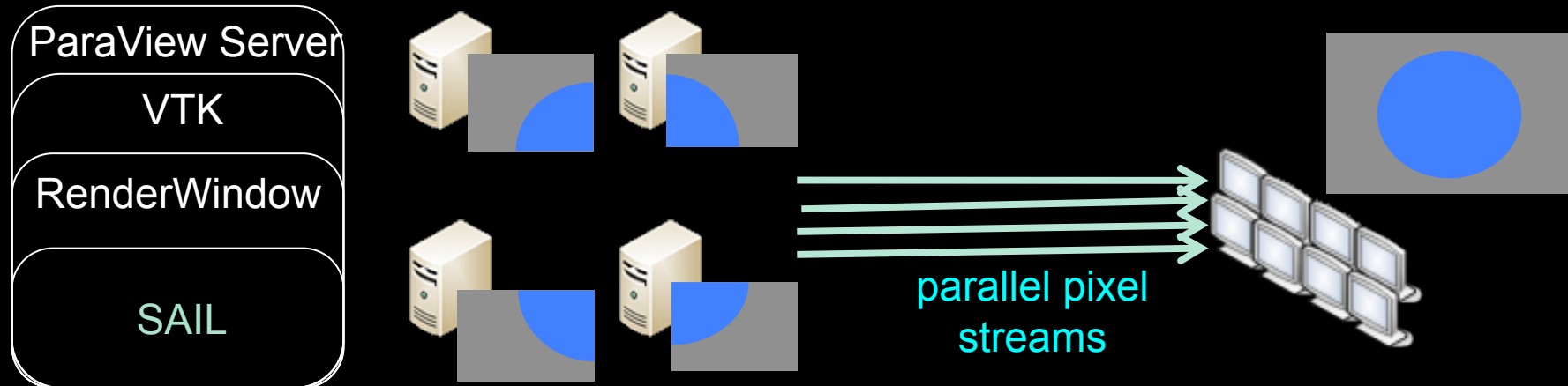
	ParaView + SAGE	ParaView	VisIt	Chromium	CGLX
Remote visualization	Yes	Yes	Yes	-	-
Local tiled display support	Yes	Yes	-	Yes	Yes
Multi-tasking on tiled display	Yes	-	-	-	-
High-res remote collaborative visualization	Yes	-	-	-	-

Major Contributions

- Provide users with a solution to visualize **large-scale** data at an **ultra-high** resolution using **remote** HPC resources
- Open the potential to apply this approach to any VTK-based visualization application by integrating **SAGE** with **VTK**
- Provide a guide for users about:
 - What would be the additional **cost** for high-resolution remote streaming in this solution?
(i.e. additional latency, performance overhead)
 - What would be the minimum **system requirement** for this solution?
(i.e. required bandwidth, computing power, display resolution)

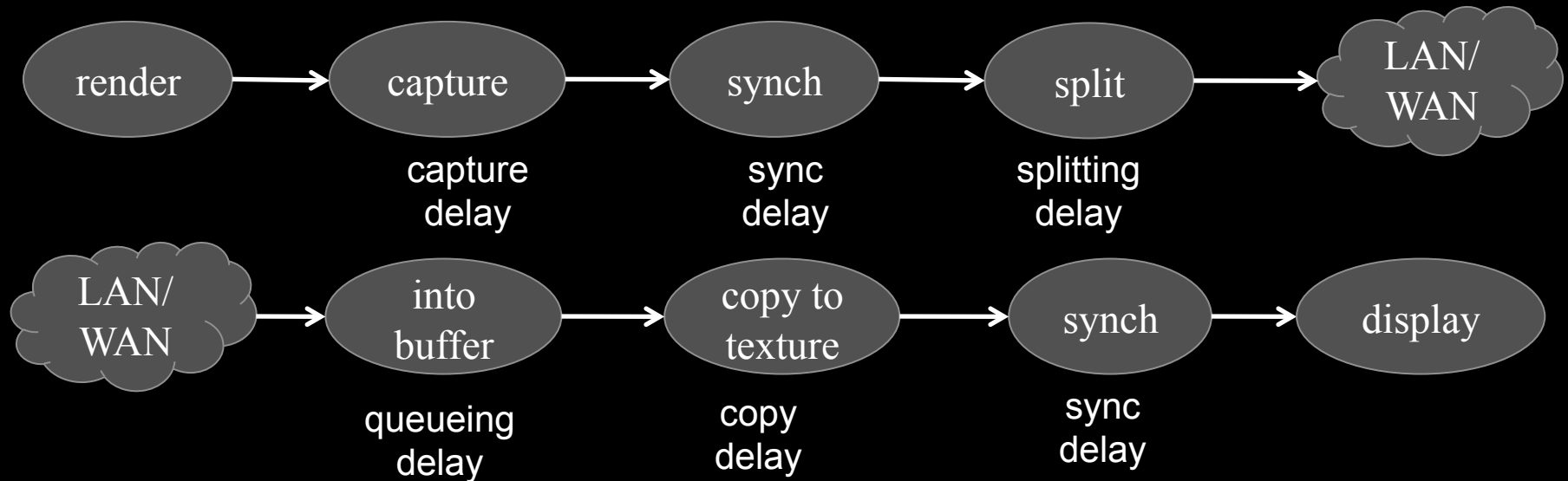
Video

SAGE Interface in VTK



- ParaView tiled-display mode
 - ParaView servers do sort-last rendering and compositing for each tile
- Insert SAGE interface inside the VTK library which ParaView depends on.

SAGE Components



- Render node

$$C_1 \frac{S_{image}}{N_{ren_node}} + C_2 N_{ren_node}$$

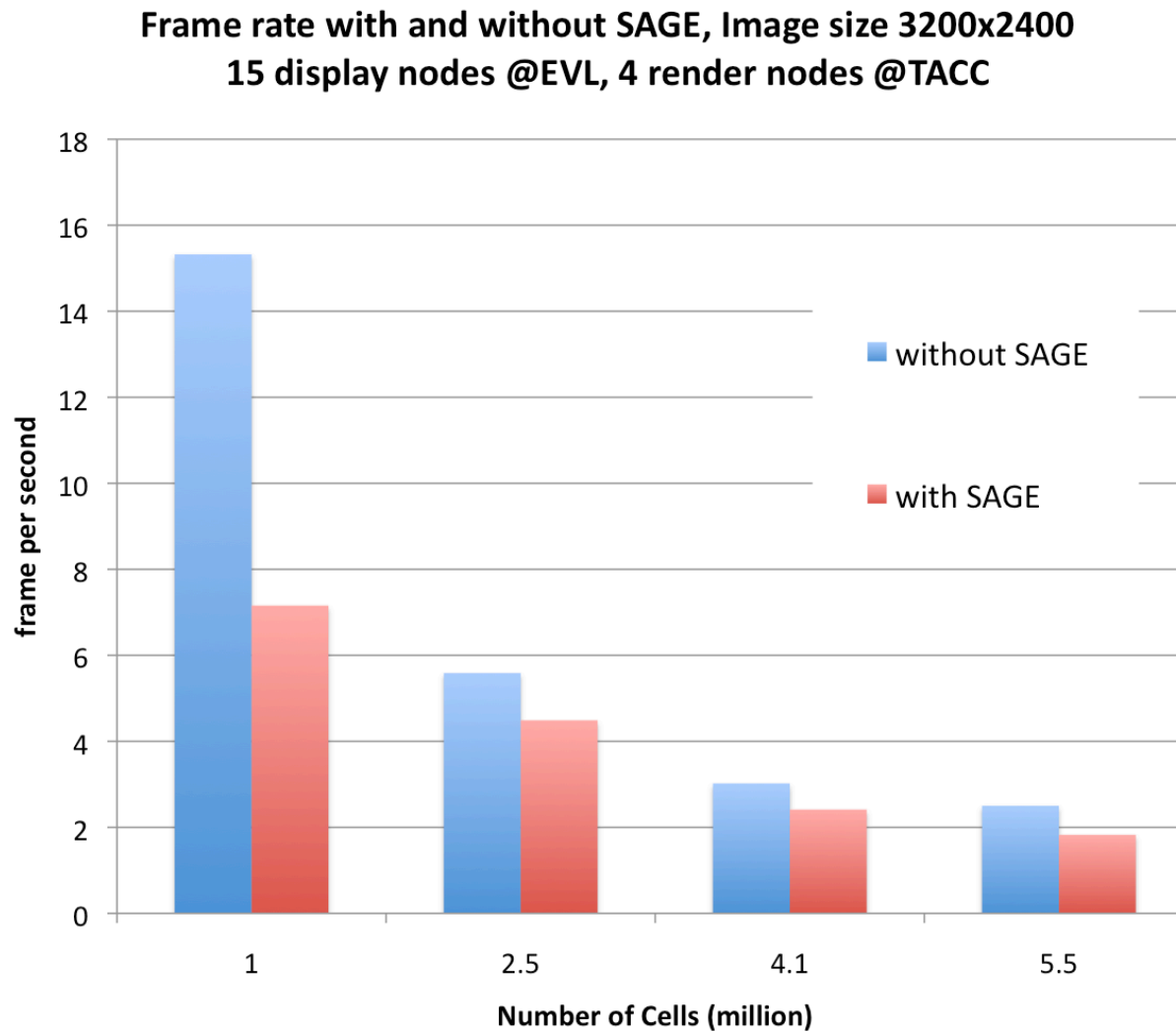
- Display node

$$C_1 D_Q \frac{S_{image}}{N_{rcv_node}} + C_2 N_{rcv_node} + D_Q$$

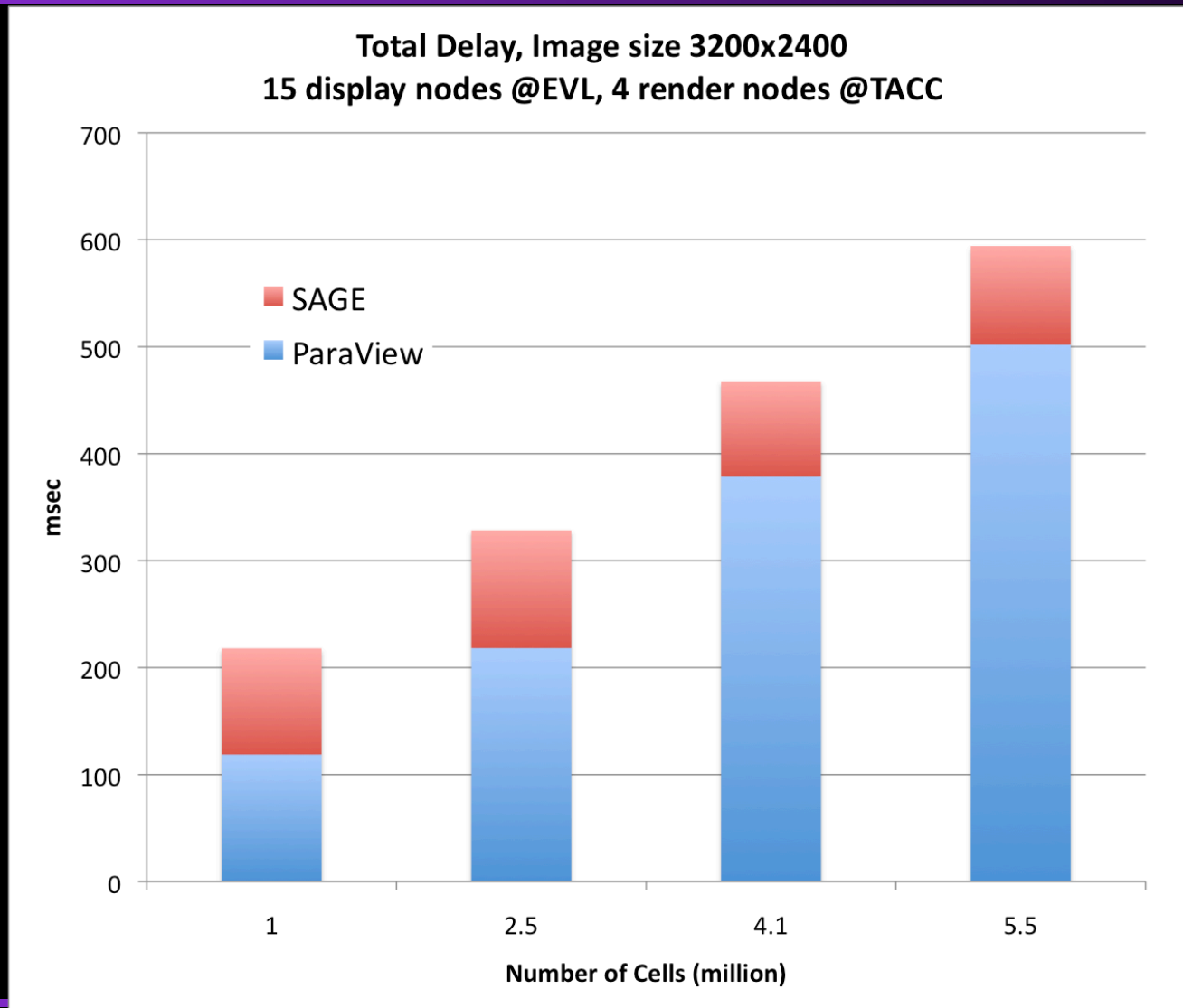
Experimental Environment

- Render nodes
 - TACC Spur vis nodes (16CPU cores, 4GPUs, and 128GB RAM per node).
- Display nodes
 - EVL LambdaVision driven by Yorda cluster
 - Each node has AMD Opteron 2Ghz, 4GB RAM,
 - Nvidia Quardo graphics.
 - Each display node has two 1600x1200 LCD monitors
- Network route
 - 10Gbps National Lambda Rail (Cavewave) via
 - San Diego

Frame Rate with Increasing Dataset Size

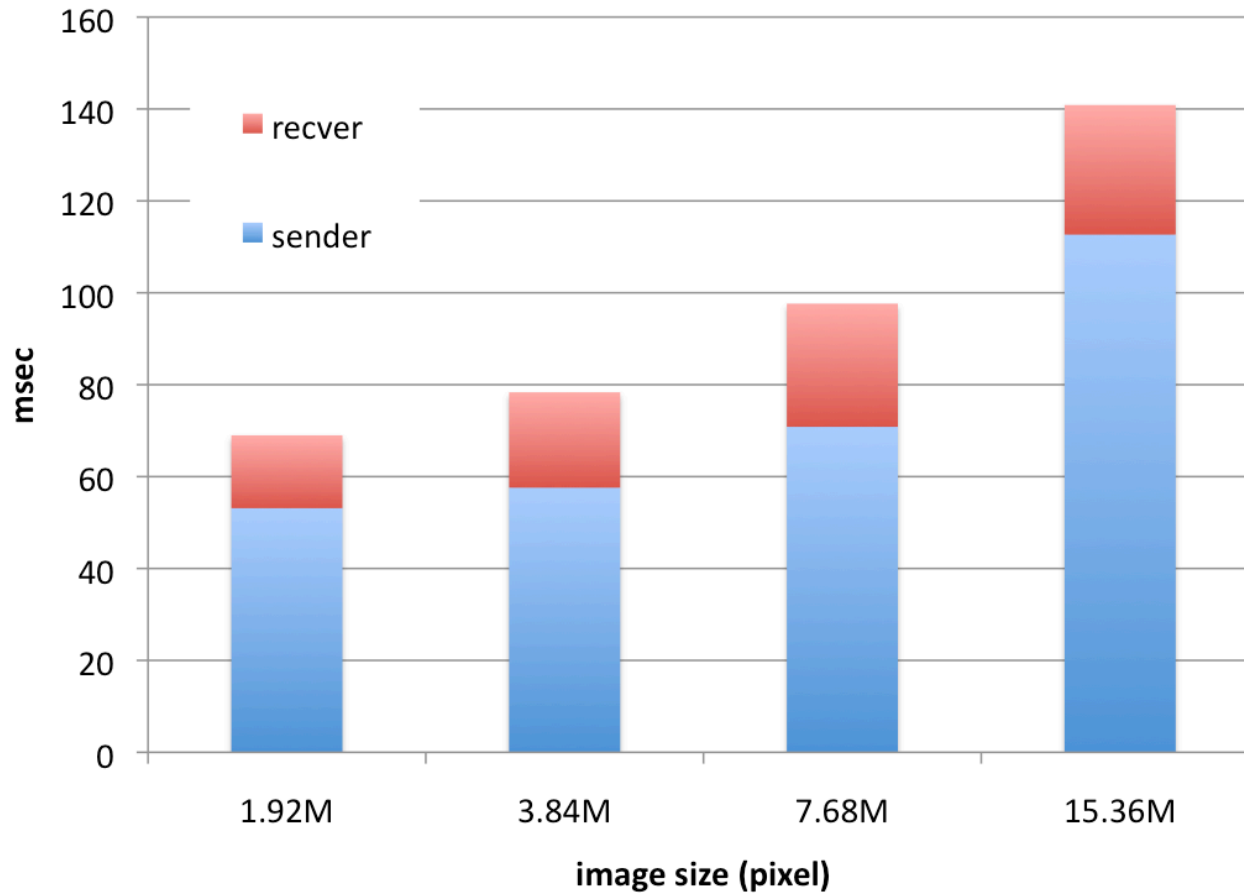


ParaView + SAGE Delay



Delay Incurred by SAGE

Delay incurred by SAGE (logarithmic scale)
4 render nodes @TACC, 15 display nodes @EVL



Future Work and Conclusion

- Automatic generation of SAGE configuration
- Integration with other parallel visualization applications
- Remote ultra high-resolution visualization with ParaView integrated with SAGE
 - Visualize large dataset using parallel computation and rendering on remote servers
 - Stream high-resolution final image over high-speed network to the tiled-display in your lab
- This will motivate more scientists to solve their problems using high-resolution displays and remote HPC resource

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Thank you